University Transportation Research Center - Region 2

Final Report

New York City Park & Ride Study

Performing Organization: Rensselaer Polytechnic Institute

Rensselaer

January 2012

Sponsor:
New York State Department of Transportation

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

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The modern professional must combine the technical skills of engineering and planning with knowledge of economics, environmental science, management, finance, and law as well as negotiation skills, psychology and sociology. And, she/he must be computer literate, wired to the web, and knowledgeable about advances in information technology. UTRC's education and training efforts provide a multidisciplinary program of course work and experiential learning to train students and provide advanced training or retraining of practitioners to plan and manage regional transportation systems. UTRC must meet the need to educate the undergraduate and graduate student with a foundation of transportation fundamentals that allows for solving complex problems in a world much more dynamic than even a decade ago. Simultaneously, the demand for continuing education is growing – either because of professional license requirements or because the workplace demands it – and provides the opportunity to combine State of Practice education with tailored ways of delivering content.

Technology Transfer

UTRC's Technology Transfer Program goes beyond what might be considered "traditional" technology transfer activities. Its main objectives are (1) to increase the awareness and level of information concerning transportation issues facing Region 2; (2) to improve the knowledge base and approach to problem solving of the region's transportation workforce, from those operating the systems to those at the most senior level of managing the system; and by doing so, to improve the overall professional capability of the transportation workforce; (3) to stimulate discussion and debate concerning the integration of new technologies into our culture, our work and our transportation systems; (4) to provide the more traditional but extremely important job of disseminating research and project reports, studies, analysis and use of tools to the education, research and practicing community both nationally and internationally; and (5) to provide unbiased information and testimony to decision-makers concerning regional transportation issues consistent with the UTRC theme.

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Principal Investigators: José Holguín-Veras, Jack Reilly , Felipe Aros-Vera - RPI
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Mailing Address:

University Transportation Reserch Center
The City College of New York
Marshak Hall, Suite 910
160 Convent Avenue
New York, NY 10031
Tel: 212-650-8051
Fax: 212-650-8374
Web: www.utrc2.org

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Nathalie Martinez: *Research Associate*

Sundari Prasad: *Graphic Intern*

University Transportation Research Center

Final Report

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NEW YORK CITY PARK AND RIDE STUDY

PROJECT C-07-66

Submitted to:

New York State Department of Transportation

Prepared by:

José Holguín-Veras, Ph.D., P.E.
William H. Hart Professor, Rensselaer Polytechnic Institute

Jack Reilly, Ph.D.
Clinical Professor, Rensselaer Polytechnic Institute

Felipe Aros-Vera,
Research Assistant, Rensselaer Polytechnic Institute

Rensselaer

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7. Author(s)
José Holguín-Veras, Ph.D., P.E.
William H. Hart Professor, Rensselaer Polytechnic Institute

Jack Reilly, Ph.D.
Clinical Professor, Rensselaer Polytechnic Institute

Felipe Aros-Vera,
Research Assistant, Rensselaer Polytechnic Institute

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Rensselaer Polytechnic Institute
Department of Civil and Environmental Engineering
4030 Jonsson Engineering Center

Rensselaer Polytechnic Institute
110 Eighth Street
Troy, NY 12180-3590

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16. Abstract
This study reviewed existing practices in Park and Ride planning, developed a methodology for evaluating candidates, and applied the methodology to the commuter market in New York City. The team identified a set of candidates based on availability for Park and Ride use and transit connectivity. The candidates were evaluated using potential demand, savings, market share, and present value of benefits as performance measurements.

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1. INTRODUCTION

In recent years, concerns about the sustainability of transportation operations and rising urban congestion have translated into increased interest in the use of Park and Ride (P&R) as a way to provide suburban commuters an attractive transit alternative. P&R combines the best elements of car use and mass transit, as they enable potential users to drive to a P&R facility where they can take a line-haul transit service to their destinations. Although a number of policy guidelines exist (AASHTO, 1992; Spillar, 1997; AASHTO, 2004), the analytical treatment and the economics of P&R systems are still in their infancy.

The New York State Department of Transportation commissioned this study to review existing practices in P&R planning, develop a methodology for evaluating sets of candidate sites, and apply the methodology to the commuter market in New York City. This report describes and applies an analytical method to review P&R sites. This project report is organized as follows:

Section 2: Design and operation of park and ride facilities

Section 2 contains a discussion of a number of travel demand, traffic and transit operational, and community planning factors in P&R service and operation. This section discusses the physical design of such facilities, including passenger amenities, attention to customer safety and security, and access by automobile and transit modes. Alternate methods for site acquisition and control, project development and operation and maintenance practices are also discussed in this section.

Section 3: Construction costs of park and ride facilities

Section 3 discusses costs related to the installation of park and ride facilities and its interrelationship with the financial constraints imposed by this kind of project. Assessing the potential locations for new P&R facilities requires evaluating the costs and benefits, key considerations in transportation planning.

Section 4: Locating the universe candidates of park and ride facilities

This section describes a set of criteria for selecting a pool of candidate sites. This was applied to the New York City area and a number of candidate sites from which to select actual sites were prepared. This original pool contains a rough number of possible facility locations, and later on this report this set is reduced to the final set of candidates.

Section 5: Methodology for evaluating park and ride facilities

A methodology for selecting among the identified candidates is presented in Section 5. Using modern transportation planning and computer modeling techniques, a model for assessing the performance of alternate sites was developed. Performance measures for the alternative under review includes: expected demand, weighted average savings, market share, and present value of benefits. Candidates in Bronx, Brooklyn, Staten Island and Queens are described and analyzed considering the proposed methodology.

Section 6: New York City shared use park and ride program (concept plan)

The New York City shared use park and ride program is a conceptual plan describing how to promote the use of underutilized parking lots as P&R facilities in the surrounding boroughs to Manhattan. This plan is motivated by the high acquisition and building cost of P&R facilities and allows to increase the supply of P&R systems at low costs of implementation.

Section 7: Conclusions

The conclusions of the study including insights for adapting the methodology to other metropolitan areas are contained in this section.

Section 8: Appendices

Appendix 8.1: Literature Review

This appendix includes a review of literature related to P&R studies in the United States and select locations in Europe. Specific emphasis is given to urban areas which are similar in density and structure to New York City. The appendix also reviews government planning studies on P&R.

Appendix 8.2: Sample Agreements

A few sample agreements for land acquisition and facility operations and maintenance are contained in this appendix.

Appendix 8.3: Site Descriptions

A detailed description of each of the candidate sites is contained in this appendix. This includes site map for geographic and tax information, and financial information obtained from the NYS Department of Finance.

2. DESIGN AND OPERATION OF PARK AND RIDE FACILITIES

One of the most important considerations is the role of P&R in the urban transportation system and how these facilities are planned, designed and operated. The purpose of this section is to review the supply side of P&R services including the design of parking facilities as well as the corresponding transit service to them. At the outset, it is difficult to divorce the design of facilities from the transit service supply. This section discusses the process of P&R facilities design which includes a combination of geometric and operational characteristics. Guidance on design of individual facilities is contained and presented through a description of previous literature, case studies, and the project team's experience.

The development of the design process is preceded by a conceptual phase that determines the major inputs that will define the design of the P&R facility. Here, the major stakeholders are defined along with their interests and objectives. Then, a final site screening and selection process is performed to determine the specific spatial characteristics that will directly affect the design. Moreover, elements regarding available resources and land acquisition are specified in order to create the design in accordance to the financial and geometric constraints. During this process, environmental requirements and community integration issues are addressed along with any local permits and requirements. The preliminary design process should result in a sketch of the potential site with a broad description of facility characteristics.

The preliminary design process is of particular importance when developing a P&R facility. Usually, these types of facilities are characterized by integrating a series of stakeholders (i.e. DOTs, Transit agencies) that need to be coordinated for the future facility to work effectively. Additionally, the community needs to be consulted and engaged to ensure the development of the facility is consistent with community values and aspirations. The following sections summarize a suitable approach to address the requirements that precede the design of a P&R facility. One of the key issues of the preliminary design phase is the identification of the involved agencies. This is sometimes naturally defined, as major inputs are needed from each agency in order to properly plan for the future P&R site. However, the function and influence of each agency needs to be specified.

Since no individual agency typically has the broad skill-sets required for successful project development and operation, one public organization is generally designated to be the project sponsor and coordinates the activities of other participants. Table 1 shows a brief assessment of the relative strengths of each possible organizational unit. It is important to highlight that the ultimate purpose of this table is to illustrate that segregating responsibilities with unified control is an intelligent strategy – not to suggest a specific implementation model.

Table 1: Roles for implementation of park and ride facilities

	DOT	Transit operator	Local government	Commercial contractor
Site acquisition	xxx	x	x	
Environmental planning	xxx	x	x	
Plans and specifications	xxx	xx	x	xxx
Cost estimates	xxx	xx	x	xxx
Contract management	xxx	xx	x	xxx
Construction inspection	xxx	xx	x	xxx
Facility operations and management	xx	xxx	xx	xxx
Transit operation		xxx	x	xxx

Notes: xxx – very well suited; xx – possibly suited; x – ill suited

The State Department of Transportation (DOT) is particularly well suited to tasks associated with land acquisition since this is a core competency required for successful management of a highway network. Similarly, the DOT is well suited, but not uniquely suited to project development tasks. Transit operators, on the other hand, are better suited to facility operations and transit services. Nearly all tasks associated with P&R development can be undertaken by commercial contractors. Once the sponsor of the project is defined and the role of each involved agency is specified, the definition of available resources is performed and the procurement process for the design of the P&R facility begins. More on the procurement and contracting of P&R facilities will be presented in the following sections of this report.

P&R facilities may either be purpose built –designed for P&R service or shared use– or used by transit commuters as a secondary use for the facility. Descriptions of both types of developments are contained in this section. For purpose built facilities development and design guidance is presented. For shared use facilities a description of arrangements between the facility owner and transit sponsor is offered.

2.1. Design of park and ride facilities

As in parking lots, the design of the facilities should be preceded by a series of data collection and analysis. The following data analyses are recommended prior to the initiation of the design process. These should provide a better understanding of the actual demand, as well as other design elements:

Parking Inventories: These include observations of the number of spaces and their location, time restrictions on use of parking, and type of parking facility (e.g. on-street, off-street lot, off-street garage).

Parking accumulation: is defined as the total number of vehicles parked at any given time.

Parking duration: is the length of time that individual vehicles remain parked. This characteristic is, therefore, a distribution of individual values.

License Plate–Origin Information: This type of study requires special permission from state authorities, and can help to obtain information regarding the origin location of lots' users. This is usually applied to shopping centers and stadiums.

Parking interviews: This is made to obtain information on trip purpose, duration, distance walked, and background of parker characteristics.

The data gathered should provide information on the demand throughout the day. The variation of duration and accumulation of vehicles for different population rates affect the final design of the P&R

facility. These data provide a broad idea of the type of parking lot that needs to be provided in order to suit the demand. After obtaining a better understanding of the temporal variation of demand, the design process can begin. The design will be strongly related to the operational characteristics of the future facility and potential demand.

Once a type of facility is selected, the internal features are specified. An optimal design of a parking facility involves many issues, including proximity to major destinations, adequate access and egress (including reservoir space), a simple and efficient internal circulation system, adequate stall dimensions, and basic security. Also, issues of architectural beauty are needed to be taken into account for community integration purposes. The elements that comprise the design of a parking facility are the following:

- Parking dimensions (e.g. stall width, parking stall length and depth, aisle)
- Parking Module or Distributions
- Parking Aisles
- Parking Garages
- Transfer Areas

Each of these elements will depend on the selected design vehicles. The facility should be prepared to serve the different types of vehicles (e.g. bus, rail, individual vehicle). Basic dimensions are based on one of two "design vehicles." Modern parking facilities often make use of separated parking areas for "small cars" to maximize total parking capacity. The transit design vehicle will depend on the service mode that is going to complement the P&R facility.

The definition of the design vehicles will define each of the elements of the P&R. Parking dimensions such as stall width, parking module, and parking aisles should be distributed to maximize capacity and meet the requirements of turning movements. Similarly, the transfer areas should be prepared to reduce the dwell time of bus or rail by providing the appropriate internal mobility. In some cases, a transfer facility will not have a reserved area given that the service can only stop for a brief time, such as in rapid transit. In these cases, on-street loading facilities should be provided near the P&R lot, as a way to reduce the dwell times and maximize the transit capacity.

After identifying the internal elements, the architectural and structural layouts are selected. There are different types of layouts for P&R facilities, for both purpose built lots and shared used lots, these are:

- Surface Park and Ride Lots
- Garage Park and Ride Lots

The P&R layout is defined along with the operation. As the distribution of vehicle parking spaces and the transit area will be defined separately. The decision of how to provide off-street parking depends on many considerations, some of which are summarized below.

- A parking facility must be convenient and safe for the intended users.
- A parking facility should be space-efficient and economical to operate.

- A parking facility should be compatible with its environs.
- A facility will heavily depend on the availability of land.

These elements specify the geometrical display of the facility to be designed. Once the base parking space is specified, then the actual design of the P&R facility is undertaken. As mentioned previously, there are two types of design for P&R. The physical design is presented for both types of facilities, purpose built lots and shared lots.

The overriding elements of P&R facility physical design are maximizing the efficiency of the parking facility, safety and security, and maximizing compatibility with other community activities. As interchange points between travel modes, P&R facilities introduce a number of conflicts between motorists, pedestrians and buses which cause safety problems. Several of these can be managed by a good design which include segregation of buses and cars on-site, and well defined pedestrian pathways to the boarding location. In some cases, P&R facilities also serve as an interchange point between the regional express and local bus network.

Vehicle circulation, both on-site and site access must be well thought out in P&R facilities. Ideally, direct access by buses to highway interchanges, at least in the morning direction, will improve the attractiveness of the P&R product. The design layout developed by the research team addressing some of the issues is shown in the sections below.

The challenge in designing suitable P&R services is to identify combinations of facilities and transit services where the P&R service can be produced at a reasonable cost per commuter. However, prior to any detail service design is undertaken, a definition of the different types of facilities is needed. The approach taken here is to identify prototypical facilities for P&R services followed by prototypical transit service types. This will be followed by the identification of feasible combinations of each.

The design of a P&R service consists of two primary components, transit operational characteristics and facility layout. The combination of both elements describes the actual design of the P&R facility and the service that will be provided.

2.2. Types of park and ride facilities according to location

AASHTO (2004) has identified a hierarchy of facility types which is illustrated in Table 2. This table has been modified in the distance to account for the characteristics of New York City. A discussion of each of the types of facilities follows.

Table 2: Types of park and ride facilities according to location

Facility Type	Distance From Primary Destination	Characteristics	Public Investment
Suburban park and Ride Lots	10 to 50 miles	Intermodal or change-of-mode service provided	Tend to be publicly funded but offer opportunities for joint ventures / privatization
Remote Long Distance Lots	50 to 100 miles	Intercity commuters served	Typically publicly funded
Local Urban Park and Ride Lots	1 to 10 miles	Fills gap between suburban market and central business district; informal, shared use, or opportunistic	Often publicly funded but provide opportunities for private operation
Peripheral Park and Ride Lots	Located at edge or up to 5 miles of periphery of primary destination	Intercept traveler prior to activity center; satellite park and ride lot	Opportunities for privates investment; public investment should be carefully evaluated

Source: AASHTO (2004)

Peripheral P&R lots

A number of communities have Peripheral P&R facilities located on the periphery of downtown areas near highways entering the downtown. In such a service, commuters accomplish the line-haul portion of their trips in their cars and a transit service operates between the P&R lot and the downtown. The primary objective of such a facility is to diminish the requirement for downtown parking. It also generally reduces the commuter parking cost.

Since the major portion of the commuter journey is on the highway network, there is bound to be considerable variability in the journey time between the residential origin and the peripheral facility location owing to traffic congestion or accidents. Accordingly, if a commuter schedules the departure time to a specific scheduled bus trip, he or she will have to depart considerably earlier to assure with high confidence that he or she will arrive in time for the scheduled bus departure. As an alternative, a preferable service plan would be to provide sufficient frequency that a commuter would be able to arrive randomly at the facility and not have an intolerable wait time. The research suggests that published headways of 12 minutes about half of the customers will arrive randomly and half will pre-time their journey to a specific bus trip. The cost of providing such service is rather expensive and is efficient if and only if there is a high volume of commuters over which to spread this cost. This dictates a certain minimum facility size. While a more detailed description of transit service supply follows, this brief discussion illustrates the interrelationship between P&R supply and demand.

Peripheral P&R facilities, by their very nature are located very close to the downtown area where land costs are high. In the New York City area, in particular, it would be difficult to assemble a land parcel of sufficient size to institute peripheral P&R service unless it were at a land parcel with few alterative uses, such as near a highway interchange. In the New York City Metropolitan area, there are a few examples of Peripheral P&R lots, particularly in New Jersey, notably the 1500 car facility at I-495 and Route 3 in North Bergen NJ operated by the Port Authority of New York and New Jersey.

Remote P&R lots

While the AASHTO facility type hierarchy shows a distinction between suburban and remote P&R lots, from a facility design point of view this distinction is not very meaningful. Remote lots (over 40 miles from the commercial destination) tend to be smaller informal facilities near highway interchanges. It is as common to see carpool users at such facilities as transit customers. In fact, there are instances particularly in smaller urban areas where such facilities do not even have transit service but enable carpool commuters to assemble at a common interchange point. In Upstate New York, the New York State Thruway Authority has been active in developing such facilities, having prepared 31 such lots (New York State Thruway Authority, 2011). The facilities in more remote areas tend to be minimal in their design with some not even being paved nor lighted.

Suburban P&R lots

The more general model of P&R facilities is a suburban P&R lot. These are purpose built facilities which enable efficient interchange between the auto and bus mode. They range in size between 100 spaces and in some cases over 1,000 spaces. In fact, in Denver and in the Washington, DC area, some of these facilities are very costly garage structures.

Transit service to such facilities can be through one of three methods. One is a dedicated service to the facility; the second is a facility being one stop among a number of stops on a particular bus trip; the third is local stops either prior to arrival to or after departure from the facility. These issues are discussed in the transit service design section.

Neighborhood P&R lots

Neighborhood facilities refer to a class of smaller P&R lots built near existing local or express transit routes. These are either purpose-built as P&R facilities or shared use in which a parking facility owners makes spaces available for commuters due to complementary usage patterns. Churches and sports arenas are most commonly used for shared use facilities. Since the transit service to these lots serves other markets, not all of the ridership on the transit routes is comprised of P&R customers. This makes neighborhood lots feasible even at small sizes.

2.3. Types of park and ride facilities according to construction purpose

The overriding elements of P&R facility physical design are safety, security and efficient circulation. As interchange points between travel modes, P&R facilities, by their very nature, introduce a number of conflicts which cause safety problems. Several of these can be managed by good design which include segregation of buses and cars on-site and well defined pedestrian pathways to the boarding location.

The design of P&R facilities is an expanded parking design. Typically, parking facilities are designed to maximize the capacity of the available land, accounting for internal mobility and circulation that will affect the operation of the facility. In addition, P&R facility design needs to account for the integration of the vehicle-pedestrian modes with different transit service. This interrelationship has to be treated with care, given that it may affect the safety and operation of the site. An appropriate facility should separate the line-haul transit service from the different access modes.

The previous section discussed P&R facilities from a system point of view. This section is intended to provide some guidance on the physical design of facilities synthesizing best practices from a number of areas. Since there are two broad types of facilities – purpose built and shared use, each with very different design, they are treated distinctly here.

Purpose Built Lots

Purpose built lots are facilities evaluated, designed, and operated as parking facilities. On the other hand, shared used P&R facilities are simply facilities originally designed to serve particular buildings, malls, churches or similar that can alternatively be used as P&R facilities. Fortunately, there is a sizable body of literature on purpose built P&R facility design from design manuals of State Departments of Transportation (California, Florida and Wisconsin are most notable) and from transit agencies such as AC Transit in Oakland, CA and Seattle Metro. Further, there is some design guidance from the European Community (Location and Design of Interchanges, Rail Bus and Car, UITP, 1995). In this project, a compendium of best practices was developed through literature review and professional experience. These included site design and geometry and customer amenities such as sheltered waiting areas, bike racks, telephones and transit information displays.

The major design requirements for such facilities are adequate safety and security. The relevant sections of the New York State Department of Transportation Design manual as well as the AASHTO Guide for Park-and-Ride Facilities (2004) provide considerable guidance on the site and geometric design of such facilities. Section 24.3 of the New York State Highway Design Manual describes engineering standards for the design of a passenger interchange facilities including P&R and park and pool lots. Some key physical design features of P&R facilities are discussed below.

An ideal facility has nearly perfect segregation between autos, buses and pedestrians to the point where a separate entrance and exit for buses is designed. In reviewing the engineering manuals of several Departments of Transportation other than NYSDOT and transit operators, the following design guidance was synthesized:

Access to any lot should not be placed at a point where it will disrupt existing traffic. Turn-ins preferably should not be at least 300 feet from other intersections, and there should be sufficient sight distance for vehicles to exit and enter the lot. Therefore, exits and entrances should not be located on crest vertical curves or on horizontal alignment where sight distance is less than 90 meters.

For many facilities, it may be necessary to provide a pick-up and drop-off area. This area should be close to the bus pick-up point and clearly separated from the parking stalls. A holding area or short-run parking facility for passenger pick-up may also be required.

Parking areas can be places on relatively steep grades, but roadways that accommodate buses should not have a grade steeper than 7 percent. Accelerations grades should not be greater than 4 percent. Curvature radii of planned vehicular paths within the parking area, and access roads should be large enough to accommodate the types of vehicles that they are intended to serve.

Parking aisles should be located perpendicular to the bus roadway so that pedestrians are not required to cross the drive path. Also, the layout should be designed so that pedestrians should not have to walk more than 120 m. Sidewalks should be a minimum of 1.5 m wide and loading areas should be 3.6 m wide.

All transit facilities should also be designed in accordance with the design standards and guidelines of the serving transit authority. Designers should take into consideration the desires of the local community when designing transit related roadway improvements and consult local planning officials regarding specific additional requirements.

The Denver Regional Transportation District (RTD) is the regional public transportation operating agency in Denver, Colorado. RTD has developed a sizable network of P&R facilities in the Denver Region. Since their role is primarily a transit operator, the agency has a slightly different perspective on P&R design criteria:

A P&R shall typically pick-up or drop-off facilities (Kiss 'N Ride, short term parking), bus transfer facilities including bus bays for loading and unloading, a drivers relief station (DRS), shelters, benches, trash receptacles, bicycle parking, lighting, information kiosks, public telephones (pay and emergency), and security features. Facilities shall be paved, landscaped and designed to provide safe and convenient parking and bus transfer facilities for transit patrons. A P&R shall be designed with consideration for efficiency of use, economical site construction of the local jurisdiction.

Bus transfer areas can be internal to the site or may be located at the edge of an adjacent roadway. Where transfer facilities are located adjacent to the site in the local roadway system, bus pads should be constructed in accordance with the RTD Standard Drawings. The location of bus pads shall be coordinated with the local roadway authority.

Where transfer areas are located on site, integrated with a P&R, bus transfer areas shall be separated wherever possible from parking areas so that bus traffic and private vehicle traffics do not share drive lanes. The bus waiting area shall be constructed with concrete pavement and concrete curb and gutter, and individual bus loading bays shall be designed in accordance with RTD Standard Drawings. The number of bus bays provided in the waiting area shall be as designated by RTD's service development division.

Access to the bus transfer areas shall, wherever possible, be located at signalized intersections. Two points of access shall be designated so that buses may enter and exit the transfer facility without reverse movement. Access to the site shall be coordinated with the local roadway authority. Bus access from the local roadway to the site shall be constructed with the use of curb returns or curb cuts, as required by the local jurisdictions. The use of curb cuts shall be avoided. Curb return and drive lane minimum radii shall be designed for the radius of the most restrictive vehicle that could access the facility.

Customer Amenities

The state of the practice of the design of P&R facilities, particularly those in suburban areas can be characterized as minimalist. Typical practice is to provide the minimum level of amenities necessary to accomplish the function of the facility. These typically include lighting, a customer waiting shelter, a public telephone and occasionally a bicycle rack.

Passenger Shelter: An enclosed waiting shelter is essential for these facilities. At larger P&R lots, an environmentally controlled building is preferred. The appropriate size depends on the arrival pattern of customers. Generally, these shelters are standard off-the-shelf products. However, there have been a number of architecturally distinctive shelters at some P&R facilities particularly in the western part of the United States. If a facility is served by a number of routes, it is good practice to have distinct boarding areas for each route.

Public Telephone: With the increased availability of cellular phones, the number of coin-operated phones has diminished considerably. Despite this trend, it is a good practice to have at least one coin-operated telephone at each facility in the event of an emergency or a car failing to start. Coin phones can be programmed to connect to a limited quantity of telephone numbers such as emergency services and the customer service center of the transit operator without depositing a coin.

Bicycle Accommodations: A number of P&R facilities throughout the country have bicycle racks and some even have bicycle lockers which can be rented from the facility operator. The bike lockers appear to be a low value amenity relative to its cost. The few transit systems which do have them do not cover the cost of the program.

Customer Information and Ticketing: It is the norm for some type of display of customer information for the transit service to be part of each P&R facility. Further, if there are particular rules of operation such as prohibitions on overnight parking, they should be posted as well. In some cases, ticket vending machines (TVM) are installed which enable the purchase of various transit fare media. At the Route 3 P&R Facility in New Jersey, where there is a distinct parking charge and transit service charge, TVM's can issue the correct set of round trip transit tickets as well as parking validation.

Electronic displays of anticipated bus arrival departures are certainly a worthwhile amenity. However, their deployment has been limited owing to the cost of operation and maintenance and the challenges of installation of an unmonitored electronic device with exposure to harsh environment.

Newspaper Rack: Newspaper racks can be a suitable amenity and can function profitably at relatively low volumes. Some transit systems have experimented with selling newspapers on buses. These are short lived promotions owing to logistic issues of assuring a suitable number of copies on each bus.

<u>Bus Storage</u>

The facility should be designed to accommodate buses recovering their time schedule at the facility. That is, there will be times where buses must wait - if the layover time exceeds the headway, and then more than one bus will be at the site. It is important the design enable random access to bus loading berths. If the lot has large capacity the layover location should be distinct from the bus loading area. Ideally, the facility should be designed so that a bus can discharge passengers on entry, travel to the layover location and return to the loading berth to pickup passengers without re-entering to the streets.

Shared use park and ride facilities

A great number of transit operators have entered into joint use arrangements for P&R services with private land owners. Among the most common arrangements are with churches, movie theaters and shopping malls where the peak parking demand is not generally during weekday daylight hours. The primary advantages of these facilities to the transit operator are significantly lower development cost and time, lower operating costs and the ability to introduce an experimental transit service without high startup costs.

There are a number of disadvantages to such an operation as well. Typical lease agreements contain clauses in which enable the landowner to terminate the arrangement for convenience on very short notice, as short as thirty days. A shared use arrangement provides the transit operator limited control on facility operation and maintenance. For example, a church lot may not require snow plowing until a weekend.

Liability for accidents ranging from trips and falls to motor vehicle collisions becomes a matter requiring negotiation with the land owner. Typically, a property owner will require the transit operator to hold harmless and defend the property owner from any claims which might arise from operation of the facility for commuter parkers regardless of the possible contributory negligence of the owner – such as failure to repair tripping hazards on the facility.

If there is either a short term lease or an agreement with an early termination clause, it will not be possible for the transit operator to invest in leasehold improvements such as shelters, additional lighting or other customer amenities since the public owner will not have satisfactory continuing control over the improvement.[1] Similarly, a short term lease would prevent customization of the facility to impart an identity consistent with the rest of the transit operation.

The largest disadvantage to a concessionary arrangement is the oftentimes imperfect location of the facility. The operating cost of public transit services serving P&R facilities is very location specific. Since operating costs of bus transit in New York City are on the order of $3.00 per minute, even slight deviations necessary to serve a specific site can result in very high operating cost premiums. However, in large cities and other densely developed areas, where there is a lack of affordable and available land, and where community and environmental issues can be significant, shared use lots, which are already built, represent an important option for developing a park & ride system. In addition, shared use lots maximize the use of already paved areas, rather than taking away space or green areas.

Methods of Developing Agreements

There are three fundamental methods of arranging such agreements – commercial negotiation, persuasion and through administrative fiat. Certainly, persuasion with a modest fee will yield the lowest facility cost to the transit operator. This method works best under the following circumstances:

There is considerable uncertainty in the anticipated demand for the facility and a means of conducting a service experiment is desired. This is particularly suitable if the transit operator has an option on another property for a purpose built facility.

Anticipated demand is likely to be low so that the cost of interruption in the case of termination of the lease by the owner will be low and the owner is not likely to be overwhelmed with additional cars.

There is some evidence that the conditions which result in shared use of the facility are stable and are likely to continue. For example, a shopping center with considerable retail vacancy may have excess parking capacity in the short run, but not be able to sustain additional cars in the long term.

A commercial lease in which there is a negotiated exchange of parking rights for a contracted price is the most practical arrangement. Unfortunately, the equilibrium price of such negotiation is not easy to determine a priori since the negotiation is typically a case of a monopoly buyer (the transit operator) and a monopoly seller (the land owner). Only in very fortuitous circumstances will the transit operator be able to choose from more than one land parcels. Negotiation as a commercial lease can provide the transit operator with considerable more latitude in negotiation of maintenance standards, term (duration) of the agreement and the ability to improve the property with certain transit amenities.

Another advantage of a commercial lease is that a system which relies solely on concessionary arrangements is very fragile. If one property owner seeks compensation for his or her site, other owners are sure to follow. Appendix A shows a short term use agreement for a shared use facility. This particular agreement permits the owner to evict the transportation operator in 60 days.

[1] A prefabricated bus shelter which can be dismantled and removed would not be considered a permanent improvement.

2.4. Transit service types and designs

P&R facilities are served by transit services in a number of ways. The primary means are: dedicated service to a single facility, dedicated service to a set of facilities, and regular transit service (express or local) serving other markets such as commuters who walk to bus stops. The following subsections define each of them and highlight main differences and peculiarities.

Dedicated service – Single facility

The most simple service mode is a dedicated service between a single facility and a limited set of points in the downtown area. This service type is sensible for both peripheral and remote P&R facilities. The primary attributes of the service are frequency and capacity. The transit operator must assure that there is sufficient capacity, as measured in seats per hour to carry the anticipated number of boarding comfortably or there is sufficient frequency so that customer wait times are not excessive. There are simple operation supply models to compute vehicle requirements for a variety of boarding patterns, distance (or time) to the central business district, running time variability and vehicle capacity.

Dedicated service – Multiple facilities

On some corridors in the US and elsewhere, congested traffic corridors might have multiple P&R facilities. Generally, these are smaller facilities in the range of 100-500 cars. They are intended to reduce access times to the sites by commuters from their homes. Their smaller size reflects demand in their market sheds and enable the development of a transit service which can provide sufficient frequency without depending on high demand from a single facility. This naturally requires some, if not all buses, to serve more than one facility.

The fundamental transit service design in such domains requires adequate supply to each facility as well as tolerable bus travel times realizing that each additional facility served by a single bus trip requires access time from the corridor, dwell time at the stop and re-entry time to the arterial or highway facility. Some transit agencies have a policy of not scheduling individual bus trips to serve more than two or three facilities. The out-of-direction travel time has strong implications for the siting of such facilities, particularly those expected to be served by enroute buses from upstream locations. These are matters not only of location relative to the arterial facility but also access time recognizing that P&R services are most effective during peak hours when interchanges surrounding arterial highways are congested.

Service by existing local or express routes

A very common P&R service is developing P&R facilities near the existing transit route network. The bus transit service in such a situation is a hybrid of fixed stops accessed by commuters walking to stops and as well as one or more P&R facilities adjacent to the route. These services tend to be in higher density neighborhoods where walking access to the bus is a feasible option for some commuters.

In the case of a new facility being developed, the service design considerations include assuring that there is sufficient capacity to accommodate additional riders and decisions about the extent to which bus routes are altered to service the facility. In most instances of this service domain, the buses do not enter the P&R facility but rather board customers curbside on the arterial street. [2]

[2] In such cases, design for safe street crossing is essential.

The selected operational design will determine the final service to be provided. This needs to be complemented by a service demand that produces appropriate travel times to reduce costs. Consistent with our viewpoint that appropriate transit service is an integral feature of P&R services. The cost of providing transit service is highly dependent on the number of peak hour buses assigned to the system. This, in turn, depends on transit running time between terminals, running time variability across trips and across days and operator practices such as terminal recover time.

Simple spreadsheet models can be developed to estimate resource requirements (peak vehicles and service hours) for different service configurations taking into account facility size, customer arrival patterns, vehicle capacity, loading standards and desired service frequencies. For illustration a prototype is presented below (see Table 3).

Table 3: Transit service design template

Facility Name			
Service Design Inputs			
	Mean peak direction running time	35	minutes
	Mean minor direction running time	20	minutes
	Dwell time at P&R	5	minutes
	Additional time for driver break	8	minutes
	Additional time for schedule recovery	10	minutes
	(dependent on travel time variability)		
	Minimum service headway peak	15	minutes
	Minimum service headway - off peak	30	minutes
	Expected riders in peak 30 minute period	180	persons
	Vehicle capacity	40	persons
Service Design Computations			
	Total vehicles required - peak	9	vehicles
	Total vehicles required - Off-peak	3	vehicles
	Daily hours of service	90	hours

Given the importance of travel time and waiting time for the selection of the P&R as a mode of transportation, the service type needs to be selected carefully. Moreover, the selected service and operational design needs to be in accord with local transportation objectives in order to perform effectively. The following section provides a brief outline of appropriate measures to integrate the service design to the transportation objectives.

2.5. Feasible combinations of transit service and facilities

Not all combinations of facility and service types are feasible. As discussed in previous section, Peripheral P&R facilities require considerable size in order to support the high transit service quality needed for their success. Similarly, Neighborhood P&R facilities in dense areas are not usually very sizable owing to difficulties and cost of assembling large land parcels for parking. Table 4 illustrates feasible combinations. In the table a distinction is made among services to remote P&R sites. It is only under certain circumstances such as a large central business district with high parking prices can support a dedicated single stop transit service to a remote lot.

Table 4: Service Combinations for Park-and-Ride Facilities

	Service Type		
Facility Type	Dedicated Single Stop	Dedicated Multiple Stop	Existing Route
Peripheral	X		
Remote		X	X
Neighborhood			X

Notes: X– Feasible under commonly occurring circumstances

Four prototype designs for P&R services are proposed. These are:

Design Type 1 **-** Peripheral P&R facilities with high frequency service

Design Type 2 **-** Dedicated multiple stop P&R

Design Type 3 **-** Remote P&R facilities near existing services

Design Type 4 **-** Neighborhood P&R facilities near existing services

There is a subtle distinction between the third and fourth prototype. For the purpose of this discussion, it is envisioned that the remote P&R near existing facilities involves operation in suburban areas where buses are likely to travel off-route to service the facility. On the other hand, neighborhood model is usually a smaller shared-use facility in a urban zone where buses do not travel off-route to serve them.

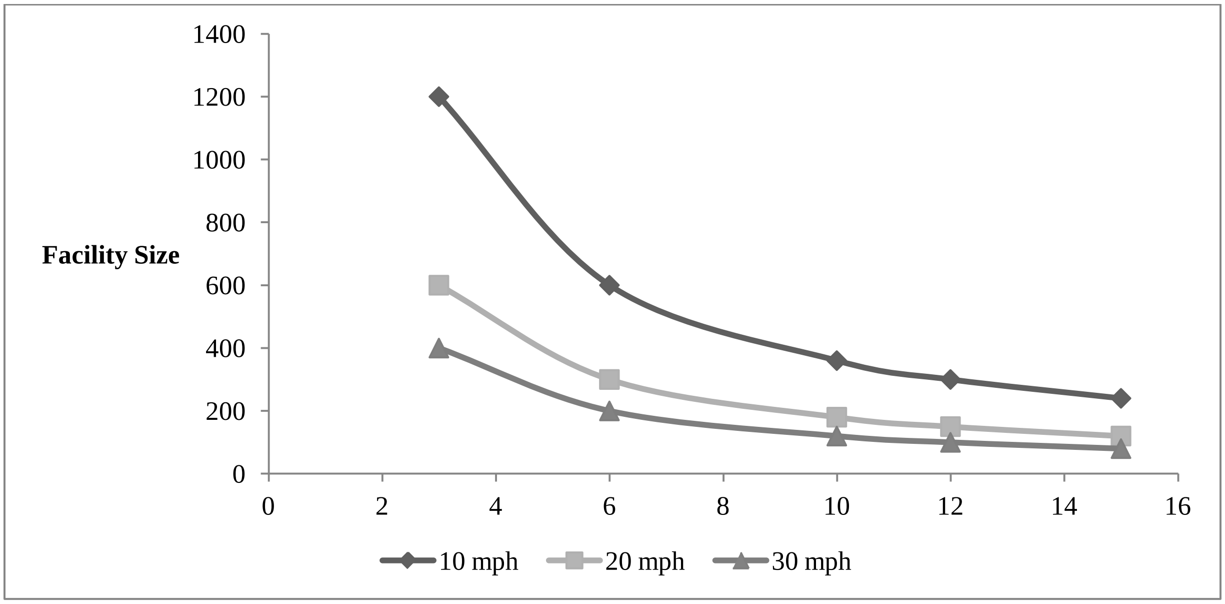
Design Type 1: Peripheral P&R facilities with high frequency service

This service domain includes the development of one or more parking facilities on the periphery of the central business district about 2-5 miles from it. Customers complete the bulk of their journey by car and take a short transit trip to access the downtown. There is a minimum feasible size for these facilities dictated by the productivity of the counterpart transit operation. As discussed previously, arrival at the facility from a remote residence is subject to variability in travel time owing to congestions, events such as collisions, breakdowns and weather. Accordingly, it is difficult for a P&R commuter in these circumstances to pre-schedule his or her departure time to meet a specific scheduled bus trip. If the service has a long headway (interval between successive bus arrivals) pre-timing to a specific trip will require departure time from the residential origin sufficient to assure that the customer will catch the desired bus with a tolerable probability. A higher probability of meeting the desired bus trip will require an earlier departure.

A transit service which is more attractive in such situations is one that arrives with sufficient frequency that a customer could arrive randomly without an intolerable waiting time. The minimum headway for such a service is about 10-12 minutes, assuming that the operation is such that evenly spaced headways are maintained. The average wait time for evenly spaced short headway buses is h/2 where h is the headway. If the headway has some random variation, the average wait time is $E(h)/2 * (1 + C(h))$ where E(h) is the average headway and C(h) is the coefficient of variation (standard deviation/mean) of the headway (Osuna and Newell, 1972).

The graph below illustrates the minimum number of customer arrivals during a two-hour peak period to assure a 150 passenger miles per bus hour productivity[3]. The graph x axis is the service frequency and there are three curves representing various average speed levels. The graph suggests that the minimum facility size necessary to achieve 10 minute service frequency at 10 miles per hour is about 300.

Figure 1: Passenger volume to achieve 150 passenger miles per service hour at various speeds



While this discussion is intended to provide some insights into facility size, more importantly it gives some guidance on the demand level necessary to sustain a certain level of transit service. Transit service design for such a facility is conceptually quite easy. For peak hour operation, there should be sufficient service to accommodate loads subject to a minimum policy headway. The load standard should be articulated as a standee policy. On expressway operations, some transit agencies require all customers be seated. This policy should be dictated by both safety concerns and market factors. A policy of **all** customers seated will require considerably more resources than one in which 95% of customers are seated. At extremely large facilities, i.e. over 1000 spaces, peak hour demand might be so high that a policy of buses leaving the P&R facility when load standards is met subject to a maximum headway might be introduced. This dynamic scheduling requires considerable on-site supervision.

A difficult matter for P&R facilities is off peak operation. Enabling access to and from the facility solely during peak hours greatly limits the market for P&R services. While the vast majority of customers are likely to arrive in the morning peak hour and depart the complementary afternoon peak hour, there will be occasional requirements for midday or evening service either due to work schedules or unexpected work departures by employees. A minimum level of off peak service somewhere between thirty and 60 minute headway is suggested. As to evening service, a similar low frequency service is also recommended. However, the concept of using taxis in some sort of guaranteed ride home program might be considered.

In Arlington, Virginia, the Guaranteed Ride Home (GRH) provides commuters who regularly (twice a week) carpool, vanpool, bike, walk or take transit to work with a free and reliable ride home when unexpected emergencies arise. Commuters may take advantage of GRH up to four times per year to

[3] This is the average productivity of buses in the New York metropolitan area.

obtain home for unexpected emergencies such as a personal illness or a sick child. GRH can also be used for unscheduled overtime when an employer mandates that you must stay late. The program requires pre-registration. Other communities have a similar program in which commuters with a periodic pass such as a monthly pass can obtain a free ride home.

Design Type 2: Dedicated multiple stop P&R

The second of the prototype designs is one of dedicated transit services to a set of facilities in a single corridor. The fundamental design guidance for P&R facilities discussed in the previous section applies to this case. However, it is possible that some facilities might not be the terminal facility for some or all bus trips. That is, in an expressway operation, some buses might divert from the line haul facility and deviate to an enroute P&R facility. These deviations can deteriorate commercial speed and market attractiveness and must be planned with care. This is particularly true of interchanges which are congested with auto traffic. Unfortunately, land near highway intersections has considerable site value and acquisition of land near them can be costly. A simple benefit-cost assessment of alternate sites should be undertaken to determine the value of sites closer to interchanges. As a start on this, one can assume that transit operating costs are in the range of $2.00 per minute and the value of travel time of customers is about 60% of average wage rate. Estimating the net present value of transit costs avoided and increased value to customers can lead to better land acquisition decisions.

Transit operations in such corridors are complicated by the competing objectives of economy of operation and provision of quality customer service. In a corridor, it is not likely that a single facility will be able to support a reasonable service frequency. Accordingly, a group of facilities in a single corridor is the usual case for transit service design. Fortunately, in contrast with Peripheral P&R sites, the travel time and distance from the residential origin to the P&R facility is short. Customers are therefore more likely to be able to time their home departures to a specific scheduled trip rather than arrive randomly. Thus, headways in the order of 15 to 30 minutes are appropriate for such sites. During off-peak hours, low frequency service with a single bus trip serving all facilities is appropriate. A reasonable allocation of specific trips to facilities would involve the following fundamental principles:

- The amount of deviation to accommodate downstream P&R customers should be less than prescribed percentage of the trip origin to trip destination.
- There should be some balance of loads among trips.
- The service design should adhere to the prescribed load standard.
- At each facility, there should be as close to a uniform headway as possible.
- The transit design should include higher frequencies to facilities with higher demand.

Design Type 3: Remote P&R facilities near existing services

A very common scheme for P&R services is the location of P&R facilities near existing transit routes. The advantages of such a service are that P&R services can be provided in areas of low demand and a single transit route can serve a number of relatively small lots. There is relatively little market risk in developing facilities near existing routes since even at low utilization, there would not be a significantly larger bus operating cost. On the other hand, P&R customers can be delayed at a number of downstream stops some of which are to service other P&R lots. It is common practice for such neighborhood lots to be shared use facilities in which commuters are permitted to park at facilities where peak traffic demands are not during normal work hours. Excellent candidates for such facilities are churches, movie theaters and cultural institutions. These design prototypes constitute the guidelines for the operational design of P&R facilities. Modification of each can be slightly done to adjust for local environs, however, the major bulk of P&R facilities will under the described classifications.

2.6. Matching park and ride service to transportation objectives

The appropriate design for a P&R system depends on policy objectives as well as supply and demand characteristics. Since the combination of facilities and services is not likely to be a commercially successful venture, the motivations for public support of these enterprises should be clearly articulated at the outset of facility development. There are a number of objectives which might be served by a P&R facility or system. These are:

- Reduce vehicle miles of travel of commuters
- Reduce arterial congestion
- Reduce downtown congestion
- Reduce land requirements for downtown parking
- Improve access to the passenger transportation network in low density areas
- Reduce transit operating costs
- Improve transit service quality

A determination of whether or not these are valid public policies warranting government investment is beyond the scope of this report. However, different P&R treatments are better suited to achieving each of these. In general, if the objective is related to downtown traffic, peripheral facilities are usually more cost effective owing to the high operating cost of transit services from longer distances. Conversely, if the objective is to reduce arterial congestion, remote facilities are better suited to this. The following table shows the preferred alternative for different objectives (see Table 5).

Table 5: Preferred park and ride alternative for transportation objectives

	Peripheral	Remote
Reduce vehicle miles of travel		x
Reduce arterial congestion		x
Reduce downtown congestion	x	x
Reduce land requirements for downtown parking	x	x
Improve access to the passenger transp network by persons in low density areas		x
Reduce transportation costs (prices) to suburban commuters	x	x

P&R development objectives are typically associated with achieving transportation system objectives such as reducing travel costs or network congestion. However, a well designed P&R network on a corridor can also be a strategy to improve transit productivity. Rather than operating a network of regular route (walk access) services to low density areas with limited frequency service, a transit operator may introduce a single P&R facility at a point closer to the central business district. The transit operator could serve this facility with higher frequency service and require commuters to drive or be driven to the parking. Similarly, given consumer preference for higher service frequency which can only be rationally achieved with high demand, it would be a wiser strategy in a corridor to place fewer, larger P&R facilities along line-haul facilities such as expressways with frequent service than locate a larger number of smaller facilities away from the line haul facility with more limited transit services.

In summary, the selection of alternative service design will meet the physical design to the local transportation objectives. Given the interrelationship that exists between operational and service design of P&R facilities, the service type selected will guide geometric layout.

2.7. ITS application to park and ride facilities

There are a number of intelligent transportation systems (ITS) applications which can improve the quality or efficiency of P&R services. As a general principle, ITS technologies which are well-suited to a P&R service are also well suited to regular route transit service in which passengers access the transit mode on foot. A notable exception to this general principle is parking lot safety and security. The introduction of automobiles introduces considerations for the safety of customers and security of the vehicles they drive to the site.

The core suite of transit operating ITS technologies includes automatic vehicle location, automatic passenger counting, traffic signal priority and advanced fare collection. The introduction of core ITS technology on buses in the New York City areas lags behind that of the rest of the country. One of the primary reasons for this is the so-called “canyon effect” which limits the range of mobile radio transmission on streets with tall buildings.

The benefits of automatic vehicle location in the P&R environment are chiefly to provide real time customer information concerning the expected arrival time of the next bus to service the facility. This would be particularly important where the journey time from the customer’s home to the P&R facility is long and subject to random variation in arrival time between days. This is common technology used in both P&R and pedestrian accessed transit services.

Two ITS technologies specific to P&R services are safety and security and advising customers of space availability at specific sites. In many metropolitan areas, certain P&R sites are oversubscribed early in the morning. Arriving customers at sites filled to capacity would be well served by variable message signing advising of space availability at other lots in the network.

In the area of safety and security, surveillance technology can be an effective substitute for staffed on-site security. A single monitoring station can observe activity at a number of facilities at once. In 1999, Metro Transit (Minneapolis) conducted a trial of the use of a range of technologies to improve the security of a specific suburban P&R site. The technologies included a PTZ (pan tilt zoom) video camera, the installation of "blue light" phones to enable direct communication with a security staff person and on-site motion detection. It was a relatively short duration, low cost trial. The project assessment report stated that there was too much latency between the time that a command was given to change the configuration of the camera to be very effective for security purposes. However, this is likely due to the data communications technology in use in the experiment. The extrapolation of these results to the New York City environment has limitations for two reasons. First, there have been considerable advances in surveillance and communications technology since the time of this project. Secondly, the application was in a remote suburban environment with little pedestrian and motorist activity during non-commuter hours. This review of P&R sites is much different.

In the deployment of ITS in general and specifically in its application to P&R services it is important to differentiate between technical feasibility and value to users. Rather than identify specific ITS P&R applications, transit operators would be better served by undertaking a systems engineering study which defines user requirements, assesses technically feasible alternatives, estimates costs and value over the lifetime of the project and provides for a common device and data architecture.

3. CONSTRUCTION COSTS OF PARK AND RIDE FACILITIES

The design process is interrelated with the financial constraints imposed by the project, given that the type of facility designed will directly affect the implementation cost. Assessing the potential locations for new P&R facilities requires evaluating the costs and benefits, which are key considerations in transportation planning. The overall cost is primarily influenced by construction and maintenance of the facility, as well as its attributes—the type, size, and location each factor into the final estimate. The benefits are obtained through the computation of savings in travel time and reductions in environmental pollution due to the change in transportation mode, from individual vehicles to public transit.

There are two types of self-parking developments—surface lots and garages—the latter of which could include above ground and underground structures. The size refers to both the number of stalls and the square feet occupied, as some potential locations may already have or may require a building. The locations are associated with land values from property reports, and in some cases, the values vary significantly between lots in the same borough.

In order to take these factors into consideration, the parking costs were measured by both the cost per stall per facility type and by the land value per square foot. The cost per space per facility type was obtained through an extensive literature review, and each source reported on a specific city or year. These values were then adjusted to obtain current values by applying construction cost indexes reported from 1919 to 2009.

In the case of surface lots, drivers are provided surface access at designated openings and progress through the facility on a single level. These parking lots must provide convenient access, road surface, appropriate markings and signals, and basic security to the users.

In the case of parking structures—whether underground or above, or a combination—drivers are supplied with an access. After entry, vacant spaces are sought first on the ground level and then gradually upward or downward from there. The multiple levels are connected and accessed by a series of ramps, which requires the provision of stairs, escalators, or elevators for the users. Beyond the structure itself and appliances, the overall necessary provisions are similar to surface lots.

Parking construction cost has two major components: the first is land value and the second is general construction costs. Land value is determined by multiplying each location's total area per unitary land value cost—this cost may vary significantly from one place to another, and it depends on different land characteristics such as location, accessibility, upgrades and improvements.

Construction costs vary from surface parking lots to parking garages. It is expected that surface parking lots have lesser costs than parking garages, as the former only requires conditioning the surface for user's circulation and parking. The latter incurs additional costs associated with the building, appliances, and excavation (for underground garages).

This document focuses on the second component of cost which is the general construction prices. Construction costs from different sources were compiled through literature review in Section 3.1, then data were standardized following methodology shown in Section 3.2. Results are presented in Section 3.3.

3.1. Review of parking costs

According to information review made by Victoria Transport Policy Institute (Victoria, 2008) in different cities of the United States and Canada, typical construction costs increase for facilities built on poor soil or significant grades, irregular shapes, landscaping, or facilities such as washrooms and elevators. In addition to these "hard" costs, facility development usually involves "soft" costs for project planning, design, permits and financing—these typically increase project costs by 30-40 percent for a stand-alone project.

Table 6 shows typical parking construction costs from year 2000 considered by VTPI (Victoria, 2008). Brook McIlroy Planning & Urban Design (McIlroy, 2003) prepared the Core Area Master Plan for the University of Saskatchewan (Saskatoon, Saskatchewan, Canada) to support the strategic directions of the university; this established the physical framework for growth of new areas and enhancement of existing areas. The Plan reported that surface parking can cost anywhere from $1,500 – $2,000 per space (with the upper limit including hard surfacing, electrical plug-ins, high level of lighting, and perimeter fencing). A single level parking deck can be in the order of $9,000 – $11,000 per space, above ground parking structures vary from $12,000 - $14,000 per space, and underground parking is in the range of $18,000 – $20,000. Again, these upper and lower bands can vary depending on efficiency, materials, ventilation design, and water problems, among others.

Table 6: Typical parking construction costs (Victoria, 2008).

	Small Site ($30,000\ ft^2$)	Medium Site ($60,000\ ft^2$)	Large Site ($90,000\ ft^2$)
Area Per Space (ft^2)	350	325	315
Surface Parking	$1,838	$1,706	$1,654
Ground + 1 level	$7,258	$6,143	$5,705
Ground + 2 level	$8,085	$6,767	$6,284
Ground + 3 level	$8,407	$6,996	$6,491
Ground + 4 level	$8,747	$7,269	$6,747
Ground + 5level	$8,973	$7,451	$6,918
Ground + 6 level	$9,135	$7,581	$7,040
Ground + 7 level	$9,256	$7,678	$7,132
Ground + 8 level	$9,351	$7,754	$7,203

Shoup had available data for 12 parking structures built on the University of California Los Angeles (UCLA) campus between 1961 and 1991 (Shoup, 1997). The construction contracts for all structures were competitively bid, so the cost records were accurate and detailed, including both the "soft" and "hard" costs of planning and design. He estimated the cost of parking spaces added by these twelve parking structures, as seen in Table 7.

To estimate the increase in the cost of construction since each parking structure was built, the 20-city average of the Engineering News-Record (ENR) Construction Cost Index for June 20, 1994, was divided by the average ENR Construction Cost Index for the year in which the parking structure was built. This ratio was then multiplied by the original construction cost to yield the construction cost expressed in dollars of 1994 purchasing power. Equation (1) explains this approach.

$$P_j = \frac{CCI_j}{CCI_i} P_i \qquad (1)$$

In this case, Pj is the construction cost brought to year j, CCIi and CCIj are the Construction Cost Indexes for years i and j, and Pi is reported parking cost from specific year i.

Table 7: The cost of parking spaces added by 12 parking structures built at the University of California, Los Angeles, 1961-1991 (Shoup, 1997)

Year Built	Spaces in Structure	Structure Cost		Cost per Space Added	
		Original $	1994 $	Original $	1994 $
1961	765	$1,091,122	$6,966,550	$2,000	$12,770
1963	1,426	$1,745,468	$10,477	$1,626	$9,760
1964	1,168	$1,859,081	$10,740,676	$1,946	$11,246
1966	1,800	$3,489,706	$18,620,085	$2,323	$12,327
1967	2,839	$6,060,753	$30,517,584	$2,789	$14,045
1969	2,253	$5,610,206	$23,908,098	$2,907	$12,389
1977	921	$7,083,893	$14,871,473	$11,762	$24,693
1980	750	$6,326,135	$10,568,750	$11,499	$19,210
1983	448	$8,849,000	$11,769,409	$19,752	$26,271
1990	2,851	$52,243,000	$59,705,071	$20,859	$23,839
1990	144	$2,040,000	$2,331,381	$22,350	$25,542
1991	716	$14.945.000	$16,715,805	$20,879	$23,346

Shoup (1999) includes further analyses which take into account construction costs per space cited on his previous work (Shoup, 1997), as well as new values for parking spaces added in 1998 and 1995. The costs on 1998 US dollars are $14,725 per stall for an aboveground facility and $26,300 per stall for an underground facility.

Table 8: Cost Estimate per Parking Stall (1997 Dollars) (Cambridge Systematics, 1997)

	Surface Lot		Above ground Multi-level structure		Below Ground	
	Low	High	Low	High	Low	High
Land	600	12,000	500	1,000	0	0
Construction	1,500	4,000	8,800	20,000	16,000	40,000
Design, Engineering & Contingency	200	800	1,800	5,000	3,200	10,000
Project Costs	**2,300**	**16,800**	**12,100**	**26,000**	**19,200**	**50,000**
Present value of Annual Interests Payments	2,100	14,700	9,700	22,700	16,800	43,700
Present value of Annual Operating Costs	700	2,800	2,800	5,600	2,800	5,600
Total Project Costs	5,100	34,300	24,600	53,300	38,800	99,300

Transit Cooperative Research Program (TCRP) Report 35 (Cambridge Systematics, 1997) provides a set of aggregate cost categories for each of the three types of parking: surface, multilevel stand-alone structure, and underground (with building space above). The costs shown in Table 8 are generic and based on a set of assumptions constant across all three types of parking. The high and low values represent national averages.

Interest expense is the present value for a 24-year loan at 4.2[4] percent discount rate; operating cost is the present value (discounted at 9.0 percent) over 24 years for monthly costs of $0.25 to $1.00 per stall for surface lots, and between $1.00 and $2.00 per square foot for multilevel and underground parking. These values include utilities, attendant, insurance, overhead, and janitorial service, among others.

National Bicycle and Walking Study (FHWA, 2004) says that although automobiles and bicycles are both potentially important modes for transit access in low density areas, the costs of park-and-ride are far higher than bike-and-ride. According to FHWA, typical construction and engineering costs for a park-and-ride facility are $3,500 – $5,000 per space for surface lots and $12,000 – $18,000 for structured parking—these costs are significantly higher than $50 – $500 per space for secure bicycle storage.

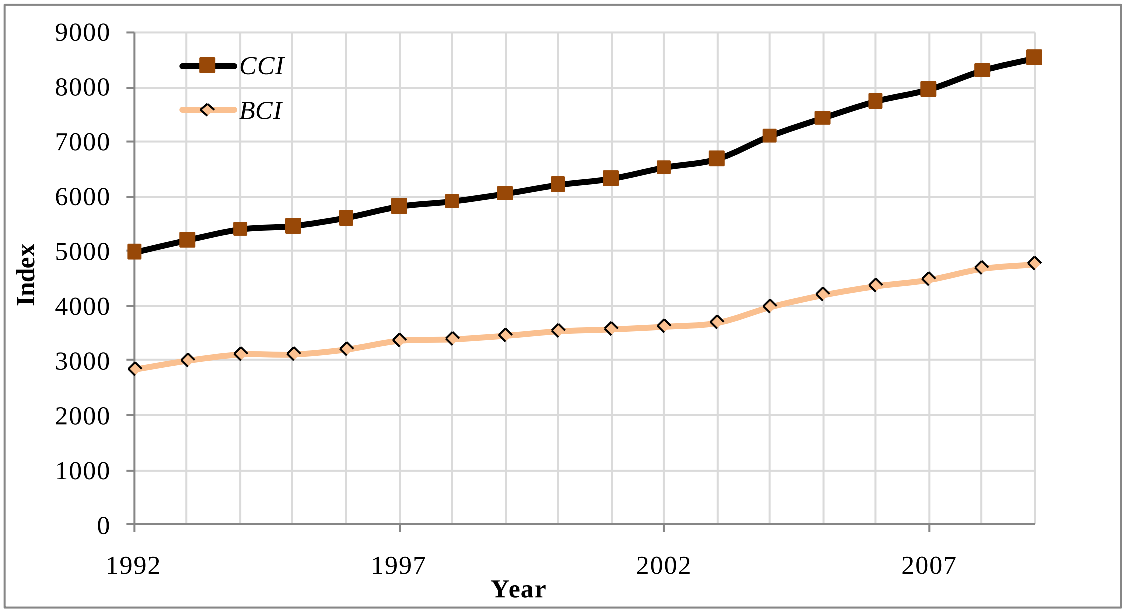
3.2. Methodology of cost estimation

Once the data is compiled for construction costs, it is necessary to define which costs will be used on the P&R project. Since each source reported data from different years, these values must be expressed in dollars of the same year in order to compare them. To do this, the 20-city average of the ENR Construction Cost Index (Grogan, 2009) is used in the same manner as Shoup (1997; 1999).

ENR presents historical data about the annual variation of construction costs in the U.S. This variation is measured by two indexes (See Figure 2): Construction Cost Index (CCI) and Building Cost Index (BCI). The CCI uses 200 hours of common labor, multiplied by the 20-city average rate for wages and fringe benefits. The BCI uses 68.38 hours of skilled labor, multiplied by the 20-city wage-fringe average for three trades-bricklayers, carpenters and structural ironworkers. Construction costs for each source were brought to present values using equation (1).

[4] Source: http://www.whitehouse.gov/omb/circulars_a094/a94_appx-c - Discount rates for cost-effectiveness, lease purchase, and related analyses – Revised December 2010

Figure 2: Construction Cost Index (CCI) and Building Cost Index (BCI) Based on 1913



Since this index does not measure cost differentials between cities, we increased the average values by a factor of 1.18 recommended for New York City in order to more closely approximate the probable costs for this specific location throughout the U.S. The adjustment factor is used to help account for regional variations of construction costs (Building News, 2008).

3.3. Results of the estimation of costs

Table 9 and 10 show the results of applying equation (1) over both construction and operation costs using CCI.

Table 9: 2009 Average construction costs per stall for each facility type and report year

YEAR	CCI	CONSTRUCTION COSTS					
		SURFACE		ABOVE		UNDER	
		P_{YEAR}	P_{2009}	P_{YEAR}	P_{2009}	P_{YEAR}	P_{2009}
1992	4,985	$ 4,250	$ 7,280	$ 15,000	$ 25,693	-	-
1994	5,408	-	-	$ 17,953	$ 28,346	-	-
1997	5,826	$ 3,250	$ 4,763	$ 17,800	$ 26,088	$ 34,600	$ 50,710
1998	5,920	-	-	$ 14,219	$ 20,508	$ 27,880	$ 40,213
2000	6,221	$ 1,733	$ 2,378	$ 7,067	$ 9,699	-	-
2003	6,695	$ 1,750	$ 2,232	$ 11,500	$ 14,667	$ 19,000	$ 24,232
2009	4,771	**Average =**	**$ 4,163**	**Average =**	**$ 20,834**	**Average =**	**$ 38,385**

Table 10: 2009 Average operation costs per stall for each facility type and report year

YEAR	CCI	OPERATION COSTS					
		SURFACE		OP ABOVE		OP UNDERGROUND	
		P_{YEAR}	P_{2009}	P_{YEAR}	P_{2009}	P_{YEAR}	P_{2009}
1997	5,826	$ 1,750	$ 2,565	$ 4,200	$ 6,156	$ 4,200	$ 6,156
2009	4,771	**Average =**	**$2,565**	**Average =**	**$ 6,156**	**Average =**	**$ 6,156**

Construction costs used on modeling will be the sum of both construction and operational costs for each type of facility multiplied by a 1.18 factor (Building News, 2008).

Facility Type					
Surface	($4,163 + $2,565)*1.18	=	$7,939.04	≈	$7,900
Above	($20,834 + $6,156)*1.18	=	$31,848.2	≈	$31,900
Underground	($38,385 + $6,156)*1.18	=	$52,558.38	≈	$52,600

P&R has been used quite successfully in a number of communities both in the US and around the world. Among the best examples in the US is Denver, which is in the midst of developing an extensive express bus and rail system connecting downtown locations to the suburbs. While there are other clusters of commercial activity in Denver outside the downtown, these have neither the scale, nor employment density, nor transit-friendly site design to support a variety of line haul transit options from a wide array of residential origins.

In the New York City area, although Manhattan is the largest employment location, it does not account for the majority of regional employment. A large number of other locations also have large employment volumes and densities to support good transit access. The extremely large transit volume by both rail and bus creates a network effect in which successful P&R service does not require direct (without transfer) service from residential origins to commercial destinations. Siting P&R facilities on a node in the dense part of the network enables commuters to access a wide variety of work locations. This is because service frequencies of intersecting routes tend to be high, reducing transfer time and customer inconvenience between routes.

New York City is unique in other respects. The high job concentration makes land close to the city center more valuable and more highly developed. This results in a limited availability and high cost of vacant land for developing facilities for P&R.

Table 11: New York City Demographic Characteristics

New York City Demographics				
Jurisdiction		**Population**	**Land Area**	**Density**
Borough	**County**	**2007**	**Square Miles**	**Pop/SqMi**
Manhattan	New York	1,620,867	23	70,472
Bronx	Bronx	1,373,659	42	32,706
Brooklyn	Kings	2,528,050	71	35,606
Queens	Queens	2,270,338	109	20,829
Staten Island	Richmond	481,613	58	8,304

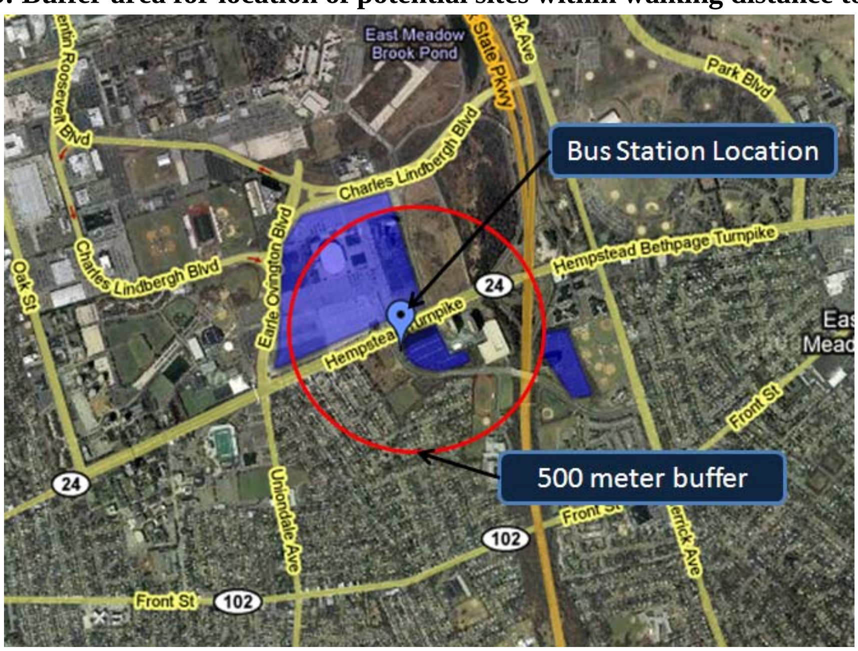
Source: United States Census Bureau

The complex travel and development characteristics of New York City provide a very good test site for developing a systematic network-based approach to the P&R facility location problem. This can serve as a guide for such facilities in other urban areas, which are likely to have less challenging environments.

4. IDENTIFYING POTENTIAL CANDIDATES FOR PARK AND RIDE FACILITIES

This section describes the method for determining the set of feasible candidate P&R sites for further evaluation. A two stage selection process was used for this. The first step was an identification of the universe of potential locations. This was followed by a more detailed assessment of the candidate sites against more complex siting criteria. To initiate the selection, a large number of sites meeting some basic criteria were considered. The project team identified all bus and rail stops in the region and detected land parcels of at least one acre within 500 meters (Burns, 1979) of the transit network. The parcels also included existing municipal parking lots in New York City owned by the Department of Transportation (New York City Department of Transportation, 2009). A total of 125 sites were identified. The selected sites were divided into two groups: rail based facilities (59 of the 125 sites), and bus based facilities (37 of the 107 sites) were served by express/local bus service. The remaining 28 sites are facilities already owned by NYCDOT. These facilities serve as municipal parking lots. The appendix to this chapter presents the descriptive attributes for each. This preliminary candidate set is within the four surrounding boroughs outside of Manhattan. The characteristics of each facility are presented along with a scaled picture to compare sites. Moreover, an enlarge picture is presented to illustrate the preliminary design of each potential P&R site. These designs serve as input for the cost estimation process done later in this project. Each facility was numbered and coded with the initial letter of the county: Bronx (B), Queens (Q), Brooklyn (K), and Staten Island (R). Some facilities outside the four boroughs were individually coded as other (O for outside NYC boroughs). The site numbering is done sequentially within boroughs (e.g. Q1, B1, Q2, B2).

Figure 3: Buffer area for location of potential sites within walking distance to transit



4.1. Selection criteria for location of park and ride facilities

The optimal set of P&R facilities from this universe depends on multiple factors. This task focuses on identifying these factors, including high potential utilization, good community integration and minimizing the negative effects associated with the site location. The final set of recommendations will be made by reviewing the tradeoffs of competing criteria that maximize the benefit of the P&R system. In later tasks, the selected methodology of task three is applied to obtain the optimal locations from this set of sites.

A thorough review of existing literature of previous practices has enabled the team to present a set of criteria for selecting P&R facilities from the universe of identified locations. Beyond a review of previous knowledge, the work is a compilation of requirements that serve as guidelines for locating the facilities. The siting considerations were grouped into four broad areas:

- Demand Considerations
- Transit Connectivity and Design
- Community Integration
- Economic Viability

Each category presented is classified according to the impact that the factor might have on the selection process. Finally, the set of potential facilities is identified in an appendix to this section.

4.2. Demand considerations

The first category of selection criteria is related to demand for a facility. Since precise travel demand models are not available, plausible characteristics of sites which are likely to spawn P&R demand are identified. The list below will serve as the starting point for any selection of future P&R facilities:

Position relative to the primary activity center: P&R lots should be placed no closer than 3 miles and preferably 10 miles from the primary activity center (Fradd and Duff, 1989). This provision reduces the potential for P&R facilities to add to the traffic congestion problem and thus creates a manageable transit ride for commuters. This assertion might be true for a wide range of community sizes. However, New York City, with its high downtown employment density, high corridor residential densities, high downtown parking charges and high congestion, this "rule of thumb" may not apply. It is likely that P&R facilities may be sustainable at longer distances from downtown Manhattan. There is ample empirical evidence that this is true. As an extreme case, there is a heavily used P&R facility in Kingston, NY which is about 100 miles from midtown Manhattan.

Maximize the service area population: The P&R facilities should be placed as close as possible to the potential users. It has been shown that 50% of the demand for P&R comes from population densities that are within a 5 mile radius (Fradd and Duff, 1989). In addition, an extra 35% of the users are located within a parabola that extends 10 miles upstream from the lot with a long chord measuring 10-12 miles. Another study by Burns (1979) found that 90% of the P&R users drive less than 10 miles to the facility.

Socioeconomic factor consideration: Several studies have identified socioeconomic characteristics (e.g. income, level of education, race, employment) as determinants of the demand for P&R facilities. Therefore, before selecting a final location for the facility a specific analysis of these characteristics in the residential catchment area should be performed and evaluated (Hamid et al., 2004).

Location relative to transit service: It is recommended to limit the walking distances to less than one fourth of a mile (Burns, 1979) since users are not willing to walk a great distance to access transit.

Site access convenience: An effective P&R facility should be easily accessible to drivers traveling to the urban area. The site should allow for an entrance on the right side of inbound Central Business District (CBD) traffic.

Location upstream of congestion: This allows the P&R service to reduce traffic congestion in the most sensitive areas, i.e., those that directly feed into the worst rush hour bottlenecks. General guidelines suggest that a corridor with a level of service E or worse has a potential of P&R usage (Spillar, 1997).

Parking demand in adjacent streets: There may be spillover parking from the P&R facility to neighborhood streets if demand exceeds facility capacity or there is a parking charge and commuters prefer free on-street parking.

Auto to transit cost ratio: P&R systems should be designed so that prices are less than the cost of driving to work and parking in the city so as to attract commuters (Faghri et al., 2002).

Proximity to freeways or arterials: The P&R facilities should be within a visible distance of major regional or high speed arterials that provide radial access to the activity center being served. This will allow the facility to be self-advertised and will be more likely that user demand increase in a fast manner (Spillar, 1997). However, in case that there is a limited availability of land for P&R facilities, such as NYC, then additional signage and advertisement should be included in the P&R development.

4.3. Transit connectivity and design

The demand and location of P&R facilities will be also highly influenced by the transit service provided and facility design should take this into account. The following is a set of recommended criteria that assures a suitable level of service and promotes the demand of each facility. A full set of facility and service design recommendations will be presented in Section 5. Some initial transit design concepts are presented here:

Frequency of transit: A P&R facility must offer frequent, quick and reliable service in both the inward (to the central area) and outward directions. This will attract and maintain customers with headways not exceeding 15 minutes, or 5 -10 minutes during the peak hour periods where necessary (O'Flaherty, 1997). This can be accomplished by using express services, Bus Rapid Transit (BRT) and rail rapid transit.

Fast service to the CBD: To compensate for the inconvenience of leaving the car to take the transit system, the facility should include provisions for transit priority such as HOV lanes, exclusive lanes on arterial streets and traffic signal priority.

Design for multimodal connections: Given the strategic goals of the DOT and other transit agencies towards a ‘greener’ New York, multimodal connections should be included whenever possible. Good pedestrian access and provision for bicycle users are important amenities.

Internal layout: The internal layout of the facility should facilitate quick ingress and egress by transit services (Niblett and Palmer, 1993).

Easy and ample parking: Adequate parking supply will make it easier for users to quickly access and exit the P&R facility. If possible, facilities should be sited to allow for expansion if necessary.

Maximize site visibility: A site should be clearly visible from the closest arterial street. A useful amenity is an LED sign advising of the number of vacant spaces (Niblett and Palmer, 1993).

Comprehensive design and supervision: Walking distances should be as short as possible between the cars and the waiting public transport vehicles. O'Flaherty (1997) identifies a set of minimum requirements that a facility should provide; which include a substantial weatherproof shelter (which should have seats and be cleaned on a daily basis), a telephone booth (for emergencies), and adequate lighting (essential for personal security in dark mornings and evenings).

Landscape areas: Locations near 'green' areas will make the users more comfortable with walking and biking to the facility, such is the case for the greenbelt in the borough of Staten Island. Further, adding attractive landscapes inside the facility may promote demand.

Multiple destination facilities: Facilities which are or can be served by transit services to a number of destinations either directly or through transfers to frequent services are preferred to those which can serve a single downtown destination.

4.4. Community integration

One of the most important aspects that must be considered before implementing any P&R facility is the attitude of the community towards the project. The P&R facility should be consistent with local land use and transportation objectives. The following list describes previous practices that have enhanced the integration of the community and P&R facilities:

Safe and secure environment: Intrusive security measures such as guards and fences should be avoided. Cameras and phones are effective security measures and less visually intrusive. Security may be enhanced through the implementation of additional lighting and roving police patrols.

Coordination with local community plans: The facilities should be located in areas with compatible land uses, and in areas that do not require a zoning change or change in the local land use plan. Further, the implementing agency should be aware of the current goals and concerns of the local community. Implementing agencies should constantly communicate with community leaders through public forums, in order to integrate the community in the development of the project.

Environmentally friendly facilities: New P&R facilities will introduce noise, traffic, and vehicle emissions to the surrounding communities. Therefore, the sites should be selected to minimize these impacts. The potential locations should be free of hazardous wastes, drainage and soil problems, brown fields, and otherwise fragile ecosystems (Spillar, 1997). In order to select a facility that follows local environmental policies and objectives, preliminary studies that consider each of these issues should be conducted before the selection process.

Land value deterioration: The potential facilities should be implemented in such a way that there are minimum adverse affects on land values in the neighborhood.

Pedestrian and bicycle pathways: In order to maximize the usage of the P&R, a sidewalk network for pedestrian and bicycle circulation should be provided within the facility and surrounding areas.

4.5. Economic viability

Finally, cost of implementation will restrict the number of facilities which can be installed. Sites which can be more cost effective or less expensive to develop are preferable.

Location in areas with compatible land uses: The P&R should be compatible with existing land use and must integrate very well with the community. Thus, while planning a P&R facility, engineers must consider parking facilities in areas with similar uses such as suburban business centers or areas with the possibility of joint usage. To minimize cost and delay in construction, a facility must be positioned in accordance with local plans and jurisdiction. Whenever possible, planners should acquire publicly owned land instead of more expensive private property.

Site expansion potential: The P&R facility sites should be flexible enough to adapt to future P&R and transit plans in the community. The ability to expand the capacity of a specific site is very important. Expansion is much less expensive than building new lots.

Joint use of lots: The creation of joint use agreements with church, malls, museums, theaters, and other private business with available parking can reduce the cost of implementing a facility. This practice should be encouraged (Witheford and Kanaan, 1972).

The operating cost of the site: Sites operating costs should be evaluated through a net present value analysis, prior to selecting the final facilities. In some instances, owned and donated lands can result in a low capital investment. However, in the long term, increased transit operating cost due to facility access and new routes could offset the initial cost saving. Therefore, the implementing agency should consider both initial and future costs in site development.

Joint development opportunities: By considering public/private partnerships, P&R implementing agencies can reduce their capital investment and operating costs. Compatible land uses such as facilities which are used more intensively at night or on weekends are natural candidates for joint development.

Size of existing lots: Facility sizing should be based on preliminary estimate of demand and the capability for expansion.

4.6. Site screening and selection

The selection methodology for P&R facilities described above resulted in a selection of potential sites for P&R facility. However, when addressing the design and implementation of a facility, a second site screening and selection process is required. Site location models are well adapted to the problem of which vicinity of a P&R lot would be well suited. However, development of a specific site within the vicinity requires considerable site-specific planning, financial analysis for land selection, environmental assessment, and community integration.

The financial analysis is performed by the sponsor agency. Once the list of potential P&R facilities has been identified using a selection methodology, a financial assessment of each potential site needs to be undertaken before acquiring a specific land. The selection of the final P&R site will be in accordance to the financial constraints of the sponsor agency and the predefined budget. In general, sponsoring agencies (e.g. DOTs) have broad knowledge and experience on this practice. Additionally, the facility site selection process requires an environmental assessment of alternatives before a decision to proceed is made. New York State has well-developed procedures for project planning and there are few environmental impacts of P&R facilities which are not routinely encountered in other highway projects. The well-documented procedures of project scoping, assessing alternatives, consideration of the natural environment, public outreach, development of mitigation measures, and traffic impacts apply to P&R facilities. It is only after completion of the environmental process that a decision to develop a project on a particular site can be made. Environmental issues associated with P&R development include but are not limited to:

- Compatibility with adjacent land uses
- Noise, air quality and traffic
- Site drainage
- Environment preservation

The identification of the environmental impacts will allow a better planning and design of the facility. Concept design considers the definition of the affecting parameters before incurring into the actual design phase. One of these elements is the environmental constraint that needs to be considered. Thus, accounting for these elements will create an environmentally friendly P&R that is more attractive for the surrounding community.

Additionally, another important aspect is the integration of the surrounding community. This is another approach adopted in context sensitive design process, where you integrate the affected community into the design to ensure the attractiveness of the facility. This is of particular interest in P&R facilities, given that the surrounding community will be the future users and will comprise the demand of the P&R site. Thus, integration of the facility through advertisement and community meetings will increase the level of acceptance of the future site. However, this process should be only undertaken in the preliminary phase and latter during the design process, but only as guidelines to understand the community needs. The design process itself should be under the professional designer's judgment that should use the inputs as guidelines and adjust the design to community needs and the requirements previously specified.

After having a better understanding of the inputs and requirements, the design process can now be undertaken. Here, the geometric and operational characteristics of the P&R facility and service are defined. Detailed characteristics are presented in the next sections, describing the design approach and the needs to achieve a sustainable facility.

5. EVALUATION OF PARK AND RIDE CANDIDATES

This section discusses the evaluation methodology applied to a set of P&R candidates in New York City. This assessment is guided by the concept of generalized cost. Generalized cost is the sum of the pecuniary (cash) cost and the monetized value of other costs such as travel time. The most obvious cash costs are fare, tolls, and parking. Examples of monetized costs are travel, walking, and transfer waiting time. Although they are not considered in this report, less tangible factors such as comfort, reliability, and externalities can also be evaluated. The value of time assumed in this report is 25 USD/hr. This is the value used in transportation planning exercises in the New York City area. While it would be logical to assume that travelers would use the least costly (lowest generalized cost) means of travel, other non cost characteristics such as habits, reliability, information, and availability influence the mode choice decision. Thus, for each site, the expected utilization is determined through the use of a transportation Logit model in which a probability of using a P&R/transit combination is determined given the attributes of competing travel alternatives. For more details on the mathematical formulation underlying, please see Appendix A.

5.1. Data source and description

Data described in previous section has been obtained from the NYMTC Best Practice Model (BPM), which is the regional planning model. This model details travel patterns according to demographic profiles and transportations systems in the region. The NYMTC BPM area covers 28 counties in New York, New Jersey, and Connecticut. This model includes 3,500 transportation analysis zones (TAZ), each of them individualized with a centroid, and a network of road facilities and transit services. The goal of BPM is "paving the way for critical improvements in research-based transportation planning in the NYMTC region" (New York Metropolitan Transportation Council, 2011). BPM provides current and forecast travel demand and time matrices by mode for each of the 3,500 by 3,500 TAZ pairs. This information is available for 2010, with forecasts for 2020 and 2030.

Demand data

The demand information used corresponds to highway AM Peak Period for Single Occupancy Vehicle (SOV). It is appropriate to use SOV since the advantage P&R facilities are highest for such drivers.

Table 12 shows the percentage of work trips from surrounding boroughs around Manhattan in the NYMTC area to Manhattan itself. Table 13 shows the total number of SOV trips. It can be seen that 33.6% are internal trips within Manhattan, and as expected, the proportion of trips to Manhattan decreases with the distance to Manhattan. In addition; the surrounding boroughs and inner suburbs (Queens, Kings, Bronx, Bergen, and Westchester counties) produce 41.2% of the total SOV trips into Manhattan. Therefore, it makes sense to propose P&R candidates in these counties.

Table 12: Distribution of proportion of trips into Manhattan by borough (%)

County	% Trips to Manhattan	County	% Trips to Manhattan	County	% Trips to Manhattan	County	% Trips to Manhattan
Manhattan	33.6%	Essex	2.7%	Monmouth	1.3%	Orange	0.3%
Queens	13.4%	Hudson	2.6%	Morris	1.2%	Ocean	0.3%
Kings	8.2%	Fairfield	2.1%	Passaic	1.1%	Putnam	0.2%
Bronx	8.1%	Union	1.8%	Rockland	0.8%	Sussex	0.2%
Bergen	6.5%	Richmond	1.8%	Somerset	0.5%	Mercer	0.2%
Westchester	4.9%	Middlesex	1.6%	Dutchess	0.5%	Hunterdon	0.1%
Nassau	3.8%	Suffolk	1.5%	New Haven	0.5%	Warren	0.1%

Table 13: Total trips to Manhattan by borough

County	Trips to Manhattan	County	Trips to Manhattan	County	Trips to Manhattan	County	Trips to Manhattan
Manhattan	52,317	Essex	4,168	Monmouth	2,069	Orange	531
Queens	20,922	Hudson	4,051	Morris	1,793	Ocean	521
Kings	12,814	Fairfield	3,227	Passaic	1,666	Putnam	355
Bronx	12,599	Union	2,873	Rockland	1,231	Sussex	307
Bergen	10,156	Richmond	2,777	Somerset	844	Mercer	238
Westchester	7,621	Middlesex	2,489	Dutchess	785	Hunterdon	199
Nassau	5,866	Suffolk	2,390	New Haven	773	Warren	118
						Total	155,700

Note: It is important to note that internal trips, e.g. from Manhattan to Manhattan, are not considered.

Car and transit data

The BPM has AM Peak travel time matrices by mode for all zone pairs in the model area. Table 14 and Table 15 show statistical information regarding each component of generalized cost for both; auto only and P&R mode, from each borough to Manhattan. Internal trips are included in the Manhattan row.

Table 14: Auto attributes by borough

County	Auto travel time (min)		Auto toll (USD)		Auto parking (USD)		Auto length (mi)	
	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev
Manhattan	25.0	14.7	0.0	0.4	0.0	0.0	4.6	2.8
Bronx	48.2	7.9	0.0	0.1	1.8	1.4	9.2	2.2
Bergen	76.8	13.5	5.8	0.4	0.1	0.5	18.5	7.0
Dutchess	151.8	12.0	0.0	0.0	0.0	0.0	78.6	9.4
Essex	97.4	9.3	6.0	0.3	1.4	2.4	21.0	3.7
Fairfield	153.0	27.8	0.0	0.0	0.0	0.0	52.1	11.2
Hudson	69.2	12.0	6.0	0.2	2.3	1.8	11.5	3.6
Hunterdon	197.2	14.3	6.3	0.2	1.8	2.8	64.0	4.9
Kings	62.6	13.6	0.1	0.2	1.2	0.6	11.6	2.9
Mercer	213.8	12.6	7.0	0.7	0.0	0.0	61.3	3.9
Middlesex	167.3	19.2	6.9	0.6	2.4	2.2	41.7	7.2
Monmouth	213.7	15.8	7.1	0.4	0.0	0.1	57.9	7.1
Morris	134.0	22.1	5.9	0.1	3.2	3.0	39.6	7.5
Nassau	118.6	17.1	1.5	0.1	0.0	0.2	26.7	5.2
New Haven	224.6	17.9	0.0	0.0	0.0	0.0	82.4	9.8
Ocean	312.8	46.7	7.1	0.3	0.0	0.0	87.6	14.8
Orange	157.2	15.9	2.0	1.7	0.0	0.0	77.5	19.4
Passaic	98.5	20.0	5.5	0.8	0.7	2.0	28.1	11.5
Putnam	125.7	7.6	0.0	0.0	0.0	0.0	53.7	4.5
Queens	63.8	17.4	1.1	0.7	1.4	0.8	12.0	4.1
Richmond	111.7	10.2	0.7	0.6	1.5	1.1	22.3	2.9
Rockland	94.7	10.5	4.5	1.1	0.0	0.0	34.1	5.9
Somerset	163.7	20.8	6.3	0.2	2.0	2.0	45.5	6.4
Suffolk	145.3	61.4	3.0	2.9	0.6	1.6	45.7	26.0
Sussex	187.5	16.5	5.5	1.1	1.2	2.5	62.1	14.4
Union	123.4	10.3	6.4	0.1	0.7	1.5	27.7	3.4
Warren	193.7	12.4	6.0	0.3	1.6	2.7	69.5	5.7
Westchester	78.6	18.1	0.0	0.1	0.0	0.1	23.9	10.1

As expected, the lowest values of car travel time are shown in the internal trips and this time increases according to distance to Manhattan. It is also important to highlight the high variability of travel times. This variability is mainly explained by the size of the borough and the fact that this data corresponds to AM peak hour. The bigger size of the borough produces a higher variability due to the differences in travel time between trips originated close and far from Manhattan.

Table 15: Transit Attributes by borough (travel to Manhattan)

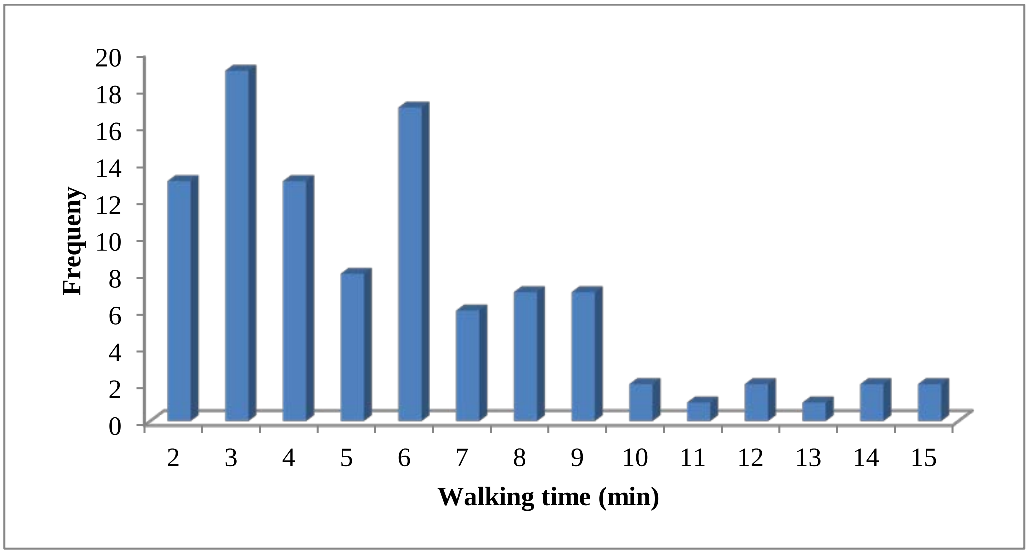
	Transit time (min)		Transit fare (USD)		Transit wait time (min)		Transit transfer wait time (min)	
	Mean	Std dev	Mean	Std dev	Mean	Std dev	Mean	Std dev
Manhattan	16.5	8.8	1.5	0.5	1.7	1.1	1.9	1.6
Bronx	34.5	9.0	1.7	0.2	2.6	1.2	3.2	1.9
Bergen	47.0	12.9	3.8	0.7	7.0	5.4	3.8	1.6
Dutchess	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Essex	51.0	9.2	3.7	0.6	5.0	3.8	8.7	3.8
Fairfield	34.8	53.1	1.2	1.8	4.3	7.1	9.1	15.8
Hudson	35.6	10.3	3.1	0.5	4.5	3.3	4.9	3.5
Hunterdon	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kings	38.9	10.6	1.7	0.1	2.5	1.2	3.0	1.7
Mercer	94.6	68.0	4.3	3.0	7.8	6.2	12.0	15.5
Middlesex	66.9	40.6	4.0	2.3	13.7	13.0	5.9	8.0
Monmouth	74.2	52.7	4.1	2.9	10.9	12.6	5.1	10.9
Morris	51.3	41.9	3.1	2.5	13.8	15.5	4.5	6.0
Nassau	81.0	23.8	3.8	1.2	7.6	6.1	8.1	3.3
New Haven	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ocean	11.9	38.5	0.6	2.0	1.6	5.4	0.5	1.8
Orange	74.7	79.0	3.4	3.7	12.6	16.0	5.3	9.5
Passaic	47.2	30.3	3.1	1.9	8.4	10.9	4.5	3.5
Putnam	41.4	68.1	1.0	1.7	10.0	18.3	14.9	25.5
Queens	44.1	14.0	1.7	0.2	2.6	1.3	4.7	2.1
Richmond	69.9	12.5	2.6	0.9	6.3	3.6	10.9	4.1
Rockland	70.0	23.1	3.2	1.2	18.7	12.4	7.3	7.5
Somerset	39.9	48.3	2.5	3.0	13.8	19.2	1.8	3.0
Suffolk	53.8	57.4	2.3	2.0	7.2	9.9	7.9	11.4
Sussex	12.6	34.3	0.8	2.2	2.2	6.0	0.4	1.0
Union	61.8	16.4	4.3	1.0	9.5	6.1	5.1	3.7
Warren	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Westchester	63.6	28.7	2.9	0.9	9.5	7.2	7.1	5.5

In the case of transit (Table 15) travel times follow a similar pattern and are, in all cases, lower than the corresponding value for cars. As pointed out before, the aggregation of centroids in a large area on each borough can explain the variability this data. Moreover, the use of different modes and also the availability and reliability of transit systems are influencing these numbers. The presence of zeros in some rows in the table means that transit is not available or NYMTC BPM does not encounter any transit information for this information.

Walking time data

P&R systems require among others good facility design and ease of access transit systems. A key issue when providing ease of access and/or good design is walking time/distance, both within the facility and between the facility and the nearest transit stop or station. This information was collected using Google maps (Google Inc., 2011). Using this tool it is possible to plan a trip using transit mode. A P&R candidate site is selected as an origin and Google maps computes the distance and time to reach the closest transit service bound for Manhattan. The transit option of Google maps allows determining distance and time to reach the closest transit service. This procedure can be easily checked since Google maps shows the location required. Figure 4 shows the frequency distribution of walking times to reach transit for the identified site.

Figure 4: Distribution of walking times



Since these candidates were selected based on feasible P&R conditions, walking times are generally low; this fact increases accessibility, and makes more attractive the P&R to users by reducing the generalized cost of the users. It is also important to point out that walking times provided by Google maps were augmented by 2 min. This rule is implanted to emulate the internal walking time by the user from the specific parking space to the entrance of the parking lot where Google maps normally considers when computing walking time.

5.2. Park and ride candidate sites

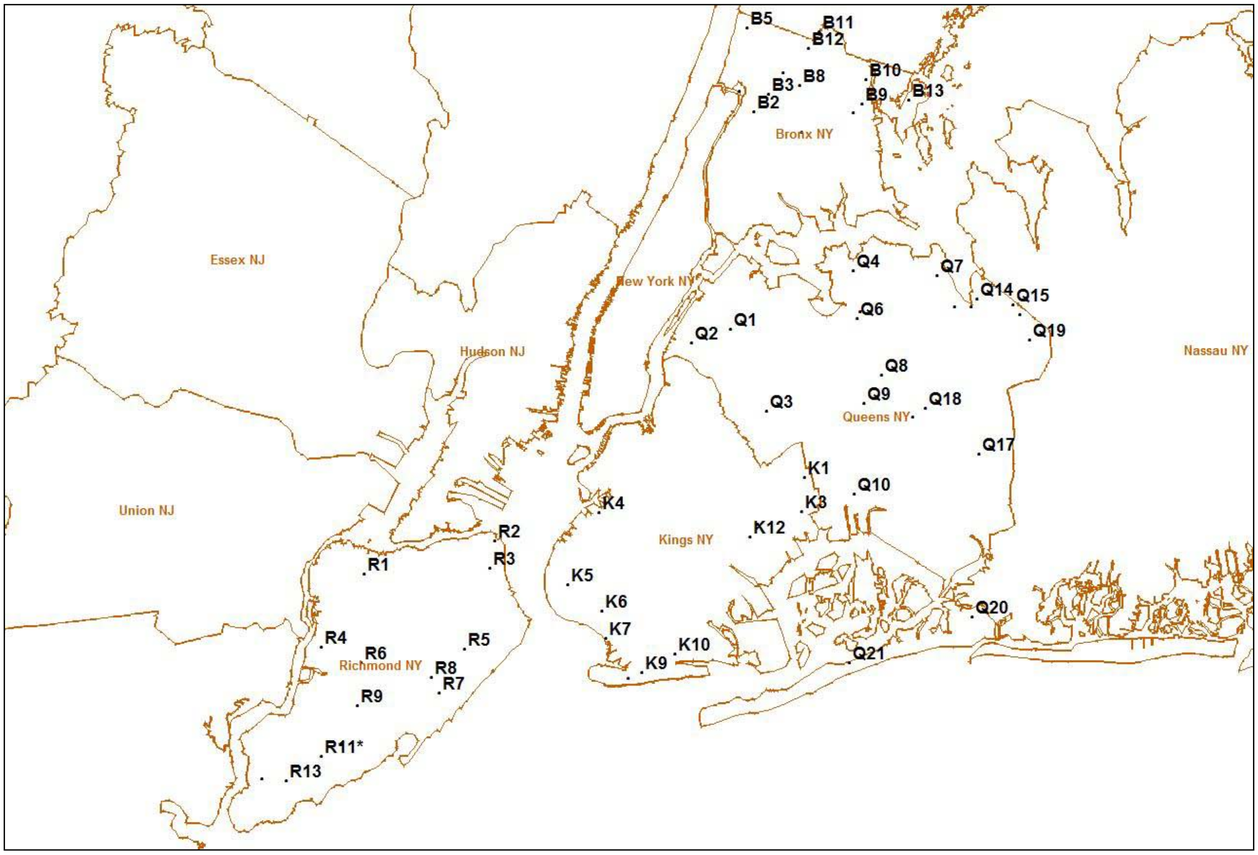
The information provided in this section and further has been stored in TransCAD 4.5 layers. Every P&R candidate has been characterized using GIS information (latitude and longitude), identification number (ID), and centroid in the NYMTC BPM model. this layer contains information regarding: address, building classification, and each of the level of performance described in previous sections, i.e. expected demand, weighted average savings, market share, and present value of benefits. Moreover, all information detailed before has been uploaded to a KMZ file that can be opened using the free software Google Earth. Finally, the team will provide a link where using the World Wide Web will be possible to visualize the same information described before simply using a normal browser.

The team originally identified 109 candidates from the surrounding boroughs. Then the team performed a detailed analysis one by one of all candidates. According to expertise and technical criteria, 40 of the original candidates were discarded. The most common criteria when disregarding a candidate was the unlikely possibility of reaching agreements to operate the candidate as a P&R facility. For example, the parking lots originally designed to serve private buildings which cannot be expected to be available for P&R use. At the end of the process, the team ended up with 59 candidates in the Bronx, Queens, Staten Island, and Brooklyn. As explained in previous sections, the selection of candidates was made by systematically scanning for vacant plots of lands a 500 meters buffer around transit lines. Consequently, each place was reviewed considering conditions described in Table 16. Figure 5 shows all candidates using B for the Bronx, Q for Queens, R for Staten Island, and K for Brooklyn.

Table 16: Park and ride selection criteria

	Description of Criteria	Recommendation for Locating PR facilities
Demand Considerations		
1	Position relative to the CBD	Greater 4-5 miles, preferably 10 miles from CBD
2	Maximize service area population	50% Demand from population within 5 miles diameter
3	Negative lot competition	Separation greater than 4-5 miles between facilities
4	Location relative to transit service	Walking distance less than 500 meters from transit
5	Site access convenience	Convenient diversion to facility prior to CBD
6	Location upstream congestion	Preferably upstream congestion with LOS E or worse
7	Parking demand in adjacent streets	Strong enforcement of informal parking near facility
8	Auto to transit cost ratio	This cost should be significantly less
9	Socioeconomic factor considerations	Analyze surrounding neighborhood's characteristics
10	Multiple destination facilities	Greater demand when greater variety of target destinations
Transit Connectivity and Design		
11	Frequency of transit	Headways not exceeding 15 min, and 5-10min in rush hours
12	Fast service to CBD	Use of bus lanes, HOV lanes, priority at intersections, etc.
13	Design for multimodal connections	Consider integration of vehicle, transit and bicycle pathways
14	Internal Layout	Strategic location of access/egress point for mobility
15	Easy and ample parking	Increase mobility by design and use of ITS technologies
16	Maximum site visibility	Location visible from important highways with clear signage
17	Passenger information system	Use of VMS and In-vehicle technologies that advertise PR
18	Comprehensive design	Weatherproof shelters, good lighting, and additional services
19	Landscape areas	Greener and comfortable park and rides will promote demand
Community Integration		
20	Safe and secure environment	Safer locations combined with non-intrusive measures
21	Coordination with local community	Consider community goals to obtain future support
22	Environmentally friendly facilities	Avoid brown field, urban parks, and rest areas
23	Relocation of existing structure	Avoid interfering with old buildings and previous build structures
24	Land depreciation	Avoid intrusion in dense residential areas to avoid opposition
25	Facility amenities	Consider integration of community centers, childcares, etc.
26	Pedestrian and bicycle pathways	Maximize pedestrian bicyclists access to facility
Financial Viability		
27	Compatible land use	Consider suburban business centers or joint use areas.
28	Facilities with potential for expansion	Consider scalability and increment of demand
29	Joint use lots	Coordinate demand patterns with churches, shopping centers, etc.
30	Sites with reduce operating costs	Coordinate with transit agency to reduce operating costs
31	Joint development opportunities	Consider locations with potential public/private partnerships
32	Size of existing lots	Large lots or combination of small lots to accommodate demand

Figure 5: Set of candidates



Using tax information it is possible to obtain the characteristics of each site such as area, owner, and building classification. Table 17 shows the different building classification encountered for all 59 P&R candidates. It is worthy to point out that several sites have the same classification, e.g. "Unlicensed parking lot". To access this information it is necessary to identify block and lot number of the property using its address. Then, tax information can be obtained from the New York City Department of Finance web page (The City of New York, 2011).

Table 17: Building classification according to NYC Department of Finance

Building class	Building classification	Building class	Building classification
E3	Semi-fireproof warehouse	Q6	Stadium, race track, baseball field
E9	Miscellaneous warehouse	T9	Miscelaneous transportation facility
G1	Garage; two or more stories	U4	Telephone utility
G2	Garage; one story semi-proof or fire-proof	U7	Transportation - public ownership
G6	Licensed parking lot	U8	Revocable consent
G7	Unlicensed parking lot	U9	Miscelaneous utility property
K1	Store building; one story	V0	Zoned resiential; not Manhattan
K2	Store building; two-story or store/office	V1	Zoned commercial or manhattan residential
K3	Department store - Multi-store	V9	Miscellaneous vacant land
K6	Shopping center with parking facility	W9	Miscelaneous educational facility
M1	Church, synagogye, chapel	Z2	Parking public parking area
O9	Miscellaneous office building	Z8	Cemetery
Q1	Park	Z9	Other miscelaneous

These different building classifications can be grouped in four types of sites:

- Sites already used as P&R locations.
- Sites at or near shopping malls where there is a *possibility* that a negotiation for leasing spaces for P&R users may be feasible.
- Vacant land parcels.
- Commercial and public parking facilities in commercial areas used primarily by shoppers.

Each of these candidates was evaluated using the methodology described in this report. In order to pursue this evaluation, data on the location, size, current use and value of candidate land parcels were obtained from publicly-available official New York City sources. In terms of modeling purposes, each P&R was assigned to the closest TAZ in the NYMTC BPM. The following subsections describe the candidates of each borough.

Bronx

Figure 6 shows the set of candidates. Again, connectivity is the primary driver for selecting candidates. Table 18 details the information regarding each P&R candidate in the Bronx. The field ID identifies the candidate. The asterisk in “B1*” highlights the fact that this candidate is composed by more than one site/parking lot. The centroid corresponds to the TAZ zone in the NYMTC BPM. It also shows the building classification, the area and number of spaces.

Figure 6: Park and ride candidates in the Bronx

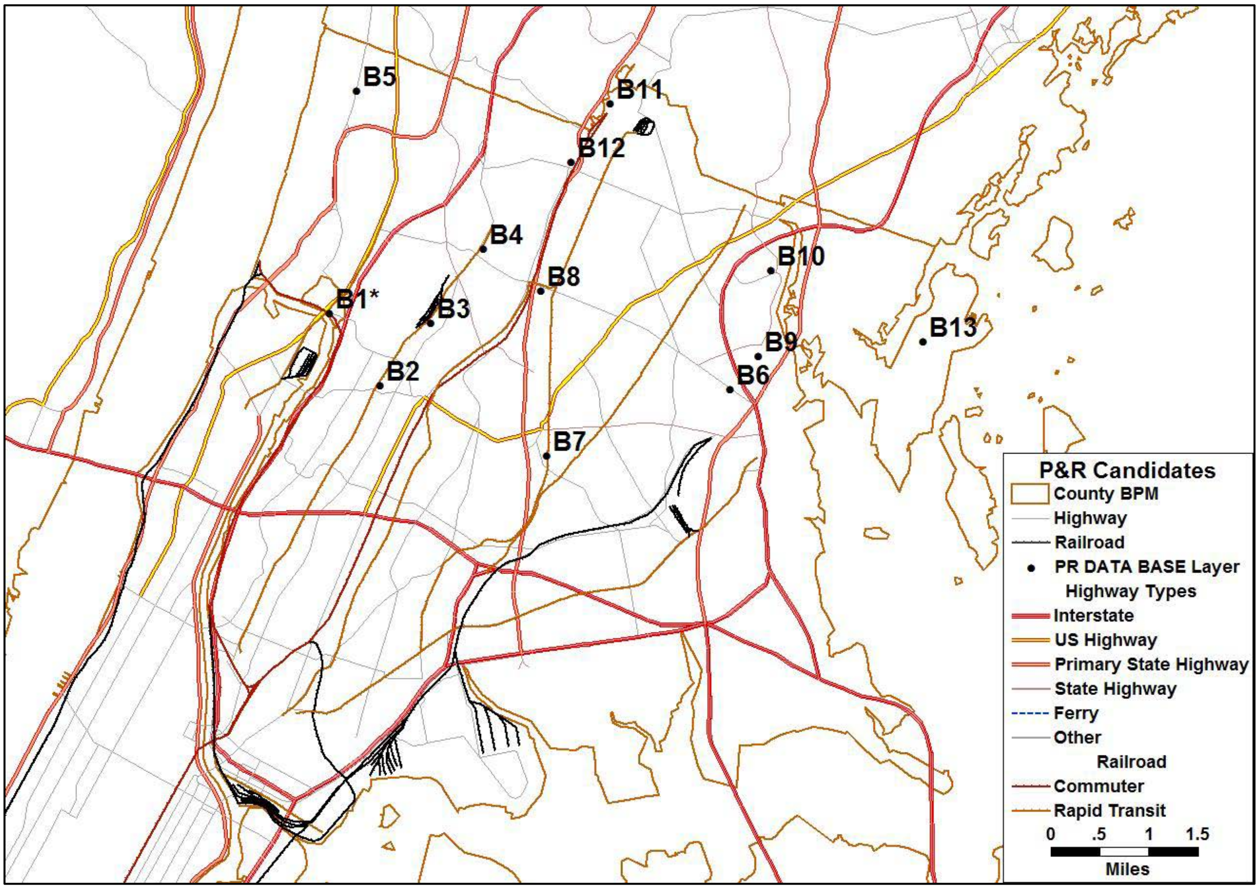


Table 18: Park and ride candidates in the Bronx

ID	Centroid	Address	Building classification	Area (sqft)	Spaces
B1*	318	5188 Broadway	Store building; two-story or store/office	129,810	226
B2	869	2476 Jerome Ave	Garage; two or more stories	23,941	42
B3	874	2885 Jerome Ave	Telephone utility	182,303	395
B4	880	3518 Jerome Ave	Parking public parking area	39,691	70
B5	902	5648 Riverdale Ave	Shopping center with parking facility	46,154	88
B6	975	1809 E Gun Hill Rd	Zoned commercial or manhattan residential	554,973	1114
B7	976	2071 White Plains Rd	Parking public parking area	36,161	60
B8	992	3444 Duncomb Ave	Miscellaneous vacant land	180,659	397
B9	995	2100 Bartow Ave	Zoned commercial or manhattan residential	1,528,584	3123
B10	1008	2280 Givan Ave	Miscelaneous educational facility	386,204	865
B11	1015	516 - 583 Wakefield Ave	Zoned commercial or manhattan residential	349,525	753
B12	1016	4201 Webster Ave	Garage; one story semi-proof or fire-proof	185,121	408
B13	1023	Orch Beach Rd and Park Drive	Park	1,765,628	2141

Brooklyn

Figure 7 shows the set of candidates in Brooklyn. Similar to the Bronx, the set of candidates was selected according to connectivity and site availability. It can be seen that a big proportion of candidates are located along or close to major highways. Table 19 details the information regarding each P&R

candidate in Brooklyn. More than 50% of them are currently related to parking activities (licensed and unlicensed parking lots, Parking public parking area, or Transportation – public ownership). Similarly to the Bronx where B1* is comprised by more than one site/parking facility, K1* and K11* are composed by more than one facility.

Figure 7: Park and ride candidates in Brooklyn

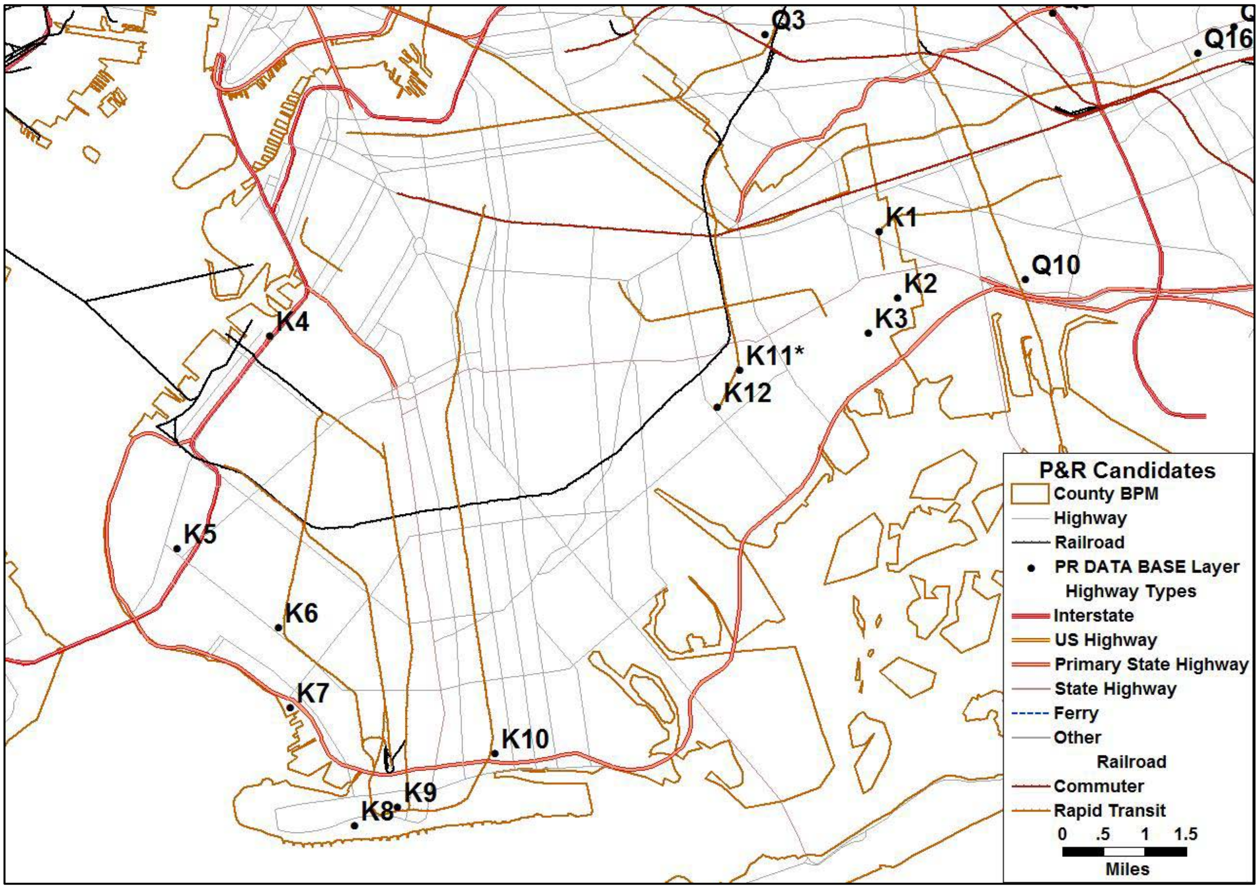


Table 19: Park and ride candidates in Brooklyn

ID	Centroid	Address	Building classification	Area (sqft)	Spaces
K1	1172	2907 Pitkin Ave	Licensed parking lot	85,178	169
K2	1177	804 Forbell St	Unlicensed parking lot	429,718	977
K3	1182	830 Fountain Ave	Other miscelaneous	629,749	1491
K4	1235	870 3rd Ave	Miscellaneous warehouse	124,997	270
K5	1299	501 86 St	Parking public parking area	22,313	44
K6	1326	1762 85th St	Parking public parking area	31,309	50
K7	1328	1608 Shore Pkwy	Shopping center with parking facility	479,739	1094
K8	1385	3098 W 19th St	Stadium, race track, baseball field	313,239	697
K9	1390	606 Sheepshead Bay Rd	Revocable consent	243,104	532
K10	1453	1501 Voorhies Ave	Zoned commercial or manhattan residential	85,826	172
K11*	1519	570 E 108th St	Transportation - public ownership	237,925	469
K12	1524	1389 Rockaway Pkwy	Parking public parking area	151,306	293

Staten Island

Figure 8 shows the set of candidates in Staten Island. This set is more uniformly distributed across the borough. Moreover, the need of closeness to transit is met when considering the rail in the cases of candidates R5, R7, and R8. Table 20 shows information regarding each candidate in Staten Island.

Figure 8: Park and ride candidates in Staten Island

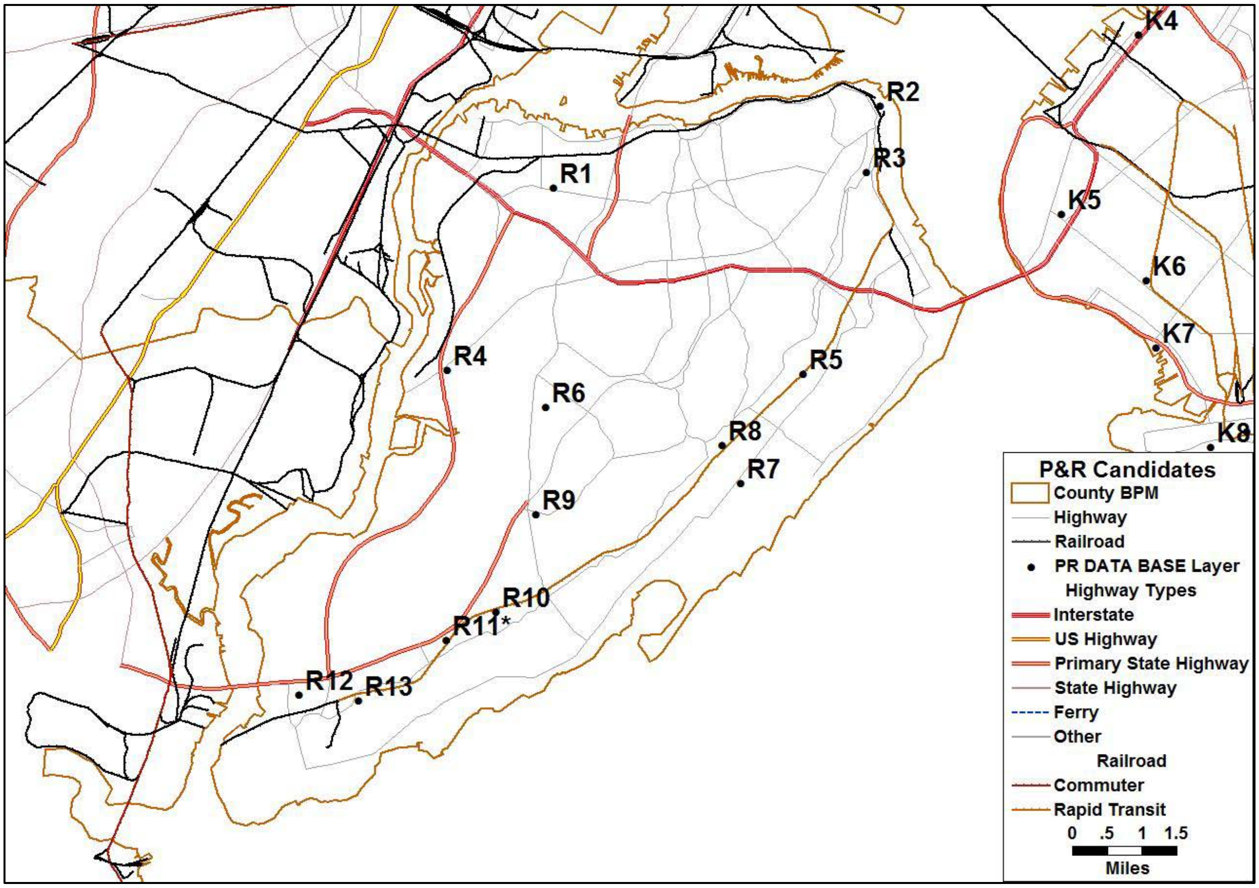


Table 20: Park and ride candidates in Staten Island

ID	Centroid	Address	Building classification	Area (sqft)	Spaces
R1	1561	2161 Forest Ave	Department store - Multi-store	252,549	526
R2	1569	3-11 Bank St	Miscelaneous transportation facility	133,165	269
R3	1570	180 Richmond Terrace	Stadium, race track, baseball field	233,066	546
R4	1578	14 Beresford Ave	Store building; one story	74,499	131
R5	1590	97 Hancock St	Miscelaneous utility property	24,317	41
R6	1595	2655 Richmond Ave	Shopping center with parking facility	1,430,908	3238
R7	1600	12 Ebbitts St	Shopping center with parking facility	656,726	1476
R8	1604	26 4th St	Parking public parking area	23,891	48
R9	1612	3231 Richmond Ave	Shopping center with parking facility	133,384	279
R10	1613	21 S Railroad St	Zoned resiential; not Manhattan	33,837	61
R11*	1617	833 Huguenot Ave	Parking public parking area	102,221	207
R12	1618	200 Boscombe Ave	Church, synagogye, chapel	71,496	137
R13	1620	6420 Amboy Rd	Shopping center with parking facility	132,683	289

Queens

Figure 9 shows the set of candidates in Queens. The location of the set of candidates is more even than the rest of the boroughs. Again, the closeness to major highways and, therefore, express transit systems is key. It is also important to point out the location of several candidates along the rail system. Table 21 details the information regarding each P&R.

Figure 9: Park and ride candidates in Queens

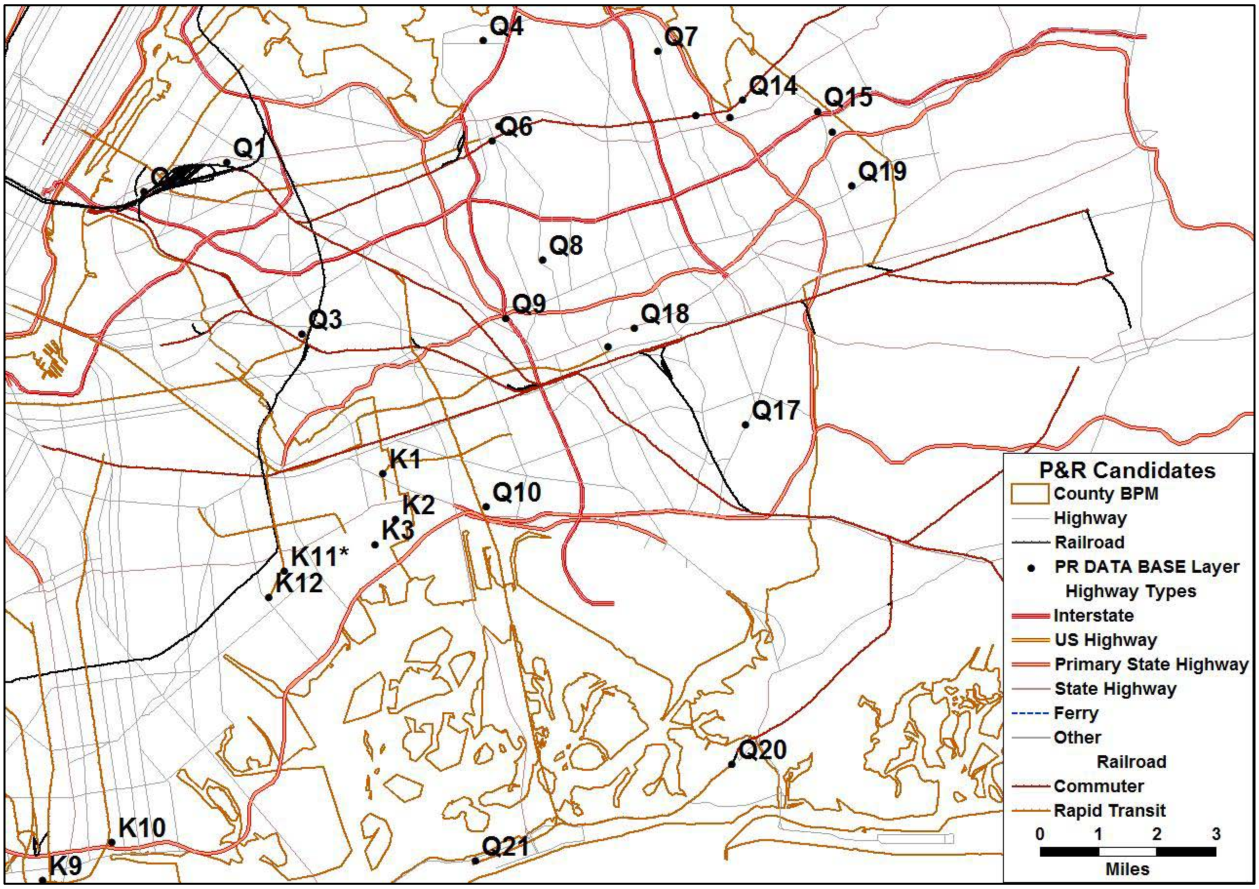


Table 21: Park and ride candidates in Queens

ID	Centroid	Address	Building classification	Area (sqft)	Spaces
Q1	349	45-10 48th St	Semi-fireproof warehouse	1,108,990	2483
Q2	363	4540 Court Sq	Garage; two or more stories	43,658	83
Q3	437	6626 Metropolitan Ave	Shopping center with parking facility	808,849	1866
Q4	491	13415 20th Ave	Shopping center with parking facility	843,676	1935
Q5*	495	138th st and 39th av	Parking public parking area	312,132	673
Q6	498	13345 41 Ave	Parking public parking area	40,984	62
Q7	529	212-15 26 Ave	Shopping center with parking facility	263,819	591
Q8	539	7201 Kissena Blvd	Shopping center with parking facility	144,462	251
Q9	543	80-25 126th Street	Parking public parking area	88,240	167
Q10	589	108-10 N Conduit Ave	Zoned commercial or manhattan residential	1,042,715	2238
Q11	623	217-1 41st Ave	Transportation - public ownership	108,639	221
Q12	632	230-1 Northern Blvd	Miscellaneous vacant land	201,693	428
Q13	636	6015 Little Neck Pkwy	Miscellaneous office building	42,157	64
Q14	637	4214 235th St	Park	55,051	85
Q15	638	25421 Nassau Blvd	Shopping center with parking facility	59,088	85
Q16	645	90-99 168th St	Parking public parking area	196,633	424
Q17	669	Springfield Blvd and 122nd Av	Cemetery	92,909	199
Q18	676	Hillside Ave and 179th St	Unlicensed parking lot	40,295	75
Q19	686	25503 Union Tpke	Shopping center with parking facility	271,002	599
Q20	735	2002 Mott Ave	Shopping center with parking facility	182,150	392
Q21	743	11301 Beach Channel Dr	Store building; one story	323,268	696

5.3. Analysis of results

This chapter discusses the results of the evaluation process. Figure 10 shows the distribution of the best 20 candidates according to expected demand (x axis), and weighted average savings (y primary axis) and present value of benefits (y secondary axis). What this figure is trying to show is how these three performance measures are distributed. Therefore, expected demand is concentrated between 4,000 to 11,000 users, while weighted average savings between 1.5 and 14 USD per user, and present value of benefits between 30 and 370 million dollars. It is important to point out that a candidate is evaluated if and only if it produces savings to users; otherwise the candidate will not have demand, and, therefore will not produce savings. Further analyses in this report describe each level of performance for the overall set of candidates, and, consequently similar analyses are developed on each borough.

Figure 10: Expected demand versus weighted average savings and present value of benefits

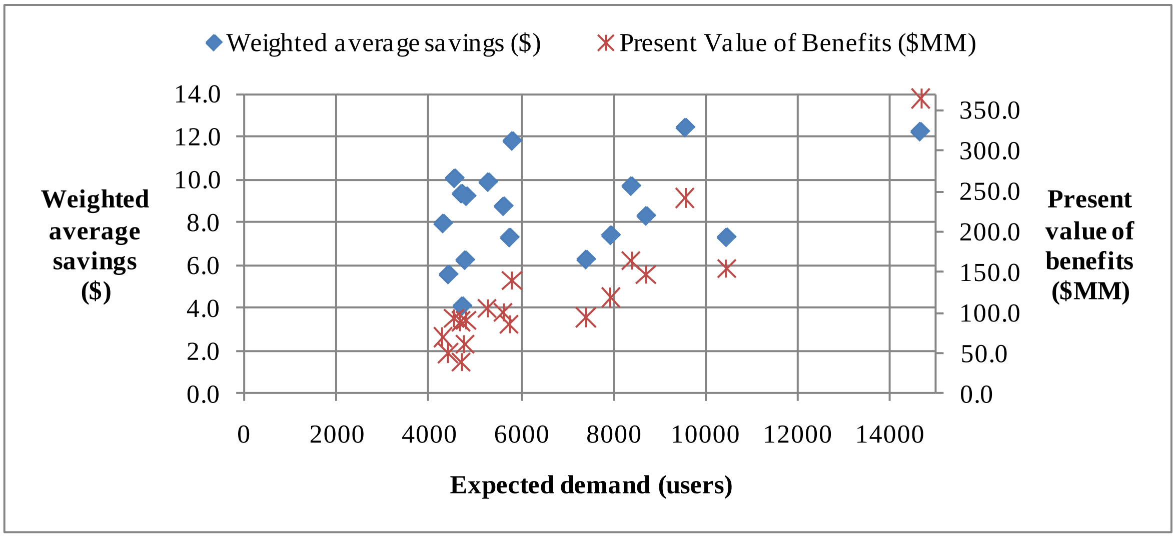


Table 22 shows the top 20 candidates according to expected demand, market share, weighted average savings, and present value of benefits. The top 10 on each level of performance are contained in this table. The same information is graphically shown in Figure 11. It is also important to note more specific characteristics of each candidate such as building classification.

Table 22: Top 20 candidates

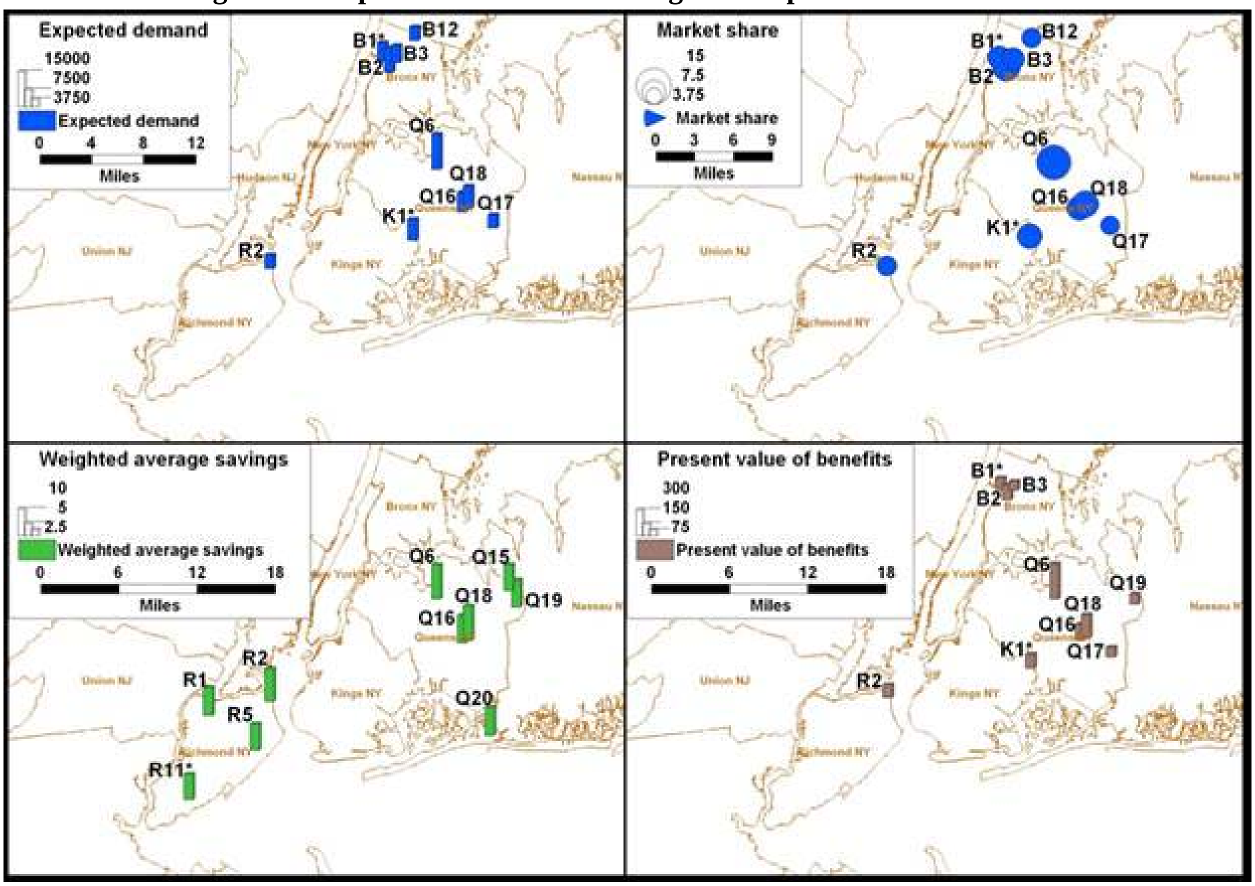
	ID	Address	Spaces	Expected demand (users)	Market share (%)	Weighted average savings ($)	Present Value of Benefits ($MM)
1	Q6	13345 41 Ave	62	14676	14.2%	12.3	364.7
2	Q18	Hillside Ave and 179th St	75	9564	9.3%	12.5	241.4
3	Q16	90-99 168th St	424	8386	8.1%	9.7	164.8
4	B2	2476 Jerome Ave	42	10461	10.1%	7.3	154.4
5	K1	2907 Pitkin Ave	169	8712	8.4%	8.3	146.4
6	R2	3-11 Bank St	269	5795	5.6%	11.8	138.8
7	B1*	5188 Broadway	226	7942	7.7%	7.4	118.7
8	Q19	25503 Union Tpke	599	5272	5.1%	9.9	105.6
9	Q17	Springfield Blvd and 122nd Ave	199	5607	5.4%	8.8	99.4
10	B3	2885 Jerome Ave	395	7404	7.2%	6.2	93.6
11	R1	2161 Forest Ave	526	4540	4.4%	10.1	92.6
12	Q15	25421 Nassau Blvd	85	4799	4.6%	9.2	89.7
13	R5	97 Hancock St	41	4692	4.5%	9.4	88.8
14	B12	4201 Webster Ave	408	5739	5.6%	7.3	84.6
15	Q14	4214 235th St	85	4290	4.1%	7.9	69.0
16	B11	516 - 583 Wakefield Ave	753	4769	4.6%	6.2	60.0
17	Q20	2002 Mott Ave	392	2496	2.4%	10.1	51.0
18	R11*	833 Huguenot Ave	207	2766	2.7%	8.9	50.0
19	Q10	108-10 N Conduit Ave	2238	4407	4.3%	5.5	49.4
20	B10	2280 Givan Ave	865	3508	3.4%	6.3	44.5

The top 10 candidates for expected demand are shown in Figure 11 top left. It can be seen that Queens and the Bronx have the majority of best candidates when considering expected demand.

When considering weighted average savings the situation is different. Figure 11 shows that in this case Staten Island and Queens account for the best 10 candidates. This situation can be explained when considering the high cost incurred to users traveling from these two boroughs. Therefore, although the level of demand can be lower than other candidates, the amount of money saved by users is considerably bigger. Table 22 details this information.

Finally, the same analysis can be made using the present value of benefits. As mentioned previously, this measures future stream of benefits. This ranking is fairly similar to the one produced by expected demand. However, from Figure 11 bottom right compared to the expected demand it is possible to notice that in this case B12 has been switched by Q19. Table 22 shows that the ranking has also a different order, e.g. Queens has the three best candidates.

Figure 11: Top 10 candidates according to each performance measure



When considering the building classification for each of the top candidates there are similarities among them. For example, there are three public parking areas (Q6, Q16, R11*), three shopping centers with parking facilities (Q15, Q19, Q20), two garages (B2 and B12), one licensed parking lot (K1*), and one unlicensed parking lot (Q18). The top 5 candidates for expected demand and present value of benefits are the same, however ordered differently. These include Q6, Q18, Q16, B2, and K1*. Looking back at each building classification, one can infer that public parking areas, unlicensed/licensed parking lots, and garages are good locations for P&R facilities. According to weighted average savings, B2, K1* and Q16 are replaced by R1, R2 and Q20 which include a department store, miscellaneous transportation facility and shopping center with parking facility respectively. Since the parking spaces available at the store parking lots both exceed 500 spaces, the expected demand and weighted average savings for users are large. The following sections describe similar analysis considering each borough.

Bronx

Figure 12 shows the ranges for each performance measure computed. In the case of the Bronx, the level of demand reached in the best case is over 10 thousand potential users. However, the weighted average savings are normally lower than 8 USD per user. Therefore, the present value of benefits for a potential candidate in this borough is normally less than 200 $MM. In addition, this borough presents several well suited alternatives to locate P&R facilities.

Figure 12: Bronx: Expected demand, weighted average savings and present value of benefits

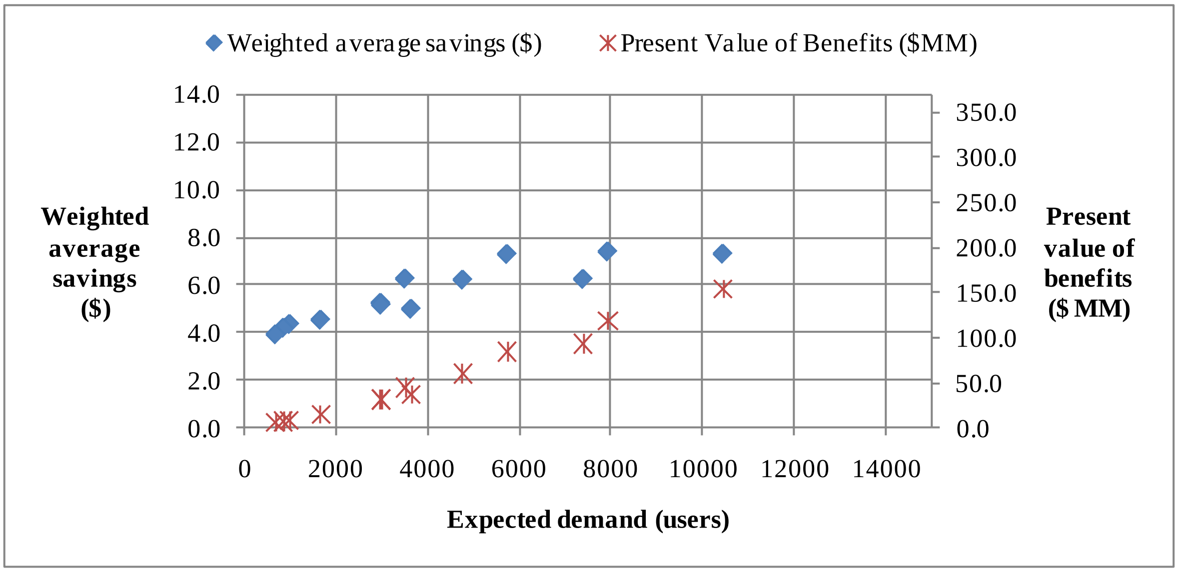


Table 23 shows all results for the Bronx. It can be seen that the top 3 candidates according to expected demand, weighted average savings, and present value of benefits are always B2, B1*, and B3. When considering weighted average savings B12 has a better performance than B3.

Table 23: Evaluation results for the Bronx

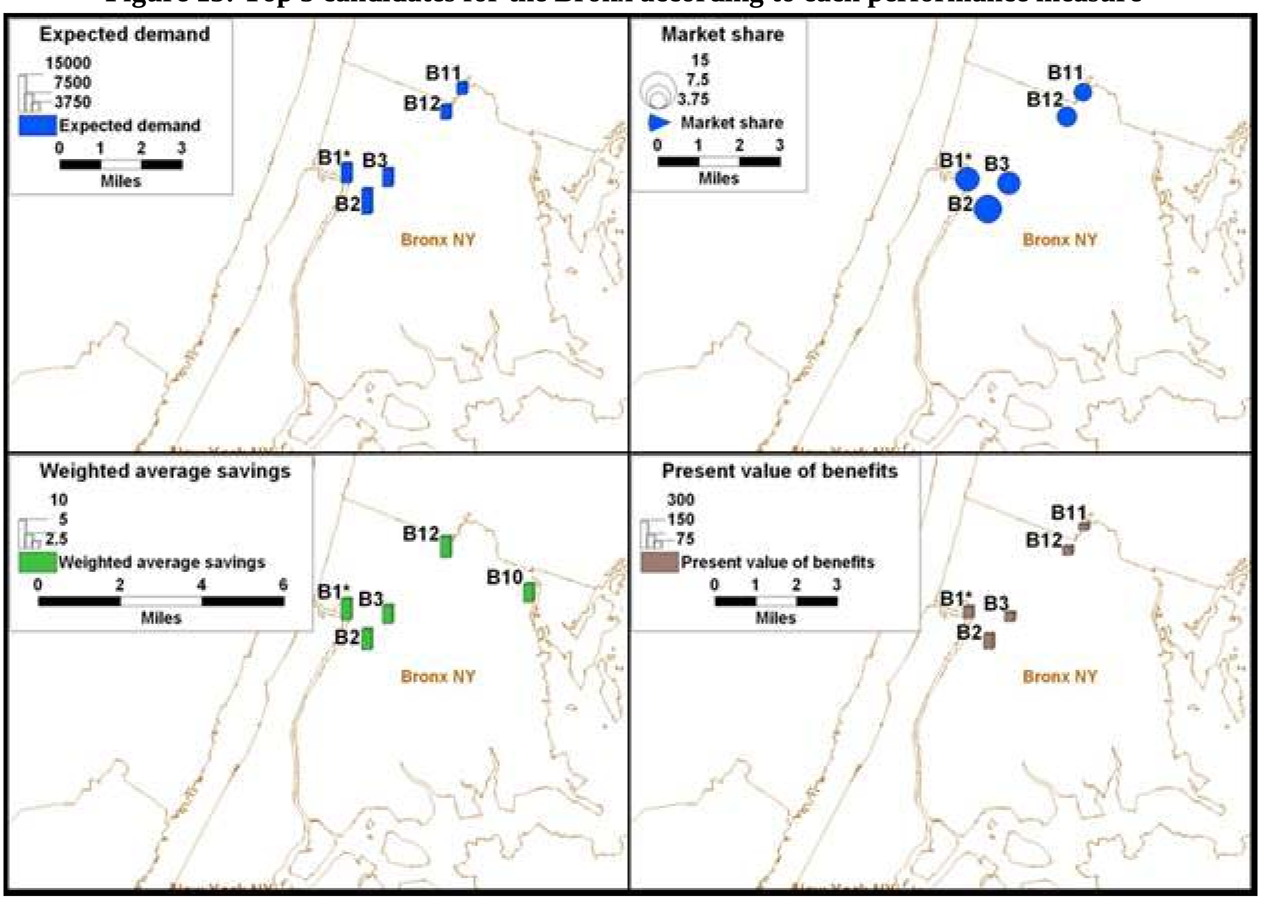
ID	Address	Area (sqft)	Spaces	Expected demand (users)	Market share (%)	Weighted average savings ($)	Present Value of Benefits ($MM)
B2	2476 Jerome Ave	23,941	42	10461	10.1%	7.3	154.4
B1*	5188 Broadway	129,810	226	7942	7.7%	7.4	118.7
B3	2885 Jerome Ave	182,303	395	7404	7.2%	6.2	93.6
B12	4201 Webster Ave	185,121	408	5739	5.6%	7.3	84.6
B11	516 - 583 Wakefield Ave	349,525	753	4769	4.6%	6.2	60.0
B10	2280 Givan Ave	386,204	865	3508	3.4%	6.3	44.5
B5	5648 Riverdale Ave	46,154	88	3640	3.5%	5.0	36.9
B4	3518 Jerome Ave	39,691	70	2972	2.9%	5.3	31.6
B8	3444 Duncomb Ave	180,659	397	2983	2.9%	5.2	31.2
B7	2071 White Plains Rd	36,161	60	1659	1.6%	4.6	15.3
B13	Orchard Beach Rd and Park Drive	1,765,628	2141	981	0.9%	4.4	8.7
B9	2100 Bartow Ave	1,528,584	3123	848	0.8%	4.2	7.2
B6	1809 E Gun Hill Rd	554,973	1114	677	0.7%	3.9	5.4

Figure 13 top left shows the top 5 candidates and the level of demand that each one would face. It is important to note that candidates increase their demand as they approach to Manhattan. The series B4, B3, and B2 exhibit this pattern. This pattern can be explained considering the P&R facility located in the limit of Manhattan, i.e. when congestion starts. In this place users will use car in the uncongested section of the trip and then switch to transit on congestion conditions. In other words, the P&R facility is located in the edge between congested and uncongested part of the trip. Indeed, assuming the edge of Manhattan as the limit of congestion they will be fully using the benefits of an express transit system.

In the case of weighted average savings, Figure 13 bottom left shows that candidates in this borough produce savings more than 4 USD despite the selected position. Figure 13 bottom right shows the pattern of increasing level of benefit according to closeness to Manhattan. Since present value of benefits combines number of commuters and level of savings, it can be seen that although some candidates can exhibit high level savings they do not necessarily have high levels of benefits due the low demand they serve. This is an important consideration because the success of a P&R facility can be assessed considering all these level of performance in a combined manner.

The corresponding building classifications for the top 3 candidates for each performance measure are store building, garage, and telephone utility. For weighted average savings, however, B3 is replaced with B12 which is another garage. Since the average savings reaches slightly over 7 USD, the garages offer reduced generalized costs for the P&R users.

Figure 13: Top 5 candidates for the Bronx according to each performance measure



Brooklyn

Figure 14 shows the distribution of the different performance criteria for candidates of Brooklyn. Top 5 candidates in Brooklyn present weighted average savings more than or equal to 4.5 USD, present value of benefits bigger than 5 $MM, and expected demand bigger than 1,500 users. Table 24 details this information which suggests that K1* is the prime candidate for Brooklyn.

Figure 14: Brooklyn: expected demand, weighted average savings and present value of benefit

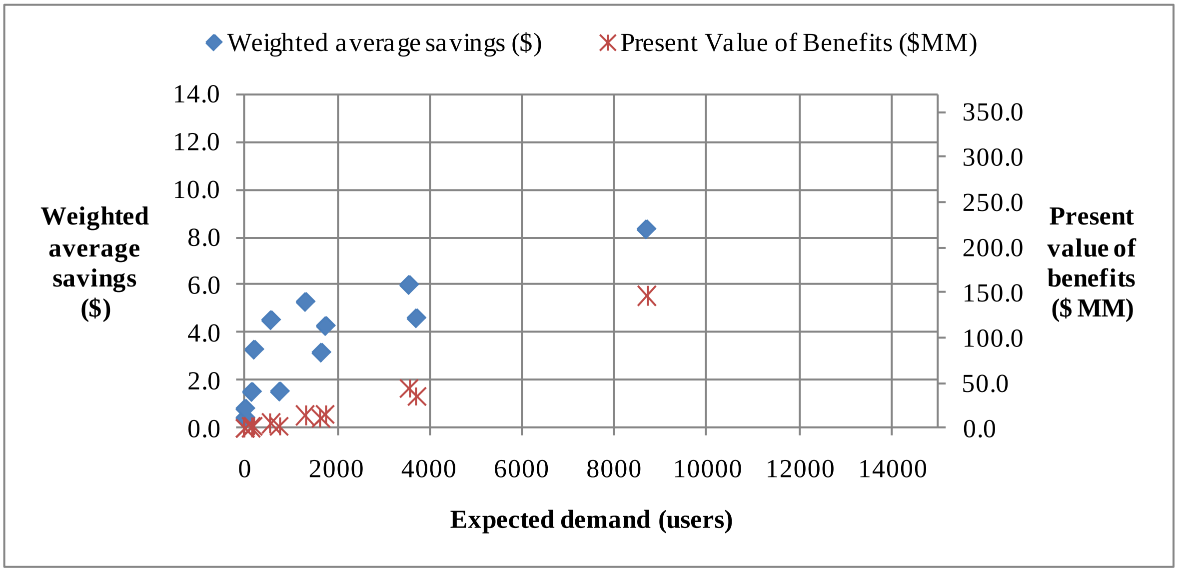


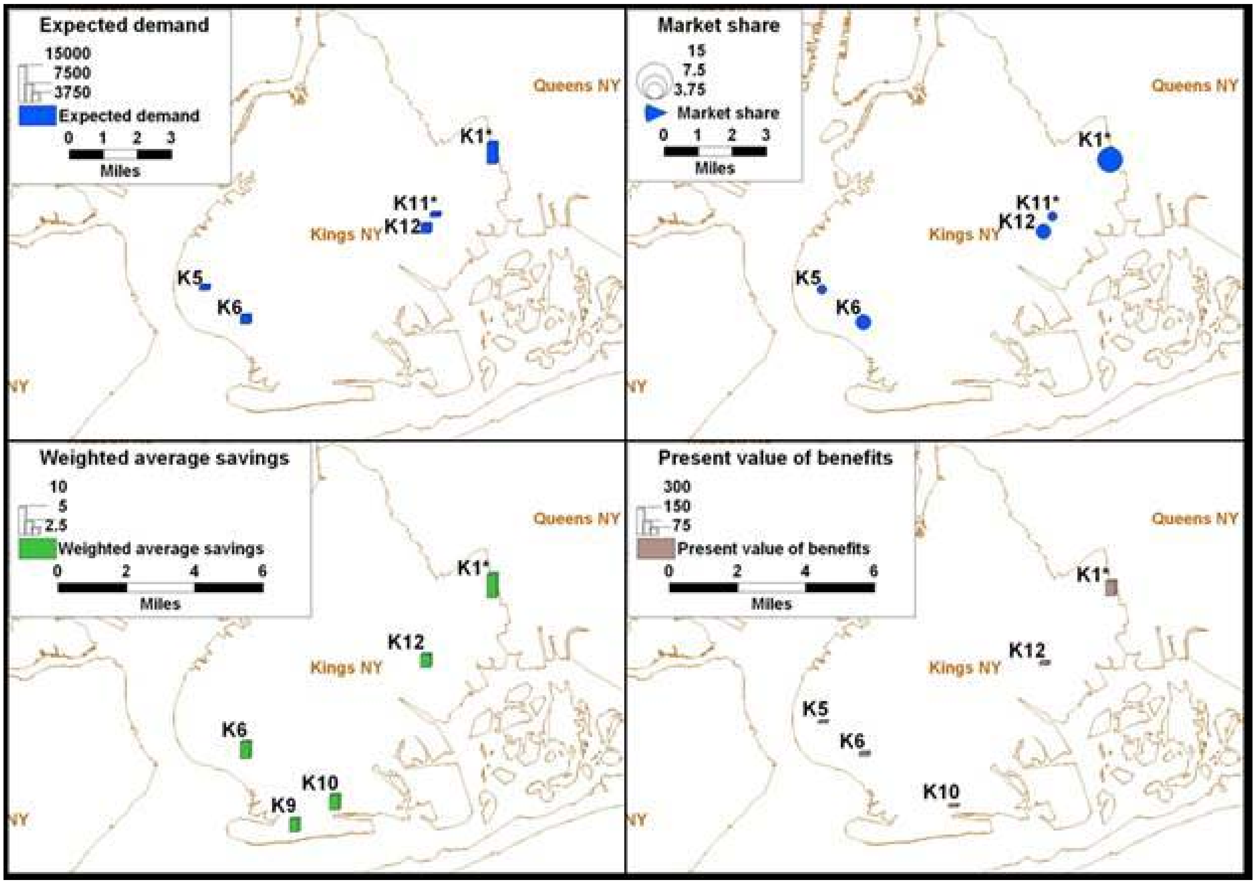
Table 24: Evaluation results for Brooklyn

ID	Address	Area (sqft)	Spaces	Expected demand (users)	Market share (%)	Weighted average savings ($)	Present Value of Benefits ($MM)
K1*	2907 Pitkin Ave	85,178	169	8712	8.4%	8.3	146.4
K6	1762 85th St	31,309	50	3558	3.4%	6.0	43.0
K12	1389 Rockaway Pkwy	151,306	293	3717	3.6%	4.6	34.4
K5	501 86 St	22,313	44	1748	1.7%	4.2	15.0
K10	1501 Voorhies Ave	85,826	172	1309	1.3%	5.3	13.9
K11*	570 E 108th St	237,925	469	1652	1.6%	3.1	10.5
K9	606 Sheepshead Bay Rd	243,104	532	560	0.5%	4.5	5.1
K2	804 Forbell St	429,718	977	751	0.7%	1.5	2.3
K7	1608 Shore Pkwy	479,739	1094	196	0.2%	3.3	1.3
K4	870 3rd Ave	124,997	270	146	0.1%	1.5	0.4
K3	830 Fountain Ave	629,749	1491	1	0.0%	0.8	0.0
K8	3098 W 19th St	313,239	697	2	0.0%	0.4	0.0

The top 3 candidates for each performance level are K1*, K6, and K12. As mentioned, K1* is a licensed parking lot that presents the most demand, average savings, and economic benefits. K6 and K12 are both parking public parking areas.

Figure 15 illustrates that K1* presents the largest values for each of the performance levels evaluated for the top 5 candidates in Brooklyn. One possible explanation for this result is the building classification of K1*, which is listed as a licensed parking lot under the NYC Department of Finance's property information system. Additionally, the walking time from K1* to transit is 3 minutes which reduces generalized costs for its users, therefore enhances the attractiveness of this location.

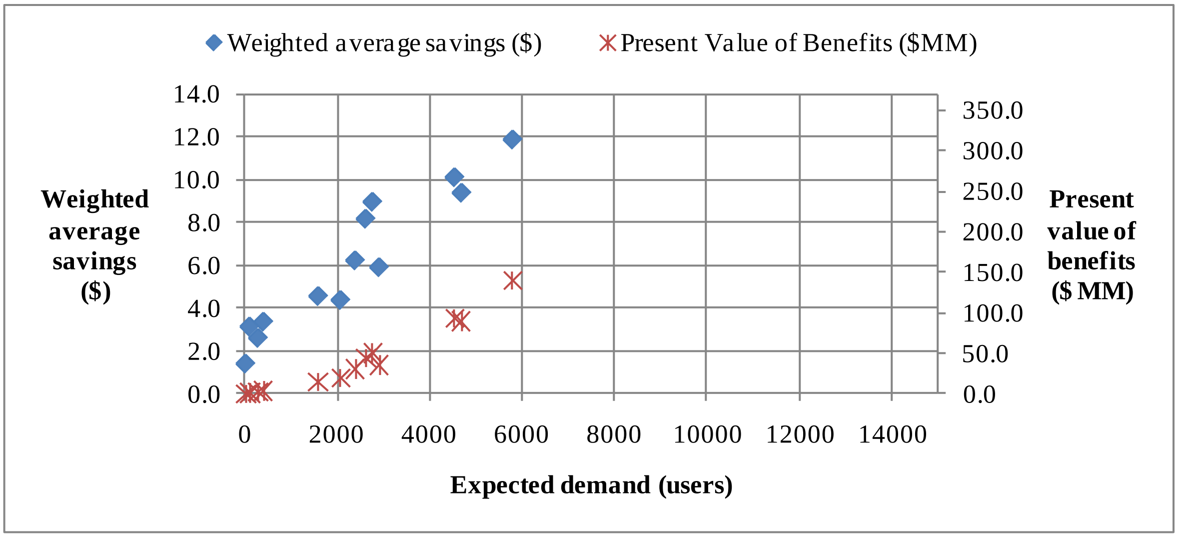
Figure 15: Top 5 candidates for Brooklyn according to each performance measure



Staten Island

In the case of Staten Island, Figure 16 suggests variable results for the suggested P&R candidates. The average savings for users is significantly large, with the top 5 candidates exceeding 8 USD and reaching up to 12 USD. The expected demand reaches 6000 users for all candidates, and the economic benefits exceed 43 $MM for each of the top 5.

Figure 16: Staten Island: expected demand, weighted average savings and potential gross benefit



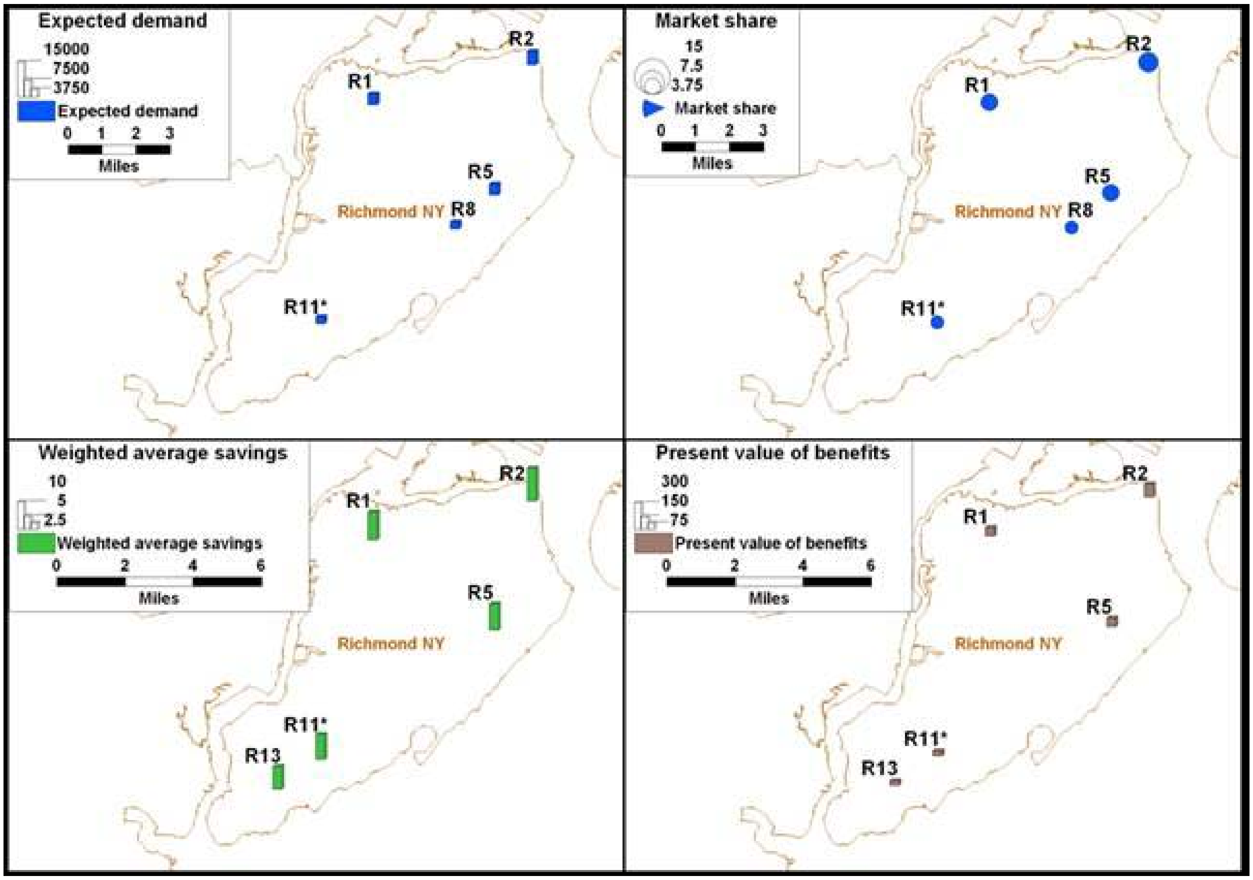
The top 3 candidates for this borough are R2, R5 and R1. The building classifications are respectively a miscellaneous transportation facility, miscellaneous utility property, and department store.

Table 25: Evaluation Results for Staten Island

ID	Address	Area (sqft)	Spaces	Expected demand (users)	Market share (%)	Weighted average savings ($)	Present Value of Benefits ($MM)
R2	3-11 Bank St	133,165	269	5795	5.6%	11.8	138.8
R1	2161 Forest Ave	252,549	526	4540	4.4%	10.1	92.6
R5	97 Hancock St	24,317	41	4692	4.5%	9.4	88.8
R11*	833 Huguenot Ave	102,221	207	2766	2.7%	8.9	50.0
R13	6420 Amboy Rd	132,683	289	2620	2.5%	8.1	43.1
R8	26 4th St	23,891	48	2911	2.8%	5.9	34.6
R9	3231 Richmond Ave	133,384	279	2392	2.3%	6.2	30.0
R7	12 Ebbitts St	656,726	1476	2076	2.0%	4.3	18.2
R10	21 S Railroad St	33,837	61	1595	1.5%	4.5	14.6
R4	14 Beresford Ave	74,499	131	412	0.4%	3.3	2.8
R3	180 Richmond Terrace	233,066	546	295	0.3%	2.6	1.5
R12	200 Boscombe Ave	71,496	137	111	0.1%	3.1	0.7
R6	2655 Richmond Ave	1,430,908	3238	25	0.0%	1.4	0.1

According to Table 25, R2 presents the largest values for each performance measure listed in the table. A logical explanation for this result would be the location of R2 in relation to Manhattan, which is much closer compared to the other top 4 candidates of the borough as displayed in Figure 17. Moreover, R2 is classified as a "miscellaneous transportation facility," further verifying the advantage of this candidate.

Figure 17: Top 5 candidates for Staten Island according to each performance measure



Queens

Queens has the greatest number of P&R candidates. The expected demand and present value of benefits exceed 14,000 users and 350 $MM respectively for the top candidate. The other locations in Queens present high performance levels as well, exceeding 8000 users of expected demand, 250 $MM in present value of benefits, and 10 USD in weighted average savings.

Figure 18: Queens: expected demand, weighted average savings and present value of benefits

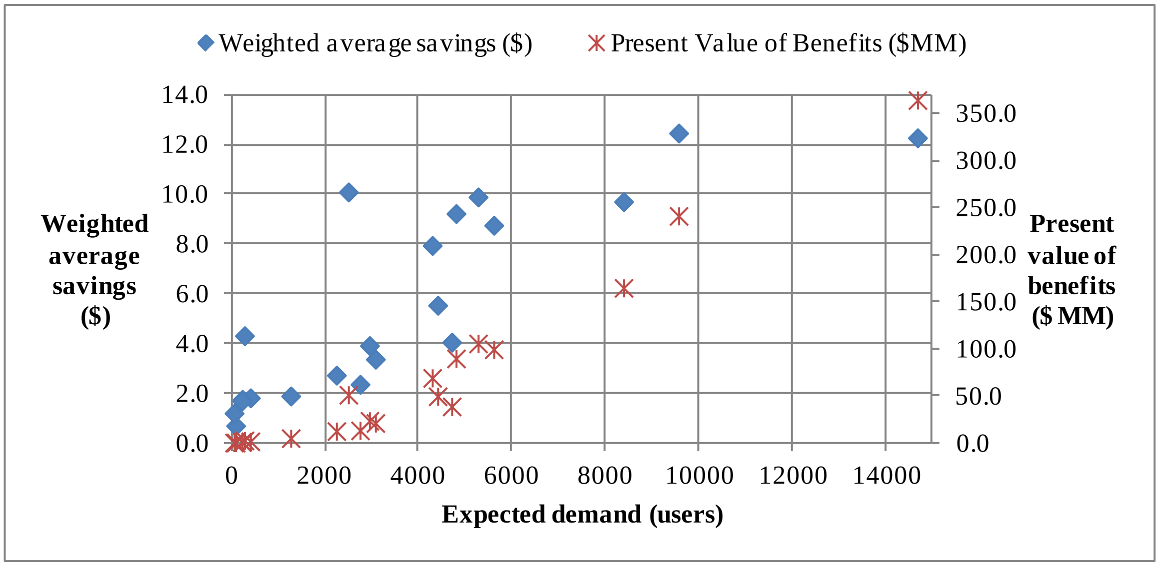


Table 26 describes the results for each performance measure ordered by present value of benefits. The weighted average savings is over 9 USD for the top 5 candidates. The top candidate in all respects is Q6, known to be a "parking public parking area" which could explain such high economic benefits to users.

When considering the distance from Manhattan, the top 5 locations in Figure 19 are more condensed toward central and eastern Queens. This further confirms that higher levels of congestion occur as the distance to Manhattan decreases. The presented P&R candidates help avoid congestion which would result in lower generalized cost benefits. Q6 is the nearest to Manhattan and therefore suggests the closer to Manhattan, the greater the demand, economic benefits, and average savings produced by the candidate.

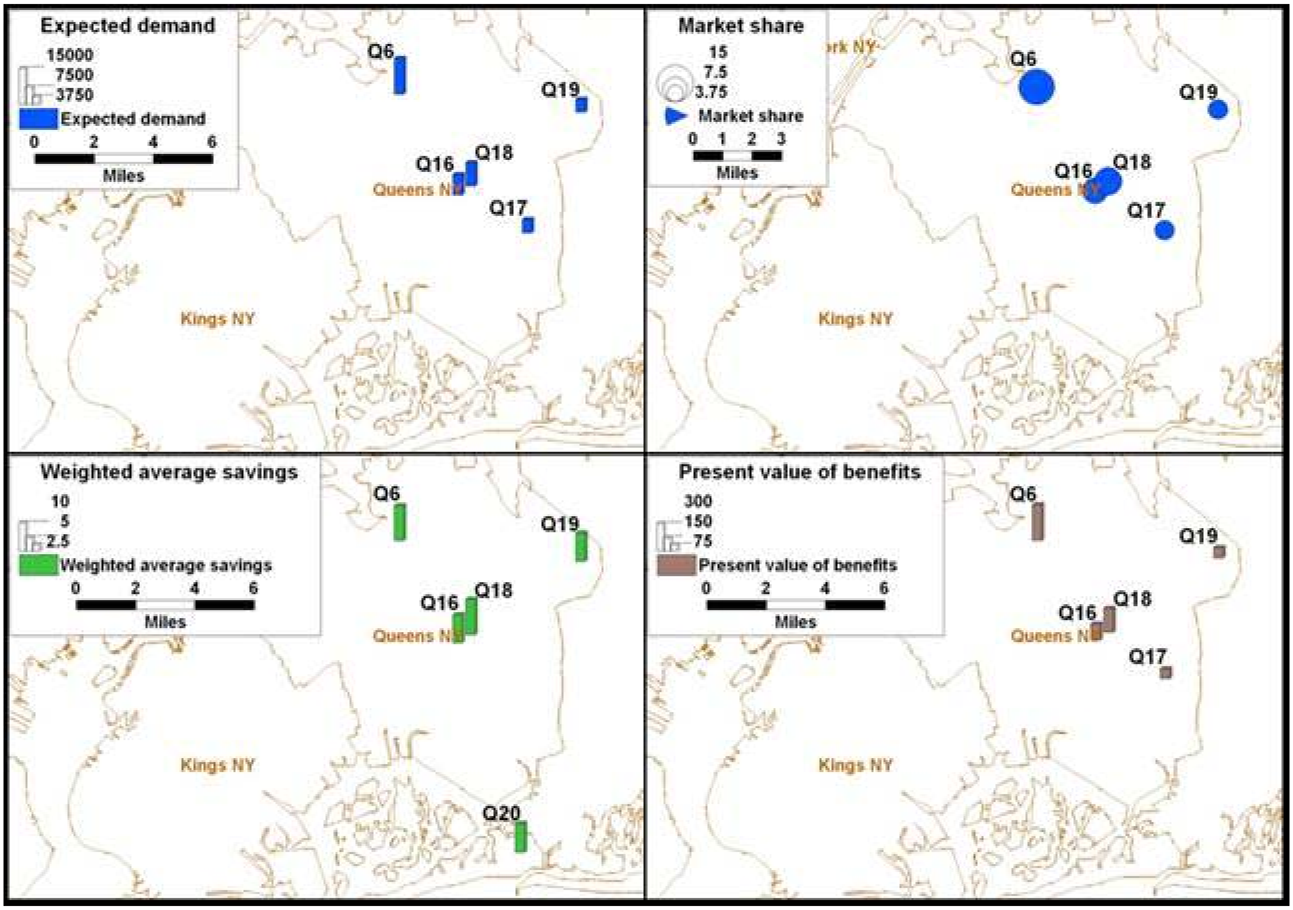
The top 3 candidates are Q6, Q18 and Q16, and they are also included in the top 10 candidates in the NYMTC area. The characteristics of these three locations can further explain the benefits for choosing P&R facilities among these choices. As mentioned in a previous section, Q6 and Q16 are both parking public parking areas and Q18 is classified as an unlicensed parking lot.

Q10 is particularly interesting. This candidate has been highlighted by the New York State DOT as a "de-facto" P&R facility. It can be seen from Table 26 that users save an average of 5.5 USD per day by using this location as a P&R lot. Moreover, this facility can ideally accommodate more than two thousand vehicles. It is important to highlight that this facility is not an authorized P&R facility so far, and the estimation of spaces has been computed using ParkCAD.

Table 26 Evaluation Results for Queens

ID	Address	Area (sqft)	Spaces	Expected demand (users)	Market share (%)	Weighted average savings ($)	Present Value of Benefits ($MM)
Q6	13345 41 Ave	40,984	62	14676	14.2%	12.3	364.7
Q18	Hillside Ave and 179th St	40,295	75	9564	9.3%	12.5	241.4
Q16	90-99 168th St	196,633	424	8386	8.1%	9.7	164.8
Q19	25503 Union Tpke	271,002	599	5272	5.1%	9.9	105.6
Q17	Springfield Blvd and 122nd Ave	92,909	199	5607	5.4%	8.8	99.4
Q15	25421 Nassau Blvd	59,088	85	4799	4.6%	9.2	89.7
Q14	4214 235th St	55,051	85	4290	4.1%	7.9	69.0
Q20	2002 Mott Ave	182,150	392	2496	2.4%	10.1	51.0
Q10	108-10 N Conduit Ave	1,042,715	2238	4407	4.3%	5.5	49.4
Q9	80-25 126th Street	88,240	167	4707	4.6%	4.0	38.6
Q7	212-15 26 Ave	263,819	591	2947	2.9%	3.9	23.3
Q5*	138th st and 39th av	312,132	673	3074	3.0%	3.4	20.9
Q8	7201 Kissena Blvd	144,462	251	2745	2.7%	2.4	13.1
Q4	13415 20th Ave	843,676	1935	2239	2.2%	2.7	12.3
Q3	6626 Metropolitan Ave	808,849	1866	1262	1.2%	1.9	4.8
Q21	11301 Beach Channel Dr	323,268	696	272	0.3%	4.3	2.4
Q12	230-1 Northern Blvd	201,693	428	399	0.4%	1.8	1.5
Q11	217-1 41st Ave	108,639	221	224	0.2%	1.7	0.8
Q2	4540 Court Sq	43,658	83	215	0.2%	1.7	0.7
Q1	45-10 48th St	1,108,990	2483	50	0.0%	1.2	0.1
Q13	6015 Little Neck Pkwy	42,157	64	82	0.1%	0.7	0.1

Figure 19: Top 5 candidates for Queens according to each performance measure



5.4. Evaluation of additional sites

This subsection discusses the economic analysis of two additional sites. R14 corresponds to the Orthodox and Catholic churches located near the intersection of Richmond Ave and Victory Blvd. Given how close they are these sites can be considered as one location. The second site, R15, is the synagogue at Arthur Kill Rd and Arden Ave. A third location, the Showcase at West Shore Expy and Victory Blvd, corresponds to R4 in the original set of candidates on Staten Island. The set of candidates on Staten Island can be seen in Figure 20 where the new candidates are highlighted. The new candidates were evaluated under the same methodology delivered on this report. Table 27 shows the results of the evaluation.

Figure 20: New candidates in Staten Island

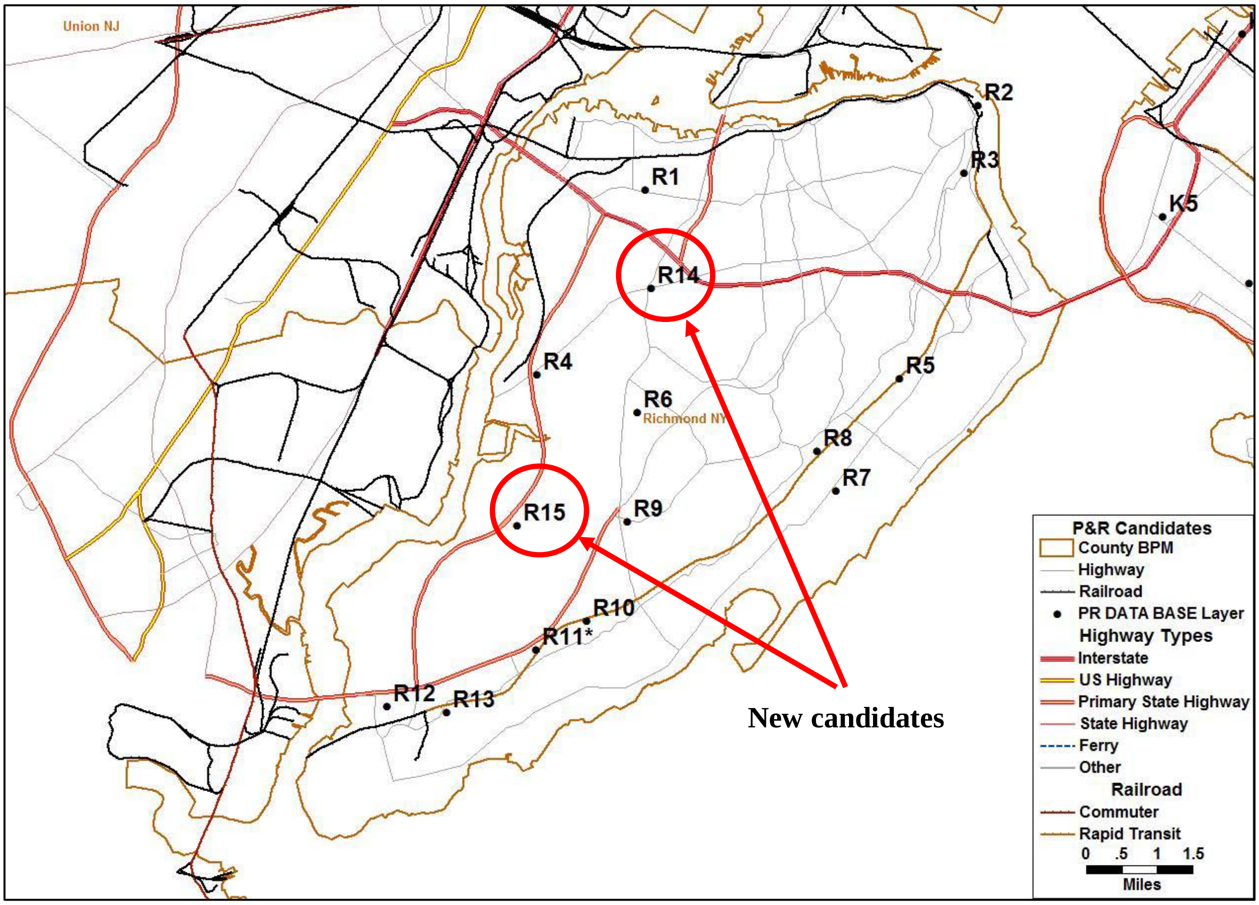
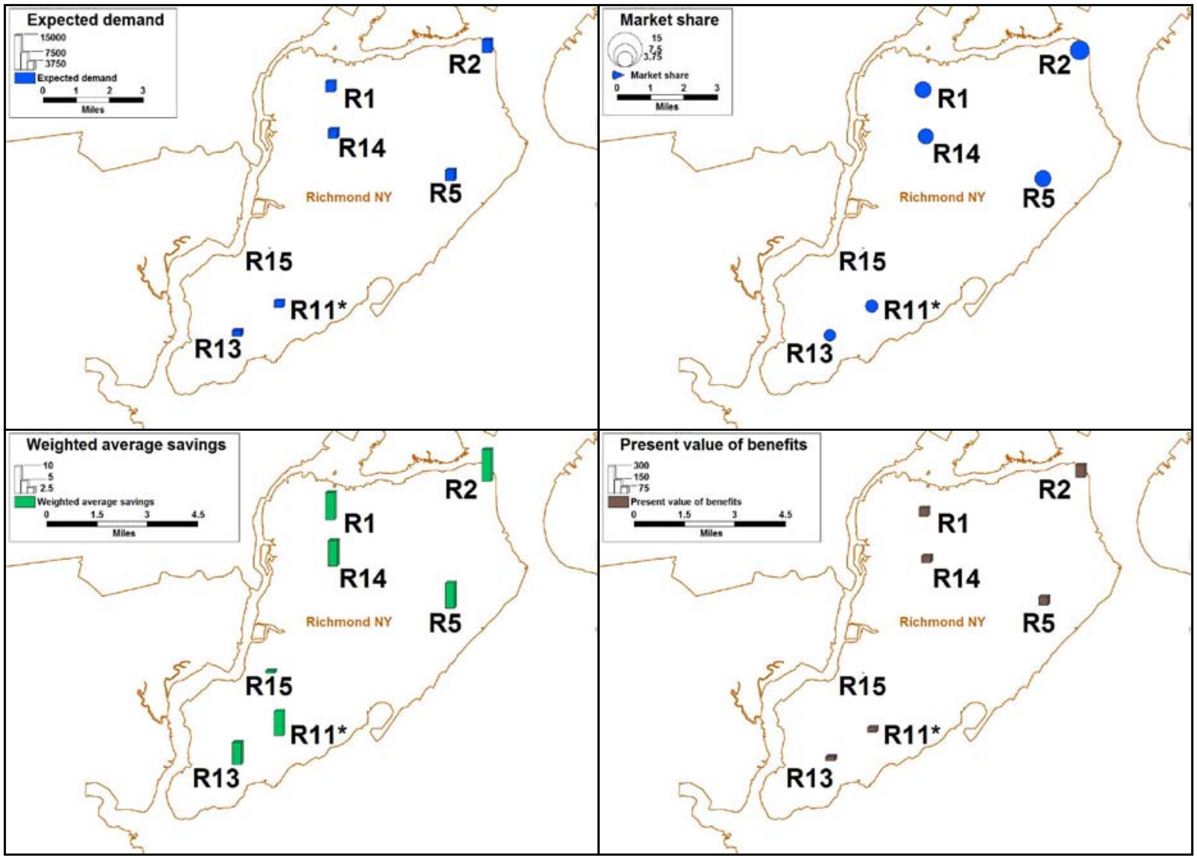


Table 27: Evaluation results for new candidates in Staten Island

ID	Address	Centroid	Expected demand (users)	Market share (%)	Weighted average savings ($)	Present Value of Benefits
R14	Richmond Ave. and Victory Blvd	1579	3993	3.9%	9.3	75.5
R15	Arthur Kill Road and Arden Ave	1615	1	0.0%	0.9	0.0

Figure 21 shows the best five candidates of Staten Island plus the two new candidates. In terms of economic benefits R14 [Richmond Ave and Victory Blvd] is a good site to develop P&R facility. This site would produce savings of around 9 USD per commuter per day and almost four thousand users is its expected demand. In addition, this site would produce present value of savings for more than 75 millions in a 10 horizon. These results are consistent with R1 [2161 Forest Ave] which is the closest facility to this site. In contrast, R15 [Arthur Kill Road and Arden Ave] exhibits low demand, attracts savings for less than a dollar per user, and provides very low present value of benefits. In light of the results R15 can be discarded as a possible place to locate a P&R facility.

Figure 21: Evaluation results for Staten Island



5.5. South Shore Atlantic Express AE7 bus line

On December 31st 2010 and after 20 years of operation the Atlantic Express AE7 bus service was cancelled. Authorities blamed demand level, estimated on 175 passengers a day in each direction, as the major issue to operate the service. Originally AE7 ridership was approximately 600 users a day per direction. The AE7 was the only bus that served the P&R near the Outerbridge Crossing.

Figure 22 shows the location of Outerbridge Crossing in Staten Island and the closest P&R site considered in the set of candidates on this report. The estimated demand of this candidate (Table 25) is 111 users per day in morning peak hour and can be used as a proxy for the demand that the actual AE7 bus stop would have expected. Despite how accurate the demand estimation is, this evaluation shows the application of the methodology developed in this paper to a real case. Moreover, having this evaluation before the implementation of the facility could have been a useful tool to determine the success of the implementation.

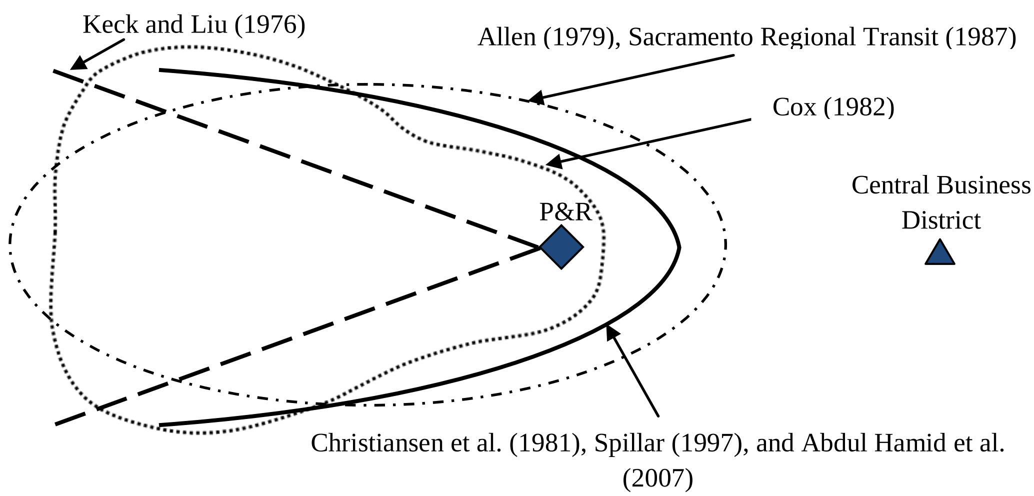
Figure 22: Outerbridge Crossing location in Staten Island

6. CATCHMENT AREA APPROXIMATION

6.1. Background and past research

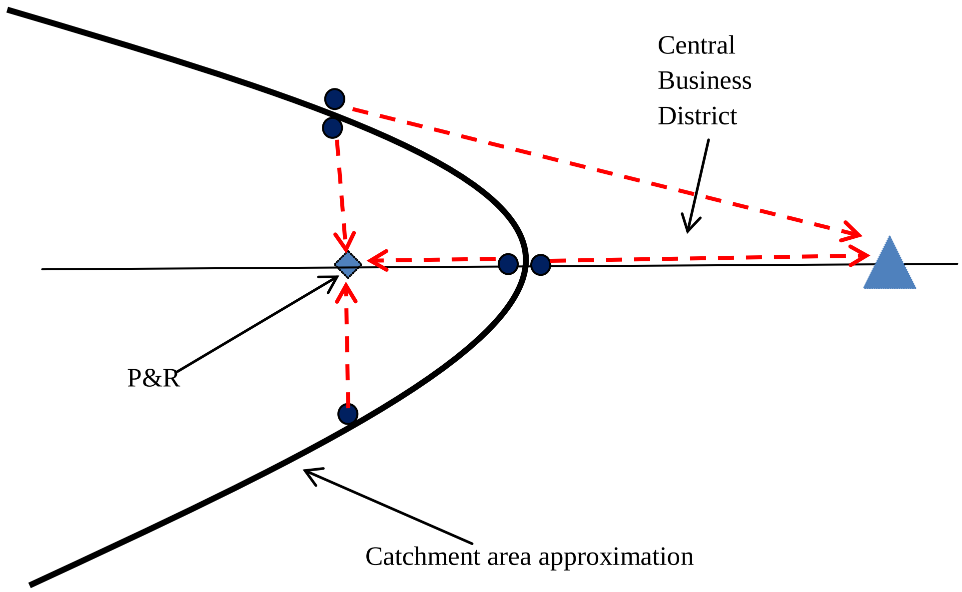
The determination of the catchment area is a common procedure for assessing the potential demand for a P&R facility. Unfortunately, the literature reveals a disparate set of catchment area determination methods. Figure 23 shows a P&R facility, the Central Business District (CBD), and the respective catchment areas described in the literature by various authors. Researchers have considered cones, parabolas, ellipses, and even pears to determine the catchment areas.

Figure 23: Catchment area determination



This chapter provides a practical and simple method to obtain an approximation of P&R's catchment area. In a related research, Holguin-Veras et al (2012) shown that the catchment area can be approximated by a parabola. The concept underlying this approximation is that commuters will use the P&R when the generalized cost —composite of all cost components of the trip such as fare, time, and parking— is lower than the generalized cost of using car to reach their final destination. As the arrows in Figure 24 show, in some cases the commuter will be willing to drive backtrack to a location further from the CBD. In other cases, the user will simply drive to the final destination if driving is less expensive than using the P&R.

Figure 24: Origins attracted by the P&R

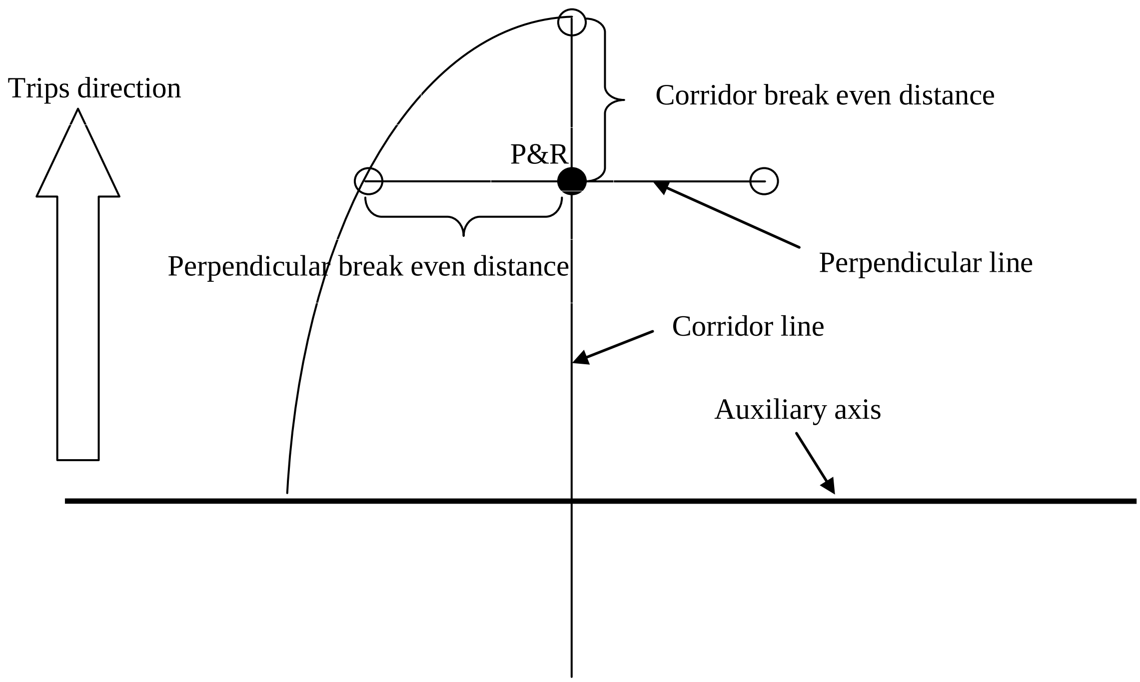


Based on this parabolic approximation, it is possible to obtain a rough idea of the area under which users will be attracted by the P&R. The concept is to delineate the parabolic shape based on two distances:

- Corridor break even distance: this is a distance along the corridor connecting the P&R and the CBD. Below this distance commuters will be willing to drive a few blocks in the opposite direction of his trip and still be better using the facility (shown in Figure 25)
- Perpendicular break even distance: similar to the previous determination but taking into account the travel of users located perpendicular to the corridor (shown in Figure 25)

In both distances, users are in the domain where they experience savings by using the P&R. From the determination of these three points —one corridor break even distance and two perpendicular break even distances— a unique parabolic shape can be drawn.

Figure 25: Schematic shape of P&R

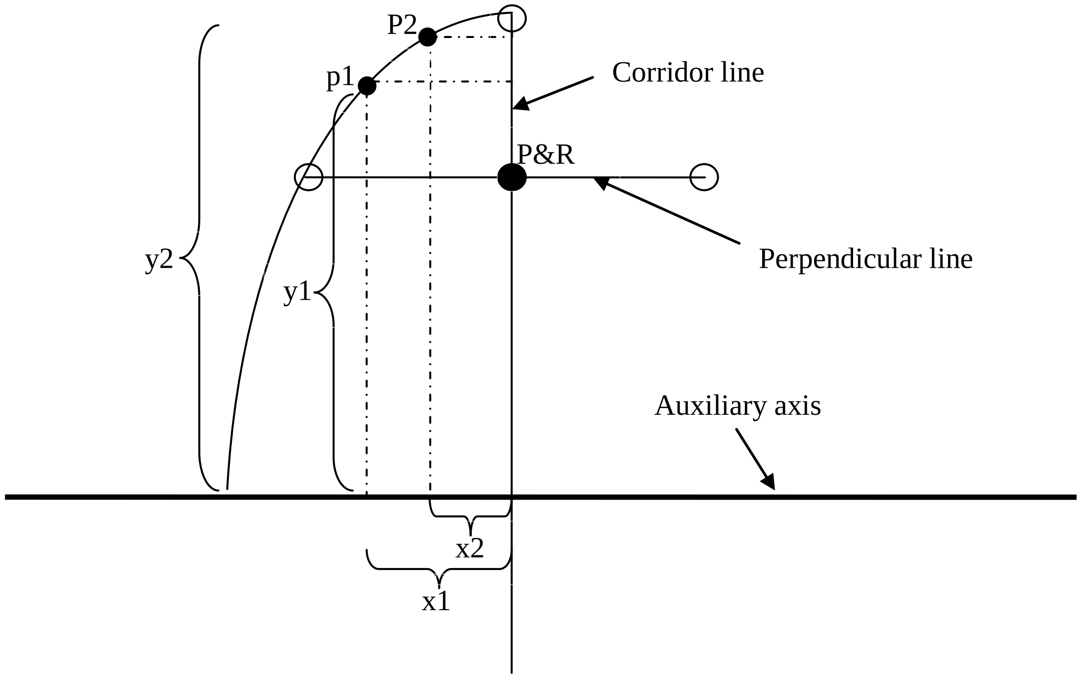


6.2. Parabolic shape drawing procedure

Since the catchment area approximation requires the determination of savings, it is necessary to obtain all components of the generalized cost described in chapter 5. These components will determine the corridor and perpendicular break even distances. Once these two points have been determined it is possible to construct a parabolic shape in the simple way explained below:

1. Draw the three points in the specific geographic locations
2. Draw both: corridor and perpendicular line to the P&R
3. Draw the auxiliary axis located three times the corridor break even distance in the opposite direction
4. Finally the parabolic shape is given by the points in which the sum of the distance to the corridor plus the distance to the auxiliary axis is the same. Figure 26 shows two of these points: p1 and p2. In this example if x1+y1 is called d, then x2+y2=d as well.

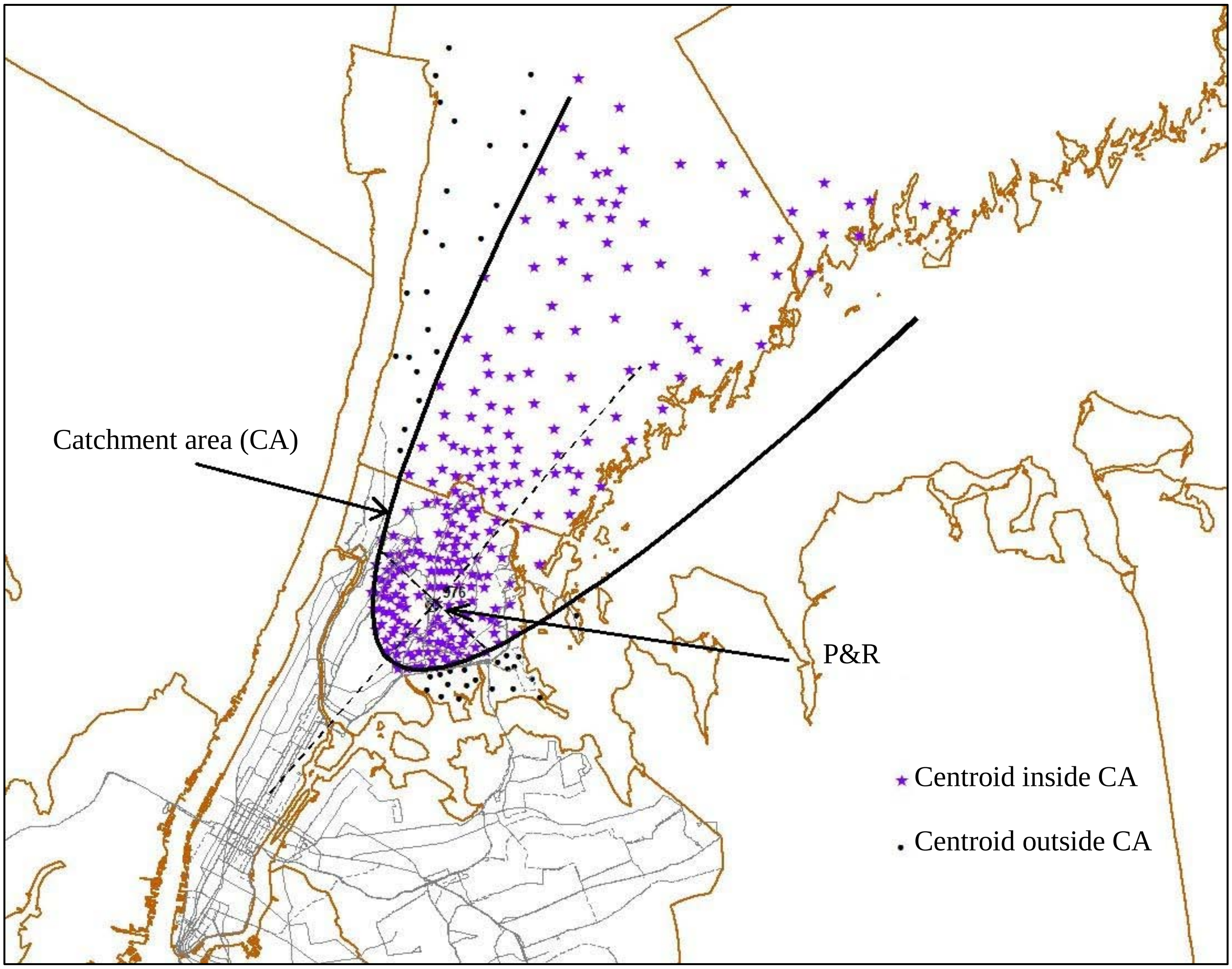
Figure 26: Parabolic shape drawing procedure



6.3. Example

Figure 27 provides the application of the methodology to a real case. The research team first determined all origins which can potentially benefit from the use of the P&R facility. The team used the procedure described previously to draw the hypothetical catchment area. The black dots and the stars are the complete set of origins obtaining savings from the use of the facility. The stars are the origins included in the catchment area approximation.

Figure 27: Catchment area determination



7. NEW YORK CITY SHARED USE P&R PROGRAM (CONCEPT PLAN)

This report demonstrates that there are high levels of user benefits associated with the introduction of P&R sites in the outer boroughs and inner suburbs of New York City. Traditional methods of increasing the supply of P&R sites through the development of purpose-built P&R lots is very costly, takes considerable development time and is subject to forecasting risk.

The team proposes the introduction of a program of regulated, branded shared-use P&R facilities in the outer boroughs and inner suburbs which could be introduced at low cost in a short period of time.

The fundamental program concept would be as follows:

1. The DOT (or other program sponsor) would develop a marketing plan to increase the number of P&R sites in the metropolitan area. This would include establishment of a brand identity, website information, trailblazer signs and integration with other traveler information sources such as 511. The sponsor would also establish minimum design, and operating standards for shared use lots including minimum size, safe pedestrian access, adequate lighting and emergency telephones. Maximum distance to the transit network and minimum transit service availability such as service frequency and span would also be established.
2. The DOT (or other public agency) would solicit proposals from owners of surface parking lots which are underutilized during the business day. Likely candidates would be churches, movie theaters and shopping centers. The proposals would include the location, number of parking spaces which could be dedicated to the program and a proposed fee schedule. The sponsor could require that the proposed site be in a specific neighborhood. The site would be required to be available for a term of at least two years.
3. The program sponsor would select a number of sites for inclusion in the program. This could be limited to one site per neighborhood.
4. Acceptance of the proposal by the sponsor would require an agreement with the following types of terms and conditions:
   - Sponsor is held harmless from personal and property liability.
   - Parking charges would remain at the proposal level during the term of the agreement.
   - Sponsor would maintain minimum design, maintenance and operating standards.
   - Operator would be committed to the program for a specific term, and would be entitled to change a fee (within the limits established by the sponsor).
5. Program sponsor would install trailblazing signs around the site and include the site in its promotional material including website, 511 traveler information, and the like.

Although fee collection would be the most difficult program activity to accomplish, this would be the responsibility of the operator so the sponsoring agencies do not need to worry about it. A proposal for consideration would be to install an automated pay station at each facility in which a user would pay the daily fee (in cash or credit or debit card) and receive a printed ticket to place in the vehicle windshield. In this simple scheme, there would not be the opportunity to purchase multiple day tickets nor the capability to use for tickets purchased at one facility to be used at another facility.

8. CONCLUSIONS

In spite of the development of transit systems in the city, congestion is the main issue costing millions every year to both, users and the authority. In this picture, P&R facilities offer the possibility of decreasing the level of congestion through attracting users to transit. As pointed out before, the idea of P&R facilities is simple: users driving until the parking facility where they park and reach to their final destination using any transit mode. In order to evaluate P&R systems it is important to highlight the importance of location decisions when siting P&R facilities. So far, practitioners and agencies have been mainly focused on investment and operational issues when deciding whether and where locating P&R facilities. However, it can be seen from the analyses that both questions need to be assessed considering the location of the P&R facility as a key factor when determining the success of the implementation. Benefits from P&R systems are mainly perceived in users' savings. However, the successful implementation of P&R facilities will decrease the level of congestion in New York City since all users switching from car to P&R will decrease the use of car, increase the use of transit, and save in costs.

The analyses indicate that P&R facilities could bring significant economic benefits to the New York City transportation system. On the overall, the evaluation estimated present value of benefits greater than one hundred millions for the best 8 candidates in a horizon of 10 years and 6% of discount rate. The best candidate, Q6 [13345 41 Ave], would produce 364 millions on savings, while the second and third, Q18 [Hillside Ave and 179th St] and Q16 [90-99 168th St], produce 241 and 164 million respectively. These values can be explained by a combination of large weighted average savings and expected demand. Queens and Bronx account for the majority of best candidates according to expected demand. Q6 [13345 41 Ave] and B2 [2476 Jerome Ave] account for more than ten thousand expected users, i.e. people saving money from the use of the P&R facility. The third candidate, Q18 [Hillside Ave and 179th St], account for almost ten thousand expected users. When considering weighted average savings, Staten Island and Queens account for the best 10 candidates. Q18 [Hillside Ave and 179th St] and Q6 [13345 41 Ave] exhibit weighted average savings larger than twelve dollars per user per trip. Similarly, R2 [3-11 Bank St] and R1 [2161 Forest Ave] present weighted average savings larger than 11 and 10 dollars per user per trip respectively. These results can be explained by the high cost incurred by users traveling, especially from Staten Island. Although the level of demand of facilities located in Staten Island can be lower than candidates in the Bronx, the amount of money saved per user is considerably larger.

To understand these results, it is worthy to consider the building classification for each of the top candidates. Among the top 20 candidates there are three parking public parking areas (Q6 [13345 41 Ave], Q16 [90-99 168th St], R11* [833 Huguenot Ave]), three shopping centers with parking facilities (Q15 [25421 Nassau Blvd], Q19 [25503 Union Tpke], Q20 [2002 Mott Ave]), two garages (B2 [2476 Jerome Ave] and B12 [4201 Webster Ave]), one licensed parking lot (K1* [2907 Pitkin Ave]), and one unlicensed parking lot (Q18 [Hillside Ave and 179th St]). The top 5 candidates according to expected high demand and present value of benefits are the same, however ordered differently. These include Q6 [13345 41 Ave], Q18 [Hillside Ave and 179th St], Q16 [90-99 168th St], B2 [2476 Jerome Ave], and K1* [2907 Pitkin Ave]. Looking back at each building classification, one can infer that public parking areas, unlicensed/licensed parking lots, and garages are good locations for P&R facilities.

An important consideration to fully assess P&R systems is the investment and operational costs incurred. Regarding investment, this research shows that many of the current best candidates to P&R facility are currently used as just parking facilities. Therefore, it is viable to propose arrangements between the authority and the owners of these facilities in order to provide P&R services. This idea requires a more deep elaboration in terms of legislation, requirements, and further development of the transit system and, in effect, this report delivers the basis for an intensive P&R program with the sake of proving a public policy encouraging the use of transit and a very low cost of implementation. In other words, it is not necessary to acquire the parking facilities but making binding arrangements with parking owners.

9. APPENDIX

9.1. Mathematical formulation of performance measures

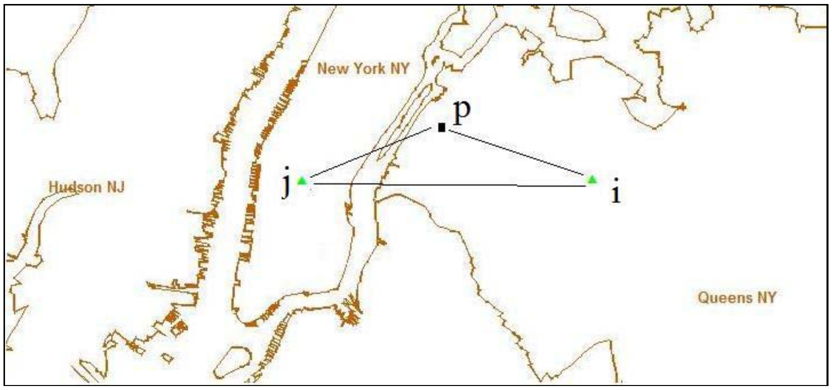
The form of the logit model is described below:

$$P_{ij} = \frac{e^{-g_{ipj}^{PR}}}{e^{-g_{ipj}^{PR}} + e^{-g_{ij}^{A}}} \qquad (1)$$

Where g_{ij}^{A} and g_{ipj}^{PR} are generalized cost of going from i to j using auto (A) and P&R (PR) respectively.

Figure 28 describes an origin (i) in Queens, a destination (j) in Manhattan, and a P&R location (p). The lines in the figure describe the two different alternatives: auto driving to Manhattan (link i, j) or driving to P&R p (link i, p) and using transit (link p, j) to complete the journey to Manhattan.

Figure 28: Park and ride methodology description



Then the generalized cost for each alternative can be written as:

$$g_{ij}^{A} = \upsilon t_{ij}^{A,IV} + f_{ij}^{A} + c^{A} d_{ij}^{A} \qquad \text{(Auto)} \qquad (2)$$

$$g_{ipj}^{PR} = \upsilon \left(t_{ip}^{A,IV} + t_{pj}^{T,IV} + t_{pj}^{T,W} \right) + f_{ip}^{A,PR} + f_{pj}^{T} + f_{P}^{PR} + c^{A} d_{ip}^{A} \qquad \text{(P\&R facility } p\text{)} \qquad (3)$$

Where:

υ = Value of time

$t_{ij}^{A,IV}$ = In-vehicle travel time by auto from i to j (similar from i to p)

$t_{pj}^{T,IV}$ = In-vehicle travel time by transit from p to j

$t_{pj}^{T,W}$ = Walking time by transit from p to j

f_{ij}^{A} = Auto out-of-pocket expenses (e.g., tolls)

f_{pj}^{T} = Transit out-of-pocket expenses (e.g., fares)

f_P^{PR} = P&R out-of-pocket expenses, e.g., parking

c^A = Auto operating cost ($/mile)

d_{ij}^A = Distance from i to j using auto (similar from i to p)

As discussed previously, the analysis is based on user benefits associated with each mode. In other words, the methodology attempts to identify markets where the generalized cost of P&R is less than the generalized cost of the driving alternative. Mathematically:

$$g_{ipj}^{PR} < g_{ij}^{A} \tag{4}$$

Therefore, for each P&R facility satisfying equation (4) it is possible to compute statistical information regarding: level of usage, mode split, savings of users and value of benefits. The following subsections describe each of these statistical indicators that can be obtained for each P&R candidate from the above methodology description.

Expected demand (ED)

Expected demand measures the number of users choosing P&R:

$$ED = \sum_{i,j} x_{ij} P_{ij} \quad \forall i, j \,/\, g_{ipj}^{PR} < g_{ij}^{A} \tag{5}$$

Where:

x_{ij} is the demand between i and j and P_{ij} is the probability described in equation (1).

Market share (MS)

Market share is the percentage of users choosing P&R and is commonly used to measure the partition of users on each transportation mode.

$$MS = \frac{ED}{\sum_{i,j} x_{ij}} \tag{6}$$

Weighted average savings (WAS)

Weighted average savings is the monetized value of savings and is given by the difference between using auto only and P&R mode for P&R users. Mathematically:

$$WAS = \frac{\sum_{i,j} x_{ij} P_{ij} \left(g_{ij}^{A} - g_{ipj}^{PR} \right)}{\sum_{i,j} x_{ij} P_{ij}} \quad \forall i, j \,/\, g_{ipj}^{PR} < g_{ij}^{A} \tag{7}$$

Present value of benefits (PVB)

Present value of benefits is a standard economic analysis method for comparing a future stream of benefits given a rate of interest. In this report each P&R candidate is a different project and, therefore, has its own present value of benefits. Mathematically:

$$PVB = \sum_{k=1...10} \frac{WA * ED}{(1+r)^k} \tag{8}$$

The assumed planning horizon considered is 10 years and the discount rate (r) is 6%.

9.2. Comprehensive literature review

PARK AND RIDE PLANNING

Several studies in park and ride facilities begin with the planning process as their first step. This process is very complex and requires several considerations. It is achieved through the integration of public agencies, the community and, sometimes, private agencies as well. The literature is presented in a manner that can help identify the different stages of the planning process and provide a better comprehension to the reader.

As a guideline for planning PR facilities, Spillar (1997), suggests a generalized park-and-ride system planning process, which highlights many of the important elements necessary for successful planning. Spillar believes that the planning process is unique to the urban area in which it is being implemented, thus the plan should be tailored to fit the local planning environment. The author sets the transit agencies as primary participant in the planning process, along with highway agencies that provide the vehicle access to each facility. These transit agencies must be able to provide service to each individual PR lot if the lot is to serve as a transfer point between auto and transit modes. Individual elements of the process should be adapted to meet the needs of the local community, transit system operator, metropolitan planning organization (MPO), and expectations of the affected jurisdiction. Although Spillar presents a common regional approach to the provision of PR facilities, he exhorts that the system plan should not be a static guideline, it must reflect inevitable evolving conditions as well as new opportunities for development over time.

Furthermore, the American Association of State Highways and Transportation Officials (2004) developed a monograph based on Spillar's manuscript, and provided several preliminary viewpoints for the planning of PR facilities. This guideline assists in the identification of site alternatives and can be used in a sketch planning process to refine the alternatives. It recommends several considerations for the facility location, as the first step of the planning process, suggesting a thorough analysis to identify the community goals with respect to the specific proposed facility as well as the universe of potential sites available. AASHTO recommends evaluation of the location of the facility based on detailed engineering studies, before any final design and construction efforts. This literature also presents some sketch planning techniques to estimate demand for park-and-ride facilities, however, this strategy does not take into account various socio-economic parameters. For a more detailed analysis, robust regional models for planning should be developed. The sketch planning techniques provide the only practical way for developing more rigorous estimates of the potential facility demand when it comes to smaller to midsize regions.

There are socio-economic and spatial factors that affect the use of PR facilities, Abdul, Mohamad and Rehan (2004), refer to the factors in a review related to the study of park and ride impacts. They focus on the understanding of the current behavior of the users and the characteristics relating to the use of the facility, considering that this will affect demand and ridership. This paper presents a brief theoretical review on the socio-economic and spatial characteristics of park-and-ride users. It highlights key findings that correlate gender, age, and income category and vehicle ownerships with the use of the facility.

The material presented by the Transportation Research Board Executive Committee (2004) gives great insight in travel demand and related aspects of providing and supporting park-and-ride and park-and-pool facilities. It offers an overview of types and objectives of PR facilities, and some analytical considerations describing the limitations of the available research and the constraints associated with the use of the data. The material reviews the underlying traveler response factors influencing choice of park-and-ride or park-and-pool as a travel mode, and the selection of which park-and-ride/pool facility to use, leading to a better siting of facilities and improved estimates of usage and demand. In summary, this literature presents a compilation of available information on park-and-ride lots and usage, and on traveler response to transportation system changes.

Lam et al (2001), approach problems, of demand growth, surging in China through Park-and-Ride facilities. They present initiatives such as park-and-ride schemes to assist transport networks to operate more efficiently. The schemes are assessed to include the facilities in the transit system. As a result of a comprehensive survey conducted on a trial park-and-ride facility in Hong Kong, lessons were learnt for the implementation of future facilities. For development of park-and-ride facilities in the new territories (i.e., outlying suburban areas), the study recommends that they be located close to both middle-income car-owning families and major public-transport centers. The paper also promotes undertaking further publicity and promotion when future facilities are introduced. Models developed as part of the analysis may also be used for analytical purposes and, with further refinement, to predict the potential performance of future park-and-ride schemes. These guidelines may also educate traffic engineers when analyzing other cities that are experiencing a similar growth and dispersal of demands on the road transport network.

Li et al (2006), implements previous work in China by proposing a network equilibrium formulation for modeling the PR services in a multimodal transportation network with elastic demand. The study assumes that commuters can complete their journeys by three options: using auto mode, walk-metro mode or an interface combined with park-and-ride facilities. The proposed model simultaneously considers commuters travel choices on travel mode, route/path and transfer point, as well as their parking choice behavior. The effects of elastic travel demand, together with passengers discomfort in metro vehicles, are explicitly incorporated. Finally, the study shows that the proposed solution algorithm could effectively solve the multimodal network equilibrium problem. The parking charge and the number of parking spaces supplied at the park-and-ride site and in the CBD area significantly influence the commuter’s behavior and the networks performance in terms of total realized travel demand and social welfare gain. Specifically, findings demonstrate that the introduction of the park-and-ride schemes could lead to a positive, neutral or even negative social welfare gain, which is related to the capital budget for constructing the facility; this is done without getting into specific details of the costs of each facility.

Therefore, the authorities should take careful actions to avoid the occurrences of the neutral and negative social welfare gains when designing the park-and-ride schemes.

Past research has identified many criteria that are relevant to identify optimal PR locations. However, although one criterion may carry more or less significance than another, they have always been considered on an equal scale. Faghri et al (2002), proposed a system to use the existing knowledge and experience to aid planners in deciding the optimum location of a PR facility. In this project, a hybrid knowledge-based expert system/geographic information system tool was developed to help determine the optimal location for this facilities. The study assembled a comprehensive list of all criteria necessary for an optimal location; it also created weighted relationships for these criteria that accurately reflect their significance. This was done through the development of a knowledge-based expert GIS system that uses these criteria relationships to select the optimal location for a park-and-ride facility given a set of potential sites.

Farhan and Murray (2005), study a GIS-based approach for delineating market areas for Park-and-Ride facilities. A market area, also known as a study, service, catchment or commuter shed area, is the geographic area from which users of a park-and-ride facility are likely to come. The approach simultaneously accounts for park-and-ride facility accessibility and user travel direction. They show that the developed approach performs better than existing approaches, in the same way; they help explain the spatial and socioeconomic characteristics of potential users in the market area as well as their associated travel characteristics. The authors believe that a visual comparison among the resultant market areas shows that the accessibility and travel direction approach is more realistic than the other approaches. They confirm this by a quantitative comparison using regression analysis. This information can then be used, for example, to predict potential demand for park-and-ride facilities and to better systems planning and integration.

Along similar lines, Celsor and Millard-Ball (2007), also work with a GIS-based analysis of thirteen US regions. They found that neighborhood and transportation characteristics are more important indicators for car-sharing success than individual demographics of car-sharing members. The study indicates that vehicle ownership has the strongest, most consistent correlation to the amount of car-sharing service in a neighborhood; this can help assess the economic viability of car-sharing in urban neighborhoods. By analyzing the neighborhood characteristics of existing car-sharing locations, it can help to assess the market potential for car-sharing in different neighborhoods, so that current or would-be car-sharing operators, transit agencies, or other partner organizations can use this as one factor in determining whether car-sharing is likely to flourish in the neighborhood.

Lin and Long (2006) presented a statistical clustering approach coupled with GIS spatial analysis to characterize neighborhood lifestyles using sixty-four features extracted from the Census Transportation Planning Package (CTPP) 2000 data. The resulting ten clusters reveal different neighborhood lifestyles in terms of individual or household socio-economics, demographics, and land use. The empirical findings have further demonstrated five factors influencing household travel: socio-economic status such as, residential location and neighborhood type, household size, activity type, and race and ethnicity. This study has important implications to the travel demand modeling and transportation planning community. Statistical classification coupled with GIS spatial tools provides the means to associate a household with its neighborhood environment. This classification improves the modeling approach and the travel demand prediction capability for future studies.

Wang et al (2004), developed a paper that investigates the optimal location and pricing of a PR facility in a linear city. In contrast to the recent literature, the presented study takes an optimization approach. To enhance analytical tractability and facilitate understanding, a simple model is adopted. Deterministic mode-choice equilibria are solved before and after the park-and-ride facility is introduced. The main objective of the paper is to provide fresh insights into the economics of PR facilities and to identify the importance of factors that have largely escaped notice in previous literature. It is hoped that this will provide useful input to the development, or refinement, of more detailed operational models, and at the same time, provide better insight into creating the demand estimation model.

Horner and Groves (2006), approach the facility location problem for identifying network flow-based models for the placement of rail park-and-ride. From this perspective, optimal placement occurs at locations where vehicles will encounter facilities early during their journeys to a centralized area or major activity center. Locating park-and-rides in this fashion maximizes the chances of removing users from the network. Two model enhancements were also explored that represent route designs with relevance to the rail planning process. In sum, the results and experience with flow-based approaches illustrate their utility in establishing candidate locations for park-and-ride facilities.

Research developed by Farhan and Murray (2006), proposes an optimization model to work with factors related to the location of park-and-ride facilities simultaneously. The paper develops a multi-objective spatial optimization model to account for park-and-ride application specific objectives. The objectives are competing and/or conflicting, but are integrated into one model. In addition, the developed model addresses issues of broad importance in location analysis in general, such as distance decay and coverage standards. One of the features of the developed model is that it can be used for siting PR facilities in the context of an existing system. This is essential for examining a spectrum of cases between the two extremes of siting PR facilities irrespective of the existing system and siting new facilities while maintaining all existing ones.

Park-and-Ride facilities require significant investment from public agencies, one of the options for reducing this investment is the possibility of a shared facility, and public/private partnerships. Benefits of shared use park and ride facilities located at commercial retail centers have not been widely documented. Wambalaba et al (2004) presented a research study in which he analyzes the impacts of the presence of a “Shared Use Park & Ride”, whether it has influence on shopping behavior patterns, whether it generates revenues for park and ride providers, and whether it generates ridership for transit service providers. The findings were broken down into three major categories: travel characteristics, spending patterns and user benefits. Implications of these research findings indicate that shopping centers might benefit if they are willing to allow their properties to be used for shared use park and ride, this will create a friendly environment in the planning process toward the usage of this methodology when facility location is studied.

Bourey et al (2000) embarked on a park-and-ride lot site selection study to identify a regional system of park-and-ride lots to support carpooling, van-pooling and the regional express bus system. The specific objectives of the study were to identify ten sites for near-term development and ten sites for long-term lots along new freeways in order to preserve right-of-way for their future development. In addition to the identification of specific sites for near-term and long-term development, this project included development of a management and operations plan for the system of PR lots, and priority programming and implementation strategies for the recommended sites. The recommended locations were identified, analyzed and ranked using an interactive agency and public involvement process, these sites were identified for budgeting and programming purposes only, so final review of environmental issues and community concerns had to be done. This study could serve as a review in the facility location process.

A study made in the United Kingdom, Parkhurst (2000), considered the traffic implications of the behavioral responses of travelers to short-range bus-based park and ride opportunities. The paper offers a new approach to the appraisal of park and ride as a traffic-reduction measure, separating the analysis into urban and rural components. The urban area analysis considers the net result of intercepting cars on the edge of urban areas and running additional dedicated bus services from the car parks. The analysis of the extra-urban effects of park and ride considers three sources of traffic increase: motorists that are intercepted detouring to reach sites, users switching from public transport services and motorists making additional trips. It is concluded that the main effect of the schemes is traffic redistribution, and that their role within traffic restraint policies is unlikely to be directly one of traffic reduction.

A study in San Francisco, Shirgaokar and Deakin (2004), made an overview on the operating conditions of PR facilities in the bay area. This large scale analysis was developed using three methods. First, an occupancy and site survey was conducted at all park and ride facilities in the region. Second, user surveys were carried out at 35 park and ride facilities. Finally, focus groups were conducted, at which park and ride issues raised by the site surveys and user surveys were explored in depth. The surveys showed that park and ride users are almost entirely commuters who work full time and use the same park and ride lot four or more days a week. It also showed that demographically, park and ride users are fairly typical of the region's workforce. Their incomes are highly varied, however, and differ substantially by location and commute mode. The findings of this study provided many insights not only into ways to improve the park and ride lots and the services offered there, but also on how travelers view transit and carpooling options from these lots. This information will provide a sound basis for planning improvements in park and ride lots and transit services. The surveys and procedures can be repeated to develop a more efficient planning approach for these facilities.

The demand estimation is one of the most important tasks in the planning of Park-and-Ride facilities; however, little attention has been paid to modeling the park-and-ride trips. Lam et al (2007) stated that previous studies have significant limitations, thus they propose an equivalent variational inequality problem for modeling the PR trips in a bimodal transport system with elastic demand. In the model proposed in this paper, the transport system is partitioned into auto and transit sub-networks by using the super-network approach. The proposed model considers the congestion interaction between different modes throughout the whole network. Commuters can complete their journeys by pure auto mode or the park-and-ride mode. The paper shows that traditional parking/park-and-ride models may overestimate or underestimate travel demand distribution over network, it also illustrates that parking/park-and-ride, transit scheduling, and carpooling schemes bring significant impacts on commuters travel behavior and network performance.

Early findings in the Bay Area, study by Rodier et al (2004), shows that advance smart parking technologies could increase effective parking capacity at a transit station. Smart parking management systems that provide real-time information to motorists about the number of available parking spaces in park-and-ride lots, the departure time of the next train, and downstream roadway traffic conditions (e.g., accidents and delays), have shown potential effectiveness for increasing ridership in a user-oriented interface. Commuter surveys at the Rockridge BART station were implemented to better understand rider attributes and the potential travel effects of a smart parking service. The study illustrates commuter patterns, as well, as demographic profiles after the use of this type of technology. This can help understand different behavioral patterns at the planning stage, and at the same time, analyze if a future facility is suited for the implementation of this system.

Although, not directly related to park-and-ride facilities, Guan et al (2005) study the modeling parking behavior. The study investigates the parking behavior at one of the busiest commercial centers in Beijing, China. The result of the survey shows that there is an unbalanced utilization of parking facilities between on-ground parking lot and underground parking garage. Generally, parking patrons prefer the on-ground parking sites. There are different patterns in parking purpose, parking time, and vehicle ownership distribution (private vs. none-private) between weekdays and weekend. The findings are not directly related with park-and-ride facilities; however, they give an overview on some aspects that may be considered when modeling the behavior of users of park-and-ride facilities.

Results from a study in the Netherlands, Bos et al (2005), demonstrated some immediate relevance for applied transportation planning practice. In practice, professionals often have to assess the feasibility of new park and ride facilities or assess the relative importance of various design attributes. The debate in such situations often focuses on the question whether such decisions could be based on general findings in the literature, or whether tailored-made additional research is required in the city of interest. This study provides some evidence that preferences for park and ride facilities can be generalized (at least within a single, small country with no extreme variation in spatial, urban or traffic conditions). Hence, additional research into the feasibility of new park and ride facilities, involving original data collection, may not be required unless on has reason to believe that there is a fundamental difference in the selection of the region.

SUMMARY

The planning process of a PR facility must be initialized with a series of public notifications, in a way that the community is integrated from the beginning; this will reduce the obstacles that appear throughout the development of the project. The team should begin with the existing inventory of park-and-ride and a study of the real and latent demand. This will reveal the current status of the system (flow characteristics, capacity and performance of existing P&R facilities, transit networks) and would be very helpful to identify the purpose and needs and develop a set of goals and objective for future planning. After creating the objectives, we can evaluate the specific issues of future planning and develop a network plan considering any possible alternatives. Finally, after a thorough understanding of community goals we can implement the plan and document it.

The planning process constitutes two important tasks, facility location and demand estimation, this, along with the facility configuration, will set the foundations on which the project will be built. The demand estimation will be performed first to analyze on which extend does this affect the size of the facility. Later, we can compare the different locations for each facility, to optimize the allocation of resources. Depending on the demand forecasts we could first evaluate the creation of a potential PR facility or the improvement of an existing one.

The literature has shown that several models for the demand estimation process are proposed. The team will identify different factors including correlations among parameters and this will be integrated into the modeling process. The goal is to develop specific models for the NYC area considering the ground realities and practical considerations that aid or hamper their implementation. Previous studies show that socio-economic, neighborhood type, household characteristics, and others, characterize the choice of travel made by the users. This experience will enable the team to create a demand forecasting model that considers the most suitable factors for the area under study.

Although the demand is one of the most important parameters to consider, the location of the facility will depend of many competing interests, as well, as community goals. The integration of the community is a key impact, since it has shown to be one of the most influential parameters when identifying the location for potential PR facilities. A thorough analysis that considers environmental impacts, site availability, financial risks, corridor adjacency, multimodal connections and community objectives, will produce a plan which best response to the systems current needs. Alternative possibilities, such as lot-sharing, land value, and depreciation factors should be considered at the moment of the decision. A thorough study should be made, to help identify the area's needs and the community current goals. This will optimize the placement of the location, avoiding poor use of the future facilities.

DESIGN OF PARK AND RIDE FACILITIES

After reviewing the literature, a brief review of the park-and-ride design literature is presented below.

Early work from the American Association of State Highways and Transportation Officials (1991) shows a detailed analysis of traffic design for PR facilities. This material reviews many traffic considerations for the coordination of traffic near the PR facilities, concentrating on traffic control devices, signals and signs, as well as, bus turnouts and stops. Later on, it presents empirical knowledge of physical design for internal/external circulation, pedestrian movements, parking layout and pavement characteristics. Finally, lighting and security considerations are mentioned and environmental concerns are considered as guidelines for future work.

The American Association of State Highways and Transportation Officials (2004), presents the most complete guide on design parameters. This material presents a full design guide that considers the various accesses and service modes associated with a park-and-ride facility, including on-site and off-site pedestrian and bicycle movements, placing these concerns and design requirements at the top of the design priority list. The reference presents an extended list of issues, such as functionality, community integrated design, pedestrian and bicyclist design, accessibility requirements, automobiles and transit vehicle requirements, and security and landscape considerations. Considering all of these factors in the design process can produce an architectural superior facility as well as a superior design, resulting in reduced maintenance requirements, lower operating costs, and manageable security risks.

Furthermore, Spillar (1997), adds-on to the AASHTO criteria for PR facility design with art and landscape considerations. He remarks the importance of integrating the design with the visual environment to reduce the impact of the facility in the community. This monograph shows that art and architectural treatments can be introduced at all levels of transit investment, whether it is a simple bus shelter, a major transit center or intermodal facility. These artistic considerations can make the transit facility more appealing to the surrounding neighborhood as to the potential users. Spillar emphasizes on the integration of art professionals in the project team, he suggests that this considerations should be taken from the beginning of the preliminary design, and follow to the conclusion of the project.

In Shank (2001), the author discusses the commuter rail stations in the New York City metropolitan area to help determine the role of parking lot design, and regulation in encouraging or discouraging the use of kiss and ride as a station access mode. Stations on Metro-North Railroad and Long Island Rail Road are examined in terms of access and parking statistics, and through site visits. Demographic characteristics of the areas surrounding the stations are also considered. The findings of this study talk about how the station and parking lot design might have an effect on the number of passengers who access these stations by kiss and ride. Furthermore, it gave several recommendations on approaches for the design, such as short-term parking, curbside drops off space, among others. Finally, he mentions some aspects that might influence the usage of the PR facilities.

The inclusion of technology is an important factor in the design of park-and-ride facilities; Lai and Shalabay (2007) present a microscopic park-and-ride simulation model using the Cellular Automata approach. Review of parking lot simulation models in the past are performed and their limitations are identified and addressed in the paper. The park-and-ride model is a discrete time and space model composed of five fundamental components that operate in each time step. These components together simulate a variety of driver actions such as surveying of environment, making parking choice decisions, steering and controlling of vehicles. The purpose of the study is to replicate realistically parking trends at park-and-ride facilities using a simulation approach and to provide a means to evaluate different park-and-ride lot designs. Using the concept of dynamic utility model and cellular automata, the developed model addresses the limitations experienced by previous parking lot simulation models.

A feasibility study of a parking information system in NYC, Teng et al (2001), showed how one could provide real-time parking information to motorists. The study presented an approach that reflected the tradeoff between the information needs for a web site and roadside displays and the costs for establishing a system that consists of these two technologies. A system that provides real-time information about parking is called a parking information system. This system can be an effective way to reduce parking search by providing drivers with information on parking availability in real-time. The study also showed an estimated of the costs for the system implementation in the NYC area. This study shows the impact of a parking information system when integrated into parking management and facility design.

SUMMARY

We believe that the integration of the community, as well as the demand estimated plays an important role in the design considerations. A design that achieves to provide the maximum possible capacity that satisfies the demand and, at the same time, follows the community goals will be a superior design. This could be met through continuous communication with community leaders with the project team, in a way that they can follow up with the projects development from the beginning. This can also help gain the community support and at the same time promote the usage of the facility.

The design process has to consider the usage of Intelligent Transportation System deployment. Smart parking, sensor implementation, among others, could help augment the capacity and mobility of the transportation facility. The PR design should be adaptable for future ITS deployment, if not implemented from the beginning; this is to consider the growth of ITS development and to promote an innovative design.

The proper design of the transit facility will determine whether the community will embrace this facility as a new mode of transportation. As mentioned earlier, a design that uses artistic techniques and integrates different considerations will promote a good and safe environment. These concepts will also need to use lighting and security measures so that the users feel safe during the daily commutes.

A design that satisfies the needs of pedestrians, cyclists and drivers, and achieves to coordinate transit around them will be an optimal one. This characteristic, along with the promotion of a secure and friendly environment will produced an ultimately superior park and ride facility.

PARK AND RIDE OPERATIONS

Operations of the park and ride facilities have a very important role in effectively utilizing park and ride facilities. Many operation aspects have been reviewed in this section. They are access management, priority treatment, signage, traveler information, fare payment and some other operational conditions such as facility sharing, kiss and ride.

Access management

Access management concerns with trade-off between reasonable access to street/highway and operation in a safe and efficient manner. This was mentioned particularly by AASHTO (2004). In that material, AASHTO recommend the policy technique and design/operation technique for vehicle access to park and ride facilities. The policy technique concerns with 1) the establishment of comprehensive access code, 2) the institutionalization of advance purchase of right of way and 3) requirement of internal circulation/site plan review. The design/operation technique concerns with 1) criteria for unsignalized access, 2) corner clearance, 3) traversable and non-traversable median, 4) driveway intersection. The website *Access Management* by TRB committee AHB70 suggested the ten principles of access management. They regard design and operation features such as frontage roads, median opening, auxiliary lanes, or channelization, in order to manage access and vehicle turning movements. The median handbook interim version (2006) by Florida department of transportation described the best ways to plan for medians and median openings. In term of access management, they implemented median management to improve the traffic operations and increase highway safety. This document includes roadway functional classification, median open placement principles and other related elements. There are also some state websites about access management materials from across the country as in *Website on access management from State Department of Transportation.*

Priority treatments

Priority treatments consider the operation of vehicles, especially transit or HOV vehicles, when entering and exiting park and ride lots as well as along the entire trip route. ASSHTO (2004) outlined 1) freeway on-ramp metering of SOVs along with an on-ramp bypass lane for transit vehicles or HOVs, 2) signal priority operation on surface streets for transit vehicles and 3) queue bypass lane on surface streets for transit vehicles. Todd, et al (2006) suggested using the Intelligent Bus Priority lanes for bus routes with large headways on major urban and suburban multi-lane arterial roads. The intelligent bus priority lanes are the lanes with intermittent priorities, variable message signs and traffic signal priority. They also use automatic vehicle location and in-pavement lights to yield right-of-way to the buses. It contributes to travel time decrease and reliability enhancement. Li, et al (2008) provided guidance on the infrastructure required for each signal control and prioritization scenario, in order to support the implementation of various types of transit signal priority (TSP) in different transit operating environments and policies. The TSP technology includes transit vehicle detection, traffic signal hardware and software, communication technology, automatic vehicle location system and transit management centers. And the TSP implementation could be centralized TSP, decentralized TSP or adaptive TSP. The evaluation of TSP performance showed significant reduction in transit travel time. Stewart and Corby (2006) described the conditional active transit priority as the sophisticated transit system priority. They also valued the cooperation between the transit agency and the traffic agency for successful transit system priority implementation. Furthermore, Meek, et al (2007), synthesized experiences from the UK with the last 40 years with transit policymakers. They emphasized the use of dedicated buses, which help to attract motorists because of the reliability and time savings of journeys.

Signage

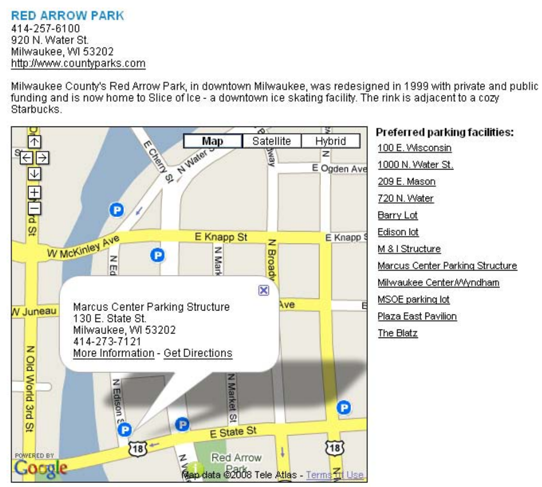
Park and ride signs should be the trailblazers for drivers to use other facilities. Therefore, where and how the transit signs should be installed need considering. ASSHTO (2004) emphasized that park and ride signs must be designed in accordance with manual on uniform traffic control devices (MUTCD) by Federal Highway Administration (2003) as well as criteria and policies of each state. TCRP-Report 12 (1996) also offers detailed guidance for signage. ASSHTO mentioned only static signs while there are also other types of changeable message signs (CMS) or variable message signs produced. NCHRP (2008) synthesized information on the various CMS types in use. They based on the information from an extensive literature review and a survey of state DOT traffic management centers (TMCs) and in agencies that operate toll roads. CMS are different for different states and producers, but they have the same purposes of attracting drivers' attention and providing information. Thus they should be efficient in design.

Traveler information

Traveler information is to help drivers making decisions on parking prior to or during a trip. It involves three main categories: 1) Pre-trip parking, 2) Reservation system, and 3) Parking guidance system.

a) Pre-trip parking

Pre-trip parking is the system that provides travelers the parking information before they get close to parking lots. ASSHTO (2004) contained general ideas about 1) pre-trip information system, 2) in-terminal and in-vehicle information system, and 3) multi-modal and personal modal information systems. However traveler information details were not included in ASSHTO (2004), rather they are elaborated on other materials. Teng, et al (2002) regarded parking information for website and parking information roadside display for New York city. They resulted that it's more expensive when providing en-route information than when giving it online. Therefore the combination of en-route and online information can reduce the cost of implementing parking information system. Sakamoto, et al (2007) reported the successful experiment in Japan by which the variety of pre-trip information are given to users. They provide road travel time; train travel time, park and ride recommendation level, parking lot availability, as well as amount of money saved and amount of CO_2 reduction. There are also many current websites which provide pre-trip information in the US and international and some systems help the users to find parking lots by cell-phone.



Pre-trip parking website
Showing the information of parking places, costs or nearby destinations
Source: http://www.parkmilwaukee.com

Pre-trip parking system using mo
Helping drivers to find available p
Source: http://www.mobileparking.c

Reservation system
Helping the travelers to reserve for parking space
Source:http://airportparkingreservations.com/

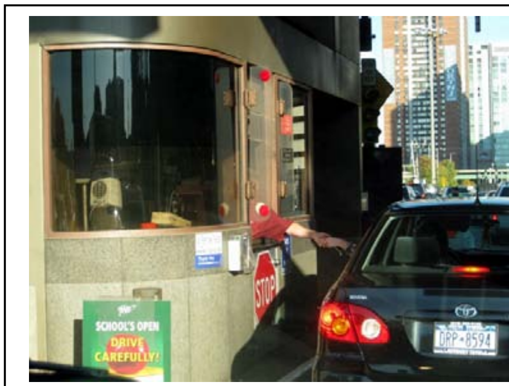
b) Reservation system

With the reservation system, drivers can reservation or even pay for the parking spaces before coming to parking lots. There are some papers and reports involved with parking reservation systems. The Federal Highway Administration (2007) mentioned online parking reservation and parking navigation systems. Drivers can pay for parking spots either online or through web-enabled cellular telephone, no sensor detector required. Mouskos, et al (2007) considered parking reservation system as a new concept of ITS to aid travelers in securing a parking space either prior to or during their trip. It's recommended for big cities to reallocate parking spaces, from overcrowded parking lots to more sparse ones. The authors mentioned the concept of dynamic parking reservation system, in which all available parking lots are assigned by individual parking demands according the demand in time, space and parking fares. In this paper, they also discussed a simulation model of that system. Moreover, Mouskos, et al (2002) formulated the stochastic parking reservation systems with fixed costs. This paper developed a universal parking reservation system. The main objective is to minimize the total travel time for all users that want to park in a specific geographical area or at various park and ride facilities within the same geographical area. Some websites specify in parking reservation, in which users can register, search and book for the reservations.

c) Parking guidance system

The Federal Highway Administration (2007) described advanced parking management system (APMS) with some other intelligent traveler information system such as lot-specific, floor-, aisle-, and space- specific parking information systems. They concluded that the application of APMS actually benefits both travelers and parking operators. Mouskos, et al (2007) had a comprehensive literature review about current detection technologies for park and ride facilities. These detectors comprise inductive loops, magnetometer sensors, video image processing, vehicle license plate recognition and radio frequency identification. The detectors seem to be the most important elements in advanced parking system. And in this paper, they suggested the suitable detectors for each function that are required by parking operators to improve parking information system. Rupert, et al (2003) evaluated findings in information content, customer needs, business/cost recovery models, technology applications, consistency and standards, and legal and policy issues of eight cities in Euro, Madrid, Barcelona, Munich, Berlin, Stockholm, Glasgow, Newcastle,

Parking guidance system
Outsite and inside building guidance system
Source: Federal Highway Administration



Traditional payment
Holland tunnel fare payment - NJ

London. They made specific recommendations for applications in the United States, such as closing the data gap in present traveler information resource, using national traveler information database, or increasing the travel/journey time information system. Shaheen, et al (2005) had a comprehensive literature review on smart parking system. They described parking guidance information system (PGI) as effective tools to minimize searching time in the city centers. With many benefits, PGI can be applied en-route to parking lots or within parking lots. In the US, Baltimore-Washington International Airport is a typical example of well applied modern PGI system. Some other articles concern with using GIS to facilitate park and ride. Of those, Farhan and Murray (2005) developed a GIS-based approach which simultaneously accounts for park and ride facility accessibility and user travel direction.

Fare payment

The traditional ways of fare payment using cash, coins with human operation is not particularly convenient to travelers. While some travelers, using smart payment, can easily get through toll station, the others can get stuck at cash payment lanes.

Many type of fare payments were mentioned by AASHTO (2004). Those are close and open system, magnetic swipe/credit cards, smart/chip cards, hybrid/combi-cards. Smart payment innovations can make efficient use of existing parking spaces, facilitate fast, convenient, and reliable reservations and parking payment.

a) Contact method:

Credit cards and debit cards are commonly used. Many cities in the US install smart electronic parking meters for using these cards. Shaheen, et al (2005) introduced smart cards that are utilized at city of Berkeley, California. Some cities make discount to travelers in order to encourage using of debit cards.

b) Contactless method:

Shaheen, et al (2005) reviewed system that used contactless cards that communicate to a card interface device (CID) via an antenna coil, developed by Lansing Community College in Michigan. And Automatic Vehicle Identification (AVI) technology tags to control cashless parking and frequent parker operations at airport parking facilities. EZ-pass is one of typical example. There are 24 agencies spread 13 states that utilize this system. Mouskos, et al (2007) regarded the parking payment guidance in which the electronic payment systems, because of their benefit, should be developed and deployed. They also show that the smart cards, with their flexibility and convenience will be the good choice for electric payment.

Contact method payment
Using credit cards or debit cards
Source: Wikipedia

c) Mobile communication devices

Jin and Guo (2006) concerned with EZ M-parking payment system. A unique number including a check digit is assigned to and painted on each parking space. Motorists only need to dial a single number to start or end their parking service. Mobile phone payment systems are widely used in some Euro countries such as England, Estonia . The m-parking system provides the travelers cell-phone payment with which they need only call or send messages to pay for parking service. The system automatically charges and reminds users for all statuses of parking. The convenience and efficiency make them potential technologies. Shaheen, et al (2005) reviewed in details some of system setup in Euro cities. With E-parking system that has been developed by a research consortium in Europe and tested in Brussels, Belgium, drivers, without ever leaving their cars, can inquire about parking availability at a given destination, reserve an available space, and pay for parking upon departure. Now there are many cities and states in the US equipped with mobile payment for parking, such as Boston, New Orleans, Miami, Winchester, Redwood, Hawaii and many others.

Other operations

Wambalaba, et al (2004) were concerned with how to share park and ride facilities with private sector. In order to efficiently utilize this idea, they suggest that some steps should be taken by service providers to ensure effective coordination with property managers, owners and developers. Schank (2002) proposed role of parking lot design and regulation in encouraging or discouraging the use of kiss and ride as a station access mode. Seik (1997), based on experience from Singapore, the country whose subway system is the most favorite mode of transportation, emphasized the necessity of the adjacency between park and ride and subway station as well as the cheaper prices for those parking spaces. There are some other experiences from Japan. Sakamoto., et al (2007) conducted a new transportation system: co-operative dynamic park and ride (CDP&R), which had many positive results. CDP&R is the system by which various train stations work in co-operation to install park and ride facilities at neighboring stations. It is the first time in Japan that roads, which follow train lines, have been concerned. From the UK, a country which has 40 years' experience of park and ride, Meek et al (2007) described that park and ride should not be viewed as a standalone measure. Rather it should be implemented as a component alongside an effective package of restraint measures on car uses. Shannon (2000) considered method of operation, cost of operation and personal management for parking facilities. He also regarded some types of management such as self-operation, lease agreement, contract agreement, concession agreement and management agreement, and considered quality of maintenance critical to the success of any parking operation. We will show some examples of park and ride facility agreements and shared-use park and ride agreements at the appendix of this literature review. Beside, Beebe et al (2000) were specifically concerned lighting, ventilation, drainage, security, and financing. Another important operation for park and ride facilities, especially for the new ones, is marketing and promotion. In park and ride strategy of South Yorkshire, UK, an objective of that project is to promote and publicize park and ride effectively. Some special actions are develop targeted marketing campaign, provide information via website, TV, posters, books and leaflets, apply attractive ticketing, and use the appropriate signage.

PARK AND RIDE MAINTENANCE

AASHTO (2004) dedicated a section related to the maintenance for park and ride facilities. Like other static facilities in transportation system, park and ride needs periodic inspection, information system, lighting, sweeping/trash picking up, snow and ice maintenance, security, and so on. Shirgaokar and Deakin (2005) concluded in the survey that drivers place a lot of importance in the quality of park and ride facilities, including security patrols, fencing, lighting, trash collection, among others. Besides, kiosks selling coffee, newspapers also would be provided. Martens and Francis (2008) proposed 10 things in need to make sure the parking facilities run smoothly and efficiently. They are: 1. Review the parking-management agreement. 2. Review the parking operator's monthly reporting package. 3. Check the entry and exit lanes. 4. Housekeeping. 5. Parking facility wash-down. 6. Lighting. 7. Water damage. 8. Internal audits. 9. Mystery shops. 10. Third-party audits. Hoffman and Staif (2000) mentioned the requirement of comprehensive and regular maintenance program to protect the investment and make the facility attractive and easy to use. They include three main components: housekeeping, equipment maintenance and maintenance of the structural system. The P&R project by Maricopa Association of Governments (2001) is concerned with the same factors but categorized them into two types for P&R maintenance. The first is routine maintenance including regular activities such as building cleaning, and grass cutting. The second is periodic maintenance addressing physical problems which occur after a period of time such as pavement resurfacing, light fixture replacement, repainting and remodeling of buildings on the site. This project also placed a lot of consideration on the cost of operation and maintenance. The trend for cities is that the bigger P&R facilities, the smaller operation and maintenance cost per space. They recommended some ways to reduce the maintenance cost such as 1) landscape maintenance and irrigation, 2) shelters, amenities, lighting, and 3) pavement. For example, the designers can select appropriate materials for ground covering, choose native or clean plants, design amenities and facilities for easy repair, and prevent large trucks to protect the pavement.

The table below summarizes the operation and maintenance costs for some P&R facilities at Phoenix, Houston, Portland and Seattle. It includes the cost landscaping, utilities, cleaning, and repairs. The different cost per space for different-sized P&R facilities is showed in table 2. Generally, the more spaces the P&R facilities have, the less cost per space is.

Annual park and ride operations and maintenance costs for selected U.S. urban areas

Lot Location/ Name	Capacity (# of Spaces)	Annual Operations/Maintenance Cost							
		Land-scaping	Utilities	Cleaning	Repairs	Supplies	Security	Total	Per Space
PHOENIX (1999)									
Dreamy Draw	230	$9,000	$7,680		$6,120 (1)		$18,240	$41,040	$178
79th Avenue	619	$14,400	$2,400		$2,400 (1)		$19,200	$38,400	$62
Total	849	$23,400	$10,080		$8,520		$37,440	$79,440	
System Avg.	425							$39,720	$93
$ Per Space		$27.52	$11.86		$10.02		$44.05	$93.45	

% of Total		29.4	12.7		10.7		47.2		
DENVER									
System Avg.	227								$88
HOUSTON (1998)									
Missouri City	779	$5,879	$5,426	$15,473	$18,026	$4,160	$22,277	$71,241	$91
Westwood	829	$10,148	$11,545	$11,061	$15,949	$4,272	$22,277	$75,252	$91
Mission Bend	872	$14,683	$18,883	$12,690	$15,949	$3,935	$14,851	$80,991	$93
Monroe	905	$10,261	$18,626	$15,473	$18,026	$3,935	$14,851	$81,172	$90
Eastex	930	$7,471	$6,023	$13,499	$15,151	$3,935	$22,277	$68,356	$74
Pinemont	957	$7,800	$9,857	$13,499	$15,151	$4,047	$22,277	$72,631	$76
West Loop	1,003	$14,568	$7,374	$14,572	$15,949	$3,935	$29,702	$86,100	$86
Kingwood	1,035	$4,139	$3,859	$11,604	$15,151	$4,047	$22,277	$61,077	$59
West Little York	1,096	$16,298	$10,841	$13,499	$15,151	$4,047	$22,277	$82,113	$75
Maxey	1,129	$5,914	$8,855	$15,473	$18,026	$4,385	$22,277	$74,930	$66
Bay Area	1,148	$5,393	$5,696	$14,924	$15,151	$3,935	$22,277	$67,376	$59
West Belt	1,175	$6,602	$7,069	$14,562	$15,949	$3,935	$14,851	$62,968	$54
Northwest	1,184	$10,208	$10,154	$11,604	$15,949	$5,284	$44,554	$97,753	$83
West Bellfort	1,214	$6,100	$15,977	$10,790	$15,949	$3,935	$29,702	$82,453	$68
Spring	1,266	$6,759	$4,480	$11,604	$15,151	$4,047	$29,702	$71,743	$57
Seton Lake	1,286	$5,404	$4,660	$11,604	$15,151	$4,047	$22,277	$63,143	$49
Kingsland	1,310	$7,234	$3,737	$14,572	$15,949	$3,935	$22,277	$67,704	$52
Alief	1,377	$4,266	$4,556	$11,061	$15,949	$3,935	$22,277	$62,044	$45
Fuqua	1,381	$16,280	$20,355	$26,566	$18,026	$2,361	$22,277	$105,865	$77
North Shepherd	1,605	$7,920	$10,799	$13,499	$15,151	$4,385	$22,277	$74,031	$46
Addicks	2,044	$10,848	$19,235	$14,572	$15,949	$4,722	$22,277	$87,603	$43
Kuykendahl	2,179	$9,250	$17,475	$14,572	$23,792	$4,722	$29,702	$99,513	$46
Total	26,704	$193,425	$225,482	$306,773	$360,645	$89,941	$519,793	$1,696,059	$64
System Avg.	1,214	$8,792	$10,249	$13,944	$16,393	$4,088	$23,627	$77,094	
$ Per Space		$7.24	$8.44	$11.49	$13.58	$3.37	$19.46	$63.59	
% of Total		11.4	13.3	18.1	21.3	5.3	30.6		
PORTLAND (1997)									
System Avg.	397								$110
$ Per Space		$33	$72	$2	$3				
% of Total		30.0	65.5	1.8	2.7				
SEATTLE (1999)									
System Avg.	298								$97

Source: MAG Park and Ride Study. Maricopa Association of Governments Phoenix, Arizona, 2001.

Table 2 - Initial estimated operations and maintenance costs for different-sized park and ride facilities

No. of Spaces at Park-and-Ride	Annual O+M Costs Per Parking Space (in 2000 $)
Less than 200 spaces	$130
200-299 spaces	$120
300-399 spaces	$110
400-499 spaces	$100
500+ spaces	$90

Source: MAG Park and Ride Study. Maricopa Association of Governments Phoenix, Arizona, 2001.

CONCLUSION

In this task, the team has reviewed many available sources related to park and ride facilities in United States, Europe and other countries in Asia. The goals were achieved, providing the team with a refinement of the study methodology and a better knowledge on what has been done in the literature. The literature focused on four steps: planning, design, operations, and maintenance, research referring to each was deeply considered. Finally, the literature provided the team with additional experience to develop the next tasks.

Furthermore, the next two tasks (task 2 and 3), will focus on the optimal location of the park and ride facilities. The team will identify parameters, such as demand and community integration, that most affect the location of park and ride facilities. Later, it will use this network to model a facility location problem that recommends the optimal placement of the park and ride facilities in the New York City area.

9.3. Samples of agreement

Sample Exclusive Park-and-Ride Facility Agreements

Source: MAG Park-and-Ride Study

METRA (CHICAGO)

AGREEMENT FOR OPERATION AND MAINTENANCE

OF COMMUTER PARKING FACILITY

THIS AGREEMENT is entered into as of this _______ day of ____________, 200__, by and between the Commuter Rail Division of the Regional Transportation Authority, a division of an Illinois municipal corporation ("Metra") and _____________________________, an Illinois municipal corporation ("Municipality"). Metra and Municipality are hereinafter sometimes individually referred to as a "Party" and jointly referred to as the "Parties".

RECITALS

A. Metra presently owns or leases the property located _________________________, identified by permanent index number(s) ____ and delineated on EXHIBIT "A" attached to and made a part of this Agreement ("Premises").

B. Metra desires to grant to Municipality the right to manage, operate and maintain a commuter parking facility on the Premises ("Parking Facility").

C. Municipality has determined that the management, operation and maintenance of the Parking Facility on the Premises is in the best interest of the public and serves a valid public purpose.

NOW, THEREFORE, for and in consideration of the foregoing Recitals, which are hereby incorporated into and made a part of this Agreement and the mutual covenants and agreements set forth herein, and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged and accepted by the Parties, Metra does hereby grant to Municipality the right to manage, operate, and maintain the Parking Facility subject to and in accordance with the following terms covenants and conditions:

1. FEE AND TERM. Municipality covenants and agrees to pay Metra the sum of Ten Dollars ($10.00) as an annual use fee for the Premises. Municipality's obligations and right to use the Premises under the terms and provisions of this Agreement shall commence on the date this Agreement is executed by all the Parties and shall continue in force and effect for a period of forty (40) years from said execution date ("Use Term") unless otherwise terminated as provided under the terms and conditions of this Agreement. Either Party may at any time terminate this Agreement by giving the other Party ninety (90) days prior written notice of its intention to so terminate.

2. PURPOSE OF USE. The Parties agree that the purpose of this Agreement is to insure that the Premises is protected, maintained and operated as a commuter parking facility with daily rates for public parking. Municipality desires to control access to said Premises and operate and maintain said Premises as a Parking Facility. Parking lot fees set and collected by Municipality shall be standardized for all patrons of the Parking Facility and Municipality shall under no circumstances discriminate against non-residents of the Municipality in setting parking fees. The Parking Facility shall be operated as a daily parking lot with spaces available on a first-come-first-serve basis. Metra reserves the right, at any time, to review and approve the amount of the parking fees charged by Municipality.

3. USE BY METRA AND PUBLIC. Metra further reserves unto itself, its successors and assigns, permittees and licensees the right to use said Premises in the general conduct of its railroad business including endeavors for the convenience of its commuters and the public. Municipality shall not interfere with or infringe upon Metra's or the public's lawful use of the said Premises so reserved. Municipality further agrees that Municipality and Municipality's employees and invitees in and about said Parking Facility shall be subject to the general rules and regulations of Metra relating to said commuter parking facilities and to Metra's railroad operations. Metra reserves the nonexclusive right to regulate and control the people who enter said Premises and their conduct and reserves the right to enter upon said Premises at any time and to eject therefrom any disorderly person or persons.

4. MAINTENANCE, ACCESS AND RELOCATION

(a) Municipality, at its own cost and expense, shall manage the Parking Facility and shall be responsible for the performance of "Routine Maintenance" throughout the Use Term. Routine Maintenance shall include but shall not be limited to snow removal, insurance, lighting upkeep, sealing and patching pavement, patrolling the Premises and payment of utility expenses associated with the operation of the Parking Facility. Municipality shall also be responsible for excavation, demolition of structures, new construction, light standard placement or replacement necessitated by damage to a structure. In the event Municipality fails to manage, operate or maintain the Premises and the Parking Facility in accordance with the terms and provisions of this Agreement, Metra may provide, or cause to be provided, such management, operation and maintenance services and Municipality shall reimburse Metra for the cost of said management, operation and maintenance services within thirty (30) days of Municipality's receipt of a written demand for payment from Metra.

(b) Municipality accepts the Premises subject to rights of any party, including Metra, in and to any existing roadways, easements, permits, or licenses. Municipality agrees to provide access to the Premises to Metra and the public over and through the existing roadways and easements should such access be deemed necessary by Metra. Municipality further agrees that Metra shall not be responsible for the care or maintenance (including snow removal) of said roadways.

(c) Municipality, at its own cost and expense, shall be responsible for the "Standard Maintenance" of all landscaping on and along the Premises as delineated on Exhibit "____" attached to and made a part of this Agreement. For purposes of this Agreement, Standard Maintenance shall include without limitation watering, weeding, mowing, trimming, and mulching as dictated by the specific plantings on the Premises and Parking Facility.

(d) Metra reserves the right to relocate the Parking Facility or any portion thereof, at its own cost and expense, in the vicinity of the Premises with no liability for damages to Municipality's interest in the Parking Facility resulting from such relocation; provided, however, that Metra shall give Municipality sixty (60) days prior written notice of its intention to relocate the existing Parking Facility or portion thereof.

(a) Municipality shall not use or permit upon the Premises anything that will invalidate any policies of insurance held by Metra or Municipality now or hereinafter carried on or covering the Premises, the Parking Facility or any improvements thereon. Municipality shall manage, operate, maintain and use the Premises and the Parking Facility in compliance with the requirements of all local, state and federal ordinances, laws, rules and regulations in effect during the Use Term.

(b) Prior to entering upon the Premises, Municipality agrees to furnish insurance in form and in such amounts as required by Metra's Risk Management Department (312-322-6991) and shall deliver to Metra's Risk Management Department certificates of insurance or such other documentation acceptable to Metra's Risk Management Department evidencing the acquisition of the required insurance. Such policies of insurance or self-insurance shall include commercial general liability insurance coverage as stated on Exhibit B, attached to and made a part of this Agreement ("Insurance Requirements"). To the extent permitted by law, said insurance shall show Metra, RTA, the NIRCRC, their respective directors,

5. SIGNS. Municipality shall not post or place any signs on the Premises without having first received Metra's approval of the content, design and location of the sign. Metra reserves the right to post or place or to have posted or placed on the Premises, informational and advertising signs.

6. COMPLIANCE (LEGAL AND INSURANCE)

(a) Municipality shall not use or permit upon the Premises anything that will invalidate any policies of insurance held by Metra or Municipality now or hereinafter carried on or covering the Premises, the Parking Facility or any improvements thereon. Municipality shall manage, operate, maintain and use the Premises and the Parking Facility in compliance with the requirements of all local, state and federal ordinances, laws, rules and regulations in effect during the Use Term.

(b) Prior to entering upon the Premises, Municipality agrees to furnish insurance in form and in such amounts as required by Metra's Risk Management Department (312-322-6991) and shall deliver to Metra's Risk Management Department certificates of insurance or such other documentation acceptable to Metra's Risk Management Department evidencing the acquisition of the required insurance. Such policies of insurance or self-insurance shall include commercial general liability insurance coverage as stated on Exhibit B, attached to and made a part of this Agreement ("Insurance Requirements"). To the extent permitted by law, said insurance shall show Metra, RTA, the NIRCRC, their respective directors, administrators, officers, employees, agents, successors, and assigns, as additional insured's and shall be endorsed to assume the contractual obligations of Municipality as set forth in this Agreement. A duplicate copy of such insurance policy or a certificate of insurance and signed copy of a report showing established insurable value shall be furnished to Metra and must show on the insurance policy or the certificate of insurance that Metra will be properly notified in writing at least thirty (30) days prior to any modification or cancellation of such policy.

(c) Municipality and its agents shall not permit the existence of any nuisance on the Premises or during the operation of the Parking Facility; shall not create dangerous or hazardous conditions on the Premises, nor allow dangerous, explosive, flammable, or combustible materials on the Premises which would increase or tend to increase the risk of fire; and further, the Municipality or its agent shall keep, observe and comply with all federal, state and local rules, regulations, ordinances, and laws having jurisdiction over the Premises or the Parking Facility. If, as a result of the Municipality's occupancy of the Premises hereunder, any such rule, regulation, ordinance or law is violated, the Municipality shall protect, hold harmless, defend and indemnify Metra, RTA and NIRCRC from and against any and all losses, penalties, fines, costs, damages, or expenses, including court costs and attorney's fees, caused by, resulting from, or connected with such violation or violations.

(d) Municipality and its agents agree to use their reasonable best efforts to prevent the occurrence of contamination, hazardous materials or any related environmental damage or condition on the Premises during the Use Term. Should any contamination or other environmental condition occur or result from Municipality's use or occupancy of the Premises, Municipality will be responsible for all costs associated with its mitigation, cleanup and any related liability. Municipality specifically agrees to indemnify, defend and hold harmless Metra, RTA and NIRCRC from all such loss, damages, costs or liabilities, including court costs and attorney's fees, arising from Municipality's use or occupancy of the Premises.

(e) Municipality's failure to obtain or to cause its contractors to obtain proper insurance coverage or to insure Metra , the RTA or the NIRCRC as additional insured's shall not, at any time, operate was a waiver to Metra's right to indemnification and defense against any claims, damages or injuries covered under the terms and provisions of this Agreement.

7. LOCATION OF UTILITIES. Municipality accepts the Premises and the Parking Facility subject to rights of any party, including Metra, in and to any existing utility or other wires, cables, poles, pipes or facilities of any kind whatsoever, whether or not of record. Metra reserves the right to grant future utility easements over, under or through the Premises provided such easements do not unreasonably interfere with Municipality's management, operation or maintenance of the Parking Facility.

8. METRA'S TITLE. Metra makes no covenant for quiet enjoyment of the Premises. Municipality assumes any damages Municipality may sustain as a result of, or in connection with, any want or failure at any time of Metra's title to the Premises.

9. LICENSE TO OPERATE. Municipality shall pay for the cost of any licenses, permits or fees required by federal, state or local rule, regulation, ordinance or law necessary to manage, operate and maintain the Parking Facility.

10. INDEMNIFICATION AND WAIVER.

(a) To the fullest extent permitted by law, the Municipality hereby assumes and agrees to release, acquit, waive any rights against and forever discharge Metra, RTA, the NIRCRC, their respective directors, administrators, officers, employees, agents, successors, assigns, and all other persons, firms and corporations acting on behalf of or with the authority of Metra, RTA or NIRCRC, from and against any and all claims, demands or liabilities imposed upon them by law or otherwise of every kind, nature and character on account of personal injuries, including death at any time resulting therefrom, and on account of damage to or destruction of property, arising from any accident or incident which may occur to or be incurred by the Municipality, its employees, officers, agents and all other persons acting on its behalf while on Metra's property. Notwithstanding anything in this Agreement to the contrary, the waivers contained in this paragraph shall survive termination of this Agreement.

(b) To the fullest extent permitted by law, the Municipality agrees to indemnify, defend and hold harmless Metra, the RTA, the NIRCRC, their respective directors, officers, agents and employees, from and against any and all liabilities, losses, damages, costs, payments and expenses of every kind and nature (including court costs and attorney's fees) claims, demands, actions, suits, proceedings, judgments or settlements, arising out of or in any way relating to or occurring in connection with Municipality's use of or the condition of Metra's property except to the extent caused by the negligence of Metra, the RTA, the NIRCRC or their respective directors, officers, agents or employees. Metra agrees to notify the Municipality in writing within a reasonable time of any claim of which it becomes aware which may fall within this indemnity provision. The Municipality further agrees to defend Metra, the RTA, the NIRCRC, their directors, officers, agents and employees against any claims, suits, actions or proceedings filed against any of them with respect to the subject matter of this indemnity provision, whether such claims, suits, actions or proceedings are rightfully or wrongfully made or filed; provided, however, that Metra, the RTA, the NIRCRC may elect to participate in the defense thereof at their own expense or may at their own expense employ attorneys of their own selection to appear and defend the same on behalf of Metra, the RTA, the NIRCRC, their directors, officers, agents or employees. The Municipality shall not enter into any compromise, or settlement of any such claims, suits, actions or proceedings without the consent of Metra, which consent shall not be unreasonably withheld. Notwithstanding anything in this Agreement to the contrary, the indemnities contained in this paragraph shall survive termination of this Agreement.

(c) The indemnification and hold harmless provisions set forth in this Agreement shall survive termination of this Agreement and shall not be construed as an indemnification or hold harmless against and from the negligence of CRD, RTA, or NIRCRC with respect to any party performing work on the Premises to the extent such violates the Illinois Construction Contract Indemnification for Negligence Act, 740ILCS35/0.01 et seq.

11. CONTRACTOR INDEMNIFICATION AND INSURANCE

(a) In all contracts executed by Municipality for maintenance of the Premises and the Parking Facility (including snow removal) or for the construction, rehabilitation, improvement, repair or maintenance of structures, facilities or improvements located on the Premises, or to be located on such

Premises, Municipality will require appropriate clauses to be inserted requiring contractors to indemnify, hold harmless and defend Metra, RTA and NIRCRC, their directors, employees, agents, licensees, successors and assigns from and against any and all risks, liabilities, claims, demands, losses, and judgments, including court costs and attorneys' fees, arising from, growing out of, or related in any way to work performed by such contractor(s), or their officers, employees, agents or subcontractors, and their agents or employees or the failure to perform such work.

(b) Municipality will further cause appropriate clauses to be inserted in all such contracts requiring contractors to procure and maintain comprehensive policies of insurance, insuring contractor, Metra, RTA, and NIRCRC, their directors, employees, agents, successors and assigns from and against any and all risks, liabilities, claims, demands, losses and hutments, including court costs and attorney's fees, arising from, growing out of or in any way related to the work performed or to be performed by such contractor(s), whether or not any such liability, claim, demand, loss or judgment is due to or arises from the acts, omissions or negligence of such contractor(s) or their officers, employees, agents or subcontractors and their agents or employees.

12. LIENS. Municipality agrees not to suffer or permit any lien of mechanics or materialmen to be placed against the Premises or any part thereof and, in case of any such lien attaching to the Premises, immediately to pay off and remove the same. It is further agreed by the Parties hereto that Municipality has no authority or power to cause or permit any lien or encumbrance of any kind whatsoever, whether created by act of Municipality, operation of law, or otherwise, to attach to or to be placed upon Metra's title or interest in the Premises, and any and all liens and encumbrances created or suffered by Municipality or its tenants shall attach to Municipality's interest only.

13. TAXES. Municipality shall be responsible for payment of all real estate taxes and special assessments, if any, assessed against the Premises and the Parking Facility, including but not limited to real estate taxes assessed as a result of Municipality's assignment or license of all or any portion of the Premises to a third party. Municipality shall protect, indemnify, defend and forever save and keep harmless Metra, RTA, NIRCRC and their directors, employees and agents licenses, successors and assigns against and from, and to assume all liability and expense, including court costs and attorney's fees, for failure to pay real estate taxes or special assessments assess against the Premises and the Parking Facility on or before the date payments of such taxes are due.

14. CAUSE FOR BREACH. If Municipality defaults in any of Municipality's undertakings or obligations of this Agreement and Municipality receives written notice of such default from Metra, then such event or action shall be deemed to constitute a breach of this Agreement and if such default remains uncured for thirty (30) days after notice in writing, this Agreement and Municipality's use of the Premises shall automatically cease and terminate.

15. SURRENDER OF PREMISES. Upon the termination of this Agreement or Municipality's use of the Premises by any manner, means, or contingency whatsoever, Municipality shall, if required by Metra, remove all of Municipality's improvements and/or property from the Premises and the Parking Facility, fill all excavations that have been made by Municipality and deliver possession of the Premises

and the Parking Facility to Metra in as good a condition or a better condition than that which existed immediately prior to the commencement of the Use Term, ordinary wear and tear excepted. Should the Municipality fail to perform such removal or restoration, then Metra, at its election, may either remove the Municipality's improvements and property and restore the Premises to its former state at the sole expense of Municipality or may retain the Municipality's improvements and property as Metra's sole property. Should Municipality retain possession or use of the Premises or any part thereof after the termination of Municipality's use by Metra or as otherwise provide for in this Agreement, any such holding over shall not constitute an extension of Municipality's use and Municipality shall pay Metra all damages, incidental or consequential as well as direct, sustained by Metra, RTA and NIRCRC and their respective directors, employees, agents and licensees by reason of such retention of possession or use. The provisions of this paragraph do not exclude the Metra's rights of reentry or any other rights to recover use and possession of the Premises afforded Metra by law.

16. RE-ENTRY. If Municipality shall breach or default in any of the terms of this Agreement and if such breach or default is not cured as proved in section 14 above, or if Municipality's use of the Premises shall expire or terminate in any manner, it shall be lawful for Metra then or at any time thereafter to re-enter the Premises and take possession thereof, with or without process of law, and to use any reasonable or necessary force for regaining possession; provided, however, that Municipality shall have the right to remove certain of Municipality's property as hereinafter provided. No termination of Municipality's use shall release the Municipality from any liability or obligation that accrued prior to said termination.

17. WAIVER OF REMEDIES. No waiver or any default of Municipality shall be implied from omission by Metra to take any action on account of such default. No express waiver shall affect any default other than the default specified in the express waiver and that only for the time and to the extent therein stated. No receipt of money by Metra from Municipality (1) after any default by Municipality, (2) after the termination of Municipality's use, (3) after the service of any notice or demand, (4) after the commencement of any suit, or (5) after final judgment for possession of the Premises shall waive such default or reinstate, continue or extend the Use Term or affect in any way such notice or suite, as the case may be.

18. PARKING REVENUES.

(a) All parking fees or other revenue derived from Municipality's use of the Premises and the Parking Facility ("Revenues") shall first be utilized for Routine Maintenance, Standard Maintenance and administrative expenses incurred from the operation of the Parking Facility. The remainder shall be deposited in a capital improvement account to be used for future renovation or rehabilitation of the Parking Facility.

(b) Municipality shall establish and maintain adequate accounting records of all Revenues based on generally accepted accounting principles consistent with the manner Municipality maintains records of its other accounts in order to insure compliance with this Agreement. Municipality shall permit and shall require its contractors to permit Metra, RTA, NIRCRC or any other agency authorized to perform such audit and inspection, to inspect all work, material and other data and records with regard to the Revenue collected and to audit the books and accounts of Municipality and its contractors with respect to said Revenues. Municipality shall submit to Metra an annual audit of its records relating to the Revenue collected and shall make its records available to Metra at mutually convenient times. Furthermore, Municipality shall immediately notify Metra if the Parking Facility is to be used in a manner substantially different from that intended by this Agreement. At the option of Metra, Metra and Municipality shall conduct a yearly joint inspection of the Premises and the Parking Facility to assure compliance with the terms of this Agreement.

19. IMPROVEMENTS. Municipality shall not make any improvements to the Premises without having first obtained the prior written consent of Metra. Municipality shall submit to Metra all plans and specifications for improvements on or to any portion of the Premises and the Parking Facility (improvements shall not include such items of Routine Maintenance and Standard Maintenance as described in section 4 of this Agreement). Metra reserves the right to have its employees, agents or independent contractors perform such work set forth in the plans and specifications it approves and Municipality agrees to pay the cost of all such improvements performed by or on behalf of Metra, whether by Metra's employees, agents or independent contractors.

20. CUMULATIVE RIGHTS. All rights and remedies of Metra shall be cumulative, and none shall exclude any other rights and remedies allowed by law.

21. NOTICES. All notices, demands, elections and other instruments required or permitted to be given or made by either Party upon the other under the terms of this Agreement or any statute shall be in writing. Such communications shall be deemed to have been sufficiently served if sent by certified or registered mail with proper postage prepaid, hand delivered or sent by facsimile transmission, with proof of successful transmission sent by regular mail by CRD or Municipality at the respective addresses shown below or to such other party or address as either Party may from time to time furnish to the other in writing.

(a) Notices to Metra shall be sent to:
Commuter Rail Division
547 W. Jackson Boulevard
Chicago, Illinois 60661
ATTN: Director, Real Estate & Contract Management
Phone: (312) 322-8010
Fax: (312) 322-7098
(b) Notices to Municipality shall be sent to:
____
____
____
____
Phone: _____________________________
Fax: _____________________________

Such notices, demands, elections, and other instruments shall be considered delivered to recipient on the second business day after deposit in the U.S. Mail, on the day of delivery if hand delivered or on the first business day after successful transmission if sent by facsimile transmission.

22. ENTIRE AGREEMENT. All of the representations and obligations of Metra are contained herein. Metra and Municipality agree that no change or modifications to this Agreement, or any exhibits or attachments hereto, shall be of any force or effect unless such amendment is dated, reduced to writing, executed by both Parties and attached to and made a part of this Agreement. No work shall be commenced and no costs or obligations incurred as a consequence of any amendment to this Agreement or any attachments hereto unless and until such amendment has been executed and made a part of this Agreement.

23. RAIL SERVICE. Metra makes no warranties or representations, expressed or implied, as to continued rail service to the Premises.

24. SALE OR ASSIGNMENT. Any assignment or transfer of this Agreement or the Premises by Municipality without the written consents of Metra its successors and assigns shall be void. No act of Metra, including acceptance of money by Metra from any other party, shall constitute a waiver of this provision.

25. SEVERABILITY. Metra and Municipality agree that if any provision of this Agreement is held to be invalid for any reason whatsoever, the remaining provisions shall not be affected thereby if such remainder would then continue to conform to the terms, purposes and requirements of applicable law.

26. USE RESTRICTIONS. Municipality agrees that none of the Premises and the Parking Facility will be used, nor will Municipality permit them to be used, for parking within twenty (20) feet of the centerline of any track age. Any portion of the Premises within twenty (20) feet from the nearest rail of any track age shall be used only for the construction, maintenance, repair and renewal of platforms and other railroad improvements located within the railroad right-of-way (subject to legal clearance requirements and Metra's clearance requirements) and forno other purpose whatsoever. Any construction, rehabilitation or repair work performed on behalf Municipality occurring within twenty (20) feet of the outer rail of any track will require flagging protection provided by Metra at Municipality's sole cost and expense. Municipality and/or its contractors shall also purchase and keep in full force and effect railroad protection liability insurance during the performance of any such work.

27. MISCELLANEOUS PROVISIONS.

(a) This Agreement shall be binding upon and shall inure to the benefit of the Parties, and their respective successors or assigns.

(b) The captions of the Sections of this Agreement are for convenience and are not to be interpreted as part of this Agreement.

(c) Whenever the context requires or permits the singular shall include the plural, the plural shall include the singular and the masculine, feminine and neuter shall be freely interchangeable.

(d) In the event the time for performance hereunder falls on a Saturday, Sunday or holiday, the actual time for performance shall be the next business day.

(e) This Agreement shall be construed and enforced in accordance with the laws of the State of Illinois.

28. CONTROL OF MASTER LEASE. To the extent applicable to the Premises, Municipality agrees to be bound by and assume all of the obligations of Metra under the terms and conditions of the Master Agreement. In the event of a conflict between a provision or provisions of the Master Agreement and a provision or provisions of this Agreement the provision or provisions of the Master Agreement shall take precedence and control. Nowithstanding anything to the contrary contained in this Agreement, in the event Railroad terminates Metra's lease of the Premises under the terms and conditions of the Master Agreement then this Agreement and the rights granted pursuant thereto shall automatically terminate.

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement on the day and year first above written.

THE COMMUTER RAIL DIVISION OF ______________________________

THE REGIONAL TRANSPORTATION

AUTHORITY:

By: ____________________________	By: ______________________________
Philip A. Pagano	
Executive Director	Its: ______________________________
ATTEST:	ATTEST:
By: _____________________________	By: ______________________________
Assistant Secretary	Its: _______________________________

Sample Shared-Use Park-and-Ride Agreements

Source: MAG Park-and-Ride Study

KING COUNTY

(SEATTLE)

PARK AND RIDE LOT AGREEMENT

THIS AGREEMENT is made and entered into this _______day of _________, 2000 by and between, , its successors and assigns, hereinafter referred to as the "Owner", and the KING COUNTY, its successors and assigns, hereinafter referred to as the “County”.

W I T N E S S E T H:

For and in consideration of the terms, conditions and covenants herein contained, the sufficiency of which is hereby acknowledged, the parties hereto agree to the following:

1. Purpose: This Agreement is intended to encourage the Owner to permit transit and rideshare commuters, hereinafter called "commuters", to use of a portion of the Owner's property (hereinafter referred to as "Premises" and described in Exhibit A which is attached hereto and made a part hereof) for a park and ride lot. Nothing herein shall be construed as creating a tenancy between the County and the Owner.

2. Payment: In exchange for quarterly payments made by the County at a monthly rate of four dollars and 00/100's ($4.00) per parking space, the Owner agrees to allow commuters to use 28 parking spaces located on the Premises and as shown in Exhibit A, under the terms and conditions stated herein. The first payment shall be , for . All subsequent quarterly payments will be due in the first month of the quarter (January, March, June and August) and under this Agreement shall be $336.00. The parties agree that said payments are complete and full for each quarter and that no further amounts shall be due for any wear, maintenance or damage accruing to the Premises.

3. Term: This Agreement shall be in full force and effect and binding upon the parties hereto beginning ________________2000 and continue thereafter until terminated. The Agreement may be terminated by either party for any or no cause by giving 60 days written notice to the other party of the intent to terminate. If this Agreement is terminated, the Owner agrees to return to "“KCDOT”" any unearned portions of the quarterly payment.

4. Use of Premises: The Premises shall be used for a park and ride lot, vehicular access for parking for commuters, ingress and egress for, and all similar and related uses. Such use shall not include buses, vans, or trucks with a gross weight exceeding 10,000 pounds. The County shall not create or maintain on the Premises any nuisance or in any way violate generally applicable laws, ordinances and public regulations now or hereafter in effect.

5. Access and Use: Commuters shall have primary right to use the Premises from Monday through Friday between 5:00 A.M. and 7:00 P.M., except for holidays. Guests, patrons, and/or visitors of

the Owner may use the Premises on a space available basis after 9:00 A.M. The Owner shall have and retain the right to use the Premises during other hours. The Owner reserves the ability to make other uses of the Premises which do not interfere with the commuters' use. The County shall have the right to enter upon the Premises at any time for purposes related to this Agreement.

6. Limits of Use: The County shall, at its expense, post at the entrances and on the Premises clear and conspicuous signs which designate the limits of the Premises and specify the grounds for towing vehicles from the Premises as "unauthorized." The Owner shall have the right to approve such markings and signs, which approval shall not be unreasonably withheld. The location of the specific identification and control signs to be used are indicated on Exhibit A and pictured on "Park & Ride Lot Signs" attached to this Agreement.

7. Towing of Vehicles: The Owner hereby authorizes the County to act as an agent on behalf of the Owner for the purpose of ordering the towing of vehicles from the Premises which are found to be "unauthorized" per the posted signs after 5:00 A.M. and before 7:00 P.M. weekdays except for holidays. The Owner shall retain the right to tow vehicles at all times. Unless a towing agreement between the Owner and a towing company already exists, the County will establish an agreement with a local towing company and arrange for signs to be installed on one or more of the posts supplied by the County for the parking control signs.

8. Lot Monitoring: A County representative shall visit the Premises once a day, between 5 a.m. and 7 p.m., on at least three weekdays per week, to check for unauthorized vehicles per the posted signs. Provided, however, during the first month of this Agreement, the County representative shall visit the Premises on all five workdays in a week unless prevented from doing so by staff absences or other unforeseen circumstances. Following the first month, the parties shall meet to evaluate the compliance of commuters with the posted parking rules. The Owner and the County maintain the right to review and modify the Lot Monitoring section as needed. Any modifications to this agreement must be mutually agreed upon by both Parties.

9. Liens and Improvements: The County shall not permit any mechanic's or materialmen's liens of any kind to be enforced against the Premises for any work done or materials furnished thereon at the request of or on behalf of the County.

10. Maintenance and Repairs: The Owner shall be responsible for all costs associated with cleaning, maintaining and repairing the Premises. The County shall only be responsible for the maintenance of markings and improvements, which it installs during the life of this agreement.

11. Governmental Charges: The Owner shall indemnify and save the County harmless from any taxes, assessments or governmental charges of any kind which may be levied against the Premises.

12. Insurance: The County agrees to maintain general liability insurance, including personal injury and property damage coverage, in an amount of at least one million dollars ($1,000,000.00) per occurrence. This requirement may be satisfied by self-insurance (to be evidenced by a letter from the County).

13. Accommodation: The parties agree to make reasonable accommodations with and to work together to resolve problems that may arise from time to time. The Owner may secure the use of the Premises on a limited number of dates, other than Monday through Friday, to allow for the construction on surrounding property or special events. Except in cases of emergency, the owner will provide a minimum of 15 days notice to County and to users. The Owner agrees to provide special consideration for vehicles displaying an accessibility decal.

14. Successors and Assigns: This Agreement and each of the terms, provisions, conditions, and covenants hereof shall be binding upon and inure to the benefit of the parties hereto and their respective successors and assigns.

15. Removal of Signs/Improvements: The County agrees that upon conclusion of the term of this Agreement, it will remove all signs or improvements placed by it on the Premises and will repair any damage caused by such removal.

16. Owner Covenants: Owner covenants that Owner holds fee simple title to the Premises and has full right to make this Agreement for the uses and purpose herein provided.

17. Entire Agreement: This document contains the entire agreement between the parties and supersedes all other statements or understandings between the parties.

IN WITNESS WHEREOF, the parties hereto have executed this instrument on the date herein set forth.

KING COUNTY DEPARTMENT OF TRANSPORTATION

By:

Roy Francis, Manager

Transportation Planning Division

Date:

PROPERTY OWNER

By:

Title:

Date:

KING COUNTY (SEATTLE)

DRAFT

EXHIBIT ----- OF KCHA & KING COUNTY LEASE

For the Overlake Park and Ride TOD Project

MAINTENANCE AND OPERATION AGREEMENT/PARKING MANAGEMENT PLAN

A. General Conditions

1) Lessee will be responsible for management, operations, maintenance and repair of all improvements associated with the Project, except as set forth below. Lessee will adopt and continue in effect for the lease term a maintenance, repair; and replacement schedule for the improvements will meet all applicable standards, rules, regulations and underwriting requirements, throughout the lease term. It is the intent of the parties to maintain the improvements to a standard that continues the Projects viability for its intended purpose as an affordable residential transit oriented development throughout the lease term. If a condition involving damage to the structure or safety of the transit users arises directly involving the parking structure, which reasonably requires repair, Lessor will provide Lessee notice of such condition and a request for repair. If Lessee fails to respond or effect such repairs as will correct the condition, Lessor will have the right to effect such repairs and obtain reimbursement from Lessee for the cost of same.

2) Lessor will be responsible for maintenance, operation, and liability of the transit facilities external to the structured parking. These transit facilities include the bus loop and join access roadway.

3) 150 stalls on the lower level of the parking structure will be available only to off sit parking & ride commuters for an eight (8) hour period beginning at 5:00 a.m. Additional parking stalls will be available on a first-come first-served basis.

4) Lessee will be re3sponsible for the maintenance and operation of the passenger loading area immediately adjacent to the structured parking and the transit loop……………………………………

5) Parking utilization for the entire site will be regulated and monitored by the Lessee. Lessee will prepare a parking utilization report on a quarterly basis for the first two year of occupancy. Thereafter, the report will be prepared twice per year. Data and information to be collected should include but not be limited to actual demand for tenant vehicles and off site parking and ride vehicles; reported violations; towing requirements.

B. Maintenance

Lessee shall be solely responsible for all maintenance of the parking facility and shall furnish all labor, equipment and supplies necessary for the proper performance of the maintenance service. Supplies include, but are not limited to, cleaners, detergents, floor polish, disinfectants, vacuum cleaners, dust cloths, wet and dry mops, waxes, buffing machines, plastic bags, graffiti removal agents, and trash can liners.

1) Scope of work: Elevators and stairs – the following shall be performed five times a week or as needed to maintain a similarly clean facility.

- Clean interior of elevators, remove stickers, graffiti, and advertisements
- Sweep and mop elevator floors
- Dust or vacuum light and fan grills as needed
- Clean exterior doors and call button areas on both floors
- Clean stairs and handrails
- Remove food and beverage spills, and gum.

2) Scope of work: Parking areas both levels – the following shall be performed five times a week or as needed to maintain a similarly clean facility.

- Pick up all paper, cigarette butts, beverage containers, and other debris from floor of garage
- Sweep floors as needed
- Sweep stairs and clean handrails
- Empty trash receptacles and replace liners
- Remove sticker, flyers, and graffiti from all surfaces including the exterior of building.
- Clean telephones, security monitors and any other miscellaneous equipment.
- Replace broken or burned out light fixtures
- Remove accumulated snow, ice, and water in and around the garage and access areas as necessary. No chloride products shall be used.

To be inserted

3) Scope of work: Passenger Loading Area

4) Scope of work: the following shall be done on a weekly basis or as needed to maintain a similarly clean facility:

- Pressure wash or hose off food and beverage spills
- Sweep the entire garage and/or hose clean
- Dust light fixtures, wash glass on security monitors

5) Scope of work: the following shall be done on a quarterly basis or as needed to maintain a similarly clean facility.

- Pressure wash stairs
- Pressure wash off grease and oil.

6) Scope of work: the following shall be done on an annual basis or as needed to maintain a similarly clean facility:

- Wash all light fixtures

7) Scope of work: Offensive Graffiti – shall be removed within 24 hours of it being reported or seen. Offensive graffiti is defined for this purpose as racially or ethically derogatory, words considered profane or socially unacceptable or pictures/drawings of an obscene nature.

C. Management

1) Facility

Lessee shall supervise the daily operation of the facility. The responsibilities of this position include but are not limited to:

- Enforce parking of transit users and residential users
- Enforcement of ADA stall use
- Removal of blocking vehicles
- Abandoned vehicles
- Responding to elevator alarms in the garage and taking steps to free any trapped users.
- Being alert for persons within the garage who do not have a legitimate purpose in the facility.
- Responding to personal or property injuries report/observed in the parking garage

2) Sole use and shared use parking

One hundred fifty (150) parking stalls in the lower level of the garage shall be designated by Lessee for sole use by park and ride users from 5 a.m. until 1 p.m., Monday through Friday. Residents with approved stickers shall be permitted use of these 150 stalls between 1 p.m. and 5 a.m., Monday through Friday. No overnight parking shall be allowed in these stalls. These 150 stalls shall be marked to indicate such usage and restrictions.

The remaining one hundred (100) stalls in the lower level of the garage shall be designated by Lessee for shared use by park and ride users and residents.

Landlord shall ensure that all parking stalls are being used by tenants riders and tenants appropriately. Lessee will accomplished with use of warning signs, patrol, and observation and other means necessary to monitor parking compliance.

Unauthorized vehicles remaining in the designated park and ride stalls within the restricted hours shall be subject to impoundment by Lessee. A maximum of two ticketed warnings shall be allowed before impoundment. If Lessee fails to impound improperly parked vehicles, Lessor shall have the right to such vehicles impounded at the Lessee’s/owner expense.

3) Safety and Security

Lessee shall be solely responsible for safety and security in the parking facility. Lessee shall take all reasonable steps to ensure the safety and security of garage users and vehicles.

All major incidents concerning the personal security and safety of transit customers will be investigated and reported to the Redmond Police immediately. Notify King County Chief of Transit Police of incident with 24 hours. Major incidents include, but are not limited to, the following:

1. Homicide
2. Arson
3. Assault
4. Robbery
5. Major Vandalism
6. Bomb threats
7. Auto theft
8. Any other serious injury

4) Signage

In consultation with Lessee, Lessor shall develop and manufacture the lot identification and welcome signs for the parking facility. The initial set of signs and specifications will be provided to the Lessee, at Lessor's expense. The Lessee will, at its expense, install the signs in the garage at locations identified and agreed to by both parties. Lessee shall, at its expense, be responsible for maintaining signs, and subsequent manufacture and replacement of removed and damaged signs.

10.REFERENCES

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Faghri, A., A. Lang, K. Hamad and H. Heck (2002). "Integrated Knowledge-Based Geographic Information System for Determining Optimal Location of Park-and-Ride Facilities." Journal of Urban Planning and Development **128**(1): 18-41.

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Fradd, C. and A. Duff (1989). "The potential for rail based park-and-ride to Heathrow." Transportation Planning Methods **426**: 81-96.

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University Transportation Research Center - Region 2
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Region 2 - University Transportation Research Center
The City College of New York
Marshak Hall, Suite 910
160 Convent Avenue
New York, NY 10031
Tel: (212) 650-8050
Fax: (212) 650-8374
Website: www.utrc2.org