# Appropriate Parking Management Strategy for Successful Transit Oriented Development

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## Abstract

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While Transit-Oriented Development (TOD) has gained currency in the United States as a means of countering sprawl, promoting smart growth, vitalizing local economy and expanding life choices over the last two decades, it is still not commonly practiced. One major challenge to implementing a TOD is parking: well-managed parking can improve the performance of a TOD in both transportation and financial perspectives; poorly-managed parking can undermine the expected benefits of a TOD and even cause the initiative to fail. Currently, most jurisdictions use "minimum parking requirements" to manage parking in general, but this highly-flawed practice could easily lead to the oversupply of parking and thus impair the intended effects of TOD. The main purpose of this study is to identify and then propose multiple specific parking management strategies for successful TOD. Three other issues will also be addressed in this thesis: 1) Definition of TOD, 2) Effects of parking on TOD's success and 3) Defects of conventional parking requirements. Finally, the thesis presents a "Parking Study" of 25 selected TOD housing projects in King County and examines its main findings by reviewing the existing parking provisions, and compares them with proposed parking management strategies. Implementation of these innovative strategies is the real challenge of TOD's parking management, and based on that, the thesis provides several recommendations as well as potential issues for future research.

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## Executive Summary

As the name implies, Transit-Oriented Development (TOD), refers to a development oriented to its proximate high-quality public transportation services such as buses, trams and light rail (Litman, 2009). As an alternative to conventional development, it is generally believed that TOD has the potential to control and manage the negative environmental and social impacts of dispersed growth patterns, such as traffic congestion, lengthy commutes, affordable housing shortages, air pollution, and incessant sprawl (TCRP, 2002). What's more, TOD can be used as a land use strategy or a planning tool that promotes smart growth, leverages economic development, and shifts housing market demands and lifestyle preferences (TCRP, 2004).

Over the past two decades, the idea of TOD has gained wide acceptance in most metropolitan areas in the United States (TCRP, 2004) and numerous TOD projects (some poorly planned) have been built all across the country. However, the actual performances of TODs are uneven (Bae, 2002) and quite a number of them have failed to achieve their intended goals. Among the various factors that can affect the fate of TOD, parking is one major issue that largely determines its success and failure from both transportation and financial perspectives (Boroski, 2005).

Parking, as one essential amenity for consumer life, has been ample and free in the United States for a long time and most authorities use "minimum parking requirements" as the major parking management strategy to ensure a project's availability and accessibility. Many critics argue, however, that parking is generally oversupplied and underpriced and is particularly harmful for TOD (Willson, 2005).

The main objective of this study is to explore the appropriate parking management strategies for successful TODs. The thesis mainly consists of five sections and the following is the thesis structure and content.

**Chapter 1:** Defines Transit-Oriented Development by reviewing its history and key features. The discussion also offers a formal definition of TOD and mainly focuses on its four essential components.

**Chapter 2:** Examines the parking effects on TOD's success. This chapter enumerates various potential benefits of TOD, identifies four primary goals that a successful TOD should achieve, and then explicates the effects of parking on them.

**Chapter 3:** Reveals potential flaws of traditional parking management strategy and then proposes appropriate ones for TOD. To understand the limitations of conventional parking requirements, the chapter reviews its history and analyzes established mechanisms. Then the chapter proposes twelve specific parking management strategies for TOD and explicates each of them.

**Chapter 4:** Presents a Parking Study on twenty-five TOD housing projects in King County, WA. The study describes the basic parking information of those selected TODs and further discusses the findings by examining the existing parking strategies in King County, particularly in Seattle.

**Chapter 5:** Conclusions derived from the research are stated, along with challenges faced in the study and directions of future research.

# Chapter 1: Define Transit-Oriented Development

Transit-Oriented Development (TOD), generally referring to development near or oriented to mass-transit facilities such as bus or rail station, first appeared in late 19th and early 20th centuries in some modern metropolitan areas in the United States, and then gained popularity across the country over the past two decades (Hondrop, 2002). During its history of nearly a hundred years, the concept and the form of TOD have evolved with the development of transportation, urban planning, real estate, etc. Based on the article "*Transit-Oriented Development: Moving from Rhetoric to Reality"* (Belzer & Aulter 2002), the evolution of TOD can be broadly divided into four phases:

## 1.1 History of Transit-Oriented Development

### *1.1.1 The Early 20th Century: Development-Oriented Transit*

Some of the very first TOD projects in the United States were railroad and streetcar suburbs which can be dated back to the turn of the last century (Belzer & Aulter 2002). In the San Francisco Bay area, for example, the San Francisco, Oakland & San Jose Railway, more commonly known as the "Key System" developed a vast network of lines in the East Bay since it began to operate in the 1870's and led to the rapid settlement of new townships in previously undeveloped areas (Hondrop, 2002). By the early 1900s, electric streetcar systems had emerged in cities throughout the United States and according to Middleton, "… more than any other development, the electric streetcars contributed to the growth of America's suburbs."(Middleton, 1967)

The railroad and streetcar suburbs can be viewed as the earliest form of TOD. In this era, however, transit lines were typically built by private developers to serve their real estate development, so the phrase "Development-Oriented Transit" is more accurate to describe these early projects (Belzer & Aulter 2002).

### *1.1.2 The Post-War Years: Auto-Oriented Transit*

The boom of the automobile industry and the subsequent construction of the Interstate Highway System after World War II thoroughly changed the means of transportation for most

Americans and made the United States a country on wheels. In the mean time, the post-World War II period also saw a precipitous decline in transit use and the dismantlement and abandonment of many rail systems (Belzer & Aulter 2002). As a result, bus systems became the primary mode of transit in most of the regions at that time, and unlike the fixed-rail transit, bus systems competed with the automobile, using the same streets, experiencing the same congestion and had less influence on land use patterns (Belzer & Aulter 2002).

In the 1970s, a new generation of transit systems, including the San Francisco Bay Area Rapid Transit (BART) system, Metropolitan Atlanta Rapid Transit Authority (MARTA) in Atlanta, and Metro in the Washington D.C. area, were built with an entirely different rationale (TCRP, 2004). The primary goal of these systems was to work with the automobile to relieve congestion on a regional scale (VTPI, 2011). For example, those systems encouraged people to drive to suburban stations rather than walking, biking or riding bus by providing large expanses of surface parking or parking structures (Carlton, 2007).

While some of these systems achieved real success in terms of their importance in those areas, they were not considered as the real Transit-Oriented Development. In particular, they failed to promote and revitalize the neighborhood near their stations, they didn't reduce automobile dependency to the extent they could, and they didn't encourage more efficient regional land-use pattern as well as they might (Belzer & Aulter 2002).

### *1.1.3. The Late 20th Century: Transit-Related and Transit-Supportive Development*

During the Post-World War II period, most of the "Auto-Oriented Transit" systems required extensive operating subsidies. A typical transit agency recovered less than one-third of its costs in fare box revenues (NTA, 2005). Transit agencies and the federal government soon realized the potential of large-scale real estate development on transit-agency-owned property as a way to generate revenue, and to increase ridership by promoting intense development around transit stations (Carlton, 2007).

This approach was referred to as "Joint Development" as it was often accomplished through a joint partnership between the transit agency and a private developer (TCRP, 2002). Throughout the 1970s and 1980s, this form of development received great attention as a revenue generator. The "Joint Development" approach has been used successfully in some notable

locations around the country including downtown San Diego, CA, Washington D.C., and Portland, OR, (Belzer & Aulter 2002).

Later in the 1980s, researchers discovered that "Joint Development" can yield many more benefits than merely financial returns. These benefits include growing transit ridership, increasing investment in transit, relieving traffic congestion and countering suburban sprawl (TCRP, 2002). Therefore, many transit authorities began to look for such projects that could bring more benefits than just revenue, including increasing pedestrian activity and promoting transit ridership (Carlton, 2007).

These developments which were built after the 1980s could be considered as the prototype of modern TOD. Most of them, however, still did not realize the full range of TOD's potential benefits. In "*The New Transit Town"* (Dittmar, 2004) and "*Transit-Supportive Development in the United States"* (Cervero, 1993), these types of projects were ultimately labeled as "Transit Related Development" or "Transit Supportive Development".

### *1.1.4. Transit-Oriented Development in 21st century*

The 20th century saw the transition of TOD from the "Development-Oriented Transit" in the early 1900s to the "Transit-Related Development" in the past few decades and much has been written about TOD in recent years (Hondrop, 2002). However, there is still no single, all-encompassing definition of TOD.

The term of Transit-Oriented Development (TOD) was codified by Peter Calthorpe (1993) in his book *The Next American Metropolis*. His definition of TOD is as follows:

*"A Transit Oriented Development is a mixed-use community within an average 2,000-foot walking distance of a transit stop and core commercial area. TOD's mix residential, retail, office, open space and public uses in walkable environment making it convenient for residents to travel by transit, bicycle, foot or car."*

(Calthorpe, 1993)

Based on Calthorpe's definition, experts and scholars in the 21th century developed a new recognition of TOD. Four quotations in the following table sample them.

**Table 1**Definitions of Transit-Oriented Development in 21st Century

*"Transit Oriented Development (TOD) refers to Residential and Commercial Centers designed to maximize access by Transit and Nonmotorized transportation, and with other features to Encourage Transit Ridership. A typical TOD has a rail or bus station at its center, surrounded by relatively high-density development, with progressively lower-density spreading outwards one-quarter to one-half mile, which represents pedestrian scale distances."*

*(Renne, 2009)*

*"Moderate to higher density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment, and shopping opportunities designed for pedestrians without excluding the auto. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use"*

*(California Department of Transportation 2001)*

*"A place of relatively higher density that includes a mixture of residential, employment, shopping and civic uses and types located within an easy walk of a bus or rail transit center. The development design gives preference to the pedestrian and bicyclists, and may be accessed by automobiles"*

*(Maryland Department of Transportation 2000)*

*"A mix of residential, retail and office uses and a supporting network of roads, bicycle and pedestrian ways focused on a major transit stop designed to support a high level of transit use. The key features of TOD include*

*(a) a mixed use center at the transit stop, oriented principally to transit riders and pedestrian and bicycle travel from the surrounding area;*

*(b) high density of residential development proximate to the transit stop sufficient to support transit operations and neighborhood commercial uses within the TOD;*

*(c) a network of roads, and bicycle and pedestrian paths to support high levels of pedestrian access within the TOD and high levels of transit use"*

*(Oregon Revised Statues, Section 307-600-1)*

*Source: VTPI, 2011*

Three common features can be extracted from these definitions (TCRP, 2002):

1. Mixed-use development
2. Development that is close to and well-served by transit
3. Development that is conducive to transit riding

Therefore, rather than a single definition, the best way to explain TOD is to discuss its key features.

## 1.2 Key Features of True TOD

Based on Aseem Inam (2011)'s report "*From Intentions to Consequences: San Diego TOD Design Guidelines and Rio Vista West Project"* and Jeffery Tumlin (2003)'s article "*How to make transit-oriented development work",* a true TOD should include most of the following twelve features:

*• The transit-oriented development lies within a five-minute walk of the transit stop, or about a quarter-mile from stop to edge. For major stations offering access to frequent high-speed service this catchment area may be extended to the measure of a 10-minute walk.*

*• A balanced mix of uses generates 24-hour ridership. There are places to work, to live, to learn, to relax and to shop for daily needs.*

*• A place-based zoning code generates buildings that shape and define memorable streets, squares, and plazas, while allowing uses to change easily over time.*

*• The average block perimeter is limited to no more than 1,350 feet. This generates a fine-grained network of streets, dispersing traffic and allowing for the creation of quiet and intimate thoroughfares.*

*• Minimum parking requirements are abolished.*

*• Maximum parking requirements are instituted.*

*• Parking costs are "unbundled," and full market rates are charged for all parking spaces.*

*• Major stops provide Bike Stations, offering free attended bicycle parking, repairs, and rentals. At minor stops, secure and fully enclosed bicycle parking is provided.*

*• Transit service is fast, frequent, reliable, and comfortable, with a headway of 15 minutes or less.*

*• Roadway space is allocated and traffic signals timed primarily for the convenience of walkers and cyclists.*

*• Automobile level-of-service standards are met through congestion pricing measures, or disregarded entirely.*

*• Traffic is calmed, with roads designed to limit speed to 30 mph on major streets and 20 mph on lesser streets.*

The twelve features of TOD can be grouped into three aspects: Design Features, Density Features and Proximity to Stations (Hondrop, 2002).

### 1.2.1. Design Features

With respect to design, TOD should promote walking and transit riding by having design features such as landscaped sidewalks, parking in the rear, and retail street walls that make walking and transit riding more enjoyable (Hondrop, 2002). Some commonly-accepted TOD design features are presented in Table 2.

**Table 2** Design Features of True TOD

- *Continuous and direct physical linkages between major activity centers; siting of buildings and complementary uses to minimize distances to transit stops.*
- *Street walls of ground-floor retail and varied building heights, textures, and facades that enhance the walking experience; siting commercial buildings near the edge of sidewalks. Integration of major commercial centers with the transit facility.*
- *Grid street patterns that allow many origins and destinations to be connected by foot; direct sight lines to transit stops.*
- *Minimizing off-street parking supplies; where land costs are high, tucking parking under buildings or placing it in peripheral structures; in other cases, siting parking at the rear of buildings instead of in front.*
- *Providing such pedestrian amenities as attractive landscaping, continuous and paved sidewalks, street furniture, urban art, screening of parking, building overhangs and weather protection, and safe street crossings.*
- *Convenient siting of transit shelters, benches, and route information.*
- *Creating public open spaces and pedestrian plazas that are convenient to transit.*

*Source: Bernick and Cervero, 1997*

### 1.2.2. Density Features

A fundamental feature of TOD is high density. Studies have shown a clear link between increased density and increased transit ridership. For example, "*TCRP Report 102"* (TCRP, 2004) examines the relationship between residential and employment density within one mile radius of rail stations and the rail transit ridership, the results are summarized in Table 3:

**Table 3** Density and Rail Ridership

| Density of Residential Units (per Gross Acre) | Percentage of Rail Commuters |
|---|---|
| 10 | 24.30% |
| 20 | 43.40% |
| 40 | 66.60% |
| **Density of Jobs (per Gross Acre)** | **Percentage of Rail Commuters** |
| 5 | 11.00% |
| 20 | 26.50% |
| 60 | 52.10% |

*Source: TCRP Report 102 (TCRP, 2004)*

In general, TOD requires at least 6 residential units per acre in residential areas and 25 employees per acre in Commercial Centers (Pushkareav & Zupan, 1977). These densities are significantly higher than the average densities in most U.S. suburbs and help create adequate transit ridership to justify frequent transit service, and stimulate active street life and commercial activities, such as grocery stores and coffee shops.

Based on Pushkarev and Zupan's work and other studies, an ideal TOD neighborhood should have 5,000 to 15,000 residents located within a half-mile of a bus or rail station. This area totals about 500 acres of land, or about 400 net acres assuming that about 20% of the land is devoted to infrastructure such as roads, parks and schools (VTPI, 2011). Table 4 illustrates the densities distribution in an ideal TOD neighborhood.

**Table 4** Density of Typical TOD Neighborhood

| | Acres | Units/Acre | People Per Unit | Total People /Acre | Total People |
|---|---|---|---|---|---|
| High-density commercial and residential | 50 | 50 | 1.5 | 75 | 3,750 |
| Mixed medium-density | 150 | 12 | 2.0 | 24 | 3,600 |
| Lower density residential | 200 | 8 | 3.0 | 24 | 4,800 |
| ***Totals*** | ***400*** | ***15*** | ***2*** | ***30*** | ***12,150*** |

*Source: VTPI, 2011*

### 1.2.3. Proximity to Stations

The majority of transit trips involve some degree of walking to access stops or stations; therefore the proximity of residences and employment to stations is also vital to for TOD (Hondrop, 2002). Research by Untermann (1984) on the walking behavior of Americans suggests that "2,300 feet" is the maximum distance people are willing to walk for general purposes. Specific studies on transit proximity and ridership in the Bay Area, Washington, D.C., and Toronto indicate that transit ridership is the highest within about one-third mile from the station (Bernick & Cervero 1997).

## 1.3 Summary of Chapter 1

Transit-Oriented Development in the U.S. has been evolving for nearly a hundred years. It first appeared as "Development-Oriented Transit" in the early 1900s shifted to "Auto-Oriented Transit" after WWII, and finally began to realize its full potential as "Transit-Supported Development" from late 1980s. In the new century, TOD became not only a narrow development pattern, but a land- use strategy and a planning tool, aiming at promoting smart growth, leveraging economic development, and catering to shifting housing market demands and lifestyle preferences (TCRP, 2004). Therefore, rather to achieve a consensus of a single definition, a reasonable way to define TOD is to recognize and understand its key features or essential elements that compose the true Transit-Oriented Development. The key elements of TOD described as most critical and essential are synthesized in Table 5.

**Table 5** the Essential Elements of a True TOD

| Elements | Further Clarification |
|---|---|
| **Compact Development** | • TOD locations within comfortable walking distance of transit station or stop (about one-quarter to one-half mile).<br>• Medium to high housing and employment density: Minimum residential density of 10-15 Units/Acre (gross), or 30 people/ acre (Net).<br>• Minimum employment density of 25 Jobs/Acre (gross).<br>• (Net is about 20% higher than gross) |
| **Pedestrian Oriented Design** | • Grid street network connecting the transit stop or station with TOD's commercial, civic and residential areas.<br>• Attractive pedestrian environment with landscaped sidewalks, street-facing building, parking in the rear, etc.<br>• Traffic is calmed, with roads designed to limit speed to 30 mph on major streets and 20 mph on lesser streets. |
| **Balanced mix of land uses** | • Diverse and complementary high-activity uses such as retail, professional services, public spaces, housing and employment.<br>• Horizontal (side-by-side) and vertical (within the same building) mixed use.<br>• Minimum of 20% land for housing. |
| **Efficient Transit System** | • Fast, frequent, reliable, and comfortable transit service.<br>• Transit facilities - rail and bus stations and stops – tailored to the level of transit service.<br>• Parking to accommodate transit users and TOD customers |

*Source: Author*

# Chapter 2: Effects of Parking on TOD's success

Over the past two decades, TOD has gained popularity in most metropolitan areas in the United States (TCRP, 2004) and numerous TOD projects have been built across the country. Despite this interest, the actual performances of TODs are uneven (Bae, 2002) and quite a number of them have failed to achieve their intended goals. Among the various factors that can affect the fate of TOD, parking is one major issue that largely determines its success and failure.

The main purpose of this chapter is to study the effects of parking on TOD performance. Therefore, the first task is to identify the success factors for TOD.

## 2.1 Successful TOD and its Potential Benefits

In general, a successful TOD should provide more transportation options, improve the "livability" of communities and serve as a key force in local economic development or revitalization of decayed neighborhoods and old city centers (Niles, 1999). Furthermore, people who live and work in TODs should tend to own fewer vehicles, drive less, and rely more on alternative transportation modes (TCRP, 1997). Successful TODs can provide numerous and diverse benefits to individuals, communities, and regions. Table 6 shows a portion of them.

**Table 6** TOD Benefits

| |
|---|
| 1. *Increase transit ridership.* |
| 2. *Encourages use of non-motorized transportation* |
| 3. *Increase mobility choices* |
| 4. *Enhance economic development and Revitalize neighborhoods* |
| 5. *Increase Land values, rents and real estate performance* |
| 6. *Increases households' disposable income* |
| 7. *Increase public safety* |
| 8. *Reduce road expenditures and other infrastructure costs* |
| 9. *Reduce traffic congestion and Vehicle Miles Traveled (VMT)-related costs* |
| 10. *Increase affordable housing opportunities* |

*Source: NHHS 2011and Park 2002*

As mentioned before, TOD should have the following essential components: 1) Compact Development, 2) Pedestrian-oriented Design, 3) Balanced mix of land uses and 4) Efficient transit systems, and a successful TOD needs to bring out the best of those four features.

According to "*Moving from Rhetoric and Reality"* (Belzer & Autler 2002), there are six performance criteria of a successful TOD:

**1. Location Efficiency:** Successful TOD should be a pattern of development that "improves accessibility between a variety of land uses and transportation" (location efficiency). Key components of location efficiency are: 1) High Density, 2) Mix of Use, 3) Proximity to transit and 4) Pedestrian-friendly design.

**2. Value Recapture:** Successful TOD can translate into direct savings for individuals, households, regions and nations.

**3. Livability:** At its core, a successful TOD strives to make places safe, comfortable, attractive, and convenient.

**4. Good Financial Return:** Typically, a successful TOD can generate substantial financial return to both public and private sectors.

**5. More Choices:** A successful TOD can provide residents more options in terms of housing types, places to shop and modes of transportation.

**6. Efficient Regional Land-use Patterns:** The successful TOD is one of the most important tools for promoting "Smart Growth" by fostering more efficient land-use patterns.

The following table elaborates each of the six criteria with the specific benefits.

**Table 7** Potential Benefits of Successful TOD

| Features | Potential Benefits |
|---|---|
| **Location Efficiency** | • Increased mobility choices (walking and bicycling as well as transit).<br>• Increased transit ridership.<br>• Good transit connections to the rest of the city and region.<br>• Reduced auto use and reduced auto ownership.<br>• Reduced transportation costs to individuals and households.<br>• Sufficient retail development (quantity, quality, and diversity) to satisfy the basic daily needs of residents and employees working in the area.<br>• Ability to live, work, and shop within the same neighborhood. |
| **Value Recapture** | • Increased homeownership rates or more adequate housing through:<br>  o Increased use of location efficient mortgages.<br>  o Creation of housing units with lower-than-average parking ratios where the cost savings from parking reductions are passed on to consumers.<br>• Reduced individual and community spending on transportation and therefore greater discretionary individual and community spending. |
| **Livability** | • Improved air quality and gasoline consumption.<br>• Decreased congestion/commute burden.<br>• Improved access to retail, services, recreational, and cultural opportunities<br>• Improved access to public spaces, including parks and plazas.<br>• Better health and public safety (pollution-related illnesses, traffic accidents).<br>• Better economic health (income, employment). |
| **Good Financial Return** | • For local governments: higher tax revenues from increased retail sales and property values.<br>• For the transit agency: increased fare box revenues and potential ground lease and other joint development revenues. For the developer: higher return on investment.<br>• For employers: shorter and more predictable commute times, easier employee access. |
| **More Choices** | • A diversity of housing types that reflects the regional mix of incomes and family structures.<br>• A greater range of affordable housing options.<br>• A diversity of retail types.<br>• A balance of transportation choices. |
| **Efficient Regional Land-use Patterns** | • Less loss of farmland and open space.<br>• More suitable regional and sub-regional balance between jobs and housing.<br>• Shorter commutes.<br>• Less traffic and air pollution.<br>• Station areas as that can serve as destinations as well as origins. |

*Source: Belzer & Aulter 2002*

Table 7 includes most of the potential benefits that could be generated by a successful TOD, and though it is hard for a single project to accomplish all of them, they can still be utilized for the assessment of its success.

In general, a successful TOD should achieve the following four primary goals:

1. Increase Transit use, support other non-motorized transportation modes (walking, biking) and Reduce auto dependency.
2. Enhance economic development and generate good financial return.
3. Maximize location and land-use efficiency.
4. Improve livability and enrich choices.

## 2.2 Effects of Parking on TOD's Primary Goals

In order to make TOD successful, a number of factors must be considered. Despite a lot of research, the appropriate level of parking for TOD has not been resolved.

Parking is a major urban land use. Its location, supply and price influence development opportunities and can affect property values, urban form, and land use accessibility. In addition, its availability is of significant importance to travelers making travel decisions such as mode choice, trip destination choice, trip frequency, etc. (TCRP, 2005). For Transit-Oriented Development, parking is especially important because it largely affects TOD's four primary goals as summarized previously.

### 2.2.1. Effects on Travel Behavior

Many studies have examined the relationship between parking and transit/auto use. According to *"Parking Strategies to Attract Auto Users to Public Transportation"* (Bianco, 1998), the key connection between parking and transit/auto use lies in the supply and price of parking: *"Where parking is scarce – typically in high-density areas – prices are normally charged and transit ridership levels are relatively high. Where parking is ample – typically in low density areas – there is usually no charge for parking, consequently, commuters have little incentive not to drive and thus transit ridership levels are low"* (Bianco, 1998).

In another study, the Victoria Transportation Institute concluded that parking fees typically have highest impact on trip decision based on a review of several parking elasticity studies (VTPI, 2011). For example, one study on commuter mode choice and parking demand in Portland, OR, found that with the provision of free parking trips would be distributed in the following manner: 62% drive alone, 16% carpool, and 22% on transit. The study concluded with the implementation of a $6.00 daily parking charge, the same trips would be distributed in the following manner: 46% drive alone, 4% carpool, and 50% on transit (STOD, 2011).

In another study "*People, Parking, and Cities"* (Manville & Shoup 2005), the authors found that shifting from free to cost parking typically reduces automobile commuting 10-30%. Similarly, in the article "*Stated Response Analysis of the Effectiveness of Parking Pricing Strategies for Transportation Control"* (Kuppam, Pendyala & Gollakoti, 1998), reported nearly 35% of automobile commuters surveyed would consider shifting to another mode if required to pay daily parking fees of $1-3 in suburban locations and $3-8 in urban locations.

In addition to the effects on transit and auto use, parking also influences other travel behaviors such as walking, and bicycling.Trace (1999) provided detailed estimates of the elasticity of various types of travel (car-trips, transit travel, walking/cycling, commuting, business trips, etc.) with respect to parking price under various conditions as shown in Table 8.

**Table 8** Elasticity of Various Travel Types with Respect to Parking Price

| Purpose | Car Driver | Car Passenger | Public Transit | Slow Modes* |
|---|---|---|---|---|
| Commuting | -0.08 | + 0.02 | + 0.02 | + 0.02 |
| Business | -0.02 | + 0.01 | + 0.01 | + 0.01 |
| Education | -0.10 | + 0.00 | + 0.00 | + 0.00 |
| Other | -0.30 | + 0.04 | + 0.04 | + 0.05 |
| Total | -0.16 | + 0.03 | + 0.02 | + 0.03 |

* Slow Modes = Walking and Cycling
*Source: Trace 1999*

In conclusion, the availability and pricing of parking significantly affects transit ridership and automobile use, thereby becoming a critical issue in the performance of TOD.

### 2.2.2. Effects on Financial Performance and Economic Development

For a Transit-Oriented Development, parking can be very expensive which could significantly influence its financial and economic performance. Therefore, understanding the finance of parking and then making it cost-effective by applying appropriate parking management strategy is critical for good financial performance of TOD and the local economic development.

The major issue of parking's finance is its costs. In general, Parking costs include **Direct costs** (also referred as Financial costs) and **Indirect Cost**:

#### 2.2.2.1 Direct Costs (Financial Costs)

The Direct Cost refers to the financial costs of providing parking facilities; there are four common types of them:

- *On-street parking* consists of parking lanes provided within public roads right-of-way
- *Off-street parking* are parking facilities on their own land, not on road rights-of-way.
- *Surface parking* refers to parking lots directly on land.
- *Structured parking* (also called parkades or ramps) are parking facilities in or under multi-story buildings.

The Direct Cost mainly includes parking facility land cost, construction cost and operating & maintenance costs (VTPI, 2011).

**1) Land Cost**

A typical parking space is 8-10 feet wide and 18-20 feet deep, totaling 144-200 square feet and off-street parking typically requires 300-350 square feet per space, including access lanes and landscaping (Hunnicutt, 1982). Land costs can vary from thousands of dollars per acre in rural areas to millions of dollars per acre in central business districts (CBDs), and since most of the parking facilities are located near destinations, it often requires relatively high-value land (VTPI, 2011).

**2) Construction Cost**

The construction costs of parking are mainly driven by the following factors (VTPI, 2011):

- **Size per space:** cost more for bigger space.
- **Shape of site**: Irregular shaped sites increase unit costs.
- **Number of levels**: More levels will increase the costs.
- **Topography**: Slopes and poor soil conditions increase costs.
- **Design**: Exterior aesthetic treatments can increase costs

According to Carl Walker's annual parking structure cost report, the national parking structure construction costs are reported to average about $17,072 per space or $50.81 per SF (see in Table 9).

**Table 9** Median Parking Structure Construction Costs 2012

| City | Cost Per Space | City | Cost Per Space |
|---|---|---|---|
| Atlanta | $15,399 | Minneapolis | $18,745 |
| Baltimore | $15,894 | Nashville | $15,023 |
| Boston | $19,701 | New York | $22,313 |
| Charlotte | $13,658 | Philadelphia | $19,326 |
| Chicago | $19,616 | Phoenix | $15,194 |
| Cleveland | $16,987 | Pittsburgh | $16,662 |
| Denver | $16,218 | Portland | $17,243 |
| Dallas | $14,580 | Richmond | $15,092 |
| Detroit | $17,618 | St. Louis | $17,567 |
| Houston | $15,075 | San Diego | $17,943 |
| Kansas City | $17,431 | San Francisco | $21,135 |
| Los Angeles | $18,489 | Seattle | $17,738 |
| Miami | $15,416 | Washington, D.C. | $17,021 |
| **National Average** | | **$17,072 (Per Space)** | |

*Source: Carl Walker, 2012*

In addition to the "hard" costs mentioned above, facility development usually involves "soft" costs for project planning, design, permits and financing, which typically increase project costs by 30-40 % (VTPI, 2011).

**3) Operation and Maintenance Costs**

Operation and maintenance (O&M) costs cover such expenses as utilities, custodial services, landscape maintenance, administration and management, repairs, insurance, and other related items. The O&M costs can vary from one to another depending on several variables, including location and size, method of operation, staffing needs, hours of operation, taxes and financing costs, etc. Despite the variety of O&M costs, they can typically be broken down into four major categories:

- **Staffing**: Staffing costs include all staff assigned to the facility, including cashiers, supervisors, manager, security personnel, etc.
- **Facility maintenance:** Regular maintenance ensures that the service life of the facility is maximized.
- **Facility utilities:** This category can include electricity, telephone and internet service, water and sewer service.
- **Management fees**: If the services of a professional parking operator will be utilized, there may be a management fee.
- **Other Expenses**: Additional expenses can include taxes, insurance, office supplies, marketing and advertising, etc.

Based on the article *What's It Cost You To Run Your Garage* (PT, 2005), following table illustrates the O&M Costs of an urban structured parking facility.

**Table 10** Typical O&M Costs of a Structured Parking

| Category | Cost (per year per space) | Percentage |
|---|---|---|
| Staffing | $300.00 | 50% |
| Facility maintenance | $96.00 | 16% |
| Facility utilities | $72.00 | 12% |
| Management fees | $60.00 | 10% |
| Other Expenses | $72.00 | 12% |
| ***Total*** | ***$600.00*** | ***100%*** |

*Source: PT, 2005*

Table 11 calculates the full range of Direct Costs for different types of parking facilities in different locations. Appendix A shows the complete Pro forma.

**Table 11** Direct Costs of Various Parking Facilities

**Basic Assumptions**

| | Suburban | Urban | CBD * | On-Street |
|---|---|---|---|---|
| *Interest Rate* | 6% | 6% | 6% | 6% |
| *Years of Payments* | 20 | 20 | 20 | 20 |
| *Days of Use Per Month* | 20 | 20 | 25 | 25 |

*CBD: Central Business District

**Input Data**

| Location | Types of Parking | Size SF/Per Space | # of Space (Per Acre) | Land Costs (Per Acre) | Construction Costs (Per Space) | O&M Costs (Per Year Per Space) |
|---|---|---|---|---|---|---|
| Suburban | On-street | 174 | 250 | $200,000 | $3,000 | $100 |
| | Surface | 396 | 110 | $200,000 | $3,000 | $300 |
| | 2- Level Structure | 379 | 115 | $200,000 | $15,000 | $500 |
| Urban | On-street | 174 | 250 | $1,000,000 | $5,000 | $150 |
| | Surface | 363 | 120 | $1,000,000 | $5,000 | $500 |
| | 3 - Level Structure | 348 | 125 | $1,000,000 | $18,000 | $600 |
| CBD | On-street | 174 | 250 | $5,000,000 | $5,000 | $200 |
| | Surface | 348 | 130 | $5,000,000 | $5,000 | $600 |
| | 4 - Level Structure | 335 | 135 | $5,000,000 | $20,000 | $700 |

**Financial Costs of Parking Facilities**

| **Types of Facility** | | **Summary of Financial Costs** | | |
|---|---|---|---|---|
| Location | Types | **Capital Costs*** | **Annualized Costs**** | **Total Costs (Per Space)***** |
| Suburban | On-street | $3,800 | $427 | $8,534 |
| | Surface | $4,818 | $714 | $14,285 |
| | 2- Level Structure | $15,870 | $1,864 | $37,287 |
| Urban | On-street | $9,000 | $924 | $18,475 |
| | Surface | $13,333 | $1,646 | $32,926 |
| | 3 - Level Structure | $20,667 | $2,377 | $47,535 |
| CBD | On-street | $25,000 | $2,349 | $46,986 |
| | Surface | $43,462 | $4,336 | $86,729 |
| | 4 - Level Structure | $29,259 | $3,215 | $64,309 |

*Capital Costs = Land Costs/ #of Space + Construction costs
** Annualized Cost = Annualized Capital Costs + O&M Costs (Per year Per space)
*** Total Costs = Annualized Costs * 20 (years of operation)
*Source: Litman 2012*

As noted in table, the financial cost ranges from about $8,000 of a suburban on-street parking space up to about $85,000 of a CBD surface Parking lot. Generally, on-street parking facilities are cheap and structured parking facilities are expensive due to the high construction and O&M costs. However, since multi-story structured parking facilities can provide more spaces with less land, then their costs may be lower than the land-consuming surface parking lot, especially in some high-land value areas such as CBDs (RA, 2009).

#### 2.2.2.2 Indirect Costs

In addition to the tangible U.S dollars, parking imposes other less obvious costs, referred to as "Indirect Costs". Broadly speaking, any expenses that are related to parking can be viewed as Indirect Costs. For example, when parking is provided to people with no charge, there will be a higher rate of SOVs (Single Occupied Vehicles), which can contribute to traffic congestion, and then the costs of traffic congestion can be counted into parking's Indirect Costs.

Indirect costs are relatively hard to measure since they depend on several variables. Moreover, some indirect costs will emerge only under certain circumstances. Despite of the ambiguity of parking's "Indirect Costs", the total amount of them can be significant but is beyond the scope of this thesis.

In terms of TODs, there are three major types of "Indirect Costs" that matter the most:

**1) Opportunity Costs**

In economics, "Opportunity Cost" is defined as the cost of any activity measured in terms of the value of the next best alternative forgone; it is the sacrifice related to the second best choice available to someone, or group, who has picked among several mutually exclusive choices (Wikipedia, 2012). For parking, the most obvious "Opportunity Cost" is the land, since it could be used for buildings, landscaping, leased or sold. This cost can be large when it's in urban areas where land prices are high, or in areas with high environmental values (VTPI, 2011). On-street parking requires less land per space than others, but its "Opportunity Costs" are also very high since those on-street parking spaces can alternatively convert to traffic lanes, bus ways, bike lanes or sidewalks. In all, parking, especially oversupplied parking often displaces potential

economic development by occupying land that could be used for more productive or higher amenity uses (RA, 2009).

In addition to land, there are several other opportunity costs that are less obvious but also very important. For example, the high parking cost itself is a heavy burden that impairs the feasibility of mixed-income and mixed-use development. For example, excessive parking will unnecessarily drive up the price of housing (Pticha & Wood, 2008) and affect its affordability. According to the report "Parking Requirement Impacts on Housing Affordability" (Litman, 2009), one parking space per unit increases housing costs by about 12.5% and two parking spaces increase it by about 25%. In markets like the San Francisco Bay area, podium, tuck-under parking or underground parking spaces can add upwards of $60,000 to the cost of housing (Cervero, 2009). Allen Greenberg (2005) estimates that the addition of each net parking space increases the cost of a typical U.S urban dwelling unit by $85,000.

Because most of the private parking costs are included as a percentage of rent or sale of the housing (Litman, 2011), excessive parking requirements hamper the housing affordability and decrease the households' disposable income. This impact can be particularly unfair for low income households since they own fewer than average cars. This negative effect on housing affordability can have serious impacts on TOD's economic performance, since income diversity is a key factor that allows TOD to promote the local economic development, and other social or environmental equity concerns.

From a design perspective, parking largely determines if there is space for retail, childcare or other different uses. Take a multi-family residential development as an example: a parking requirement of two spaces for each unit would consume 300-350 square feet per space, by reducing the parking requirement to 0.75:1, enough ground floor space would be available to allow for a childcare center and 10,000 square feet of retail, and these different uses have great potential to boost local business and generate more revenues for the developer (City of Phoenix, 2009). However, there must be enough parking for customers or the business will fail.

For many old neighborhoods or decayed city centers where individual sites or buildings await revitalization, redevelopment efforts can also be hampered by excessive parking requirements (Dewitt, 2003). Finally, parking could potentially reduce tax revenues for local

government and fare box revenues, potential ground lease and other joint development revenues for transit agency (TCRP, 2002). Land used for parking is typically taxed at a lower rate than land used for other commercial or residential uses, for example, government and church parking is not taxed at all. Thus when parking standards are set to too high, or when developers build parking above minimum requirements, property tax revenues are lost unnecessarily (Dewitt, 2003). Similarly, since excessive parking requirements could decrease the transit use, the fare box revenues, potential ground lease and other joint development revenues for transit agency will decrease correspondingly.

**2) Free Parking Costs**

With the exception of CBDs, airports, and major institutions like hospitals and universities, parking is always "free" to most of the users (Dewitt, 2003). According to a 1995 Nationwide Personal Transportation Survey, of the 95% of US commuters who drive, only about 5% pay full parking costs and 9% pay a subsidized rate, free parking is provided for more than 94% of non-commute trips (Shoup, 2005). In 2002, the total subsidy for off-street parking was up to $386 billion, equal or even higher than Medicare expenses ($231 billion) or National Defense Expenditure ($349) (Shoup, 2005). These huge costs of free parking are borne by businesses and governments, but ultimately paid by everyone indirectly, especially for non-motorists.

For example, a software company provides its employees with "free" parking in an attached ramp. The cost of leasing space in the ramp is included with the office rent and increases the cost of the products sold. Employees who ride the bus or walk to work receive no benefit from the "free" parking. Retail businesses have the same situation: a grocery store chain provides abundant "free" parking for its employees and customers. The parking lot and its maintenance are simply treated as a cost of doing business and are paid for by raising the price of everything from pickles to toothpaste. Customers who walk or bike to the store also pay for the parking (Dewitt 2003). Moreover, free parking also encourages auto use, thus all expenditures related to vehicle travel will be raised up consequently. All those hidden costs of free parking can leave fewer dollars circulating in the local economy and impede the overall economic development.

**3) Environmental Costs**

Parking also has impacts on the environment. These impacts include degraded water quality, storm water management problems, exacerbated "heat island" effects, green space loss, etc (Litman, 2010). For example, runoff from the impervious surfaces of parking lots and garages can damage rivers and streams, increase storm water runoff and result in more flooding. If the runoff contains pollutants such as heavy metals, oils, and gasoline, it will exacerbate the water pollution. Dark pavement can artificially raise air temperature. This can result in 'heat islands' that increase air-conditioning bills. Furthermore, the loss of green space will increase the spending on cleaning air, processing storm water and providing wildlife new habitats (EPA, 2006).

Additionally, the construction of parking facilities, particularly parking structures, consumes large quantities of energy and results in significant emissions of greenhouse gases; ongoing operations and maintenance also requires energy and materials that have environmental costs (VTPI, 2011). Donald Shoup (2005) cites a UCLA Environmental Impact Report data to estimate external congestion costs of $73 per month per space and pollution costs of $44 for a total external cost of $117 per month per space.

In summary, providing parking facilities requires substantial capital investment and imposes many external expenses which are normally higher than they seem to be, and due to its high "Direct" and "Indirect" costs, parking significantly affects the TOD's financial and economic performance.

### 2.2.3 Parking and Location/Land Use Efficiency

Maximizing location and land-use efficiency is one of the four primary goals of a successful TOD, and as a major urban land use, parking, therefore, also has close relationship with a TOD's location and land use efficiency. Parking, as one of the most land-consuming uses, could influence development density in many ways. For example, most surface parking favors outlying suburban areas where land costs are lower and large tracts of land are available (TCRP, 2005).

Currently, the dominant land use surrounding suburban transit stations in the United States is surface parking. In many lots, exiting the turnstile, the first thing one often sees is a sea of surface parking (Cervero, 2009). Such practices will greatly lower development density near the transit stops and make it hard to create a successful TOD. In Urban areas, especially in some older neighborhoods, excessive parking requirements can hinder redevelopment in those areas. These parcels may remain vacant or are developed into parking facilities which will contribute to low-density development and lead to urban sprawl (Dewitt, 2003).

**Figure 1: Surface Parking Lots around Northgate Transit Center, Seattle, WA**


Another way that parking requirements can affect density is that required parking often restrains development to less floor area than the zoning otherwise allows (Shoup, 2005). This mechanism is very similar with effects on the feasibility of mixed-use development as discussed previously. For example, consider a zone with a permitted floor-area ratio (FAR) of 1.0, and a developer wants to build a one-story restaurant requiring 1,000 square feet of floor area, and the parking requirement is 10 spaces per 1,000 square feet, and because of the parking requirements, the FAR shrinks from 1.0 to 0.25 (Shoup,2005):

**Table 12** How Parking Requirements Reduce FAR

| Dimension | Measurement |
|---|---|
| Restaurant area (SF) | 1,000 |
| Parking requirement (Spaces per 1,000 SF) | 10 |
| Required Parking spaces | 10 |
| Area per Parking Space (SF) | 300 |
| Total Parking lot area (SF) | 3,000 |
| Total Site area (SF) | 4,000 |
| ***Feasible FAR*** | ***0.25*** |

*Source: Shoup, 2005*

Besides the effects on density, Parking can also influence the accessibility and connectivity between various land uses. For example, large tracts of surface parking surrounding transit stations will decrease the accessibility to the transit, especially for non-drive users. Meanwhile, according to *"Seattle's Transportation Strategic Plan"* (2005), the location and design of parking has a major impact on the pedestrian environment which is a vital element for TOD. The plan notes locating parking in the front of buildings disconnects the public street and sidewalk system from building entrances. This can create unattractive and potentially unsafe building access for pedestrians. Furthermore, large, open parking lots make for a discouraging and unpleasant streetscape, and the blank walls of parking garages make streets particularly pedestrian-unfriendly (City of Seattle, 1998).

Finally, providing excessive parking facilities can encourage dispersed, low-efficient land use patterns. For instance, the station area of a successful TOD should serve as a destination as well as an origin, however, typical stand-alone, park-and-ride facilities make the area only a place to transfer, rather than a place that people want to stay.

To sum up, because parking is land-consuming, its location, size and design have great impact on TOD's density, accessibility, connectivity, walkability and general land use patterns.

### 2.2.4. Parking and Livability

At its core, a successful TOD intends to create a place that works well for people, or generally speaking, improves people's livability (RA, 2009). Livability, which commonly referred to as quality of life, is a very subjective term and is difficult to define. It can include all aspects of life such as economic development, household income, air quality, public safety,

commute time, traffic congestion, etc. Therefore, the effects of parking on the other three central benefits of TOD would indirectly contribute to effects on livability. For example, parking significantly influences auto use, and auto use can affect the air quality, gasoline consumption and traffic congestion. Moreover, appropriate parking can make people's lives more convenient by improving location efficiency so that people can have easy access to transit stations, different retail and services, and improve overall mobility. This is especially important for young, elderly and other non-motorists (NHHSRP, 2011).

In addition, parking has certain effects on public safety as well as aesthetics. The ingress and egress of parking lots can potentially be dangerous for people walking and bicycling. On-street parking may block drivers' vision when they are crossing the intersections or scanning the surrounding pedestrians (Park, 2002). Besides traffic safety, dark, desolated parking lots can make places inactive and thus decrease safety for pedestrians, and transit-users, when compared to places that are active and busy (DVRPC, 2004).

Visually speaking, parking facilities, particularly for surface parking lots, often have negative aesthetic effect on streetscape, as described by Jim Gibbons (1999), *"parking lots are often urban eyesores and broken tooth gaps in the Pepsodent smile of the urban streetscape."*

So in order to make the TOD a place that is safe, comfortable, healthy, pedestrian-friendly and appealing, parking needs to be carefully managed.

## 2.3 Summary of Chapter 2

This chapter discusses the effects of parking on the four primary goals that a successful TOD should achieve. The conclusion is that Parking has significant impacts on TOD's travel behavior, financial return, economic development, location and land use efficiency and general livability.

Moreover, in most cases, oversupplied parking or excessive parking requirements have negative effects on those performances. The following table presents the detail:

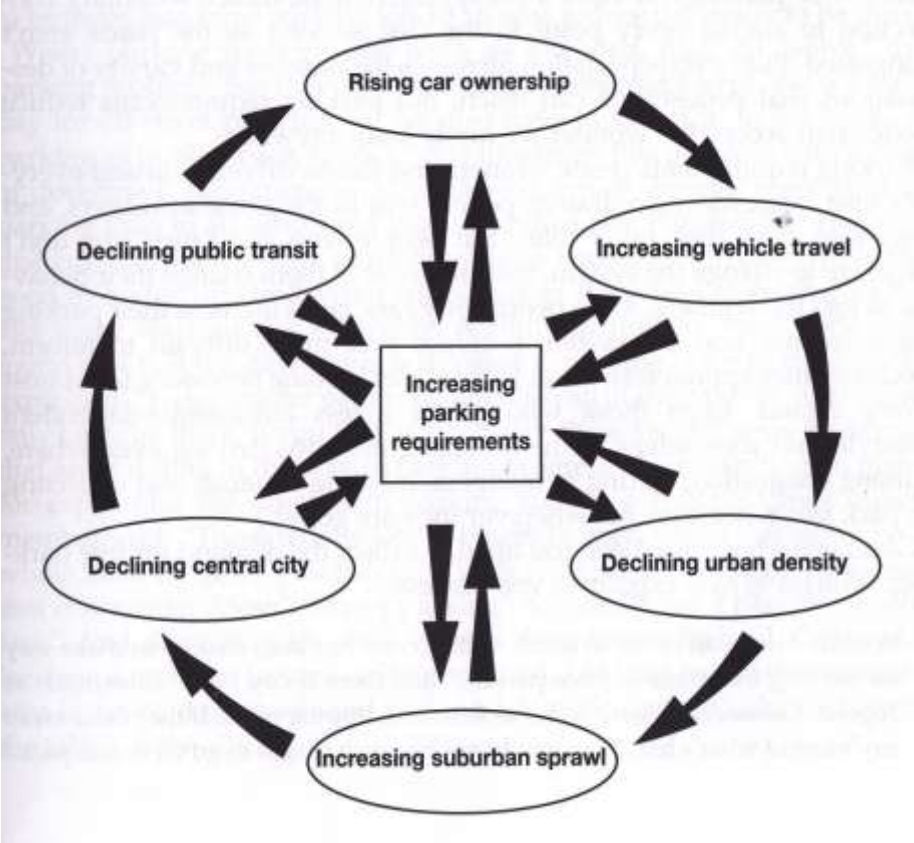
**Table 13** Negative Effects of Oversupplied Parking

| Category | Negative Effects |
|---|---|
| **Travel Behavior** | • Decrease Transit Ridership.<br>• Increase automobile dependency.<br>• Discourage other mobility choices like walking and bicycling. |
| **Financial Return/ Economic Development** | • Increase development costs and lower the financial return.<br>• Displace potential economic development.<br>• Hinder redevelopment and revitalization.<br>• Reduce housing affordability<br>• Impair the feasibility of mixed-use development.<br>• Increase transportation costs to individuals and households and therefore decrease their disposable income.<br>• Increase environmental costs.<br>• Reduce tax revenues for local governments.<br>• Reduce farebox revenues and potential ground lease and other joint development revenues for transit agency. |
| **Location/ Land Use Efficiency** | • Low development density.<br>• Weak accessibility and connectivity.<br>• Less pedestrian-friendly.<br>• Encourage dispersed, low-efficient land use patterns |
| **Livability** | • Worse health and public safety.<br>• More traffic and air pollution.<br>• Unappealing streetscape.<br>• Distort Urban form and degrade Urban design.<br>• Inconvenient to work, live, shop within the same neighborhood. |

*Source: Author*

Most of these negative outcomes will emerge and react with each other in a chain or a circle. The following figure illustrates some of the effects reacted as a cycle by increasing parking requirements:

**Figure 2: Cycle Effects of Increasing Parking Requirements**




*Source: Shoup, 2005*

To conclude, parking is a critical issue in the performance of TOD from either functional or financial perspective.

# Chapter 3: Parking Management Strategy for TOD

Parking management refers to various policies and programs that result in more efficient use of parking resources. It includes several specific strategies and, when appropriately applied, parking management can better control existing and potential parking supply and demand (Litman, 2011). One common regulatory mechanism that jurisdictions use to manage parking is to set minimum off-street parking requirements for every land use. These requirements are used to ensure that new residential development contains an adequate number of parking spaces to avoid parking spillover onto adjacent streets and properties, to maintain traffic circulation, and to ensure the economic success of the development (Willson, 2000). The methodology of creating parking standards is complex and it is often difficult to support a successful Transit-Oriented Development. This chapter will discuss the history of parking management, the methods to establish off-street minimum parking requirements and its impact on TODs. In conclusion, this chapter will propose twelve appropriate parking management strategies for successful TOD.

## 3.1 History of Parking Management

*"In the beginning the earth was without parking. The planner said, Let there be parking, and there was parking. And the planner saw that it was good. And the planner then said, Let there be off-street parking for each land use, according to its kind. And developers provided off-street parking for each land use according to its kind. And again the planner saw that it was good. And the planner said to cars, Be fruitful, and multiply, and replenish the earth, and subdue it, and have dominion over every living thing that moves upon the earth. And the planner saw everything he had made, and, behold it was not good."*

*—Shoup 2005*

Since the advent of the automobile, people started using personal vehicles to travel between locations and therefore required a parking space at the origin and destination of their trip. Once parking demand emerged and grew, parking supply and management became necessary.

Parking management has been a matter of public policy in the United States since the early 1900s (Weinberger, 2010). Parking bans and strict time limits were imposed on downtown

streets across the country by police departments and traffic engineers. For example, Detroit imposed time limits on curbside parking in 1915; Boston did so in 1920 (Norton, 2008). For decades after the advent of the automobile, city engineers and planners strongly opposed on-street parking because it was an inefficient use of public space and impeded traffic. However, as car ownership increased in the mid-1900s and on-street parking became scarce, the pressure for parking grew. From 1920 to 1960, most of the American cities responded to this demand by increasing the supply of on-street parking and establishing minimum parking requirements (TCRP, 1998). Cities removed on-street parking bans, built parking garages, metered on-street parking and finally, required that both new residential and commercial development include off-street parking (Weinberger, 2010).

On-street parking meters were first introduced in 1935, in downtown Oklahoma City, OK, and the same year, Los Angeles, CA was the first major city in the world to enact parking regulations for new developments (Rowe, 2010). By 1955, almost all major U.S cities had metered their CBDs and main retail streets. Most U.S. cities had established some form of minimum parking requirements by 1960 (Weinberger, 2010).

In 1956, the Bureau of Public Roads (BPR, 1956) published an influential pamphlet defining parking problems and solutions based on the following three assumptions:

- The automobile is the best mode for every trip.
- Highways are equally desirable and appropriate for short neighborhood and local business trips as they are for longer distance travel between cities, and between cities and suburbs, as well as access to major shopping centers.
- Highways should be free-flowing and highway capacity should be increased to accommodate growing demand.

According to BRP's philosophy, the public policy toward parking was established to satisfy the automobile use. The guiding theory was that parking should be cheap and convenient, and any kinds of parking shortages were unacceptable. Thus, planners and city officials began to require sufficient parking space to serve the highest projected parking demand, under the assumption that all visitors would arrive by private automobile and parking would be free

(Weinberger, 2010). In the United States, automobile ownership increased by 200% and vehicle miles traveled (VMT) increased by 250% from 1946 through 1991. Minimum parking requirements for multifamily residential developments have also increased by 61% from 1951 through 1990 (Rowe, 2010). Today, minimum parking requirements remain the most prevalent parking management policy, and the underlying idea is still to satisfy peak parking demand of any new developments.

## 3.2 Establishing Minimum Parking Requirements

Determining the minimum parking requirement for different land use development can be a complex process, but most of the requirements are set arbitrarily by most planners or city officials through a highly flawed three-step process (Shoup, 2005).

### Step 1: Identify the Land Use

Planners usually require parking spaces for different land uses, thus the first step in setting a parking requirement is to define the land use, which is not an easy task. The Planning Advisory Service (PAS) of the American Planning Association (APA) reports that cities require parking for at least 662 different land uses. The following table shows a few land uses that require parking.

**Table 14** Land Uses that Have Parking Requirement

| | |
|---|---|
| Apartment | Ice cream manufacturing |
| Batting cage | Junkyard |
| Convent | Kennel |
| Diet clinic | Landfill |
| Exterminator | Massage parlor |
| Furrier | Night club |
| Gas storage plant | Pet cemetery |
| Horse stable | Zoo |

*Sources: PAS, 2003*

Parking demand varies greatly among different land uses, and it also varies among different cities for the same land use, determining the parking requirements for every conceivable land use in every city is indeed a daunting task (Shoup, 2005).

**Step 2: Choose the Basis for the Requirement**

After identifying the specific land use, the second step is to choose one or more factors as the bases that the required parking spaces in proportion to (Shoup, 2005), such as the number of dwelling units, square feet of gross area, seats of the theater, etc. Those bases should be the factors that most influence the parking demand for each land use. For example, the number of employees who will use the office building, the total housing units of a multifamily apartment, or the total square feet of a retail space. Table 15 shows some common factors which planners have chosen as the bases for parking requirements.

**Table 15** Factors Used as a Basis for Parking Requirements

| | |
|---|---|
| Gross floor area | Dining area |
| Gross leasable area | Employees |
| Active members | Parlors |
| Bank Machines | Service stalls |
| Bedrooms | Taxis |
| Chairs | Vehicles owned |

*Source: Shoup, 2005*

However, because many bases for parking requirements can be changed easily, most cities usually require parking in proportion to the square feet of the built floor space since it is difficult to change and easy to be measured.

Unfortunately, there is a lack of theory and data to support whether the bases are the ones that affect the parking demand the most. Sometimes, even for the same land use cities may choose different factors as the bases for the parking requirements. Table 16 shows 66 cities' parking requirements for funeral parlors based on different factors:

**Table 16** Bases of Parking Requirements for Funeral Parlors

| **Bases** | **Number of Cities** |
|---|---|
| Per sq. ft. | 10 |
| Per dwelling unit | 2 |
| Per seats | 3 |
| Per funeral vehicle | 1 |
| Per parlor | 3 |
| Per person | 1 |
| No bases | 2 |
| Mix of different bases | 25 |
| No requirements | 19 |
| ***Total*** | ***66*** |

*Source: PAS, 1971*

The factor used as the basis for a parking requirement can have many unintended consequences. For example, a city can require one parking space per employee for a manufacturing use. In such cases, a firm needs to add more parking spaces whenever it wants to hire more staff. In this case, requiring parking in proportion to employees could increase the cost of employing labor and, therefore, affect the firm's hiring decisions. If the city chose the floor area as the basis, then it will affect the firm's investment decision since it could not expand its plant without adding more parking even if the expansion adds no new employees (Shoup, 2005).

Choosing factors as the bases for setting parking requirements raises or will raise numerous problems and that may flaw the whole process.

**Step 3: Establish how many parking spaces to require per unit of the basis**

The final step in establishing a parking requirement is to specify the number of spaces required. There are two most common methods used by planner: 1) Copy other cities and 2) Consult Institute of Transportation Engineers (ITE)'s *Parking Generation* Report.

**Copy other cities**

Copying nearby cities' parking requirement is an inexpensive and non-controversial strategy for any land uses. However, this strategy is not applicable in the following two scenarios:

1. The physical and social characteristics of the neighboring city are not similar.

2. The current parking requirements of nearby cities are not reflecting the actual parking demand.

As a result, copying nearby cities' parking requirements could either fail to meet the local parking demand or simply repeat someone else's mistakes (Shoup, 1999).

In addition to copy neighboring cities, one source that planners use to learn about other cities' parking requirements is the PAS National Survey, which has released five publications since 1964. These surveys tell how many parking spaces cities do require, not how many a city should require (Shoup, 1999). Nevertheless, the survey itself warns that copying from other cities is very risky. The following quotation from PAS illustrates the potential risks of copying the surveys' results:

- *Copying other cities' parking requirements may simply repeat some else's mistakes*
- *For every land use whose parking demand planners know something about, at least a dozen remain mysteries.*
- *Absurd twists of logic in the way the standards were drafted sometimes make it impossible to say which of two cities requires more parking for the same land use.*
- *Many communities have created parking standards that require developments to build parking spaces far in excess of demand.*

Therefore, setting parking requirements by relying on other cities not only risks repeating someone else's mistakes, but also fails to reveal the actual parking demand.

**Consult ITE *Parking Generation* Report**

To establish parking requirements on more objective data, another method that planners often use is to consult the handbook *"Parking Generation,"* published by the Institute of Transportation Engineers (ITE). For each land use, this publication reports the "parking generation rates" observed in surveys by transportation engineers. The parking generation rate is

defined as the peak parking occupancy to a characteristic of the land use, such as the floor area or number of employees at a site (Litman, 2011).

The most recent edition, the 4th edition of ITE's *"Parking Generation Report"* was published in the fall of 2010, it includes 106 different land uses with parking datasets, and the following table contains a sample of the report's data:

**Table 17** Peak Parking Rates from 4th Edition Parking Generation Report

| Land Use | Rate in Vehicles per: | Rate |
|---|---|---|
| Industrial Park | 1000 sq.ft. of gross floor area | **2.18** |
| Low/Mid-Rise Apartment | Dwelling Unit | **2.28** |
| Condominium/Townhomes | Dwelling Unit | **1.79** |
| Attached Senior Adult Housing | Dwelling Unit | **0.78** |
| Hotel | Occupied Room | **1.27** |
| Multiplex Movie Theater | Seat | **0.24** |
| Health Club | 1000 sq.ft. of gross floor area | **9.95** |
| Recreational Community Center | 1000 sq.ft. of gross floor area | **5.92** |
| High School | Student | **0.29** |
| Church | Seat | **0.29** |
| Daycare Center | 1000 sq.ft. of gross floor area | **4.35** |
| Hospital | Beds | **8.65** |
| Nursing Home | 1000 sq.ft. of gross floor area | **1.76** |
| Office Building | 1000 sq.ft. of gross floor area | **4.06** |
| Medical-Dental Office Building | 1000 sq.ft. of gross floor area | **5.02** |
| Free Standing Discount Store (in December) | 1000 sq.ft. of leasable floor area | **4.81** |
| Shopping Center (in December) | 1000 sq.ft. of leasable floor area | **5.94** |
| Supermarket | 1000 sq.ft. of gross floor area | **5.94** |
| Bank with Drive-Through | 1000 sq.ft. of gross floor area | **6.67** |
| Sit-Down Restaurant (High Turnover) | 1000 sq.ft. of gross floor area | **19.18** |
| Fast Food Restaurant with Drive Window | 1000 sq.ft. of gross floor area | **17.80** |

*Source: ITE, 2010*

Although ITE is the only national resource collecting and publishing parking data, there are limitations to its use. The "*Parking Generation"* report states the limitations in its own introduction:

*Most of the data currently available are from suburban sites with isolated single land uses with free parking… More parking data are needed in order to understand the complex nature of parking demand…such as type of area, parking pricing, transit availability and quality,*

*transportation demand management plans, mixing of land uses, pedestrian friendly design, and land uses density (ITE 2010).*

Therefore, the following points call into question the ITE's "*Parking Generation"* data:

1. The report is based on data collected where parking is free.
2. The report focuses on suburban sites with lack of public transit.
3. The report focuses on peak parking occupancy.

To conclude, this three-step process for establishing minimum parking requirements is highly flawed and cannot reflect the actual parking demand. The overarching principle of this parking management strategy is to require enough parking spaces to meet the peak demand for free parking, which could easily cause the oversupply of parking and then seriously harm the TOD's performance.

## 3.3 TODs are Over-Parked

One most likely outcome of the prevalence of minimum parking requirements among most American cities is to exaggerate the actual parking demand, and therefore provide excessive parking which make TODs over-parked. In his article "Are TODs Over-Parked?" (Cervero, 2009), Professor Cervero believes that most TODs' parking supplies are over-inflated. This was based on his study of 31 housing complexes near rail stations in the San Francisco Bay Area , on-site parking supplies in Portland, OR and a national survey of professional planners from 80 U.S municipalities with rail stations. The study found (Cervero, 2009):

- For the 31 surveyed multi-family projects combined, there were 1.57 parking spaces per dwelling unit, nearly a 30% higher than ITE's suburban standard of 1.2 spaces per unit.
- From supply-demand standpoint, the weighted-average supply of 1.57 spaces per unit was 37% higher than the weighted-average peak demand of 1.15 parked cars per unit.
- From national survey responses, the estimated average minimum parking requirement for multi-family housing near rail transit was 1.48 spaces per unit, also well above the ITE standard.

As discussed at the end of Chapter 2, excessive parking could hinder the core purposes of a TOD and obstruct it from yielding the hoped-for benefits, like substantial ridership gains, decrease of automobile usages, better accessibility and connectivity, pedestrian-friendliness, more efficient land use patterns, etc (Zhang, 2012).

In order for the success of TOD, this over-parked situation must be changed by applying appropriate parking management strategies.

## 3.4 Specific strategies for TOD Parking Management

To support a successful TOD, parking management may need a paradigm shift, a fundamental change in how the parking problems are perceived and how solutions are evaluated. The current paradigm assumes that parking should be abundant and free by maximizing supply and minimizing price. The end result is that offer parking lots are never be filled up (VTPI, 2011).

The new paradigm for successful TODs strives to provide optimal parking supply and price, use existing parking facilities efficiently, charge parking costs directly to users, and encourage people to reduce their parking demand (Litman, 2011).

**Table 18** Old Parking Paradigms vs. New Parking Paradigm for TOD

| Old Parking Paradigm | New Parking Paradigm for Successful TOD |
|---|---|
| • "Parking problem" means inadequate parking supply. | • Excessive parking supply is the biggest burden of TOD. |
| • Parking should be provided free, funded indirectly. | • As much as possible, users should pay directly for parking facilities. |
| • Parking should be available on a first-come basis. | • Parking should be regulated to favor higher priority uses and encourage efficiency. |
| • Parking requirements should be applied rigidly, without exception or variation | • Parking requirements should reflect each particular situation, and should be applied flexibly. |
| • "Transportation" means driving. Land use dispersion is acceptable or even desirable. | • Other Transpiration modes like Transit, Walking and Bicycling are more favorable; automobile-dependent land use patterns are unacceptable. |

*Source: Litman, 2011*

In all, the guiding principle of a TOD's parking management strategy is to minimize parking supply as well as demand to reduce parking spaces. However, the "number" is not the only problem that needs to be considered. The location, design and daily operations of parking

facilities are equally important. In all, well-managed parking should help enhance a TOD's whole performance.

This section proposes twelve specific parking strategies that could best help a TOD to minimize its parking spaces and maximize other core performances. All of them will be categorized as "Price-Based" and "Nonprice-Based" parking strategies.

### 3.4.1 "Price-Based" Parking Strategies

Currently, most parking are free, subsidized, or bundled with building purchases and rents. The underlying rationale of "Price-Based" Parking strategies is to: 1) require motorists to pay directly for using parking facilities in order to reveal their true costs, and 2) use price as a tool to adjust parking supply and demand. The following strategies could be very effective:

#### 1) Price Parking

Charging prices for parking, normally at the market rate, can be implemented as a parking management strategy to recover parking facilities costs, or to raise revenue for other purposes. However, when motorists do pay directly for parking, it is often a flat annual, monthly or daily fee. (Litman, 2011) For example, in some downtown areas parking facilities may offer "early bird specials" with lower rates for all day parking or contracts for monthly parking. This pricing strategy will reduce commuters' incentives to use transit or other modes of transportation and thus is not suitable for TODs (DVRCP, 2004).

**Figure 3: Low Rates for All Day Parking**


Therefore, instead of a fixed fee, the parking price should vary based on its performance, known as *"Performance-Based parking pricing."* This strategy will set parking rates based on a set of data-driven characteristics such as occupancy rate and turnover rate (SDOT, 2011). Furthermore, the parking rates may change by time-of-day, season, events and locations, for example, rates should increase during peak hours and in places with higher demand (Litman, 2011). Higher rates for central parking facilities make them available for high turnover traffic

and lower prices of remote facilities can accommodate long-term parkers (Zhang, 2012). These strategies can help manage existing parking facilities efficiently and encourage drivers to switch to using transit or other transportation modes. This pricing strategy has already been implemented in many cities, such as "SF Park" in San Francisco, "Express Park" in downtown Los Angeles, "Park Smart" in New York City, and the "Performance-Based Parking Program" in Seattle (SDOT, 2011).

**2) Unbundle Parking**

The concept of unbundling parking generally applies to residential developments, where the sales or the rents of a unit often include the cost of parking (Zhang, 2012). Separating the two gives residents the option to rent or lease housing and parking separately, and thus help alter people's behavior by allowing the market to reveal how much residents value and truly need parking spaces, which lets developers build parking to the true demand (Shoup, 2005). This strategy could effectively help TODs fully exploit the advantage of good transit services and pedestrian-friendly environments. By applying this parking strategy, the TOD can expect a decrease of car usage and ownership, a reduction of parking spaces, an increase of transit use and more disposable income of every household (DVRCP, 2004).

This strategy can be written into zoning codes or enacted by the developers. For example, according to Article 1.5, Section 167 of the San Francisco Zoning code, new residential structures of 10 dwelling units or more must sell or lease off-street parking separate from the rental or purchases fees of the housing (City of San Francisco, 2010).

**3) Offer Commuters Financial Incentives**

This strategy means that travelers, particularly commuters are offered financial benefits for reducing their automobile trips. These benefits represent the cost savings that result from reduced parking demand (VTPI, 2005). Following are three major types of financial incentives (Litman 2011):

- **Parking cash-out:** Employers offering free or subsidized parking to employees can implement "parking cash out." With parking cash-out, an employer gives employees a

choice to keep a parking space at work, or to accept a cash payment and give up the parking space.

- **Transit Benefits:** Employees are given transit fare vouchers that can be used to purchase transit tickets, tokens and passes, or they can directly receive subsidized transit passes.
- **Universal transit passes:** It means that a group purchases discounted, bulk transit passes for all members.

All of these incentives encourage commuters to use money that would otherwise be spent on parking to be spent on transit, thus reducing the parking demand and improving the transportation performance of the TOD as whole. Another incentive is to provide discounted or preferential parking for ride-share (carpool and vanpool) vehicles which also rewards people who reduce vehicle trips and parking demand. These incentives are also part of the Transportation Demand Management (TDM) programs that will be discussed later in this section.

#### 4) Parking Impact Fees and In-Lieu Fees

Impact fees are charges assessed by local governments against new development projects that attempt to recover the cost incurred by government in providing public facilities required to serve the new development (MRSC, 2012). Since providing parking facilities will have impacts on many public affairs such as transportation, environment and public infrastructure, some authorities impose a one-time fee on developers. This impact fee is meant to cover the costs the parking creates for those public issues.

Parking impact fees can offset the incentive of the "free" parking, and encourage developers to provide only the amount of parking actually needed. On the other hand, the revenue from these charges can be used to fund local transport programs or other public programs (Dewitt, 2003). For example, the City of San Francisco has imposed a surcharge of 25% on parking fees at all parking garages in the city for nearly 20 years. The substantial revenue from this surcharge is paid into the City's general fund and a portion of it, along with a portion of parking meter revenue, is used to support MUNI, San Francisco's transit agency. In 2001, 24% of MUNI's annual operating budget was paid from the parking impact fees (City of San Francisco, 2002).

The primary benefit of this strategy is to reveal the costs of satisfying the parking requirements (Shoup, 2005). However, this strategy may harm the developers' interests; thus, it should be combined with other strategies to maximize its effect on reducing parking for TOD and minimize its negative effects as well.

There is another type of charge for parking, known as *"In-Lieu parking fees."* Instead of "required" as the *"Parking impact fees"*. Some municipalities give developers an option to pay a fee in lieu of providing the required parking spaces. The cities then use the revenue to replace the private parking spaces the developers would otherwise have provided (Dewitt, 2003). This strategy provides several benefits for both cities and developers such as more flexibility, promoting shared parking, better urban design, etc.

**5) Improve Parking Pricing Methods**

This strategy can be applied to pricing on-street parking. Much of the resistance to charging for on-street parking results from inconvenient pricing methods, for example (Litman, 2011):

- *Many require payment in specific denominations (coins or bills).*
- *Many require motorists to predict how long they will be parked, with no refund available if motorists leave earlier than predicted.*
- *Some payment systems cannot easily handle multiple price structures or discounts.*
- *Some are confusing or slow to use.*
- *Some have high equipment or enforcement costs and enforcement often seems arbitrary or excessive.*

Therefore, improving pricing methods can make parking pricing more cost-effective, convenient and fair. To be more specific, using newer electronic pricing systems that can accommodate various payment methods like credit/debit cards, charge only for the amount of time parked, incorporate multiple rates and discounts, and automatically vary rates by day and time (Zhang, 2012). Another benefit of implementing advanced pricing methods is to help recording data such as utilization rate and turnover rate, which could also support the *"Performance-Based Parking Pricing"* strategy.

### 3.4.2 "Nonprice-Based" Parking Strategies

Nonprice-based parking strategies include setting flexible parking requirements and innovative parking regulations, instituting special zones and districts for TOD parking, encouraging shared parking and, implementing TDM programs and other policies.

#### 1) Reduce Minimum Parking Requirements

The main purpose of minimum parking requirements is to ensure an adequate amount of parking to meet the peak demand, which often results in excess supply. In addition, blanket, city-wide parking requirements only based on land use type ignores that different areas have unique features, including the socio-economic and demographic market it attracts, the location of the site, and its proximity to public transit, all of which will significantly impact its parking needs (Rowe, 2010). Therefore, changing parking requirements to reflect actual needs is imperative and especially urgent for a TOD.

The unique features of a TOD offer great opportunities to reduce the number of parking spaces below conventional parking requirements for retail, office and residential land use (Boroski, 2005). The following table illustrates how parking requirements can be adjusted based on TOD's unique features.

**Table 19** Parking Requirements Adjustment Based on TOD's Features

| TOD Features | Description | Typical percentage of reduction |
|---|---|---|
| **Proximity to transit station** | TOD locations within 1/4 to1/2 mile of transit station. | • 10% within 1/4 mile of frequent bus service.<br>• 20% for within 1/4 mile of frequent rail transit station. |
| **High housing and employment Density** | Minimum Density of 10-15 dwelling units/acre,or 30 people/acre.<br>Minimum employment density of 25 Jobs/acre. | • 1% for each resident per acre.<br>• 10-15% for 50 or more employees per gross acre. |
| **Mix of Land Uses** | Diverse and complementary high-activity uses such as retail, professional services, public spaces, housing and employment. | • 5-10% in mixed-use developments. |
| **Pedestrian- friendly environment** | High walkability and connectivity | • 5-15% in walkable communities |
| **Demographics** | Demographic features of most TOD residents (Cervero, 2009):<br>*1. Young professionals, singles, retirees, childless household.* | • 20-40% for young (under 30) elderly (over 65) or disabled people. |

| | | |
|---|---|---|
| | 2. *Require less housing units than traditional "nuclear families".*<br>3. *Work downtown and in other locations well served by transit.* | |
| **Income** | TOD offers more affordable and low-income housing | • 10-20% for the 20% lowest income.<br>20-30% for the lowest 10%. |

*Source: Cuddy, 2007*

When considering the above features, a typical TOD's parking requirement should be reduced by 10-30% (Litman, 2011). In some areas like downtowns or special transit zones, the minimum parking requirements can be completely eliminated or waived.

Another way cities can allow developers to provide an amount of parking below the minimum parking requirements is to issue conditional-use permits (TCRP, 2005). In this scenario, developers are often required to support alternative transportation modes or pay money in to a city "in-lieu" fund as *"In lieu parking fees."* In most cases, the in-lieu funds are used to either finance public parking facilities like municipal parking lots and structures which encourage more efficient and shared use, or develop commuter programs and improve transit.

**2) Set Maximum Parking Requirements**

Similar to minimum parking requirements, parking maximums define the upper limit on the amount of parking spaces permitted on a site according to the type and size of uses on the site (Dewitt, 2003). It can be applied to individual developers or as "Parking Caps" for an entire area or district. These "caps" can be in addition to or instead of minimum parking requirements.

Maximum parking requirements can be an effective tool to avoid parking oversupply as well as to reduce parking demand, and will work best in areas where transportation alternatives, such as transit and pedestrian facilities, are well- provided (DVRPC, 2004). Therefore, setting maximum parking requirements could be very suitable for a TOD.

In "Transit Oriented Development Design Guidelines" (FDOT, 2005), the Florida Department of Transportation provides maximum parking requirements for different TODs based on their locations and transit services as below:\

**Table 20** Maximum Parking Requirements for Different TODs

| Location | Transit Services | Maximum Residential Parking Requirements | | |
|---|---|---|---|---|
| | | **Residential (Spaces per Unit)** | **Office/Retail (Spaces per 1,000 SF)** | **Surface lots (% of Total Spaces)** |
| **Urban Core** | *Commuter Rail/LRT/BRT** | 1.0 | 1.0 | 10% |
| | *Local Bus Hub* | 1.5 | 2.0 | 15% |
| **Urban General** | *Commuter Rail/LRT/BRT* | 1.5 | 2.0 | 15% |
| | *Local Bus Hub* | 1.5 | 2.0 | 15% |
| **Suburban** | *LRT/BRT* | 2.0 | 3.0 | 20% |
| | *Commuter Rail* | 2.0 | 3.0 | 25% |
| | *Local Bus Hub* | 2.0 | 3.0 | 30% |
| | *Express Bus* | 2.0 | 3.0 | 30% |
| **Rural** | *Express Bus* | 2.0 | 4.0 | 40% |

**LRT: Light Rail Transit, BRT: Bus Rapid Transit*
*Source: FDOT, 2005*

When setting such requirements, authorities should be very careful not to simply copy other municipalities' regulations or national standards, just as with minimum requirements (Zhang, 2012).

**3) Shared Parking**

Shared parking means that a parking facility serves multiple users or destinations (VTPI, 2005). This strategy is most successful if destinations have different peak periods. This typically occurs between two or more different land uses such as office and church, restaurant and office, movie theatre and shopping center, or school and a recreational event (TCRP, 1998). The City of Seattle identifies different parking periods for different land uses which shared parking could potentially be applied to:

**Table 21** Typical Peak Hours for Various Land Uses

| Daytime Uses | Nighttime and Weekend Uses |
|---|---|
| Commercial uses | Auditoriums |
| Storage uses | Religious Facilities |
| Manufacturing uses | Entertainment uses |
| Schools and educational institutions | Eating and drinking establishments |
| Professional services | Parks, shops and malls |

*Source: City of Seattle, 2011*

Besides the differences of peak periods, Shared Parking would be successful only if there are mixed-use developments on a single site or on different sites but located suitably close. As a

result, a TOD that is composed of compact developments and mixed land-uses is perfectly suitable for implementing this strategy.

#### 4) Transportation Demand Management Program

"Transportation Demand Management" (TDM), also known as "Mobility Management" is a general term for strategies that increase transportation system efficiency by changing travel behavior (VTPI, 2005).TDM programs include multiple specific strategies that affect travel frequency, mode, destination, etc., and some of those strategies can be used to reduce parking demand, control parking supply and support other TOD's performances as well.

In this study, the following TDM programs are mainly considered as appropriate parking management strategies for TOD

**Table 22** Transportation Demand Management Programs

| TDM Programs | Description |
|---|---|
| **Satellite Parking and Shuttle Service** | Employers or a Transportation management association (TMA) providing dedicated off-site parking for employees and then served by shuttle service or public transportation (Litman, 2011). |
| **Car sharing** | A membership program that allows members to use vehicle from a fleet on an hourly or daily basis (Rowe, 2010）. |
| **Bicycle and Pedestrian Improvements** | Support non-motorized, environmentally friendly forms of transportation like biking and walking:<br>1. Provide adequate infrastructures like bike parking, bicycle lanes.<br>2. Design safe, pleasant, and intuitive pedestrian environment to encourage more walking. |
| **Smart Growth** | Development policies that result in more efficient transportation and land use patterns, by creating more compact, development with multi-modal transportation systems (VTPI, 2005) |

Besides, TDM programs also include some strategies mentioned earlier, such as preferential parking for carpoolers and transit incentive programs.

In all, TDM programs both support and are supported by a TOD's parking management strategies and can effectively reduce parking demand in either direct or indirect ways. For

example, the City of Redmond, WA, allows reductions in required parking if an approved TDM is recorded with the property (City of Redmond, 2010).

**5) Improve Parking Regulations, Enforcement and Control**

Parking regulations control who, where and how long vehicles may park at a particular location, in order to prioritize parking facility use (Litman, 2011). For a TOD, parking regulations should aim at increasing transit use, reducing parking demand, relieving traffic congestion, etc. Setting "Maximum Parking Requirements" can be viewed as one parking regulation, other regulations may include reserving high-demand spaces for short term, high-turnover users, limiting the on-street parking of large vehicles and prohibiting on-street parking on major roads during peak travel times (DVRCP, 2004).

Once those parking regulations have been established, it is important to ensure they are enforced frequently, effectively and considerably. Many citizens often ignore or evade parking regulations and payments, despite criminal penalties. Therefore, the effectiveness of parking regulations will be heavily discounted. To respond to this problem, improving the parking's enforcement and control is necessary. Strong enforcement and good control will significantly support TODs' parking management by increasing the regulatory and pricing effectiveness (Litman, 2011).

**6) Enhance Parking's Physical Layout and Operation**

Parking's physical layout often refers to its location and physical design. Since "good" urban design is one essential element of a successful TOD, improving parking facilities' physical layout so that they can be better integrated into their surrounding environment is also crucial for a TOD's success. For example, the locations of parking facilities do not always need to be adjacent to the transit stations or in front of destinations. Instead, parking facilities can be located to the rear of buildings or a distance from stations. The ingress and egress of parking should be from side streets or alleys (Zhang, 2012).

Besides location, the physical appearances of parking facilities should also be designed to be compatible with adjacent buildings, architecture and the overall pedestrian-friendly

environment (Shoup, 2005). Planners should separate parking from pedestrians and use landscaping to screen parking facilities or to divide large parking lots (Willmer, 2007).

In addition to parking facilities' physical layout, it is also important to improve the quality and efficiency of daily management and operation. Some innovative technologies can help a TOD to achieve this goal. For example, "mechanized parking" can be used to vertically stack up to three cars into one parking spot equivalent to one level of parking, thus effectively reducing the amount of physical space required for structure parking (Boroski, 2005).

**Figure 4: Mechanized Parking**

Improving "user information" can also solve many parking problems effectively. "User information" refers to information for travelers about parking availability, regulations and price, and about travel options, such as walking, ridesharing and transit (Litman, 2011). Traditionally, user information can be provided by signs, maps, brochures, websites and electronic guidance system, and some municipalities implement more advanced information systems to serve users better. For example, Berkeley, CA is introducing a three-tier parking info system which: 1) directs visitors to downtown or university district, 2) routes them to a neighborhood destination and 3) Informs of space and rates of facilities (Boroski, 2007).

**7) Establishment of Special Parking Zones and Districts**

Another strategy of TODs' parking management is to establish some special parking zones and districts. "TOD Overlay District" is one good example. The intent of setting TOD overlay district is to promote its overall performance by identifying its unique features and particular needs. Since parking is one essential element of the TOD, the establishment of an overlay district will allow multiple parking strategies, policies, regulations, and other programs to be combined and implemented together so that to manage the TOD's parking more effectively and efficiently. For example, the bylaw of *"*transit-oriented development overlay districts*"*

(Willmer, 2007) from the State of Massachusetts combined various parking strategies such as Maximum Parking Requirements, Shared parking, Pedestrian-friendly parking design, etc. as the overall parking requirements for a TOD Overlay District (see in Appendix B).

Besides the TOD overlay district, cities can also set some special parking zones or districts to address specific problems. For example, establishment of a residential parking zone (also known as a "Permit Parking" district), which requires residents living in the area to apply for an on-street parking permit, can effectively solve the problem of parking spillover (Rowe, 2010). Similarly, Parking Benefit Districts, as a variation on "Permit Parking" allows the community to sell a certain number of permits to employers, employees, or nearby residents who need parking. All these special parking districts can help control the parking supply, specify the use of parking and further reduce the parking demand (Dewitt, 2003).

## 3.5 Summary of Chapter 3

This chapter demonstrates that traditional parking requirements can lead to oversupply of parking and thus cause the TOD initiative to fail. Therefore, having appropriate parking management strategies is essential to ensure the desirable form and functionality of a TOD. In total twelve specific strategies have been proposed in this chapter, the following table summarizes them with brief descriptions and their main effects.

**Table 23** Summary of Twelve Specific Parking Management Strategies

| Strategies | Description | Main Effect |
|---|---|---|
| **Price Parking** | Performance-based Parking pricing | Reduce parking Demand and Supply |
| **Unbundle Parking** | Separate parking costs from housing sales or rents | Reduce parking Demand and Supply |
| **Offer Commuter Financial Incentives** | • Parking cash-out<br>• Transit Benefit<br>• Universal Transit Passes | • Reduce parking Demand<br>• Increase transit use |
| **Parking impact fees and in-lieu fees** | • Charge for external cost<br>• Pay a fee in lieu of providing parking | Reduce parking Supply |
| **Improve parking pricing methods** | • Accommodate various payment methods<br>• Charge for actual parking time<br>• Incorporate multiple rates and discounts | Support *"Price Parking"* |
| **Reduce Minimum Parking requirements** | Reduce requirements based on the TOD's essential features:<br>• Proximity to transit<br>• High Density<br>• Mix land uses<br>• Pedestrian-friendly<br>• Diverse Demographic and Income | Reduce parking Demand and Supply |
| **Establish Maximum parking requirements** | "Parking Caps" that set the upper limit of parking spaces | Reduce parking Demand and Supply |
| **Shared parking** | One parking facility serves multiple users or destinations, especially for those have different peak periods. | Reduce parking Supply |
| **TDM program** | • Satellite parking and shuttle service<br>• Car sharing<br>• Bicycle and Pedestrian Improvements<br>• Smart growth | • Reduce parking Demand and Supply<br>• Decrease auto use<br>• Encourage non-motorized transportation modes |
| **Improve Parking Regulations, Enforcement & Control** | Increasing the regulatory and pricing effectiveness. | Support other strategies |
| **Enhance Parking's Physical Layout and Operation** | • Better location and physical design to integrate into overall TOD community<br>• Innovative parking technology and information system | Support overall TOD performance |
| **Establish TOD Overlay Districts and other special parking zones.** | • TOD Overlay District<br>• Permit Parking District<br>• Parking Benefits District | Support other strategies |

*Source: Author*

# Chapter 4: TOD Parking Study in King County

In King County, there are currently two major public transit authorities-"King County Metro" and "Sound Transit"- providing public transportation services for 1.9 million people (Census, 2010) living in more than 40 cities and towns including Seattle, the 15th largest U.S. metropolitan area. King County Metro or Metro for short, primarily provides transit bus services by operating a fleet of about 1,300 vehicles on 223 routes, it currently has about 9,500 stops and 13 transit centers (King County Metro, 2012). Sound Transit is the popular name of Washington State's Central Puget Sound Regional Transit Authority. It mainly operates Light Rail, Express bus and Commuter Rail services with 350 vehicles on 30 lines. Among these lines, the Central link, as one line of the Sound Transit's Light Rail System running between downtown Seattle and Sea-Tac International airport, is considered as the most important link in the area (Sound Transit, 2012).

Because of the high-quality mass-transit services provided by both Metro and Sound Transit, a number of projects near some major transit stations have been developed as TODs. As discussed before, parking is a critical issue for those TODs and largely determines whether they are successful or not. This Chapter provides a "Parking Study" of 25 existing TOD housing projects, and then a discussion of its main findings.

## 4.1 Parking Study of TOD housing projects in King County

### 4.1.1 Introduction

Beginning in August 2011, a two-month parking study was conducted. This study investigated the parking conditions of 25 selected TOD housing projects in King County. The main purpose of this study was to understand the basic parking information of typical TOD housing projects. The main results and findings of this study include:

1. The overall average parking supply is 1.11 spaces per unit.
2. 92% of selected apartments are mixed-use projects.
3. 52% of studied housing projects have shared parking.
4. All of projects charges parking separately.

### 4.1.2 Methodology

This parking study included two major phases: 1) selecting appropriate housing projects as study objects, 2) obtaining parking information by conducting a five question open-ended survey.

In the first phase, the objective housing projects were selected based on the following four criteria:

1) Located within one quarter mile of a certain Transit Hub

2) Market rate multifamily apartments.

3) Have 20 or more residential units.

4) Built after year of 2000.

A Transit Hub refers to either a light rail station or an existing King County Metro Transit Center. In this study, 5 King County Metro Transit Centers and 9 Sound Transit Light Rail stations were involved totaling 14 Transit Hubs. The original data source of Transit Hubs is from WAGDA, the data source of housing projects is from King County Assessor and the major tool for the selection is GIS. In total, 20 apartments in this study were selected by using GIS's "Geocode", "Buffer" and "Selection" functions, and due to the GIS's inefficiency and the incompleteness of the original data, especially the database "Residential Building" from King County Assessor. Five more projects were selected manually by looking through "Dupree and Scott" and other related websites.

For comparison study, all 25 selected housing projects were divided into two groups, one group is located near Sound Transit Light Rail Stations, and the other group is adjacent to King County Metro Transit Centers. Appendix C shows maps of each Transit Hub and selected TOD projects, it also includes the background information of those 25 housing properties.

The second phase of the study was to obtain the basic parking data by conducting a five question survey as follows:

*1. How many parking spaces your apartment has totally? How many of them are designated for Residential use and how many for Commercial use? (if the project has commercial use space)*

*2. Number of structured parking spaces? Number of surface parking spaces?*

*3. What is the parking rate? Is parking bundled with the units?*

*4. Do you feel the building is over/under parked?*

One more discussion was added sometimes:

*What percentage of the tenants uses public transportation? Does the proximity to public transit affect the marketability of the units?*

To ensure the accuracy of the information, "King County E-Property" database and "Dupree and Scott" were also utilized. The survey was conducted over the phone and most responders were leasing agents and a few property managers.

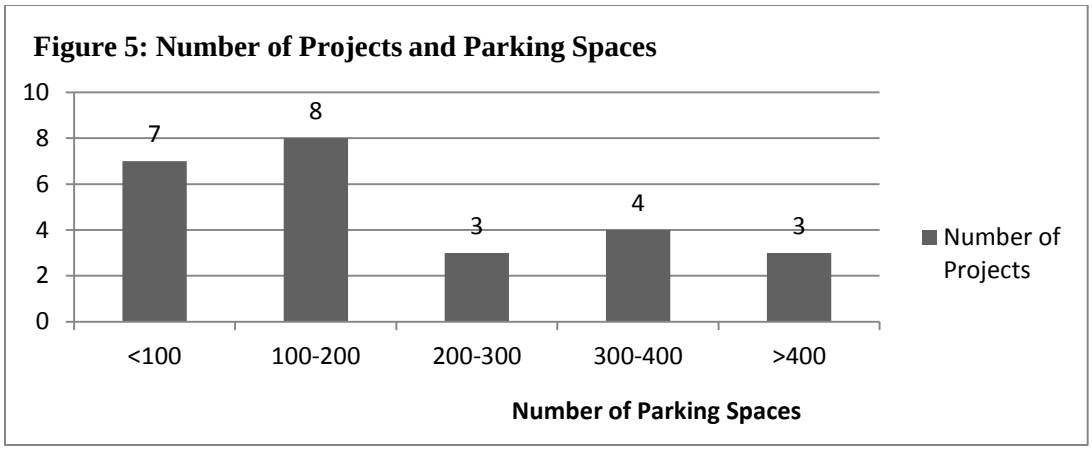
### 4.1.3 Findings

Based on the property information and responses of the survey, the study had the following important findings**:**

#### 4.1.3.1 Findings from the survey:

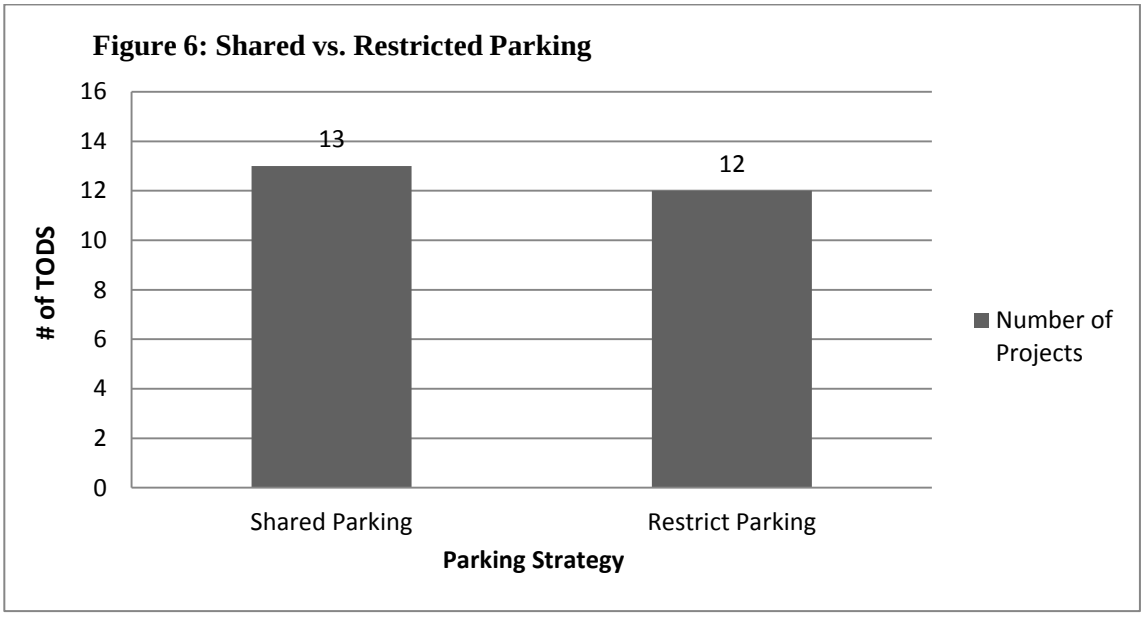
*1). How many parking spaces your apartment has totally? How many of them are designated for Residential use and how many for Commercial use (If the project has)?*

According to the parking space data (see in Appendix D), there are 5,593 parking spaces that all 25 projects have in total for this study, and approximately 223.72 parking spaces per project; the maximum number of parking spaces that one project has is 704, the minimum is 23. More details are shown in Figure 5.




- **Shared vs. Restricted Parking**

There are two different parking strategies among all the selected TODs. The first one is "Shared Parking", which means the parking spaces of the project served for multiple uses. The second one is "Restricted Parking", which means the parking spaces are restricted to a specific purpose and cannot be shared. For example, one mixed-used project, The Station at Othello Park, has totally 280 parking spaces and 150 of them are restricted to residential use and the rest of 130 are designated for the first-floor retail use. Figure 6 shows the number of TODs for each parking strategy.




For all 25 selected TOD projects, 13 of them have "Shared Parking" and 12 of them have "Restricted Parking".

- **Parking Supply**

Based on the parking spaces data and number of units (see in Appendix D), the parking ratio of each projects can be calculated, the complete results are tabulated in Appendix D. The following table summarizes the result:

**Table 24** Average Parking Supply of Selected TODs

| **Average Parking Ratio*** | | |
|---|---|---|
| Overall | TODs near Metro Transit Center | TODs near Light Rail Station |
| **1.11** | **1.25** | **1.01** |

**Parking Ratio: Spaces per dwelling unit*

The overall average parking ratio of the 25 TODs is 1.11, Thornton Place Plaza has the highest parking ratio of 2.52 with 704 parking stalls shared with the Northgate Transit Center P & R facility (excluded from average calculation), and the Station at Othello Park offers minimum parking supply with the parking ratio of 0.43.

One interesting finding is that the average parking ratios of selected TODs near King County Metro Transit Center (1.25) is higher than those near Sound Transit Light Rail Station (1.01). This may imply that light rail transit provides more incentives for its nearby projects to reduce their parking supply than bus transit does.

*2).Number of structured parking spaces? Number of surface parking spaces?*

According to the responses to this question, all the selected projects have structured parking, or in other words, all the parking spaces in this study are in garages. A few projects also have some street parking as supplements.

*3).What is the parking rate? Is parking bundled with the units?*

The parking rate of each project varies widely (see in Appendix D), it ranges from $35 to $165 per month per space. All parking charges were a flat monthly fee and were mainly determined by the market. All of the projects charge for parking separately from housing rents, and 5 projects charge higher parking prices (150% -200% of basic rate) for additional or reserved parking spaces.

Among all 25 surveyed housing projects, only two of them- Aspria and The Olivian- have upper limits about how many parking spaces a tenant could have. In general, the maximum number depends on the unit types he or she rents, i.e., tenants of a one bedroom unit is assigned with one parking space and tenants of two-bedroom unit could have two parking spaces and so on.

*4).Do you feel the building is over/under parked?*

Most responses to this question are: "we have 'sufficient' or 'enough' parking spaces", and most of the leasing agents or the property managers do not know the specific parking occupancy rate, none of them claimed to worry about the problem of being over-parked. This implies that developers are still concerned more about parking shortages than parking oversupply.

*Additional Question: What percentage of the tenants uses public transportation? Does the proximity to public transit affect the marketability of the units?*

Only 4 responders answered or partially answered this question. Three responders from The Station at Othello, Veloce and Travigne answered that most of their current residents use public transportation frequently and believed that the proximity to public transit was the key feature to attract them. One responder from the project Ten 20 Tower answered that only a small portion of his residents use public transportation and the proximity to public transit has little effect on its marketability.

**4.1.3.2 Other findings:**

1. Among those 25 selected housing apartments, 23 of them have retail or other commercial use on their first floor (known as mixed-use projects).

2. Among the 14 Transit Hubs, 4 of them are located in a "Park & Ride (P&R)" lot. These municipal "P&R" facilities provide hundreds of free parking spaces and occupy large tracts of valuable land surrounding the Transit Hubs (see in Table 25).

**Table 25** Parking & Rides Facilities of Four Transit Hubs

| Transit Hub | P&R Facilities | Types | Parking spaces | Bicycle Parking | Reserved for carpool |
|---|---|---|---|---|---|
| Northgate Transit Center | 3 | Surface | 856 | 16 | 50 |
| Aurora Village Transit Center | 1 | Surface | 202 | 4 | 0 |
| Redmond Transit Center | 2 | Garage | 377 | 24 | 0 |
| Renton Transit Center | 1 | Garage | 150 | 8 | 0 |

*Source: King County Metro*

In King County, there are 132 P&R facilities containing a total of 24,525 parking stalls (King County Metro). Those P&R facilities have great development opportunities to realize the nearby transit hubs' potential. For example, King County Metro is now working with Sound Transit and the City of Seattle to undertake a large mixed-use project called the "Northgate Transit Oriented Development" on a 5 acre P&R surface lot, and the Northgate Transit Hub is just located in the middle of the parking facility now.

## 4.2 Discussion of the findings

Based on the statistical parking data, this study generated several important findings that are worth further discussion.

### 4.2.1 Parking supply

According to the study, the average parking supply of the 25 housing projects is 1.11, while, as illustrated below, King County's minimum parking requirement for "residential apartment use" is 1.60 (see in Table 26). Therefore, the actual parking supply is reduced by **30.63%** from the general minimum parking requirements.

**Table 26** Minimum Parking Requirements of Residential Apartment in King County

| Residential Apartment | Parking requirements (Per Unit) |
|---|---|
| Studio units | 1.2 |
| One bedroom units | 1.5 |
| Two bedroom units | 1.7 |
| Three bedroom units or larger | 2.0 |
| ***Average*** | ***1.6*** |

*Source: King County Code*

The first reason that may contribute to this phenomenon would be the reduction of minimum parking requirements under special circumstances. For example, the City of Seattle sets special parking requirements for special area and land uses (see in Table 27).

**Table 27** Reduce Parking Requirements in Seattle

| **Residential Use Requirements within specific location** | |
|---|---|
| Urban Centers | No minimum requirement |
| Station Area Overlay District (Detailed later) | No minimum requirement |
| Located within ¼ mile (1,320 feet) of frequent transit service. | No minimum requirement |
| Multifamily dwelling units, within the Alki area. | 1.5 spaces per unit |
| **Residential Use Requirements with specific Income/Demographic residents** | |
| Household income below 30 % of the median income. | 30% reduction |
| Household income between 30 – 50 % of the median income. | 25% reduction |
| Low-income disabled multifamily residential uses. | 1 space for each 4 units |
| Low-income elderly/disabled multifamily residential uses. | 1 space for each 5 units |

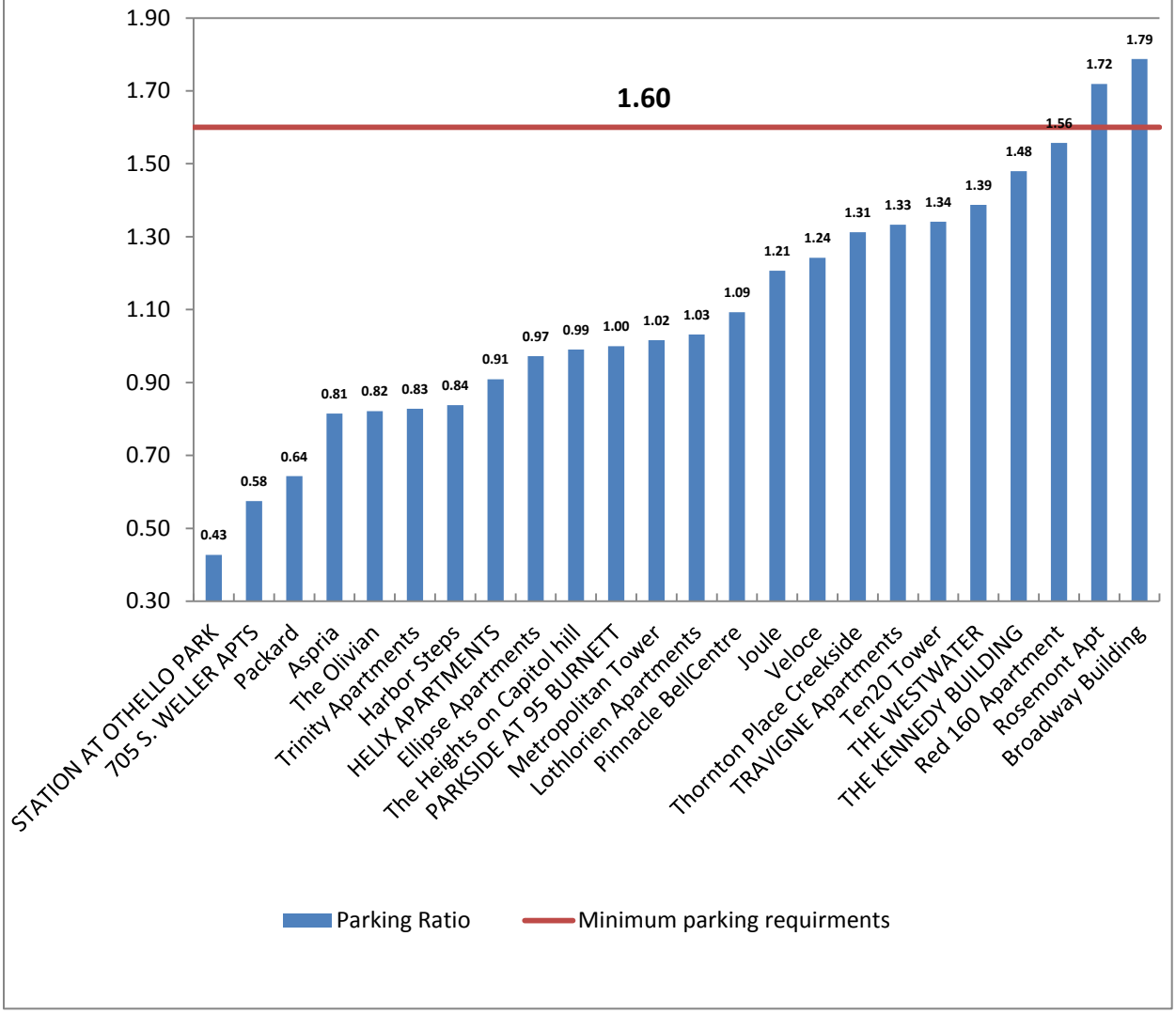
*Source: Seattle Municipal Code, 2010*

Since 18 out of 25 selected housing projects are within Seattle and all of them are selected as located within ¼ mile of major transit stations, they are not subject to the blanket, county-wide minimum parking requirements and are able to provide fewer parking spaces.

In addition to reducing or eliminating minimum parking requirements, some municipalities establish "Parking Caps" to further control the parking supply. For example, the City of Seattle set maximum parking requirements for the Northgate Overlay District and Stadium Transition Area Overlay District. Appendix E (City of Seattle, 2001) provides the detail.

To further prove these policies' effectiveness, Figure 7 compares each project's parking supply with the minimum parking requirements in King County.

**Figure 7: Parking Supply vs. Minimum Parking Requirements**




According to Figure 7, only two projects have parking spaces that are lightly more than the county's minimum parking requirement. This implies that most TOD projects are willing to reduce their parking supply when policy allowed.

### 4.2.2. Shared vs. Restricted Parking

The study shows that only 13 out of 25 selected housing projects have shared parking, even though most of them are mixed-use projects. The Shared Parking is very suitable to be implemented by TOD projects. However, both the County and municipalities have more

limitations rather than encouragements for “Shared Parking”. Generally, the restrictions of implementing “Shared Parking” include:

- **Size/Scale:** The parking facility must exceed a certain area or amount. For example, the County requires that the total parking area of shared parking facilities should exceed 5,000 square feet (King County Code, 2012).

- **Uses/Operation hours:** The Shared Parking is only allowed between certain different categories of uses or different operation hours. For example, the City of Seattle assigns the particular land use categories that office and residential building can share parking with.

- **Location:** The shared parking facilities must be located in a certain area or within a certain distance. 800 feet is a common standard, which means no building or use should be more than 800 feet from the most remote shared facility.

- **Approval:** Shared parking must get approval from the Director since the application must prove that the hours of actual parking demand for the proposed uses will not conflict and those uses will be served by adequate parking. In this case, a parking demand study is often required, and it usually needs a professional traffic engineer to prepare the study.

- **Allowed Reduction:** The primary incentive for having shared parking is that this strategy could reduce the amount of required parking spaces. However, there are still restrictions on this only benefit. For example, the City of Seattle allows parking reductions only up to 20% when parking is shared between Office and other permitted uses, and in most cases, the reduction cannot exceed the minimum parking requirement for any single use.

Due to the severe limitation on shared parking, the fact that only half of these mixed-use TOD housing projects have shared parking is not surprising. Appendix F contains the Shared parking requirements from King County Code and Seattle Municipal Code.

#### 4.2.3 Unbundle Parking Cost

All the housing projects studied charged monthly fees for every parking space, which implies that the parking costs are unbundled from the whole development cost and not included

in rents. Instead of a flat monthly fee, 5 projects discourage "Reserved Parking" or "Extra Parking" by charging higher monthly fees, and 2 projects set the upper limit of parking spaces that residents could have based on their unit type. These two specific strategies are worth learning and can be promoted and implemented in other TOD projects.

#### 4.2.4 Over/Under Parking

All the projects still put having an adequate parking supply as its priority, and any strategies that can reduce parking requirements come in second place. Both the authorities and developers still believe that the problems caused by under parking overwhelm those caused by over-parking, and the benefits of parking reduction, like cost savings or transit ridership increase, are insignificant.

#### 4.2.5 Station Area Overlay District

The City of Seattle established the Station Area Overlay District, with the purpose of preserving or encouraging a diverse, mixed-use community with a pedestrian orientation around proposed light rail stations or access to other high-capacity transit, where incompatible automobile-oriented uses are discouraged and transit-oriented use and development is encouraged (City of Seattle, 2001). Appendix E presents the criteria for establishing a Station Area Overlay District.

The Seattle Station Area Overlay District is the best practice of the last proposed parking management strategy – "establishing a TOD overlay district", and, as expected, Seattle's Station Area Overlay District also has a "Parking Provisions" package:

- **Reduce minimum parking requirement:** As described previously, there is no minimum parking requirement in Station Area Overlay District.
- **Off-Site Residential Parking:** The Station Area Overlay Districts allow off-site residential parking to be leased on nearby sites, and the off-site parking will not be allowed outside of the overlay district.

- **Commuter Parking:** The Station Area Overlay District will prohibit principal-use long-term non-residential parking. This will prohibit new Park & Ride and commuter parking facilities within the overlay district.

- **Location & Access to Parking:** To promote the TOD and a pedestrian environment within station areas, the parking in Station Area Overlay District must be located to the rear of a structure or built into or under a structure (City of Seattle, 2001)

## 4.3 Summary of Chapter 4

This chapter first presents a "Parking Study" which investigated the basic parking information of 25 selected TOD housing projects in King County, WA. It was mainly completed by conducting a telephone survey. The main findings are as follows:

1. 5,593 parking spaces that all 35 TODs have in total for this study, and 223.72 parking spaces per project.

2. 13 of selected TODs implemented "Shared Parking" strategy and other 12 have "Restricted Parking".

3. The overall average parking supply of selected TODs are 1.11, which is 30.63% lower than the general minimum parking requirements in King County.

4. All the studied projects have structured parking.

5. The parking rate of each project varies widely, ranging from $35 to $165 per month per space. All these parking charges were a flat monthly fee determined by market and charged separately from rents.

6. All those projects claimed that they have "enough" or "sufficient" parking spaces and none of them worried about the problem of "over-parking".

Then the "Discussion of the findings" tries to explore the reasons of some interesting findings by reviewing the existing parking policies, regulations and programs coded in King County and cities within its boundary. It finds that all the twelve Parking Management Strategies proposed in last chapter are included, or partly included in current parking provisions.

Therefore, it can be concluded that most authorities agree that implementing an appropriate parking management strategy is essential to create a Transit-Oriented Development. However, the real challenges lie in specific implementations, such as how to implement, to what extent, in what scale, by whom and who should be managed or regulated.

As a result, different implementations will have different effects, even with the same strategy. On the other hand, authorities can use different parking strategies to achieve a similar goal. In conclusion, the best parking strategy should be one that most suits the local conditions most precisely.

# Chapter 5: Conclusions

This thesis has intended to develop a full understanding of "Transit-Oriented Development" and related parking management strategies that could help its success. The following section includes the key conclusions, recommendations and ideas for future research.

## 5.1 Key conclusions of this study

The main body of this thesis consists of four chapters:

**In Chapter 1**, the thesis discussed the definition of "Transit-Oriented Development" by reviewing its evolution, history, and key features. This chapter concluded that a TOD is a development that must have the following four elements:

- Compact development
- Pedestrian-oriented design
- Balanced mix of land uses
- Efficient transit system nearby

**In Chapter 2,** the main objective of this chapter was to study the effects of parking on TOD's success, and before exploring their relationship. Chapter 2 first identifies the four primary goals that a successful TOD should achieve:

- Increase transit use, support other non-motorized transportation modes (walking, biking) and reduce auto dependency.
- Enhance economic development and generate good financial return.
- Maximize location and land-use efficiency.
- Improve livability and enrich choices.

Based on that, the thesis then explored the parking's impacts on each one of them. The conclusion of this chapter is clear: Not only does parking significantly influence the core performances of the TOD, but severely harms it whenever parking is oversupplied.

**In Chapter 3,** the thesis answered two main questions; the first is "Does traditional parking management fit for a TOD?" and the second "What are the appropriate parking management strategies that could potentially address the parking issue of a TOD?"

Some literature suggested answer to the first question is "no". Because the guiding principle of conventional parking management is to require enough parking spaces to meet the peak demand for free parking, this results in parking being oversupplied and underpriced. There are many studies that proved a large number of TODs are over-parked because of traditional parking requirements.

The second part of this chapter proposes twelve specific parking management strategies that could minimize parking demand and supply, or briefly speaking, reduce the parking. Each of those twelve strategies has its particular effects, and the best practice is to implement them as combinations.

**In Chapter 4,** the thesis presented a parking study which investigated the parking information of 25 TOD housing projects in King County, WA. The data obtained from the study included:

- Actual Parking Supply (Parking Ratio)
- Shared or Restricted Parking
- Structured or surface Parking
- Parking Rate
- Unbundled or not from unit Rents

The following are the three main findings:

1. The average parking ratio of these 25 TOD housing projects is 30.63% lower than the general minimum requirements of King County.
2. Only 12 of them have shared parking
3. All the projects charge parking independently, most as flat monthly fees.

The thesis also examined the existing parking policies, regulations and programs coded in King County and cities within its boundary, particularly in the City of Seattle. It turns out that all the twelve parking management strategies proposed in Chapter 4 are included, or partly included

in current parking provisions. Therefore, it can be concluded that the real challenge for a TOD's parking management strategy is no longer "what?" but "how?"

## 5.2 Recommendations and Future research

Getting parking right for a TOD, particularly avoiding oversupply of parking is critical to the TOD's success. The twelve specific strategies proposed in the thesis could effectively address the TOD's parking issues. However, the real challenge is implementing in reality. For example, to implement a same strategy, different jurisdictions might have different approaches.

The following section provides a series of recommendations for cities, transit agencies and developers in King County.

- **Encourage or require unbundled parking:** The thesis does not find any requirements that mandate the costs of parking to be unbundled from the cost of housing in King County. Therefore, setting "Unbundling Parking" as a requirement is necessary to realize the positive effects of this strategy to maximum.
- **Implement performance-based parking pricing for off-street parking:** The City of Seattle has already adopted the "performance-based" parking pricing program that sets paid parking rates by neighborhood. However, this program was only for on-street parking and most parking rates of off-street parking are still charged with flat monthly fees. Due to the success of this program for on-street parking, it suggests that expanding this program on off-street parking is both feasible and worthwhile. Charging higher fees for reserved or additional parking spaces is a good start, and it is perfectly possible to set different parking rates for residents on a daily, hourly base.
- **Make strategies easier to be implemented:** The effects of any parking management strategy are largely influenced by how easily it can be carried out. For example, although King County and City of Seattle clearly shows their acceptances of shared parking, however the complicated application processes and restrictive limitations of shared parking make it hard to be really implemented.
- **Combine multiple strategies and implement together**: Implementing strategies independently could significantly limit potential effects; thus, the best practice is to

implement them as a combination or a package. The key idea for is recommendation is to identify complements for each strategies. For example, reduced minimum parking requirements could be implemented along with setting maximum parking requirements.

- **Strengthen cooperation between governments, transit agencies and developers:** Adopting innovative parking management strategy to support TOD needs close cooperation among multiple players, particularly local jurisdictions, transit agencies and developers. The foundation of this cooperation is to recognize fully the necessity and superiority of new parking management, and through closer cooperation, each party could maximize its own interests while not hampering others.

Future research could be built on the parking study presented in this thesis by looking at subsidized housing apartments, condominiums, and commercial buildings to develop a more comprehensive understanding of current parking conditions of TODs in King County. Future research could also assess the effectiveness and feasibility of each proposed parking strategy in different scenarios. Additionally, the relationship between each strategy is one interesting topic, too. Finally, the specific implementation methods of TODs' parking management need to be studies in future research.

In conclusion, to be successful transit-oriented development should apply special parking management strategies to plan its parking. Hopefully, the results can be used by cities, transit agencies and developers to understand better parking and its effects on TOD projects and help to make them successful by getting parking right.

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# Appendix A: Pro forma of Parking's Direct Cost

**Basic Assumptions**

| | Suburban | Urban | CBD* | On-Street |
|---|---|---|---|---|
| *Interest Rate* | 6% | 6% | 6% | 6% |
| *Years of Payments* | 20 | 20 | 20 | 20 |
| *Days of Use Per Month* | 20 | 20 | 25 | 25 |

*CBD: Central Business District

**Input Data**

| Location | Types of Parking | Size SF/Per Space | # of Space (Per Acre) | Land Costs (Per Acre) | Construction Costs (Per Space) | O&M Costs (Per Year Per Space) |
|---|---|---|---|---|---|---|
| Suburban | On-Steet | 174 | 250 | $200,000.00 | $3,000.00 | $100.00 |
| | Surface | 396 | 110 | $200,000.00 | $3,000.00 | $300.00 |
| | 2- Level Structure | 379 | 115 | $200,000.00 | $15,000.00 | $500.00 |
| Urban | On-Steet | 174 | 250 | $1,000,000.00 | $5,000.00 | $150.00 |
| | Surface | 363 | 120 | $1,000,000.00 | $5,000.00 | $500.00 |
| | 3 - Level Structure | 348 | 125 | $1,000,000.00 | $18,000.00 | $600.00 |
| CBD | On-Steet | 174 | 250 | $5,000,000.00 | $5,000.00 | $200.00 |
| | Surface | 335 | 130 | $5,000,000.00 | $5,000.00 | $600.00 |
| | 4 - Level Structure | 323 | 135 | $5,000,000.00 | $20,000.00 | $700.00 |

**Financial Costs of Parking Facilities**

| **Types of Facility** | | **Capital Costs (Per Space)** | | | |
|---|---|---|---|---|---|
| Location | Types | *Land Costs (Per Acre)* | *Land Costs* | *Construction Costs* | **Total** |
| Suburban | On-Steet | $200,000 | $800 | $3,000 | **$3,800** |
| | Surface | $200,000 | $1,818 | $3,000 | **$4,818** |
| | 2- Level Structure | $200,000 | $869.57 | $15,000 | **$15,870** |
| Urban | On-Steet | $1,000,000 | $4,000 | $5,000 | **$9,000** |
| | Surface | $1,000,000 | $8,333 | $5,000 | **$13,333** |
| | 3 - Level Structure | $1,000,000 | $2,667 | $18,000 | **$20,667** |
| CBD | On-Steet | $5,000,000 | $20,000 | $5,000 | **$25,000** |
| | Surface | $5,000,000 | $38,462 | $5,000 | **$43,462** |
| | 4 - Level Structure | $5,000,000 | $9,259 | $20,000 | **$29,259** |

| **Types of Facility** | | **Annal Costs (Per Space)** | | | |
|---|---|---|---|---|---|
| Location | Types | *Annualized Land Cost* | *Annualized Construction Costs* | *Annual O & M Costs* | **Total** |
| Suburban | On-Steet | $69 | $258 | $100 | **$427** |
| | Surface | $156 | $258 | $300 | **$714** |
| | 2- Level Structure | $75 | $1,290 | $500 | **$1,864** |
| Urban | On-Steet | $344 | $430 | $150 | **$924** |
| | Surface | $716 | $430 | $500 | **$1,646** |
| | 3 - Level Structure | $229 | $1,547 | $600 | **$2,377** |
| CBD | On-Steet | $1,719 | $430 | $200 | **$2,349** |
| | Surface | $3,307 | $430 | $600 | **$4,336** |
| | 4 - Level Structure | $796 | $1,719 | $700 | **$3,215** |

| **Types of Facility** | | **Summary of FINANCIAL COSTS** | |
|---|---|---|---|
| Location | Types | Years of Operation | Total (Per Space) |
| Suburban | On-Steet | 20 | **$8,534** |
| | Surface | 20 | **$14,285** |
| | 2- Level Structure | 20 | **$37,287** |
| Urban | On-Steet | 20 | **$18,475** |
| | Surface | 20 | **$32,926** |
| | 3 - Level Structure | 20 | **$47,535** |
| CBD | On-Steet | 20 | **$46,986** |
| | Surface | 20 | **$86,729** |
| | 4 - Level Structure | 20 | **$64,309** |

# Appendix B: Parking Requirements within the TOD Overlay District

**Section 8.0 Parking Requirements**

Parking requirements within the TOD Overlay District are as follows:

1. A maximum of 1 parking space per multi-family unit, plus 1 guest space per 15 units, is permitted.
2. Parking for non-residential uses shall be provided at not more than 3 per 1,000 square feet (gross) and not less than less than 1 per 500 square feet (gross) for uses covering less than 1,000 square feet.
3. Further reduction in the number of required parking spaces may be permitted by a Special Permit granted by the Planning Board after a finding by the Board that the development will be adequately served by users of public transportation.
4. Shared parking is strongly encouraged. On lots serving more than one use, the total number of spaces required may be reduced, provided that the applicant submits credible evidence to the satisfaction of the City/Town Planning Board that the peak parking demand of the uses do not coincide, and that the accumulated parking demand at any one time shall not exceed the total capacity of the facility. Such evidence must take into account the parking demand of residents, employees, customers, visitors, and any other users of the lot. It must also take into account parking demand on both weekends and weekdays, and both during the daytime and overnight.
5. Where feasible, ingress and egress from parking shall be from side streets or alleys.
6. Surface parking lots must be to the rear of buildings, and shall not exceed one acre in size. Surface lots are prohibited in front of businesses.
7. Surface parking lots with more than thirty spaces shall be divided into separate areas by landscaped areas of at least 10 feet in width. A minimum of 15 percent of all surface lots shall be landscaped. No row of parking shall be more than 10 spaces wide without being interrupted by a landscaped area. Each landscaped area shall have at least one tree. Landscaped areas should be planted with low-maintenance, salt tolerant plants capable of withstanding extreme weather conditions.
8. Surface lots shall be screened along all sidewalks by a landscaped buffer of not less than six feet, or three foot walls or fencing compatible with the adjacent architecture.
9. Surface parking lots shall provide pedestrian walkways and connections to the sidewalk system.
10. On-street parking is permitted and encouraged.
11. Parking structures shall have well-designed and marked pedestrian walkways and connections to the sidewalk system.
12. Parking structures must include ground level retail along all streets and sidewalks.
13. Parking structures shall be designed to be compatible with adjacent buildings and architecture.
14. Bicycle racks shall be provided on site at a ratio of 1 space for every 15 automobile parking spaces or portion thereof.

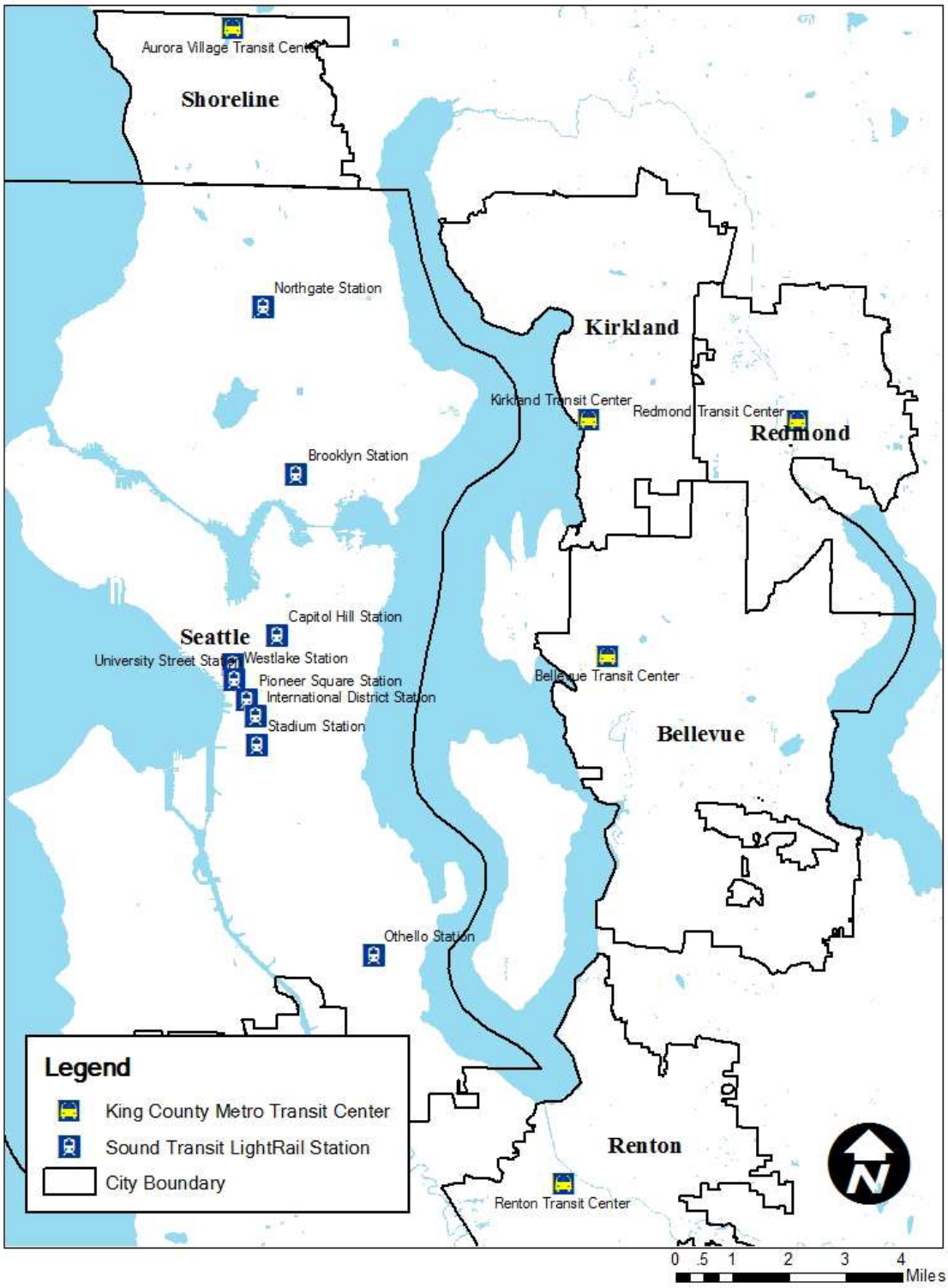
*The Massachusetts Office of Commonwealth Development is developing Bicycle Parking Facility Requirements for its Transit Oriented Development Bond Program. Municipalities adopting a TOD overlay district are encouraged to review these requirements and incorporate some of the bicycle parking design and materials requirements into their bylaws to ensure that quality bicycle parking is provided.*

15. All parking lots and structures must provide pedestrian access ways to streets that meet the Dimensional Requirements detailed in section 9.0, below.
16. Signage that shows the location and best means of access to the transit station must be provided at all parking facilities.

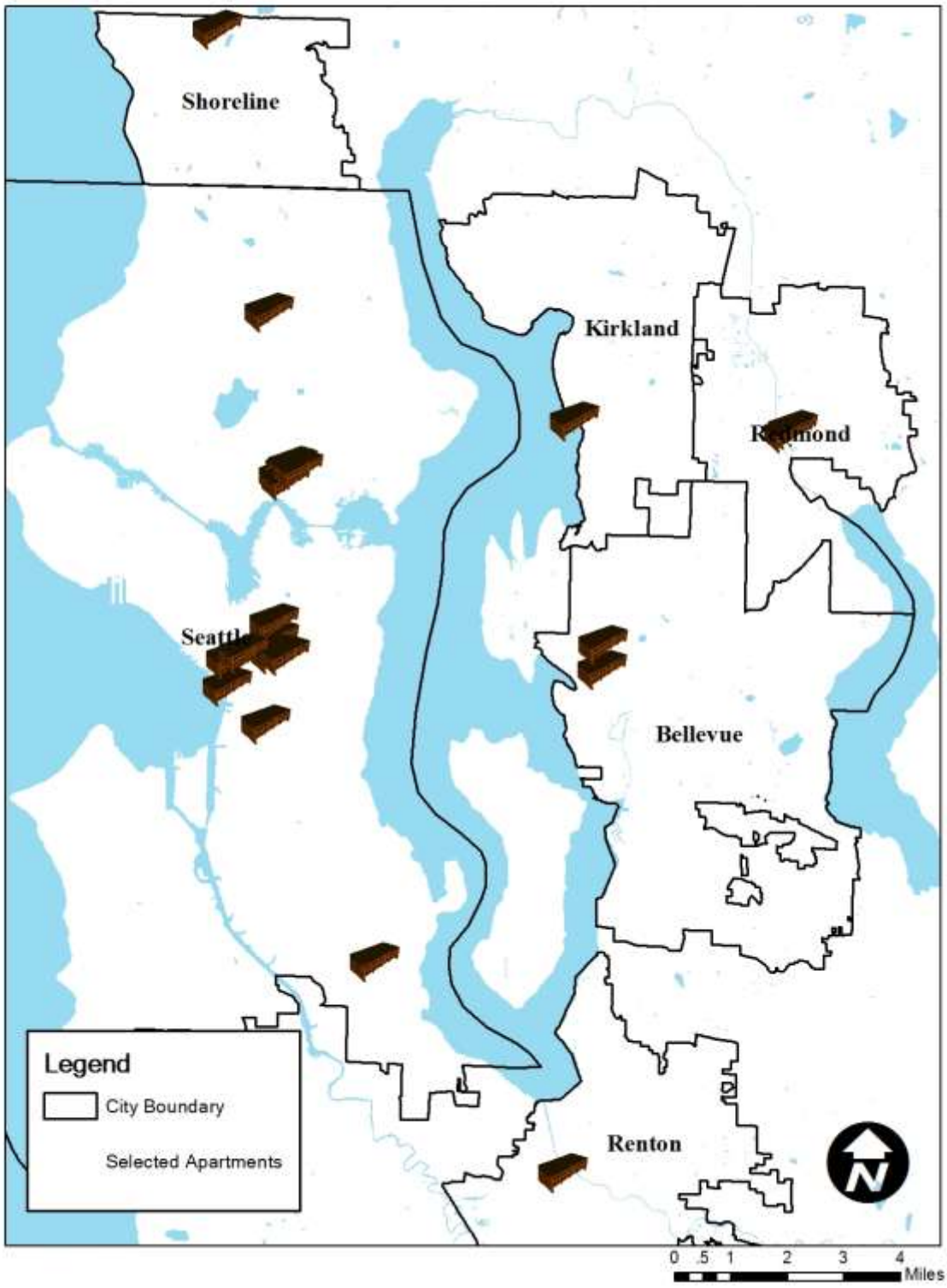
*The density and location of the TOD district will dictate whether or not structured parking should be encourage or allowed. In more suburban town centers, structured parking is less desirable than in more dense urban areas.*

## Appendix C: Maps and Background Information of 25 Selected TOD Projects

Map 1: Selected Transit Hubs



## Map 2: Selected TOD Projects



Background property information of 25 selected housing projects

| King County Metro Transit Center | | | | | |
|---|---|---|---|---|---|
| **Nearby Transit Center** | **Property Name** | **Property Type** | **Year Built** | **# of Units** | **Commercial sq ft** |
| *Bellevue Transit Center* | Ten20 Tower | Mixed Use | 2007 | 129 | 20715 |
| | Pinnacle BellCentre | Mixed Use | 2000 | 248 | 12366 |
| *International District Transit Center* | 705 S. WELLER APTS | Mixed Use | 2006 | 40 | 1018 |
| *Kirkland Transit Center* | THE WESTWATER | Mixed Use | 2006 | 62 | 7543 |
| *Northgate Transit Center* | Thornton Place Plaza | Mixed Use | 2009 | 279 | 23376 |
| | Thornton Place Creekside | Mixed Use | 2009 | 109 | N/A |
| *Redmond Transit Center* | Red 160 Apartment | Mixed Use | 2010 | 235 | 12785 |
| | Veloce | Mixed Use | 2006 | 322 | 5066 |
| *Renton Transit Center* | PARKSIDE AT 95 BURNETT | Apartment | 2006 | 106 | N/A |
| *Shoreline Transit Center* | Rosemont Apt | Mixed Use | 2006 | 32 | N/A |
| **Sound Transit Light Rail Station** | | | | | |
| **Nearby Transit Center** | **Property Name** | **Property Type** | **Year Built** | **# of Units** | **Commercial sq ft** |
| *Brooklyn Station* | Ellipse Apartments | Apartment | 2006 | 73 | N/A |
| | THE KENNEDY BUILDING | Mixed Use | 2004 | 125 | 6621 |
| | TRAVIGNE Apartments | Mixed Use | 2007 | 75 | 3836 |
| | HELIX APARTMENTS | Mixed Use | 2006 | 77 | 2245 |
| | Trinity Apartments | Mixed Use | 2008 | 99 | 3700 |
| | Lothlorien Apartments | Mixed Use | 2007 | 125 | 23190 |
| *Capitol hill Station* | The Heights on Capitol hill | Mixed Use | 2006 | 103 | 8860 |
| | Broadway Building | Mixed Use | 2010 | 94 | 26500 |
| | Joule | Mixed Use | 2010 | 295 | 26390 |
| | Packard | Mixed Use | 2010 | 56 | 11364 |
| *Othello Station* | Station at Othello Park | Mixed Use | 2006 | 351 | 17591 |
| *University Street Station* | Harbor Steps | Mixed Use | 2000 | 758 | N/A |
| *West Lake Station* | The Olivian | Mixed Use | 2007 | 224 | 7645 |
| | Metropolitan Tower | Mixed Use | 2006 | 366 | 7,730 |
| | Aspria | Mixed Use | 2010 | 324 | 6458 |

# Appendix D: Parking Data Obtained from the Survey

1. Parking Spaces data

| King County Metro Transit Center | | | |
|---|---|---|---|
| **Property Name** | **Total Parking Spaces** | **Spaces for Residential Only** | **Spaces for Commercial Only** |
| Thornton Place Plaza* | 704 | 0 | 0 |
| Thornton Place Creekside | 143 | 0 | 0 |
| PARKSIDE AT 95 BURNETT | 106 | N/A | N/A |
| Pinnacle BellCentre | 287 | 271 | 16 |
| Veloce | 424 | 400 | 24 |
| Red 160 Apartment | 366 | 0 | 0 |
| THE WESTWATER | 90 | 86 | 4 |
| Rosemont Apt | 55 | 0 | 0 |
| Ten20 Tower | 253 | 173 | 80 |
| 705 S. WELLER APTS | 23 | 0 | 0 |
| **Sound Transit Light Rail Station** | | | |
| **Property Name** | **Total Parking Spaces** | **Spaces for Residential Only** | **Spaces for Commercial Only** |
| Ellipse Apartments | 71 | N/A | N/A |
| The Olivian | 184 | 0 | 0 |
| STATION AT OTHELLO PARK | 280 | 150 | 130 |
| Harbor Steps* | 635 | 0 | 0 |
| Metropolitan Tower | 372 | 352 | 20 |
| THE KENNEDY BUILDING | 185 | 0 | 0 |
| TRAVIGNE Apartments | 100 | 100 | 0 |
| HELIX APARTMENTS | 70 | 0 | 0 |
| The Heights on Capitol hill | 102 | 0 | 0 |
| Trinity Apartments | 92 | 82 | 10 |
| Lothlorien Apartments | 129 | 0 | 0 |
| Broadway Building | 168 | 0 | 0 |
| Joule | 356 | 256 | 100 |
| Packard | 36 | 36 | 0 |
| Aspria | 362 | 264 | 98 |

2. Actual Parking Supply in "Parking Ratio*"

| King County Metro Transit Center | |
|---|---|
| **Property Name** | **Parking Ratio** |
| Thornton Place Plaza | 2.52 |
| Thornton Place Creekside | 1.31 |
| PARKSIDE AT 95 BURNETT | 1.00 |
| Pinnacle BellCentre | 1.09 |
| Veloce | 1.24 |
| Red 160 Apartment | 1.56 |
| THE WESTWATER | 1.39 |
| Rosemont Apt | 1.72 |
| Ten20 Tower | 1.34 |
| 705 S. WELLER APTS | 0.58 |
| **Average** | **1.25** |

| Sound Transit Light Rail Station | |
|---|---|
| **Property Name** | **Parking Ratio** |
| Ellipse Apartments | 0.97 |
| The Olivian | 0.82 |
| STATION AT OTHELLO PARK | 0.43 |
| Harbor Steps | 0.84 |
| Metropolitan Tower | 1.02 |
| THE KENNEDY BUILDING | 1.48 |
| TRAVIGNE Apartments | 1.33 |
| HELIX APARTMENTS | 0.91 |
| The Heights on Capitol hill | 0.99 |
| Trinity Apartments | 0.83 |
| Lothlorien Apartments | 1.03 |
| Broadway Building | 1.79 |
| Joule | 1.21 |
| Packard | 0.64 |
| Aspria | 0.81 |
| **Average** | **1.01** |
| **Average of all selected TODs** | **1.11** |

**Parking Ratio: Spaces per dwelling unit*

3. Parking Rates

| **King County Metro Transit Center** | |
|---|---|
| **Property Name** | **Parking Rate (Per month Per space)** |
| Thornton Place Plaza* | $70 |
| Thornton Place Creekside | $90 |
| PARKSIDE AT 95 BURNETT | $35/ $50 Tandem |
| Pinnacle BellCentre | $50 |
| Veloce | $75/ $155 addition |
| Red 160 Apartment | $165 |
| THE WESTWATER | N/A |
| Rosemont Apt | N/A |
| Ten20 Tower | $100/ $150 addition |
| 705 S. WELLER APTS | N/A |
| **Sound Transit Light Rail Station** | |
| **Property Name** | **Parking Rate (Per month Per space)** |
| Ellipse Apartments | N/A |
| The Olivian | $175 |
| STATION AT OTHELLO PARK | $75/ $150 addition |
| Harbor Steps* | $265 |
| Metropolitan Tower | $165 |
| THE KENNEDY BUILDING | $90/ $114 Reversed |
| TRAVIGNE Apartments | $125 |
| HELIX APARTMENTS | N/A |
| The Heights on Capitol hill | $150 |
| Trinity Apartments | $100 |
| Lothlorien Apartments | $85 |
| Broadway Building | $160 |
| Joule | $100 |
| Packard | $160 |
| Aspria | $150 |

## Appendix E: Maximum Parking Requirements for Overlay Districts

1. Northgate Overlay District

**SMC 23.71.016 Parking and access**

A. Required Parking.

1. Off-street parking requirements are prescribed in Chapter 23.54, except as modified by this chapter. Minimum and maximum parking requirements for specified uses in the Northgate Overlay District are identified in Table A for 23.71.016.

Table A for 23.71.016

Minimum and Maximum Parking Requirements

| | LONG TERM | | SHORT TERM |
|---|---|---|---|
| | Minimum | Maximum | Minimum |
| Office | 0.9/1000 | 2.6/1000 | 0.2/1000 |
| General sales and service (Customer service office)* | 1.0/1000 | 2.4/1000 | 1.6/1000 |
| General sales and service (other and Major durables retail sales)* | 0.93/1000 | 2.4/1000 | 2.0/1000 |
| Motion picture theaters | N/A | Min: 1/8 seats<br>Max: 1/4 seats | |

2. Stadium Overlay District

**SMC 23.74.010 Development standards**

A. Within the Stadium Transition Area Overlay District, the following development standards apply to all uses and structures except for spectator sports facilities:

b. The maximum parking ratio is one (1) space per six hundred fifty (650) square feet of gross floor area of all uses for which required parking is expressed in terms of square footage, except for institutions for which minimum parking requirements apply, and except for parking accessory to a spectator sports facility or exhibition hall. Nonrequired parking accessory to a spectator sports facility or exhibition hall is not permitted in the overlay district.

## Appendix F: Shared Parking Requirements of King County and Seattle

1. King County Code:

**21A.18.040 Shared parking requirements.** The amount of off-street parking required by K.C.C. 21A.18.030 may be reduced by an amount determined by the director when shared parking facilities for two or more uses are proposed, provided:

A. The total parking area exceeds 5,000 square feet;

B. The parking facilities are designed and developed as a single on-site common parking facility, or as a system of on-site and off-site facilities, if all facilities are connected with improved pedestrian facilities and no building or use involved is more than eight hundred feet from the most remote shared facility;

C. The amount of the reduction shall not exceed ten percent for each use, unless:

1. The normal hours of operation for each use are separated by at least one hour; or

2. A parking demand study is prepared by a professional traffic engineer and submitted by the applicant documenting that the hours of actual parking demand for the proposed uses will not conflict and those uses will be served by adequate parking if shared parking reductions are authorized;

3. The director will determine the amount of reduction subject to paragraph D of this section.

D. The total number of parking spaces in the common parking facility is not less than the minimum required spaces for any single use;

E. A covenant or other contract for shared parking between the cooperating property owners is approved by the director. This covenant or contract must be recorded with the records and licensing services division as a deed restriction on both properties and cannot be modified or revoked without the consent of the director; and

F. If any requirements for shared parking are violated, the affected property owners must provide a remedy satisfactory to the director or provide the full amount of required off-street parking for each use, in accordance with the requirements of this chapter, unless a satisfactory alternative remedy is approved by the director.

2. Seattle Municipal Code:

**G. Shared Parking.**

1. Shared Parking, General Provisions.

a. Shared parking is allowed between two (2) or more uses to satisfy all or a portion of the minimum off-street parking requirement of those uses as provided in subsections G2 and G3.

b. Shared parking is allowed between different categories of uses or between uses with different hours of operation, but not both.

c. A use for which an application is being made for shared parking must be located within eight hundred (800) feet of the parking.

d. No reduction to the parking requirement may be made if the proposed uses have already received a reduction through the provisions for cooperative parking, subsection H.

e. Reductions to parking permitted through shared use of parking will be determined as a percentage of the minimum parking requirement as modified by the reductions permitted in subsections A though F.

f. An agreement providing for the shared use of parking, executed by the parties involved, must be filed with the Director. Shared parking privileges will continue in effect only as long as the agreement, binding on all parties, remains in force. If the agreement is no longer in force, then parking must be provided as otherwise required by this chapter.

2. Shared Parking for Different Categories of Uses.

a. A business establishment may share parking according to only one of the subsections G2b, G2c or G2d.

b. If an office use shares parking with one of the following uses:

(1) general sales and services.

(2) heavy sales and services uses.

(3) eating and drinking establishments.

(4) lodging uses.

(5) entertainment.

(6) medical services.

(7) animal shelters and kennels.

(8) automotive sales and services, or

(9) maritime sales and services;

The parking requirement for the non-office use may be reduced by twenty (20) percent, provided that the reduction will not exceed the minimum parking requirement for the office use.

c. If a residential use shares parking with one of the following uses:

(1) general sales and services,

(2) heavy sales and services uses,

(3) medical services,

(4) animal shelters and kennels,

(5) automotive sales and services, or

(6) maritime sales and services;

The parking requirement for the residential use may be reduced by thirty

(30) percent, provided that the reduction does not exceed the minimum parking requirement for the nonresidential use.

d. If an office and a residential use share off-street parking, the parking requirement for the residential use may be reduced by fifty (50) percent, provided that the reduction does not exceed the minimum parking requirement for the office use.

3. Shared Parking for Uses With Different Hours of Operation.

a. For the purposes of this section, the following uses will be considered daytime uses:

(1) Commercial uses, except eating and drinking establishments, lodging uses, and entertainment uses;

(2) Storage uses;

(3) Manufacturing uses; and

(4) Other similar primarily daytime uses, when authorized by the Director.

b. For the purposes of this section, the following uses will be considered nighttime or Sunday uses:

(1) Auditoriums accessory to public or private schools;

(2) Religious facilities;

(3) Entertainment uses, such as theaters, bowling alleys, and dance halls;

(4) Eating and drinking establishments; and

(5) Other similar primarily nighttime or Sunday uses, when authorized by the Director.

c. Up to ninety (90) percent of the parking required for a daytime use may be supplied by the off-street parking provided by a nighttime or Sunday use and vice-versa, when authorized by the Director, except that this may be increased to one hundred (100) percent when the nighttime or Sunday use is a religious facility.

d. The applicant must show that there is no substantial conflict in the principal operating hours of the uses for which the sharing of parking is proposed.

e. The establishment of park-and-pool lots is permitted, provided that the park-and-pool lot will not use spaces required by another use if there is a substantial conflict in the principal operating hours of the park-and-pool lot and the use.