USING PRICING TO INCREASE THE EFFECTIVENESS OF ON-STREET PARKING

FINAL REPORT

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11. Abstract

This report summarizes research into the use of pricing to increase the effectiveness of on-street parking spaces in and adjacent to commercial areas of the District of Columbia. Research emphasis was directed toward accomplishing three primary objectives: 1) to summarize information gathered from previous studies of on-street parking operations in the District, 2) to identify best practices in on-street parking from urban areas throughout the country, and 3) to develop a pilot study for testing innovative on-street parking strategies with known potential to increase effectiveness. The recommended pilot study involves the use of graduated pricing via mid-block, pay-and-go meters in loading zones and variable pricing using the same type of meter in residential permit parking and currently metered parking zones. Recommendations include studying the parking behaviors of both commercial and passenger vehicles in select commercial areas of the District, and in the adjacent mixed-use areas where there is both residential and commercial development. The intended purposes of the pilot study are to assess the effectiveness of current on-street parking operations in the District and to test the potential to achieve more effective operations through changes in pricing.

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EXECUTIVE SUMMARY

The purpose of on-street parking in commercial areas is to provide short term vehicle storage space for convenient access to nearby properties, including retail and entertainment establishments. Effective policies governing the operation of on-street parking are especially necessary in urban areas where there is little to no right of way for the expansion of existing or the construction of new off-street parking facilities to accommodate vehicular traffic; the District of Columbia is no exception. In order to promote the effective usage of on-street parking spaces in and adjacent to commercial areas of the District, research emphasis was directed toward accomplishing three primary objectives: 1) to summarize information gathered from previous studies of on-street parking operations in the District, 2) to identify best practices in on-street parking from urban areas throughout the country, and 3) to develop a pilot study for testing innovative on-street parking strategies with known potential to increase effectiveness.

The primary measures used to assess the effectiveness of on-street parking are average duration (amount of time a vehicle remains parked), occupancy (percentage of available parking spaces that are occupied), and turnover (number of vehicles that occupy a given space or set of spaces in a specified time interval). There are no known studies that have investigated these measures for the District of Columbia, specifically. Several parking studies, such as the Mayor's Parking Taskforce and the Motor Carrier Management and Threat Assessment, have, however, suggested that a pilot study be conducted to research the impacts of changes in the prices and policies that govern on-street parking operations.

This report summarizes research into the use of pricing to increase the effectiveness of on-street parking in the District. A recommended strategy for pilot study experimentation is also included, based on identified best on-street parking practices in the United States. The intended purposes of the pilot study are to assess the effectiveness of current on-street parking operations in the District and to test the potential to achieve more effective operations through changes in pricing. The pilot study design involves graduated pricing using mid-block, pay-and-go meters in loading zones and variable pricing using the same type of meter in residential permit parking and currently metered parking zones. Recommendations include studying the parking behaviors of both commercial and passenger vehicles in select commercial areas of the District, and in the adjacent mixed-use areas, where there is both residential and commercial development.

1.0 INTRODUCTION

1.1 Problem Description

The Purpose of On-Street Parking

The surface transportation system is comprised of several components whose individual function is essential to the overall quality of service provided by the system. Among these critical components are streets, intersections, freeways, interchanges, and parking facilities. Although sometimes overlooked, the need for vehicle storage space on both the origin and destination ends of a trip is critical. Accommodating the vehicles that require space for parking is a particular challenge in urban areas, where there is little to no right of way to expand existing or construct new off-street parking facilities. Effective policy governing the use of on-street parking spaces is therefore a necessity, providing incentive for increased commerce and tourism and for enhancing the overall quality of travel.

On-street parking enables convenient access to adjacent properties and activity centers. In urban areas where the demand for parking often exceeds the supply, metering of on-street spaces is a well-established strategy for increasing parking opportunity. Parking meters are used to help enforce time limit restrictions and support the goal of providing short-term on-street parking on city streets. (1)

Measuring Effectiveness

Effective on-street parking operations are characterized by the extent to which turnover, occupancy, and duration goals are met. For example, in the District of Columbia (DC), a commonly reported on-street parking problem is the frequency of "over-parking," which occurs when a vehicle remains parked longer than the maximum allowed time. Over-parking negatively impacts turnover by increasing the average duration of parked vehicles in a given block or corridor. These decreased turnover rates would prompt the on-street parking to be characterized as ineffective.

In many DC neighborhoods, where the demand for parking is high and the turnover rates are low, drivers are commonly reported "circling the block" in search of an available parking space, although off-street parking may be available at a higher hourly price. Circling

the block, which has become a common, aggressive behavior that negatively impacts traffic flow, can be attributed to a lack of on-street parking opportunity. Parking opportunity is reflected by occupancy rates. In a block operating at 100% occupancy, there is no opportunity for arriving vehicles to secure a parking space. This then leads to double parking, another undesirable condition that indicates ineffective parking operation.

Some drivers violate maximum parking duration policies by as much as six hours a day, when a single vehicle occupies an on-street parking space for a full eight-hour workday, although the maximum allowed duration is two hours. Occurrences such as this demonstrate the need for the City to explore innovative means of using existing on-street parking capacity more effectively.

On-Street Parking Challenges in the District of Columbia

In addition to a need to use existing on-street parking capacity more effectively, the City is also challenged to address variable parking demands. In residential areas, most notably those that border popular retail and entertainment zones, residents report being unable to find parking spaces near their homes because of non-resident parking associated with nearby shopping, restaurant, and night club activities. Many DC residents are dissatisfied with the residential permit parking (RPP) program because they believe that the hours of enforcement do not align with the times of greatest need. (2) During the daytime hours of enforcement, numerous on-street parking spaces are available because many residents have driven to work and any vehicle without a residential parking sticker is allowed to remain parked for two hours at most. At night and on weekends the restrictions do not apply in most areas, and residents, their visitors, and patrons of nearby restaurants and night-time entertainment compete for the limited on-street parking. The RPP program was originally designed, however, as a daytime program to restrict commuters from parking on residential streets. The dissatisfied residents, then, are actually acknowledging the success of the RPP program, as originally designed, and desiring that the hours of enforcement be extended to include nights and weekends in neighborhoods that are adjacent to entertainment and shopping districts. City Council legislation disallows the enforcement of RPP restrictions and parking meters on evenings and weekends, however, except in those areas specially designated by the Mayor, such as Georgetown and the area near the MCI Arena. This suggests that policy plays an important role in increasing the

effectiveness of on-street parking and addressing the varying demand for parking that is experienced throughout the day.

On-street parking in commercial areas is intended to accommodate retail trips, whose duration is relatively short in comparison with commuter trips, which typically require a much longer duration in order to support the typical eight-hour work day. Decreasing the demand for on-street parking by commuters would be beneficial to decreasing average duration and increasing turnover. Also, in areas plagued by recurring traffic congestion where on-street parking spaces could be removed in order to increase roadway capacity, the reduced parking supply could enhance traffic operations.

The challenge is to identify and test potential solutions to these on-street parking issues and to recommend strategies that will promote the most effective use of the on-street parking supply. There are numerous measures that have the potential to solve parking problems. This study focuses on pricing measures that can accomplish the goal of increasing effectiveness in on-street parking operations in the District. In 1999, the Federal Highway Administration (FHWA) formally began the value pricing pilot program, whereby funding was provided for state and local agencies to test the impact of levying fees or tolls for road use that vary with the level of congestion in order to reduce the waste associated with congestion. (3) A similar concept, applied to parking is proposed in this report. The methodology would involve varying the price of parking throughout the day in order to achieve the most optimal level of parking activity.

The Need for Research

An evaluation of existing on-street parking prices and policies in the District of Columbia is necessary for measuring quantitatively the current effectiveness and for proposing solutions that can meet existing and future needs. Two past efforts have helped to identify parking needs in the District from various perspectives – the Mayor's Parking Taskforce and the District of Columbia Motor Carrier Management and Threat Assessment Study. Both studies have recommended a pilot study to test strategies that can improve on-street parking operations in commercial areas of the District of Columbia.

1.2 Research Overview

The primary goal of this research project is to develop a plan for assessing the current effectiveness of on-street parking in the District and to recommend an experiment design that can be used to test pricing strategies with potential to prompt improvements in on-street parking operations. The research effort will identify best practices and will gather information from previous studies to articulate on-street parking needs in the District. Pertinent literature will be reviewed in order to identify best practices that can enhance the development of a pilot study. Ultimately, this research is expected to lead to the adoption and implementation of more effective on-street parking practices in the District of Columbia. In order to accomplish this goal, the following research objectives are needed:

1. To summarize information gathered from previous studies of on-street parking operations in the District of Columbia.
2. To identify best practices in on-street parking operations throughout the country.
3. To develop a pilot program for testing innovative on-street parking strategies with potential to increase the overall effectiveness of operations in and adjacent to commercial areas of the District.
4. To prepare a report that synthesizes the findings, including pilot program design and rationale.

2.0 LITERATURE REVIEW

2.1 District of Columbia Parking Needs Assessment

Pertinent issues and concerns related to on-street parking in residential and commercial areas of the District were identified by the Mayor's Parking Taskforce in 2003. The Taskforce utilized focus groups and other discussion formats to assess parking problems and needs from the perspectives of District agency officials, citizens, and neighborhood associations. The pertinent issues identified in the final report for the Taskforce are presented here "to summarize existing data on the District's parking supply, demand, and the full range of issues." (2)

Commercial vehicle parking needs and the associated impacts on the surface transportation network were identified in the District of Columbia Motor Carrier Management and Threat Assessment Study. The report developed by the Volpe National Transportation Systems Center presented pertinent findings related to on-street parking that are summarized here.

The economic principles of supply and demand can be applied to the dilemma of providing parking (supply) to resident, visiting, and commuting vehicles whose origin and/or destination is in the District for home, work, shopping, food, entertainment, and church trips (demand). There are approximately 260,000 on-street parking spaces in the District, about 16,000 of which are controlled by meters. (2) In many areas, the demand exceeds supply – a phenomenon which could be explained by the fact that there are 215,000 registered motor vehicles in the District that are accompanied by the nearly 200,000 vehicles that enter the District during the average, weekday morning travel peak. Although all of these approximately 415,000 vehicles are not competing for on-street parking spaces, because of the availability of parking in garages, driveways, and other off-street vehicle storage facilities, these statistics begin to reveal why reform may be needed in on-street parking policies to accommodate a larger number of vehicles throughout the District.

2.1.1 Residential Needs

Home-to-work trips are not the only trip type actively demanding parking in residential areas. Vehicles used for shopping, food, entertainment, and religious trips are also known to seek parking in residential areas adjacent to commercial zones. These areas are termed "mixed-use" because commercial and residential activities coexist in a single block or series of blocks.

Depending on the purpose of a trip, parking is desired at different times throughout the day. The temporal component of parking is not only comprised of when there is demand for parking, but also how long space for parking is desired. The Residential Permit Parking (RPP) program was established in the District in the 1970's to give residents priority in long-term parking over commuters and visitors. On any street where the RPP program is in place, vehicles without an RPP sticker can remain parked for no more than two hours. These restrictions are typically enforced between 7:00am and 8:30pm. (4) Studies have shown, however, that the largest accumulation of vehicles in residential parking areas occurs after 8:30pm, suggesting that the RPP program may not address a critical time of resident parking needs. (5) This is supported by Taskforce discussion which revealed that many residents believe non-resident restrictions are needed at night and on weekends, especially in mixed-use or commercial areas.

The Mayor's Parking Taskforce identified three primary areas of concern that relate to on-street, residential parking.

1. Parking priority: to provide explicit priority to District residents

   Priority discussion included questions such as: how many permits should a household be able to receive? Should a resident with off-street parking be eligible for an on-street permit? Is owning a registered vehicle in the District an appropriate permit prerequisite? Can permits be made available for household employees like child-care workers and contractors?

2. Parking pricing: to utilize market mechanisms to establish varying parking fees to better reflect the true cost of parking based on location and time of day.

   Pricing discussion included consideration of meter technologies for residential areas whereby non-residents are required to pay for on-street parking. Variation in pricing, maximum duration policies, and hours of enforcement would ideally vary as a function of parking demand and supply.

3. Parking information: to simplify parking signage and replace existing, confusing signage with clear, consistent signage throughout the District, identifying parking locations, policies, and alternatives

Another important consideration of the Taskforce was to have systematic standardization in residential parking policies with a balance of sufficient flexibility to accommodate varying neighborhood needs.

Conversation with DDOT officials revealed additional needs in residential areas of DC with RPP programs. Although RPP zones are sometimes small and discrete, the RPP stickers are issued by Ward. Therefore, the RPP program, which was designed to protect neighborhood residents from outside commuters, shoppers, or restaurant patrons, allows for intra-ward commuting. Designation of smaller RPP zones would protect the ability of residents to park within a reasonable distance of their homes. Although smaller RPP zones would create difficulty at zone boundaries, special signage could provide a remedy whereby signs in Ward border areas would read, "Two-Hour Parking; Zone a/b/c permit holders excepted." A second issue involves the number of DC residents with vehicles not registered in the District. Under the current system, these vehicles can remain parked indefinitely after 6:30pm in some RPP areas and after 9:00pm in others. This may contribute to the lack of available parking spaces in RPP areas in the evenings. A final issue raised by DDOT officials involves commuters, primarily store owners and their employees, who move their vehicles throughout the day to different parking spaces within RPP zones. Identifying and attempting to mitigate this parking behavior in RPP zones would be beneficial to maintaining the goals of the RPP program.

2.1.2 Enforcement

The Mayor's Parking Taskforce report also noted that any efforts made to improve on-street parking operation should be supplemented by enforcement efforts and available technologies that can increase the effectiveness of and ease in parking. For example, bar codes on RPP stickers and visitor permits would allow for quicker scanning, verification, and ticketing by enforcement officials. In general, enforcement is critical to the success of any parking program; reliable enforcement promotes adherence to the established policies. Testing new and revising existing policies regarding the price or procedure for on-street parking must be done with the full support of enforcement.

2.1.3 Commercial Needs

The motor carrier study, conducted by the Volpe Center, helped to identify specific parking-related problems in commercial areas of the District. Two primary issues related to heavy vehicle traffic were found to be double-parking on arterials, especially in Georgetown, Downtown, and the Golden Triangle, and the lack of exclusive loading zone parking for trucks arriving during off-peak times.

Increasing turnover rates could decrease occurrences of double parking and generate more patronage for businesses. "Customers of commercial establishments should have priority in commercial area on-street parking, and [time limits] should be set and enforced to best facilitate commerce." (2) Opinions concerning "ideal" pricing and procedural strategies were generated by the Mayor's Parking Taskforce, including metered parking in all commercial areas, with prices that reflect the demand for on-street, short-term parking, metering in loading zones, and an increase in the amount of on-street parking space dedicated to loading/ unloading operation. Metering loading zones, however, is expected to increase turnover and might alleviate the need for increasing he physical allocation of on-street parking space for loading/ unloading activity.

The Volpe study identified issues with enforcement times and relative sizes of loading zones, stating that hours of enforcement are not consistent with truck arrival times and that location and size of loading spaces are often not accommodating. In an analysis of commercial loading/ unloading operation on K Street between 16th and 21st Streets NW, located in the Golden Triangle, the study showed that deliveries peak around 10:00am, 12:30pm, and 5:00pm, but take place throughout the day between 7:00am and 6:00pm. "More trucks entered the study period during the hour just after the morning peak period loading zone restrictions expired and during the lunch hour between noon and 1pm than during any other hours of the day." (6) This disparity between provision of and demand for dedicated loading/ unloading space must be addressed to promote the effective use of commercial vehicle parking spaces. Drivers of larger trucks, like single-units with three or four axles, admitted to double parking to make deliveries, especially when loading/ unloading space is provided in alleyways where relatively large trucks cannot maneuver easily. Other commonly cited problems included the occupation of reserved loading spaces by passenger vehicles and the lack of reserved loading space in the needed block.

Another Taskforce idea was to expand the current hours of meter enforcement for passenger vehicles in commercial areas to weekends and evenings, which most areas in the District have not yet implemented. The report cited a study by the District Department of Transportation (DDOT) curbside management division which found that 70% of vehicles parking in the central business district on Saturday remained all day, resulting in a turnover rate of less than 10%. An inadequate supply of short-term parking was also noted in the Volpe study due to low turnover rates at meters. By increasing meter rates, however, to reduce demand and increase turnover, the District might create an increase in the effective supply of o-street parking, even though the physical supply is limited.

The Mayor's Parking Taskforce also noted the need to vary specific parking prices and procedures according to area type (e.g. residential where demand exceeds supply, residential where supply exceeds demand, mixed use, and commercial); the prevailing thought being that there are no mixed use or heavily commercial areas in the District where on-street parking supply exceeds demand. A final Taskforce recommendation related to simplifying and clarifying commercial parking information, including a simplification of parking fines and fine categories, better signage and consistent policies in attempt to decrease driver confusion. The Volpe study supported this recommendation.

2.1.4 Pilot Testing Recommendations

The Mayor's Parking Taskforce recommended flexibility in pilot testing to study several parking pricing and procedural strategies in various areas, with the ability to apply lessons learned to other, similar parts of the District. The critical concerns were noted to be identification of suitable test areas and provision for readily measuring benefits and impacts.

The problems related to loading/ unloading operation identified in the Volpe study led to the following recommendations for a pilot study:

- Increase the number of dedicated loading/ unloading spaces per block
- Expand enforcement hours
- Implement maximum time for occupying a loading/unloading zone OR install parking meters to encourage turnover OR have courier companies pay a premium for dedicated short-term parking spaces

- Issue a limited number of permits to building owners allowing for long-term parking in loading/ unloading zones for maintenance or similar work in the buildings (DDOT officials believe that another effective strategy might be to have building owners or tenants apply for a public space permit if they need to occupy on-street parking space for an extended period in excess of the parking regulations.)

2.2 Residential Parking Policies in Other Regions

Before an effective pilot study design for mixed-use/residential parking can be developed for the District, there should be adequate consideration of current residential parking practices in other urban areas. Identified best practices will help to design an experiment for testing those strategies with known potential to increase the effectiveness of on-street parking operations. The following is a brief summary of residential parking procedures compiled by the Mayor's Parking Taskforce from numerous cities, counties, and regions throughout the United States.

2.2.1 Arlington County, Virginia

Residential zone parking is established in neighborhoods adjacent to major corridors and commercial areas and drivers without permits are restricted from parking in these areas during certain hours. A driver is issued a permit when his/ her vehicle is registered or upon request if a resident or homeowner's address coincides with a restricted parking area. Two visitor permits are available per household, valid for one year.

2.2.2 Boston, Massachusetts

The resident parking program originally imposed 24-hour, non-resident parking restrictions, but these restrictions are being reconsidered. No visitor permits are available. Residents are required to pay $10 per year for a permit.

2.2.3 Chicago, Illinois

Residential parking permits are issued to restrict parking on designated residential streets during certain times for non-residents, excluding guests of and those providing services to residents. Applicable streets are those where traffic studies have proven that 33% or more of the parked vehicles are not owned by residents of that block. Residents with a current, valid

Chicago City Sticker and Illinois License Plate can purchase a permit for $25 or 24-hour guest passes for $3 per pack of 15.

2.2.4 Denver, Colorado

Residential parking permits exempt residents from on-street parking time limits in residential areas. Each household in an affected area is eligible for one permit per licensed driver in the house plus an additional permit for general, household use, all at no cost. Qualified residents may also obtain two guest permits at no charge, which are valid for the same period as the resident permit.

2.2.5 Los Angeles, California

In those areas where at least 25% of the parked vehicles in a 6-block or larger area are non-resident vehicles and 75% of the on-street parking spaces are occupied, a preferential parking district for residents is established. Restrictions vary based on the need in a particular area. Each household in the affected area may purchase up to three permits at a cost of $15 per vehicle per year. Each household with a preferential parking permit may also purchase two visitor permits per year, each of which is valid for four months and costs $10. An unlimited number of one-day guest permits may be purchased for $1 each.

2.2.6 Philadelphia, Pennsylvania

Non-permit holders in affected residential areas are allowed to park their vehicles for two hours or less between the hours of 8am and 6pm or 8am and 10pm, depending on the activity in the area. The program intent is to enhance quality of life for residents in congested neighborhoods. Any vehicle whose owner and principal driver lives in a district with parking restrictions is eligible for a permit at an initial cost of $35, renewable annually for $20. One temporary permit, valid for 15 days, may be purchased per household for $15.

2.2.7 San Francisco, California

In order to establish residential parking restrictions, at least 50% of vehicles parked on the street must be owned by non-residents and 80% of the available on-street spaces must be occupied on weekdays. Residents of those streets where restrictions are imposed may purchase

four permits per household at a cost of $27 each, per year. A qualified household may also purchase unlimited temporary permits at a cost of $10 each for a two-week period.

2.2.8 Seattle, Washington

Residential parking zones are established to discourage long-term parking by non-residents on residential streets near businesses, hospitals, schools, or factories during certain times of day. Residents are able to purchase one permit for every vehicle owned at a cost of $27 each for a two-year period. One guest permit is given to each household with a purchased permit at no additional charge.

2.3 Commercial Parking Policies in Other Regions

This portion of the literature review explores a variety of commercial district parking prices, policies, and procedures used in various urban areas throughout the United States. Of these, best commercial practices can be identified, upon which the pilot test for the District can be modeled.

A recent study of on-street parking in large central cities stated that managing parking with the competing, sometimes contradictory objectives and interests of the users is an issue for most urban areas. (7) Acknowledging the importance of "a practical exchange between cities of knowledge and problem-solving information to improve on-street parking management," the study brought together representatives from nine central cities in the United States and the resulting paper summarized a variety of parking practices and policies and identified best practices. The participating metropolitan areas were: Boston, Chicago, Dallas, Los Angeles, New York City, Phoenix, Portland, San Francisco, and Washington, DC.

Practices with respect to innovative metering technologies have been tested in Chicago, Los Angeles, Portland, and New York, where mid-block, pay and display meters are being used. Some cities have implemented the use of Smart Cards to pay for parking and the integration of these cards with payment for other transportation services like rail and bus. Portland's use of the Smart Card payment option is discussed in detail in Section 2.3.2. Other innovative on-street parking metering practices were mentioned, such as pay-by-phone, currently being used extensively in other countries, whereby drivers call an automated, toll-free number using a cellular phone to begin and end payment for parking at a specific space. This

method does not require drivers to know the amount of parking that will be needed ahead of time; it also disallows paying for parking over the maximum time limit. Other innovations that were noted include sonar and laser technologies that determine when a vehicle has left a space and reset the meter and personal, in-vehicle meters, which are discussed in more detail in Section 2.4. Each of these metering innovations was identified as a best practice, along with the New York City loading zone metering practice that is discussed in more detail below.

2.3.1 New York, New York (8)

In New York City, a parking price increase was implemented in attempt to reduce traffic congestion and double parking in midtown Manhattan. This program involves commercial vehicles, which could previously park in marked loading/unloading zones free of charge. The policy change resulted in fees ranging from $2 to $9 for one to three hours of parking respectively, for loading or unloading in the designated zones between the hours of 7am and 6pm on weekdays. Non-commercial vehicles were also affected by a rate increase for meters and municipal parking garages and lots where passenger vehicles are permitted to park. Implementation of this policy change was characterized as "successful" by the New York City Department of Transportation in that occurrences of double parking were reduced.

2.3.2 Portland, Oregon (9)

The Smart Meters project was approved by the Portland City Council in January 2002 for widespread use in the downtown central business district (CBD). This project involves the use of smart card and central pay station technologies to decrease expenditures related to maintaining and repairing the 7000 individual space parking meters being used in Portland and to improve meter reliability. Persons desiring parking use coins, credit/ debit, or smart cards to pay for a specified amount of parking. The printed receipt from the solar-powered pay station must be returned to the vehicle and serves as the permit to park. The pay station is located in the middle of each CBD block.

Results from a six-month demonstration project, begun in Summer 2000, indicated that these technologies would benefit on-street parking management in commercial areas of Portland. Benefits included increased space for pedestrian movement due to removal of individual space meters and a decrease in response times for problems with meters due to the

two-way communication between each meter and a central monitoring system. Information concerning time limits, and parking costs can be easily displayed and updated on the electronic display.

Other features and policies were implemented to accommodate commuters and visitors. For example, a commuter arriving before the 8am start time for meter enforcement may still buy the maximum time for parking and his/her receipt would be given a beginning time stamp of 8am. Also, a person with time remaining on his/her receipt may park at another location and use the same receipt until the time has expired.

2.4 Metering Alternatives

The Washington Metropolitan Area Transit Authority has begun implementing a fare collection system that uses smart card technology for payment on the bus, rail, and park and ride components of the public transportation system. The "SmarTrip" cards are permanent, rechargeable farecards, similar in material and size with a credit card and embedded with a special computer chip that keeps track of the value remaining on the card. (10) In determining potential metering strategies for on-street parking in the District, only those technologies that can be used in tandem with a smart card were considered in order to promote a systems approach to transportation system fare collection. Four metering alternatives are discussed in detail: single-space parking meters, multiple-space parking meters, in-vehicle meters, and pay-by-phone. Each of these is currently being used in cities around the world with the goal of making on-street parking more effective. A description of each technology, along with specific deployments, advantages and disadvantages, is included.

2.4.1 Single-Space Meters

Currently, single-space meters are used throughout the District. These meters can be updated to accept smart cards for payment, but they do not, at this time, have that capability. There are two types of single-space meters: mechanical and electronic. Mechanical meters require that a knob be turned after inserting coins, while electronic meters do not. By virtue of the name, single-space meters accept payment for a single parking space and are activated when a specified amount of money is inserted, whether in the form of smart cards, coins, or bills,

buying a corresponding amount of parking time. Once the purchased time runs out, the meter displays the message, "expired."

Single-space meters are the most widely used fare collection system for on-street parking in the United States. However, in order to accept smart cards for payment, the existing meters heads must be replaced with those having a smart card payment mechanism. Arlington, VA and Minneapolis, MN currently use single-space meters that accept coins and smart cards. (11,12) The reasoning given for allowing motorists to pay using smart cards was to provide a convenient way to pay for metered parking.

Among the advantages of the single-space meter is motorist acceptance and familiarity. However, single-space meters are often victim to vandalism and theft. Another disadvantage is the large number of man-hours required to service and enforce single-space meters due to the quantity of meters needed to collect fares at individual parking spaces. Single-space meters in need of repair may be out of service for a week or longer, meaning loss of revenue because vehicles can then park free of charge. Other advantages and disadvantages of the single-space meter are presented in Tables 2.1 and 2.2, respectively.

2.4.2 Multiple-Space Meters

An alternative to the single-space meter is the pay station, or multiple-space meter. This technology uses a single meter to collect payment for multiple parking spaces. Sometimes termed "mid-block meters" because of their typical placement, pay stations have two primary variations. The first, termed "pay and display," requires that motorists purchase a parking receipt for the desired amount of parking time, using cash, coins, or smart cards, from a centralized metering terminal. The actual metering device, which is capable of displaying messages in multiple languages, leads users through the transaction process using a display screen that also includes the price for parking. Variable pricing is an option using these meters as the messages can be updated from a central programming station in the overseeing department. The meter prints a receipt that must be displayed on the vehicle dashboard in order to avoid receiving a citation. Implementation of this technology would involve the removal of single-space meters and the installation of no fewer than one pay station per street block.

Pay and display meters are currently used in cities such as Portland, Oregon, New York City, New York, San Francisco, California, and Seattle, Washington. Seattle has made plans to

replace 9,000 parking meters with 1,600 pay stations, expecting an increase in revenue due to the decrease in "downtime" experienced when a meter in need of service cannot collect parking fares. (13) The city's parking policy manager stated that up to 80 parking meters are out of service on any given day. Pay stations have proven to be more reliable than single-space meters, in terms of requiring maintenance, so although the type of pay station being used in Seattle costs just under $7,000 each, the city expects to recover the investment within three years. Before implementing the pay stations, Seattle studied Portland's pay stations that have been in use for nearly two years. More detail on the Portland multi-space metering program is presented in Section 2.3.2 of this report.

A pilot study of multi-space meters was also conducted in the Georgetown section of Washington, DC in 2003. The objectives of the project were to enhance the streetscape and to offer more convenient parking options for the community. Two variations of the multi-space meter were tested – "pay and display" and "pay and go." "Pay and Go" meters require that parking spaces be numbered at curbside. The motorist then makes payment for parking in a specific parking space at the centralized metering terminal. Enforcement is simplified with pay and go meters because officers need only check the centralized meter as opposed to verifying the receipt displayed in each vehicle windshield. (14) "Pay and go" metering also offers an advantage over "pay and display" in accommodating persons with disabilities. Instead of having to access the centralized metering terminal, return to the vehicle to display a receipt, and then proceed to their destination, persons with disabilities would only be required to access the meter to make payment and proceed to their destination when using "pay and go" meters. No literature was found that specifies the required maximum distance between multi-space meters and accessible parking spaces in considering the Americans with Disabilities Act. A representative of the Disability Rights Section of the US Department of Justice confirmed that there are currently no established guidelines in this regard.

Among the advantages of multi-space meters is the potential for increased revenues by reducing occurrences of motorists parking free-of-charge when a previous patron "leaves time" on a meter. (15) Multi-space meters also reduce sidewalk clutter, improving the aesthetics of the surrounding area. (13,16) Conversely, successful pay station deployments require initial marketing campaigns to ensure patron understanding and acceptance. Seattle plans to have "meter greeters" in areas where the new pay stations are being installed to help people learn the

new system. Another disadvantage of the pay-and-display variation of this technology is that patrons have to walk to the pay station for payment, back to their vehicle to display the receipt, and finally to their destination. (15) A more detailed summary of the advantages and disadvantages of multiple-space meters is provided in Tables 2.1 and 2.2, respectively.

2.4.3 In-Vehicle Meters

Another innovation in metering technology is the in-vehicle meter, a small credit-card sized meter that is purchased by motorists and stored and operated from inside the vehicle. There are several variations of this technology. Some are displayed from the windshield of a vehicle, hanging from the rearview mirror, while others are attached to the side window facing the sidewalk. (17) All require activation of the meter once the vehicle is parked and deactivation at the end of the desired parking time; the means for completing this process vary according to the company marketing the technology. Some in-vehicle meters have "On/Off" buttons, while others require that a smart card be inserted into the small meter to begin payment for parking and removed to end payment.

The primary disadvantage of the in-vehicle meter is that another metering technology must be used as a supplement in order to provide payment options for those motorists who have not purchased an in-vehicle meter. Tourists and visitors, for example, would require some other means of paying for their parking time. As a stand-alone system, in-vehicle meters would require no outdoor parking meter infrastructure. This is impractical, however, and therefore cannot be considered as an advantage of this metering technology. Also, the increased walking distance characteristic of using a pay station is unnecessary with in-vehicle meters operating as a stand-alone system because the meter is activated from inside the vehicle. Average walking distance would therefore be decreased in a system of metering that included in-vehicle meters.

The smart card or pre-paid account that is necessary to purchase parking time with an in-vehicle meter could be seen as an advantage and a disadvantage, depending on the perspective of the motorist. Generally, a driver would be required to input city or parking zone codes, which are displayed on nearby signs, to activate the meter and begin deducting the parking cost from a pre-paid account. Parking enforcement officers are able to see the amount of time remaining and issue parking citations to only those who have expended their pre-paid account or those who do not have a meter displayed.

In-vehicle meters are currently used in Aspen, Colorado, Arlington County, Virginia, Fort Lauderdale, Florida, University of Wisconsin-Milwaukee, University of Wisconsin-Madison, and University of Oregon. (16) In the city of Aspen, in-vehicle meters have been in use since 1995 and are known to be the longest, sustained deployment in the United States. (16) Although the in-vehicle meter used in Aspen is not the most sophisticated available, it is considered to be user-friendly and effective. The city of Aspen is comprised of approximately 5,000 citizens and 11,000 commuters on an average weekday and nearly 18,000 in-vehicle meters are currently in operation. The program is characterized as "very efficient" and "successful," and is believed to be so because of the metering system it forms with multi-space meters. (18) The most notable benefits in Aspen are the "real-time" nature of in-vehicle meters, whereby motorists pay only for time parked, and the decreased need for the excess walking required of multi-space meters.

Other advantages of the in-vehicle meter include its simplicity for the user and cost-effective implementation process for the governing authority. These meters help to reduce the cash handling required of those responsible for collections and in-vehicle metering is favorable because no receipts are necessary. (17) In-vehicle meters can, however, be stolen and the technology has not yet been programmed to respond to variable meter rates. In-vehicle meters are also restrictive in that open-air vehicles like motorcycles and convertibles cannot use them securely and it is possible that a motorist returning to his/her vehicle forgets to turn the meter off, inadvertently wasting money from the associated pre-paid account. (16) Tables 2.1 and 2.2 provide a listing of in-vehicle meter advantages and disadvantages.

2.4.4 Pay-By-Phone

Pay-by-phone is the final metering option being considered for on-street parking in Washington, DC. There are two primary derivations of the pay-by-phone method – phone-fed metering and fully automated parking. Phone-fed meters are operated from a pre-paid account or billing system and accessed through a radio frequency identification (RFID) transponder. The RFID card is housed inside the vehicle and is activated by a phone call. The caller is required to input a number identifying the block on which he/ she is parked; this number is displayed on nearby signs for convenience. A similar phone call is used to terminate parking, allowing motorists to pay only for time parked. (19)

In the fully automated system, motorists call a toll-free number displayed on nearby signs and enter an identification number specific to the area or block in which they have parked. The parking charge is then debited from a credit card or pre-paid account. Prior to the expiration of the purchased parking time, a text message is sent to the mobile phone used to activate parking as a reminder. The motorist can then opt to purchase more time remotely, up to the maximum allowed duration. Enforcement is also fully automated as enforcement officers access the list of license plates that have paid to park for that time period from any device with internet access; this could be as simple as a cellular telephone or as complex as a portable, hand-held computer designed specifically for parking enforcement applications. There are multiple deployments of this technology throughout Canada, but American cities like Seattle, Washington and Santa Barbara, California have also implemented fully automated, pay-by-phone systems. Cited benefits include monetary savings for motorists who pay only for time parked, reduction of parking hassle and anxiety because of features like the ability to add time remotely, and ease of use for open-air vehicles, unlike multi-space meters. (20) Also, motorists using pay-by-phone metering would no longer need to carry coins in order to pay for parking. The primary disadvantage to this metering method, as with the in-vehicle metering system, is that its operation as a stand-alone system would be impractical because of the obvious exclusion of those who do not own cellular telephones. In contrast to the in-vehicle meter, however, pay-by-phone is more accommodating of tourists, in that any tourist with a cellular phone and credit card would be able to pay for parking without purchasing any hardware or activating any pre-paid account. Tables 2.1 and 2.2 provide a tabular view of these advantages and disadvantages, relative to those of the other metering technologies as well.

2.4.5 Comparison of Metering Technologies

The lists of metering technology advantages and disadvantages in Tables 2.1 and 2.2 are provided as a basis for comparing technologies and should not be considered exhaustive. No weight has been assigned to the listed characteristics because the value assigned would depend heavily on the perspective being considered, whether of the motorist, enforcement officer, tourist, traffic engineer, or other involved party. A quantitative analysis would require that the advantages and disadvantages be weighted, but the means of comparison in this study are qualitative and therefore do not necessitate a weighting system.

Each of the four metering methods considered has important advantages and disadvantages. Ability to integrate with smart card technology is a primary concern and each of the alternatives has this capability. A considerable advantage of the single-space meter is its widespread usage, acceptance, and familiarity throughout the United States and especially in the Washington, DC area. There are several other advantages, however, that are not characteristic of the single-space meter, which suggest that other methods may have greater potential to prompt an increase in the effectiveness of on-street parking.

The only technology that is feasible to operate as a stand-alone system, aside from single-space metering, is multi-space metering. This advantage, coupled with the characteristics that indicate a potential to increase overall effectiveness, make multi-space meters the most favorable candidate for a pilot study. Although the pay-by-phone system is ideal in terms of not requiring a large capital expenditure, the "special equipment" required to utilize this method makes it an infeasible alternative for the purposes of this study. Future studies would likely be enhanced by exploring the further possibilities for increased effectiveness made possible by this and similar technologies, such as in-vehicle meters.

Multiple-space meters are favored over single-space because of the potential to reduce costs associated with powering meters, collecting revenues, and maintaining broken meters. Also, multiple-space meters can be programmed for variable pricing, unlike the current technologies available in single-space meters, and exploring the impacts of variable pricing for on-street parking is a fundamental component to this study.

Table 2.1 Metering Technology Advantages

Metering Method	Pay-by-Phone	In-Vehicle	Multi-Space	Single-Space
Widely accepted/ familiar				X
Patrons have a choice of payment method			X	X
Patrons can use smart card (do not have to carry cash)	X	X	X	X
Provides reminder before time expires	X			
Reduces time and cost associated with collections	X	X	X	
Reduces energy costs	X	X	X	
Reduces installation/ replacement costs	X	X		
Reduces operational/ maintenance costs	X	X	X	
Reduces initial investment required	X			
Motorists pay only for time parked	X	X		
Patron not required to walk to a pay station	X	X		X
Provides a receipt for parking	X		X	
Existing meter poles can be used				X
Practical to operate as a stand-alone system			X	X
Accommodating of tourists	X		X	X
Allows for variable pricing	X		X	

Table 2.2 Metering Technology Disadvantages

Metering Method	Pay-by-Phone	In-Vehicle	Multi-Space	Single-Space
Enforcement difficult if windshield covered with snow		X	X	
Requires training for enforcement officers	X	X	X	
Can inadvertently be left running	X	X		
Inappropriate for open-air vehicles		X	X	
Susceptible to theft or vandalism		X	X	X
Requires special equipment to operate (e.g. cell phone)	X	X		
Requires physical servicing and maintenance			X	X
Requires walk to pay and to display			X	
May be physically infeasible for disabled persons			X	
Requires initial marketing for understanding and acceptance	X	X	X	
May require longer process for payment than expected by motorist	X			
Currently unable to adjust for variable pricing		X		X

2.5 Parking Pricing

There are two basic questions applicable to parking pricing in Washington, DC – whether or not to charge for on-street parking and whether to implement static, graduated, or variable pricing. A static price for a given parking space remains unchanged, regardless of parking duration or time of day. Graduated pricing increases the hourly cost of parking as duration increases. Finally, variable pricing alters the charge for parking according to time of day and associated congestion levels.

2.5.1 Priced versus Unpriced Parking

Many transportation professionals agree that unpriced parking contributes adverse impacts to the transportation system. "Unpriced parking is a market distortion that violates the basic principles of economic efficiency: that consumers should have viable options to choose from and prices that reflect marginal costs." (21) Numerous studies have proven that large amounts of unpriced parking contribute to traffic congestion problems by promoting single-occupant vehicle trips.

In those areas where drivers are required to pay a static price for on-street parking, there are found large disparities between the costs of on-street and off-street parking, suggesting that static prices for on-street parking may not reflect the market value. (7) In Washington, DC, the average fee for off-street parking is $11.50 per day, whereas the average on-street parking meter fee is $1 per hour ($8 per day, if considering the typical eight-hour work day, although on-street parking is not intended for work trips). Each on-street parking space thereby generates at least $3.50 less per day, on average, than an off-street parking space. In Chicago, where meters fees are also $1 per hour on average, the off-street parking is approximately $18 per hour – an even larger difference than in the District. (7) In order to increase the effectiveness of on-street parking and lessen this disparity, pricing to reflect the market value is necessary.

Typically, references to on-street parking fees are made with respect to meters in commercial areas. Residential areas, however, also incorporate fees for on-street parking, usually via permit programs. In a survey of cities and counties with RPP programs, 19 of 54 reportedly do not charge residents for on-street parking; the remainder of whose fees range from $2 to $30 annually. (22) The procedures governing visitor permits varied greatly, but 30 of the 54 cities distribute visitor permits free of charge, while others assess some fee. Despite levying these fees, over half of the surveyed cities and counties were cited as having insufficient revenues from permit sales to fully administer the RPP program. This phenomenon suggests that while on-street, residential parking is priced in many areas, market-based pricing may be more beneficial. If market prices for RPP stickers are infeasible, the charges levied could be raised to at least cover the administrative costs of the program, in those areas where permit sales do not generate enough revenue to administer the RPP program. However, RPP programs were intended to be a benefit for residents, as opposed to a revenue enhancement for

a city. So, there are multiple interests that must be considered in determining whether market-based pricing should be applicable to residents and patrons of retail and entertainment establishments.

In general, the need for pricing parking and market-based pricing, more specifically, is well documented in literature. Recent research focus is shifting to an assessment of the benefits of value pricing.

2.5.2 Static versus Variable Pricing

According to the FHWA, value pricing is "a way of harnessing the power of the market and reducing the waste associated with congestion [by imposing] fees or tolls for road use which vary with the level of congestion." (3) Value pricing strategies include high occupancy toll lanes and variable parking fees. Parking pricing involves establishing hourly or sub-hourly prices for parking based on the market value, especially during peak vehicle travel periods. An example of value pricing might be a central business district that charges $1 per hour for on-street, metered parking from 2pm to 4pm, but charges $4 per hour for parking in this same area from 4pm to 6pm.

Although the intent of value pricing is to charge relatively higher prices for use of the roadway networks during peak travel periods, some strategies labeled as value pricing do not employ this methodology. Transportation professionals in Chicago, Dallas, Los Angeles, New York, San Francisco, and Washington, DC say that value pricing strategies are in place in their cities, referring to the lower prices charged for on-street parking in areas of relatively less demand. (7) In New York City, graduated pricing, which may be classified as value pricing, has been implemented for commercial vehicles, whereby the longer a vehicle remains parked, the higher the hourly cost. (The details of this program are summarized in Section 2.3.1.) The Venice Beach area of Los Angeles is said to employ value pricing techniques using meter rates that change depending on the time of day. (7) This parking pricing strategy, by which hourly parking rates depend on demands and time of day, is most consistent with the goals of value pricing. No supporting data was found, however, as to the specific deployment of variable pricing in Venice Beach. Overall, no literature was found identifying variable pricing programs for on-street parking that have been implemented. The strategy was tested in Tampa,

Florida with off-street parking, but there are no known deployments of variable pricing in on-street parking operations.

2.5.3 Determining Market Value

A recent paper suggests two methods for making a preliminary determination as to the market value of an on-street parking space. (23) The first is based on the cost of adjacent land. Under this methodology, the on-street parking lane is considered to have equal value, proportional to the relative area, of the property it fronts. Thereby, revenues generated from on-street parking should be proportional to the land rent of the adjacent property and the relative area of both the parking spaces and the adjacent properties. This approach is not considered for the study of on-street parking, however, because it does not allow for variable pricing during peak hours of travel.

The second approach considers the cost of providing off-street parking alternatives. Given the choice of parking off-street at the associated rate or parking on-street at a relatively lower rate, the motorist will opt for the cheaper alternative. Therefore, in order not to inflate the demand for on-street parking, especially in times of peak demand, an on-street parking space should cost no less than the average off-street parking space. (23) Although the intended purposes for on- and off-street parking differ, off-street parking is the only alternative to on-street in most urban areas and is therefore the basis of this methodology of determining a price for on-street parking that more closely reflects the market value. In order to effectively utilize this method, consideration must be given not only to off-street parking costs, but also to occupancy rates and the increase in convenience of on-street parking relative to the final destination.

In order for the price of parking to vary by time of day, being higher during periods of peak travel, the algorithm for computing market value would have to take into account parking demand, traffic congestion, or some measure of vehicle trip activity. Economic theory suggests that a market value for a good or service can be determined by considering trade-off values. Accordingly, the price of on-street parking should equal or exceed the monetized value of using that space as an additional travel lane. One approach for assigning a monetary value to the benefit of an additional travel lane is to consider the potential time savings. Research has determined that an individual commuter's travel time is worth approximately $6 an hour. (24)

Therefore, variable on-street parking prices can be set to recover the cost of delays experienced by motorists during different times of day.

2.5.4 Parking Pricing Impacts

Numerous papers have addressed the inelasticity of parking demand relative to increases in price. One study found that "in general, travel is fairly inelastic to price, that is, there is relatively little change in travel over time due to a change in price." (25) Another study noted that parking prices have a greater impact on travel than vehicle operating costs, but still computed a negative value for parking price elasticity. (26) This same study, however, recognized that "non-commute" travel, characterized by relatively shorter durations as is the goal for on-street parking, is more sensitive to changes in price because these trips are more discretionary than commuter trips. (26) This suggests that goals of increasing turnover and decreasing average duration for on-street parking is possible through changes in pricing, although the overall effect over time may be characterized as inelastic.

2.6 Measures of Effectiveness in Parking Studies

There are several factors that may be considered when assessing the effectiveness of on-street parking. These factors include where and why vehicles are parked, the duration of their stay, the length of walk required to reach desired destinations, parking space occupancy, and vehicle accumulation. Which of these factors are incorporated into a study depends on the study purpose. Common measures of effectiveness are average occupancy, accumulation, duration, and turnover. These variables, which are not mutually exclusive, are generally used to provide a measure of "parking activity." Parking activity is a critical consideration in evaluating parking effectiveness relative to the goals intended for the parking spaces. (27) Definitions of the more common measures are as follows:

- Occupancy – the percentage of time in a study period that a parking space is in use; provides a surrogate measure of "cruising"
- Duration – the amount of time a vehicle remains in a parking space
- Turnover – the number of different vehicles that use a parking space in a given unit of time
- Accumulation – the total number of vehicles parked in a study area at a given time

Occupancy and accumulation data help to determine the distribution of parking demands and peak parking times. The distribution of individual vehicle durations and the average duration allow a basis for comparison with maximum durations imposed at meters. While duration indirectly provides a measure of parking opportunity, turnover data allows for an enhanced assessment of parking opportunity. Where short-term parking goals are being met, turnover will be relatively high and durations relatively low.

Benchmark values of these measures are needed in order to establish thresholds to define "effective." The only standard provided in literature as to a benchmark by which to measure effectiveness is that 85% occupancy is optimal. (28) There is no known literature that provides benchmark values for the other key variables, namely duration and turnover, because these thresholds are highly dependent upon local goals and conditions. The pilot experiment design will therefore recommend a before-and-after study in order to obtain existing measures of parking activity that can be compared with the same measures after pricing changes have been implemented.

2.7 Best Practice Summary

Of the many approaches to operating residential and commercial parking that have been evaluated, there are several that have proven to be beneficial in the cities and municipalities where they have been implemented. Two of these are highlighted here. The specific strategies recommended in the pilot experiment were determined based on these best practices.

- *Metering Loading Zones*: Graduated pricing of commercial vehicle parking in Midtown Manhattan, New York City began in 2003. Under this new policy, loading zone parking is metered and hourly prices increase with length of stay. Reduced occurrences of double parking and increased turnover are among the favorable results of this change.
- *"Pay and Go" Meters*: Multi-space meters provide the convenience of a stand-alone metering system that requires no supplementary metering methods for comprehensive, feasible operation. The pay and go variation, specifically, reduces the need for drivers to walk to a pay station and return to their vehicle to display a receipt. This type of meter has been tested in the Georgetown area of Washington, DC and is recommended for this pilot study.

2.8 Conclusion

This review of literature has introduced the concepts important to the development of an on-street parking pilot study for the District of Columbia. The fundamental parking needs have been summarized, along with an overview of current procedures and innovations in both residential and commercial parking throughout the country. Other information concerning parking pricing and measures of effectiveness was also presented in order to determine the necessary components of the pilot study and the data that need to be collected.

3.0 PILOT STUDY DEVELOPMENT

3.1 Methodology Overview and Scope

A pilot experiment has been designed to test various strategies in the District with identified potential to increase the effectiveness of on-street parking. Given the range of residential and commercial parking needs in DC, as identified in Section 2.1, the scope of this research had to be established. The pilot study is focused on those issues involving on-street parking in and adjacent to commercial areas of the District and is centered on those issues that can be addressed by changes in the price of parking and related policies.

The structure of the pilot study is based on the before-and-after statistical methodology, which involves collecting data on the selected measures of effectiveness at two separate times – before a change has been made and again after. A common challenge associated with this method is identifying and adjusting data to account for history effects. "History refers to changes in [measures of effectiveness] values through the before and after periods caused by factors other than the treatment." (5) Incorporating control sites, where data will be collected in the before and after periods without the implementation of new prices or procedures, will provide a measure of "history" variations that can be used to adjust the data collected at test sites. The adjustments made possible by the provision of control sites will increase the reliability of the results of a pilot study, especially in the event that data cannot be collected at the same time of year for the before and after periods. Many transportation experiments utilize before-and-after experimentation and this methodology will be the most effective format for the study needed to assess the effectiveness of on-street parking in the District of Columbia.

Random sampling in any statistical study helps to ensure the validity of results, which will ultimately be inferred to a larger population. Random sampling reduces the likelihood of bias existing in the sampling frame. Due to the fact that parking congestion is not randomly distributed throughout the District, however, final site selection will be based on a consensus about areas where there are issues with parking congestion and where the piloted technologies may show promise for improving the situation. The selection of sites must also ensure that the experiment can be completed in a timely and methodical manner.

3.2 Pilot Study Structure

The specific testing units, measures of effectiveness, and variables recommended for the on-street parking pilot study in the District are discussed in detail in the sections that follow. Although there is no direct mention of enforcement in the structure of the pilot study, the critical role of enforcement in the success of any parking program has not been overlooked. Even enforcement is assumed to apply throughout the experiment, before the application of any treatment at the test sites and after, as well as in the control sites.

3.2.1 Testing Units

The focus of this research is on-street parking in commercial areas of the District and the adjacent mixed-use/ residential areas. Land use being the primary consideration in the selection of test units, geographic information systems were used, along with site visits, to identify and confirm the land use for the proposed data collection sites. Individual street blocks or sub-blocks in commercial or mixed-use areas will comprise the set of testing units. Three street block/ sub-block types will be evaluated in the experiment.

- loading zone parking (LZP): intended for commercial vehicle loading/ unloading
- metered commercial parking (MCP): currently metered spaces for passenger vehicles in commercial areas
- residential permit parking (RPP): in mixed-use areas where there is both residential and commercial activity

3.2.2 Measures of Effectiveness

In order to assess the effectiveness of on-street parking in the District, measures must be selected that can describe quantitatively the parking activity in a street block or sub-block. The measures of effectiveness proposed for the pilot study are as follows:

- occupancy (the percentage of parking spaces occupied over a given period of time; used to assess hourly variation and peak parking demand; provides a surrogate measure of “block circling” and “cruising”)
- duration (the individual and average length of time that vehicles remain parked)
- turnover (the number of different vehicles that can occupy the same parking spaces)
- citations (the number and type of tickets issued during the before and after periods)

- double-parking (a count of occurrences to obtain a quantitative measure of the magnitude of this problem; provides a means of determining whether increases in turnover prompt significant decreases in double parking)

3.2.3 Variables

Those factors that will be manipulated in the pilot experiment concern either the price or procedure involved in on-street parking. These variables are intended to influence one or more parking activity measures in attempt to increase overall operational effectiveness. Table 3.1 gives the proposed variables to be evaluated in the pilot study (price and procedure) and the possible variations for each variable, including the "do nothing" (no change) option. Other strategies were considered, but only those that support the goals of increasing effectiveness, addressing variable demand, and reducing demand in select areas, were included. Each variation is explained in detail below.

Table 3.1 Variations in Proposed Variables for On-Street Parking Pilot Study

Variation	Procedure	Price
1	No Change	No Change
2	Change hours of designated loading zones	Meter loading zones
3	Change hours of RPP parking restrictions	Meter nonresident parking in mixed-use RPP areas
4	Change metering method	Variable pricing of metered commercial parking

Procedure Variations

Revisiting the times that certain on-street parking spaces are reserved for commercial vehicle loading/ unloading may prove beneficial to increasing effectiveness. Most DC loading zones are designated as such from 7:30am to 6:30pm. This on-street space may be used more effectively by allowing short-term parking of passenger vehicles during certain hours of the

day, ensuring that sufficient time is provided to accommodate loading/ unloading activity. There are also on-street parking spaces that are designated as loading zones between the hours of 7:00am and 9:30am and again from 4:30pm to 6:00pm. A study of a small sample of this type of loading zone found that the majority of commercial vehicles arrive after the spaces have been opened to passenger vehicle parking. One option for a procedure variation is therefore to change the hours of designated loading zones to effectively accommodate both commercial vehicle and passenger vehicle parking, increasing available parking supply.

Residential areas may also be able to benefit from revisiting the times that non-resident parking restrictions are imposed. The DC Mayor's Taskforce on parking, whose findings are summarized in Section 2, found that many residents believe on-street parking restrictions are needed at night and on weekends, in addition to the current daytime hours of enforcement. Table 3.2 provides a summary of typical RPP enforcement hours in other cities, providing some perspective of the range of related practices throughout the United States. Washington, DC RPP practices have also been included. While many of these cities note that hours of enforcement vary depending on the needs of the affected communities, Table 3.2 presents the more common hours of RPP enforcement. More congested DC neighborhoods may benefit from 24-hour restrictions like those in Boston, Chicago, and Denver. A practice similar to that of Houston might also be beneficial to increase the availability of parking for residents during the times when non-resident parking is at a peak demand.

The final procedural change involves a change in metering method. In order to accommodate the graduated and variable pricing variations that are recommended for the pilot study, more innovative metering methods than the current single-space meters will be needed.

Price Variations

Parking management literature and transportation economic theory support market-based pricing of on-street parking spaces. Currently in Washington, DC, no maximum duration is imposed upon loading zones. However, the lack of a maximum duration, coupled with the current system of not metering loading zone parking has led to abuse of loading zones, as commercial vehicles sometimes remain parked although loading/ unloading activity is not active. A similar strategy to that of Midtown Manhattan is suggested for commercial delivery vehicles in Washington, DC, whereby an hourly fee is charged for loading zone parking that

increases with duration. In New York City, commercial vehicles are charged $2 for the first hour of parking, $5 for two hours and $9 for three hours. This is the type of graduating pricing system that may prove beneficial to utilizing existing parking capacity more effectively in the District.

Table 3.2 Customary Residential Permit Parking Hours of Enforcement in Select U.S. Cities

Location	RPP Hours of Enforcement*
Boston, Massachusetts	8am – 6pm; 24 hours
Chicago, Illinois	24 hours
Dallas, Texas	10pm – 4am, Thu – Sat
Denver, Colorado	24 hours
Houston, Texas	6pm – 2am, Thu – Sun
Los Angeles, California	8am – 6pm
Philadelphia, Pennsylvania	8am – 6pm; 8am – 10pm
San Francisco, California	8am – 10pm
Seattle, Washington	7am – 6pm
Washington, District of Columbia	7am – 8:30pm, Mon – Fri

** In most of these cities, including the District of Columbia, neighborhoods with intense recreational, entertainment, and retail activities have extended RPP hours of enforcement to include nights and weekends. The hours listed here are the most prominent hours of enforcement, not the only hours of enforcement.*

The second price variation suggests metering non-resident parking in RPP areas, allowing any vehicle without a residential permit to occupy a parking space for the maximum-allowed duration at an hourly cost. District residents are assessed an annual fee of $15 to obtain a permit for each registered vehicle in a household. Visitor, contractor, and temporary permits are available free of charge for limited time periods that vary depending on the purpose of the trip. This proposed price variation would not alter the current permitting structure as residents, long-term visitors, in-home nurses, and contractors would still be able to obtain their respective permits; only those vehicles occupying a parking space without an RPP sticker or other authorized permit would pay an hourly fee for the use of this on-street parking space. For

the purposes of the pilot study, only those RPP blocks that are considered mixed-use will be considered for implementing metering.

The final price variation applies to currently-metered parking spaces within the District. This change involves replacing the current system of static pricing with variable pricing to achieve the goals of using existing parking capacity more effectively, addressing variable parking demand, and reducing parking demand. The price for on-street parking would be increased to more closely reflect a market value for at least two time periods – travel peak and off-peak. Implementing variable pricing would also require a more innovative means of metering because there is no known upgrade to the single-space meter that would feasibly accommodate variable pricing. Based on the discussion of metering technology advantages and disadvantages in Section 2.4.5 of this report, the pay-and-go variation of multi-space metering is the recommended method for the DC on-street parking pilot study.

Treatments

The specific variations of the price and procedure variables that are applied to a testing unit are called treatments. For example, one treatment recommended for the pilot study is variable pricing in currently metered parking (MCP) blocks. Table 3.3 lists the treatments that have been approved by the DDOT project team for the pilot study and the testing units to which the treatments will apply. The scope of the pilot study required that only a few treatments be tested so that the cause of any changes in parking effectiveness could be clearly identified and analyzed. Of all the possible treatments, these three were identified for their potential to impact the desired goals for on-street parking and to produce substantive outcomes for the pilot study.

Table 3.3 On-Street Parking Pilot Study Treatments

Treatment	Testing Unit	Description
1	LZP	Install "pay and go" meters to implement graduated pricing in loading zones
2	RPP	Install "pay and go" meters in currently non-metered parking spaces of mixed-use/RPP zones to implement variable pricing for nonresident parking
3	MCP	Replace single-space meters with "pay and go" meters to implement variable pricing in currently metered commercial parking

3.3 Data Collection Logistics

3.3.1 Duration and Timing of Study

The pilot experiment will have both "before" and "after" data collected for a period of approximately one month each. There will also be a one month start-up period after changes are made during which no data will be collected while users familiarize themselves with the new parking prices and procedures.

The recommended times for data collection are Sunday through Saturday in select two-hour intervals between 7:00am and 9:00pm. Additional nighttime data collection hours will be considered for select sites based on the parking activity and reported problems occurring after 9:00pm. Seasonal peaks in travel behavior will be avoided in order to obtain data on the average, "typical" travel and parking patterns. Data collection is therefore recommended for the period between mid-September and mid-November and mid-January to mid-March, prior to winter holiday travel and following summer, tourist travel peaks.

3.3.2 Site Selection

The sites recommended for data collection are comprised of several street blocks where at least two of the testing units can be observed. Implementing changes on a single block could skew results because motorists looking for a parking space could relatively easily find parking on a nearby block that may not be included in the pilot study. In order to minimize these effects, a

series of street blocks have been identified for study at each of the recommended sites, as opposed to individual, isolated blocks.

Table 3.4 provides an overview of the suggested data collection sites that have been approved by the DDOT project team. Wards Four (4), Five (5), Seven (7), and Eight (8) do not appear in Table 3.4 because preliminary project team discussions and site visits did not lead to the identification of appropriate sites in these regions, where on-street parking problems are recurring in commercial areas with currently metered parking that has not been the focus of a recent study. Further investigation and impending changes to on-street parking practices in these wards are expected to reveal candidate data collection sites that can be incorporated if this pilot study is implemented. Of the identified data collection sites, at least two are needed to function as control sites. The recommended control sites are Farragut North and Cleveland Park, which are similar in land use and parking activity to the other sites. Maps of the specific street blocks where data collection is recommended are shown in Figures 3.1 through 3.5. Both sides of the street, where parking is allowed, in the highlighted blocks are recommended for data collection.

3.3.3 Determining Prices

Of the varied approaches to determining a market-based price for on-street parking, the suggested methodology for the purposes of this pilot study is to determine the hourly cost of parking based on the desired goals for the measures of effectiveness, namely duration, occupancy, and turnover. The recommended benchmark value for occupancy is that supported by the literature (85%). (28) Benchmark values for duration/ turnover will be established based on a comparative analysis of existing conditions at the data collection sites, once preliminary data are collected, prior to the implementation of any changes. This is necessary because there are no known goals that have been established for the most optimal duration and turnover for on-street parking in and adjacent to commercial areas of the District. Given the current prices for parking and the current values of occupancy, turnover, duration, and double parking that will be determined in "before" period data collection, the pricing structure for the "after" period of the pilot study can be established with the intent of prompting more effective values of these measures. The fundamental goal is to establish objective standards by which to evaluate the measures of effectiveness. Sufficient flexibility is also recommended so that on-street parking

prices can be adjusted throughout the pilot study in order to achieve the desired goals based on the observed demands.

Table 3.4 Recommended Data Collection Sites

Site	General Area	Testing Units	Ward	Quadrant
1	Adams Morgan (18th Street & Columbia Road)	LZP, MCP, RPP	1	NW
2	Cleveland Park (Connecticut Avenue & Macomb Street)	LZP, MCP, RPP	3	NW
3	Farragut West (15th & Eye Streets)	LZP, MCP	2	NW
4	Farragut North (17th & L Streets)	LZP, MCP	2	NW
5	Eastern Market (Pennsylvania Avenue & 7th Street)	LZP, MCP, RPP	6	NE

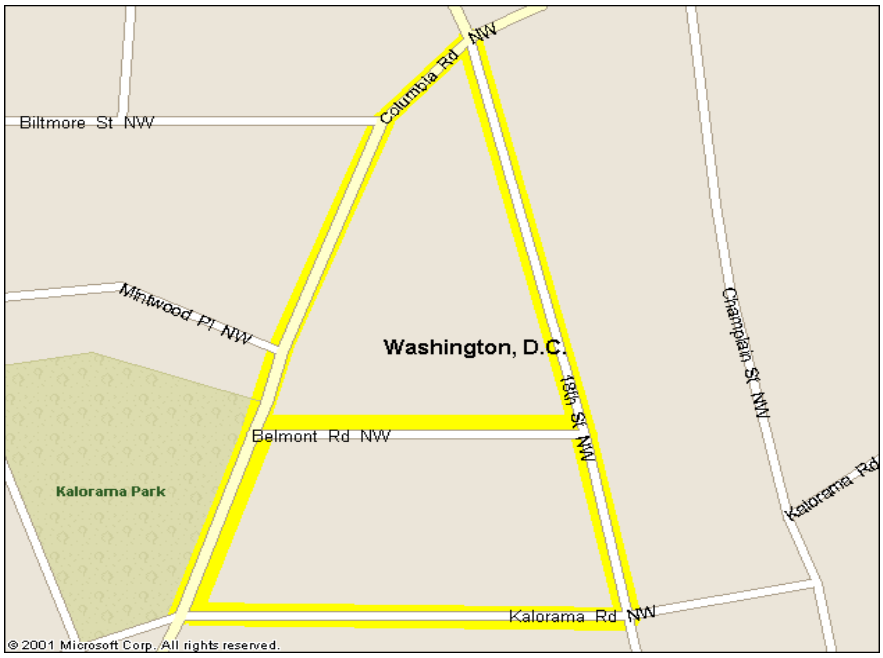

Figure 3.1 Adams Morgan Test Site

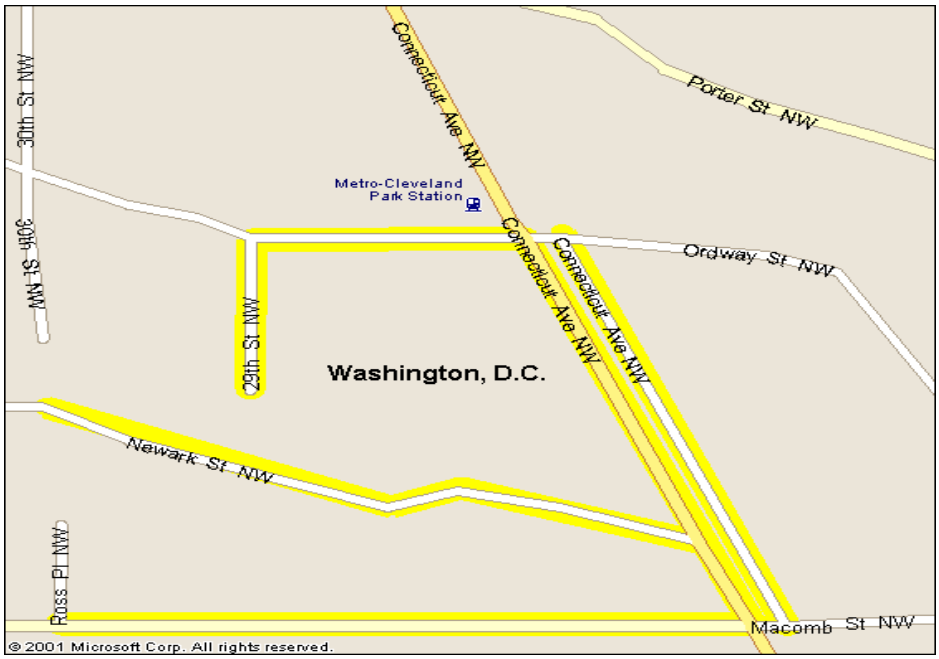

Figure 3.2 Cleveland Park Control Site

Figure 3.3 Farragut West Test Site

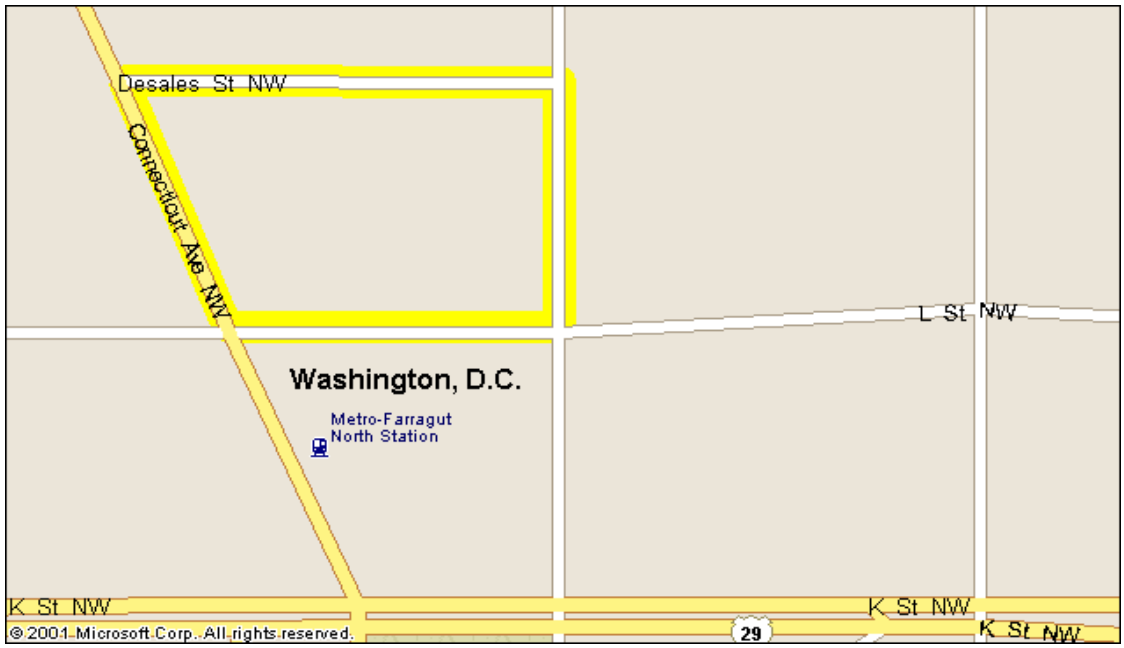

Figure 3.4 Farragut North Control Site

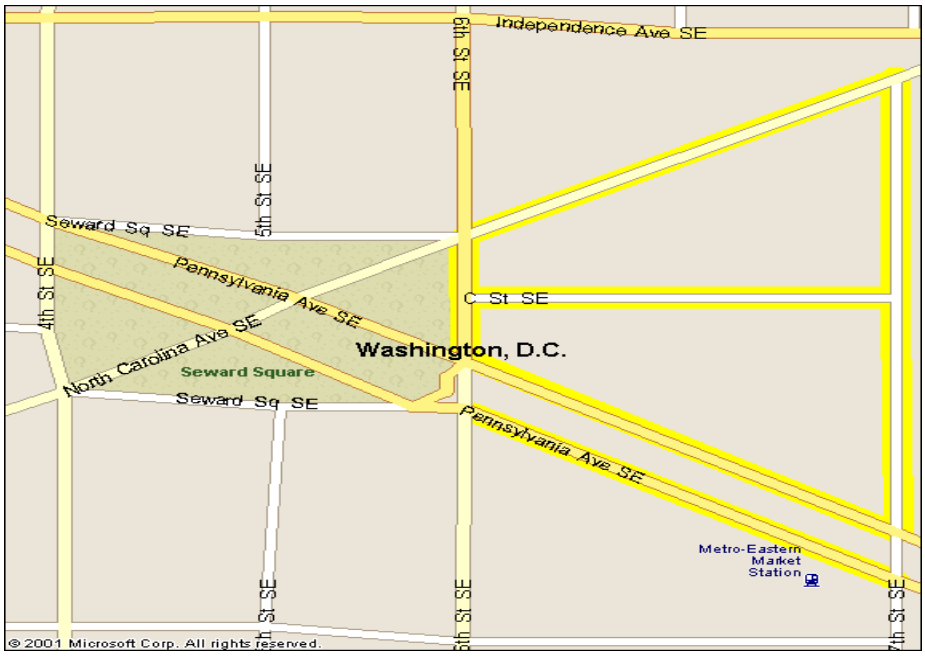

Figure 3.5 Eastern Market Data Collection Site

4.0 CONCLUSIONS AND RECOMMENDATIONS

Given the recurring, reported problems with on-street parking in the District of Columbia, the goal of this study was to explore the potential to achieve more effective on-street parking operations through changes in pricing. Effectiveness is characterized by the extent to which specific goals for parking duration, occupancy, and turnover are met. These measures are known to vary by region, land use, and time of day; yet, there is no known comprehensive study that has collected quantitative data on the effectiveness of on-street parking, as indicated by duration, occupancy, and turnover, for the District of Columbia, specifically. Without knowledge of existing conditions, there is no barometer by which to measure the success of future changes. For this reason, a pilot study has been developed, not only to assess current on-street parking conditions in the District, but also to test innovative on-street parking strategies with potential to increase effectiveness in and around commercial areas of the District.

Based on information obtained from the literature review, the pilot study is comprised of identified best practices that exhibit characteristics believed to be well-suited for the District. The pilot study incorporates graduated pricing in loading zones and variable pricing in mixed-use/RPP and metered parking zones. Experimentation would involve the on-street parking practices of both commercial vehicles and passenger vehicles in commercial zones, including the mixed land uses that involve adjacent residential and commercial development. A new pricing strategy for on-street parking in DC is expected to prompt improvements in parking operations. Graduated pricing has demonstrated benefits in Manhattan, New York City loading zones. Several variable pricing tests, conducted with support from the FHWA value pricing pilot program, have yielded favorable results, but there is no known study that has tested variable pricing for on-street parking. The results of variable pricing research on other facility types, however, have led to suggestions in literature that this strategy be used for on-street parking.

The review of available literature concerning on-street parking practices in cities throughout the United States revealed that most on-street parking studies focus on a specific district or corridor and thereby yield results that cannot be readily inferred to a larger population of cities outside that particular region. Implementation of the pilot study designed as a part of this research is therefore strongly recommended. Outcomes of this study are expected to enhance on-street parking operations in the District as strategies are identified that

have quantitatively demonstrated potential to increase overall effectiveness. The recommendations for lasting change that will result from pilot study findings will not only benefit the residents, commuters, and visitors to Washington, DC, but will also add to state-of-the-practice literature in the area of on-street parking and enhance future research efforts and practices throughout the country.

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