Research, Development
& Technology Transfer Program

District Department of Transportation

Trip Generation Data Collection in Urban Areas

Final Report

September 2014

Disclaimer

This research was performed in cooperation with the District Department of Transportation (DDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or DDOT. This report does not constitute a standard, specification, or regulation.

Research, Development & Technology Transfer Program

Trip Generation Data Collection in Urban Areas

Rachel Weinberger, Karina Ricks, Jason Schrieber, Liza Cohen
Nelson\Nygaard

September 2014

Research Project
Final Report 2014-01

Technical Report Documentation Page

1. Report No. DDOT-RDT-14-01	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Trip Generation Data Collection in Urban Areas		5. Report Date September 2014
		6. Performing Organization Code
7. Author(s) Rachel Weinberger, Karina Ricks, Jason Schrieber, Liza Cohen		8. Performing Organization Report No.
9. Performing Organization Name and Address Nelson\Nygaard Consulting Associates 1400 I Street, NW Washington, DC 20005 Symmetra Design, LLC 727 15th Street NW, Suite 1000 Washington, DC 20005		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DCKA-2010-T-0066
12. Sponsoring Organization Name and Address District Department of Transportation Research, Development, & Technology Transfer Program 55 M Street, SE, 5th Floor Washington, DC 20003		13. Type of Report and Period Covered April 2013 – July 2014
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

There is currently limited data on urban, multimodal trip generation at the individual site level. This lack of data limits the ability of transportation agencies to assess development impacts on the transportation system in urban and multimodal contexts. This project sought to begin addressing this gap by developing and testing a protocol for collecting trip generation by mode at the site level.

The report provides a comprehensive review of previous research and develops and defines a data collection protocol for site and context data. The report documents the results of a pilot data collection that tests the protocol. The results of the pilot data collection are compared to the predicted impacts based on the industry standard, the Institute of Transportation Engineers (ITE) *Trip Generation Manual*, and to six alternative methods, all of which pivot from ITE's data. None of the existing methods reliably predict the field data. The report identifies next steps for DDOT and other agencies to take to improve multimodal trip generation estimation. To that end, a field-guide for future data collection, based on this pilot, is included as an appendix.

17. Key Words Trip generation, data collection, survey, urban mobility		18. Distribution Statement No restrictions. This document is available from the Research Program upon request.	
19. Security Classification (of this report) Unclassified.	20. Security Classification (of this page) Unclassified.	21. No. of Pages 97	22. Price N/A

Acknowledgements

Project Panel Members

Jamie Henson, Project Review Manager
Jonathan Rogers, Transportation Management Specialist

Research Program Staff

Soumya Dey, Director of Research and Technology Transfer
Stephanie Dock, Research Program Specialist

Contents

Figures

Tables

Executive Summary

Introduction

There is a widespread belief that the available tools for estimating travel demand from urban development are not as accurate as they could be, particularly at the individual site level. The implications are that cities may be hindered in developing appropriate travel impact mitigations; that cities lack good information to communicate to existing residents regarding potential travel impacts of proposed development; and that cities, with better tools, would be able to make stronger policy based on more reliable understandings of travel demand and development impacts.

To address this concern, the District Department of Transportation (DDOT) has undertaken an initiative to improve the agency's understanding of urban, multimodal trip generation in Washington, D.C. DDOT is interested in the question of how trip generation is shaped by the relationship between land use and transportation infrastructure in heavily urbanized areas. The ultimate objective of the larger effort is to develop a better suite of tools to understand development impacts so that appropriate mitigations can be made. The project documented here represents the intermediate step of developing a field-tested data collection methodology that captures multimodal trip-making behavior at the building level. Better data is critical to developing a better process.

The data collection methodology consists of site selection, a process for collecting context variables, and a person count and intercept survey strategy that captures total trip generation and allows trip generation estimation by mode. Data from sixteen sites was collected and represents the foundation of a database. The data will help DDOT to better assess potential transportation impacts of new development throughout the District, ultimately providing guidance and the foundation for a bigger, perhaps national, data collection effort to estimate multimodal trip generation in urban contexts.

To date, DDOT has relied on a variety of data sources, including Institute of Transportation Engineers' (ITE) trip generation rates, Census data, and Washington Metropolitan Area Transit Authority (WMATA) Development-Related Ridership Survey data, when assessing the impact of new development on the transportation system. Even when taken together, these sources fail to provide a robust idea of a development's trip generation. ITE's *Trip Generation Manual*, long relied upon as the industry standard for predicting travel behavior, represents vehicle trip rates in areas with single-use, low density zoning and land uses, typically with limited or no pedestrian, bicycle and/or transit amenities. Thus, with very rare exceptions, ITE rates are only truly applicable in contexts where auto access is the dominant mode. ITE rates are only given for automobile trips and, *de facto*, assume most access and all impacts are due to automobile.

Washington, D.C., by contrast, is primarily dense and mixed-use, which, in combination with the availability of walking, biking, and public transit modes, represents a very different trip-making context. This context is guaranteed to create fewer vehicle trips than ITE rates would predict and, quite possibly, more total trips overall (due to different trip-chaining patterns and greater density that both permit and necessitate more but shorter trips, for example). The limitations associated with ITE rates for this context are well understood, not least by ITE who is currently embarked on a process to improve the applicability of their practice guidance for urban and mixed use contexts. Census data also have limitations in that only journey to work trips are represented. Journey to work tends to have unique characteristics that are not necessarily representative of travel for other purposes; hence inference to other trip types cannot be made from Census data. Finally, while the WMATA data provides local multimodal information, the data were collected at limited sites and are becoming out-of-date. These sources are neither complete nor easily combined hence the need for the fresh perspective on trip generation that is herein documented.

The benefits of this project are multi-fold, addressing the concerns raised in the opening paragraph. First and foremost, this project produced detailed data on individual site trip generation that has not previously be available. This data allows the agency to better understand travel demand, which in turn allows for a better understanding of the potential transportation impacts of developments in the District. This will lead to more appropriate mitigations and fewer inappropriate mitigations at the site level. By quantifying observed behavior, this data can also assist in addressing traffic impact concerns from residents, decision makers, and other stakeholders. Similarly, the data could lead to better District-wide policy-making by more closely tying policies about mitigations to how residents make trips.

Literature Review

The research team undertook a comprehensive literature review that covers the academic and grey literature pertinent to data collection for place-based trip generation models and a review of the key context variables that affect trip generation and mode split. The literature review includes a summary of site-based trip generation models in use and/or recently developed. The sheer volume of studies devoted to the topic show that policy-makers have a critical interest in accurately estimating trip behavior and that our understanding of this topic is still evolving.

The review of multimodal data collection methodologies found that several researchers had applied a combination of surveys and door counts to determine site-specific multimodal trip generation. Context variables identified in the literature included density, land use mix, parking price and availability, transit quality, biking quality, and walking quality. Each of the variables reviewed had some relationship with trip generation. Generally, researchers found that density was correlated with increased rates of walking and transit use. In some cases, density was correlated with a reduction in VMT, but not always. Land use mix, measured in a variety of ways, can be a predictor of increased walking trips as well as decreased vehicle trips and trip lengths. Parking pricing and availability can drive mode choice – it is more burdensome to drive when one is not assured a parking space at the beginning or end of a trip or one must pay more for a space. Findings include a decrease in the number of vehicles per household as parking price at the home end of a trip increases as well as reduced vehicle trips to work as destination parking becomes more expensive.

Increasing walk, transit and bicycle “quality” are also associated with increased use of those modes, however there are multiple approaches to measuring quality. For example, transit presence, frequency, and proximity could all be measures of quality, and can also break down into different analytical variables. The literature not only showed that transit quality is correlated with transit usage, it is associated with a decrease in driving trips and an increase in walking trips. Similarly, walking quality is significantly associated with walk trips, and in some cases predicted increased bicycling and transit use and a decrease in driving. In contrast, the reviewed studies of bicycling quality found an association with cycling trips only.

The literature review also examined the trip generation estimation tools available. Some are predicated on original data collection; others rely on secondary sources; URBEMIS, one of the estimation tools, relies on secondary research results. Most modeling efforts pivot from ITE *Trip Generation* rates applying a series of trip reduction factors. Table 1 summarizes these tools.

Table 1. Trip Generation Estimation Tool Summary

Tool	Applicability	Dataset	Associated Publications	Input Summary	Output Summary
NCHRP Report 684 (2011)	Mixed-use developments (at least three uses)	Intercept surveys and door counts at 3 mixed use developments in Florida, and one each in Dallas, Atlanta, and Plano (TX)	n/a	Square footage of multiple uses Proximity of uses (not required)	ITE-based vehicular trip reductions due to internal capture
EPA- MXD Trip Generation for Mixed-Use Developments (2010)	Mixed-use developments	Travel surveys from 239 mixed-use developments in 6 urban regions in the US	▪ Ewing et al., 2011 [1] ▪ SANDAG, 2010 [2] ▪ Fehr & Peers model overview [3]	Multiple context variables Size of uses	ITE-based vehicular trip reductions ITE-derived transit trips ITE-derived walking trips Internally captured trips
SANDAG MXD Trip Generation for Smart Growth (2010)	An adaptation of the EPA-MXD model. Used for Smart Growth developments in California	Based on the EPA-MXD model (above)		Multiple context variables Size of uses	ITE/*San Diego Traffic Generators* vehicular trip rates
California Smart Growth Trip Generation Rates (SGTG) (2012)	Smart growth developments (particular criteria given)	Door counts and intercept surveys at 30 smart growth locations in California	▪ Handy et al., 2012 [4] ▪ Schneider et al., 2013 [5]	Multiple context variables Size of uses	ITE-based vehicular trip reductions
URBEMIS2007 (2007)	All	Based on previous research	▪ n/a	Context and programmatic variables Size of uses	ITE-based vehicular trip reductions
Portland State University (PSU) Models A, B, and C*	All	195 travel surveys from Oregon, Washington and Baltimore.	▪ Currans and Clifton, 2014 [6]	Simple lookup table of activity density OR multiple context variables	ITE-based vehicular trip reductions (Adjustments A, B and C) and trips by mode (Adjustment A only)

Tool	Applicability	Dataset	Associated Publications	Input Summary	Output Summary
CAPCOA (2010)	All	Based on previous research	▪ n/a	Context and programmatic variables Size of uses	Quantification of pollution mitigation due to transportation measures. Could be translated to trip reduction.
TRIMMS (2012)	All	Based on previous research	n/a	Context and travel demand management programmatic variables	Social benefits including trip generation and trip reduction
Tripgenie (2012)	All	Based on previous site-specific counts	n/a	Place type Land use	Trips by mode
NCHRP Report 758 (2013)	Infill development (particular criteria given)	n/a – Methods recommendations rather than a model	n/a	Regional travel demand model data	ITE-based vehicular trip reductions

***Note: Model name created for the purposes of this paper only.**

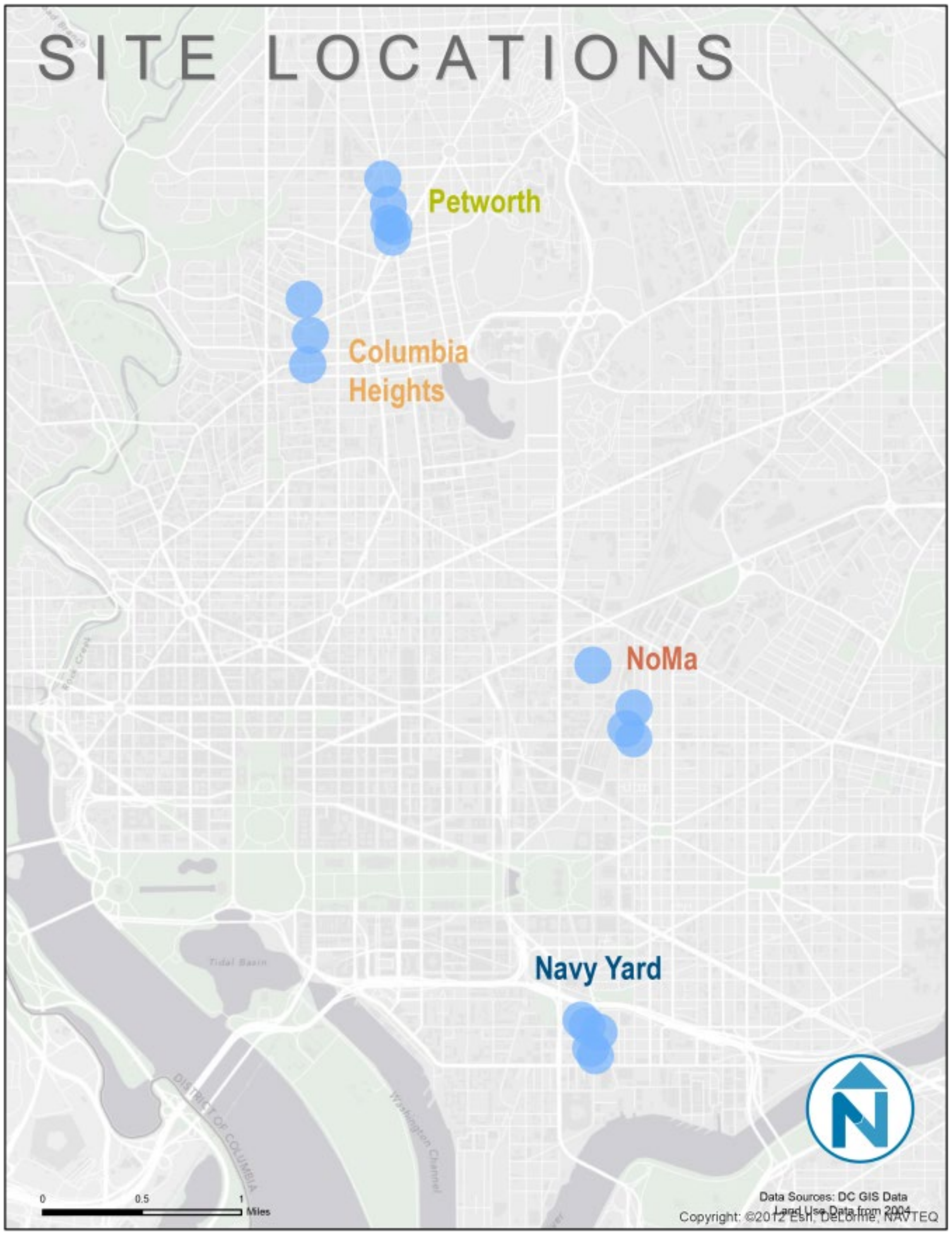
The literature review yielded three significant conclusions. The primary conclusion is that a good trip generation model should consider measures of density, transit availability and quality, parking availability and walkability at a minimum. A secondary conclusion is that the ITE trip generation methodology can be appropriate for suburban development patterns, but that relevant proxy sites for urban and infill development are lacking. Finally, as noted in the introduction, the literature review also highlighted the extent to which accurate multimodal trip generation is at issue. While regional efforts such as municipal models or even national efforts like the US Census strive to create good data on travel patterns, site-specific multimodal trip generation remains an outstanding issue to date.

Field Methodology and Recommendations for Future Data Collection

The main objective of this study was to create, execute and formalize a methodology for multimodal trip generation data collection.

To that end, the research team developed a methodology for data collection encompassing a person count and intercept survey strategy, following the general approach of similar studies. The team then tested the methodology at sixteen sites in the neighborhoods of Petworth, Columbia Heights, Navy Yard, and NoMa in Washington, DC. Figure 1 shows the general location of these sites, labeled by neighborhood.

Figure 1. Site Locations



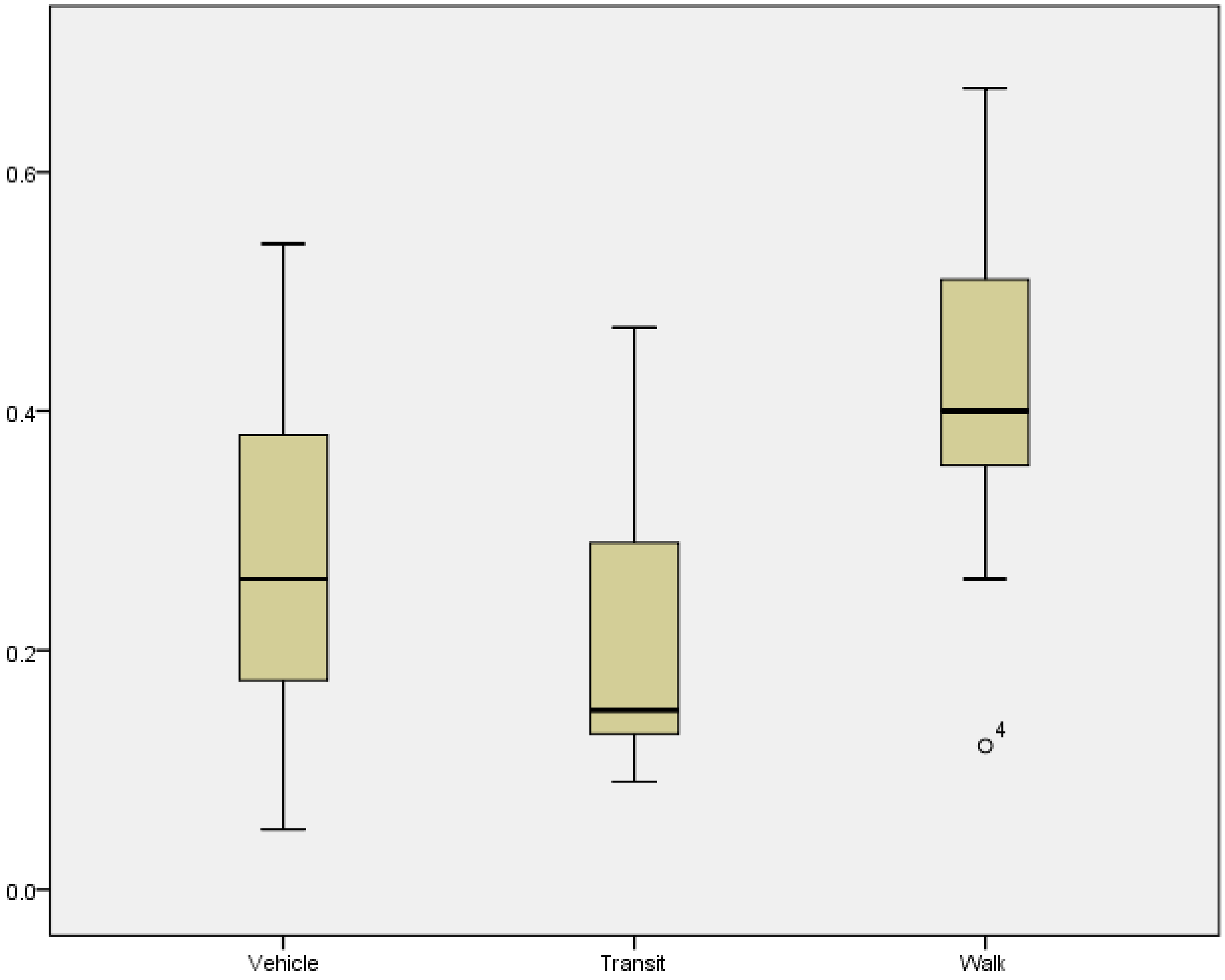
Data were collected during winter 2013-2014. Data collectors counted and surveyed people entering and exiting the sampled buildings during peak morning and evening hours of 7 a.m. – 10 a.m. and 4 p.m.-7 p.m. respectively. Surveyors intercepted subjects to learn and record the **most immediate or recent** mode before walking up to the interviewer (besides the act of walking from a parking space, bus stop, etc. to the front door.) Surveyors generally asked some variation of the question, “How did you get here today?” or “How are you getting to your next destination?” If the respondent drove, a follow up question probing where they parked was also asked. In addition, site data were collected including the presence and use of bicycle racks, the quality of bus stops/shelters, proximity to Metro stations and qualitative information regarding parking utilization and presence of publically accessible parking lots.

Data Collection Results

Walking proved to be the dominant mode of travel with a median value of 40% and a maximum of 62% for the sixteen sites. As shown in the box diagrams in Figure 2, private vehicle followed with a median of 26% and maximum of 54%. Transit is also very close with a maximum of 47%, but a lower median at only 16%. The very compressed lower end of the transit boxplot indicates that transit usage at about half the sites is in a small range (between 11% and 16%) but the upper portion shows a much greater variation with transit shares ranging from 21% to 47%.

Consistent with findings reported in the literature review, the research team found transit and drive trips to be substitutes while walk trips are complementary to both transit and driving. That is to say, the correlation between transit trips and private vehicle trips is greater than is the correlation between walk trips and private vehicle trips.

Figure 2. Variability in Mode Share



Comparative Results

The following trip generation models were tested as part of the project to see which could best predict the counts obtained in the fieldwork phase:

- Institute of Traffic Engineers (ITE) *Trip Generation*
- Urban Emissions Model (URBEMIS)
- Environmental Protection Agency Mixed Use Model (EPA-MXD)
- Smart Growth Trip Generation Model (SGTG)
- Clifton and Currans (PSU Models)

Of particular interest to this study was the comparison between the industry standard of ITE *Trip Generation* and the observed counts. ITE under-predicted person trips and over-predicted vehicle trips in the urban context. Figure 3 and Figure 4 illustrate the extent to which the over-prediction of vehicle trips and under-prediction of person trips occurs.

Figure 3. DDOT Estimated Vehicle Trips v. ITE Predicted Trips

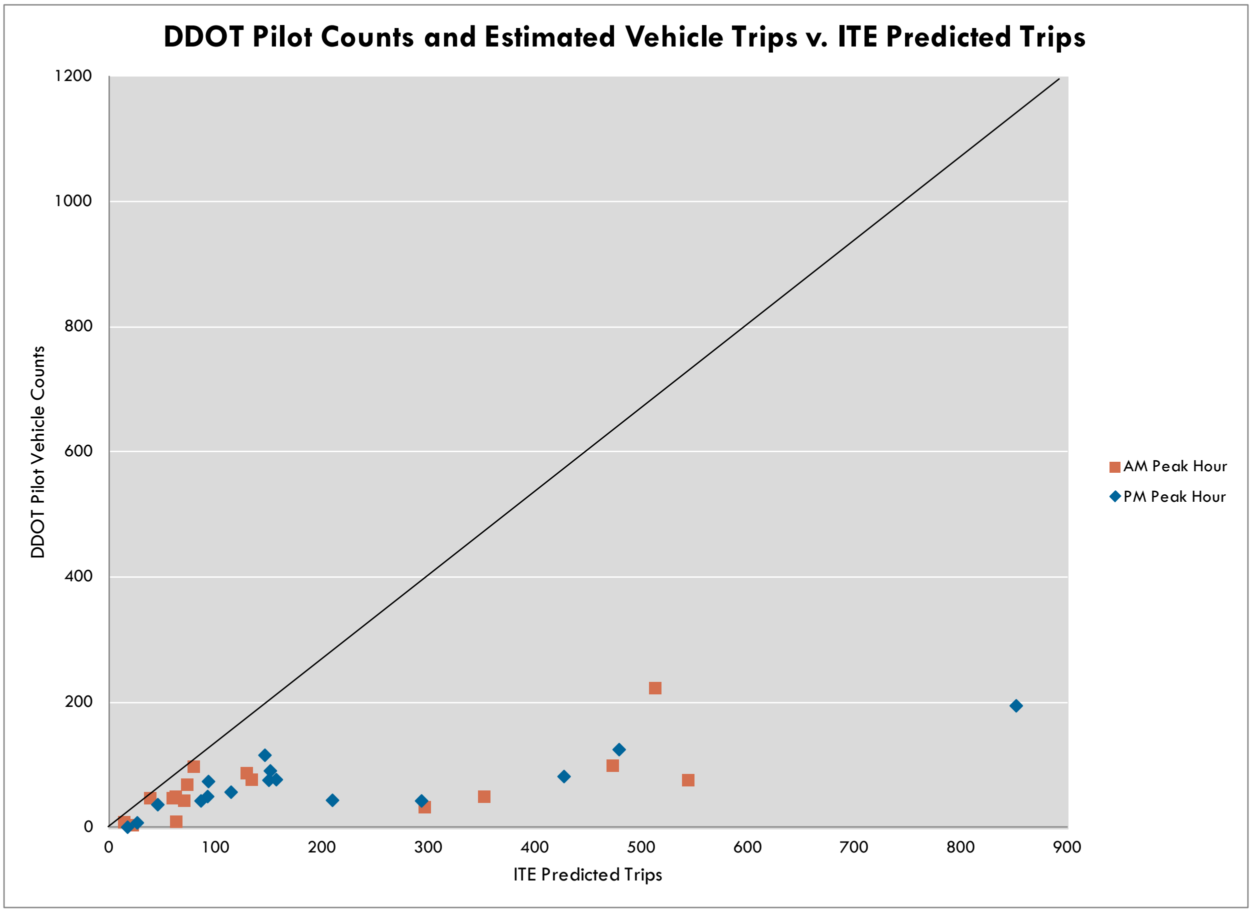
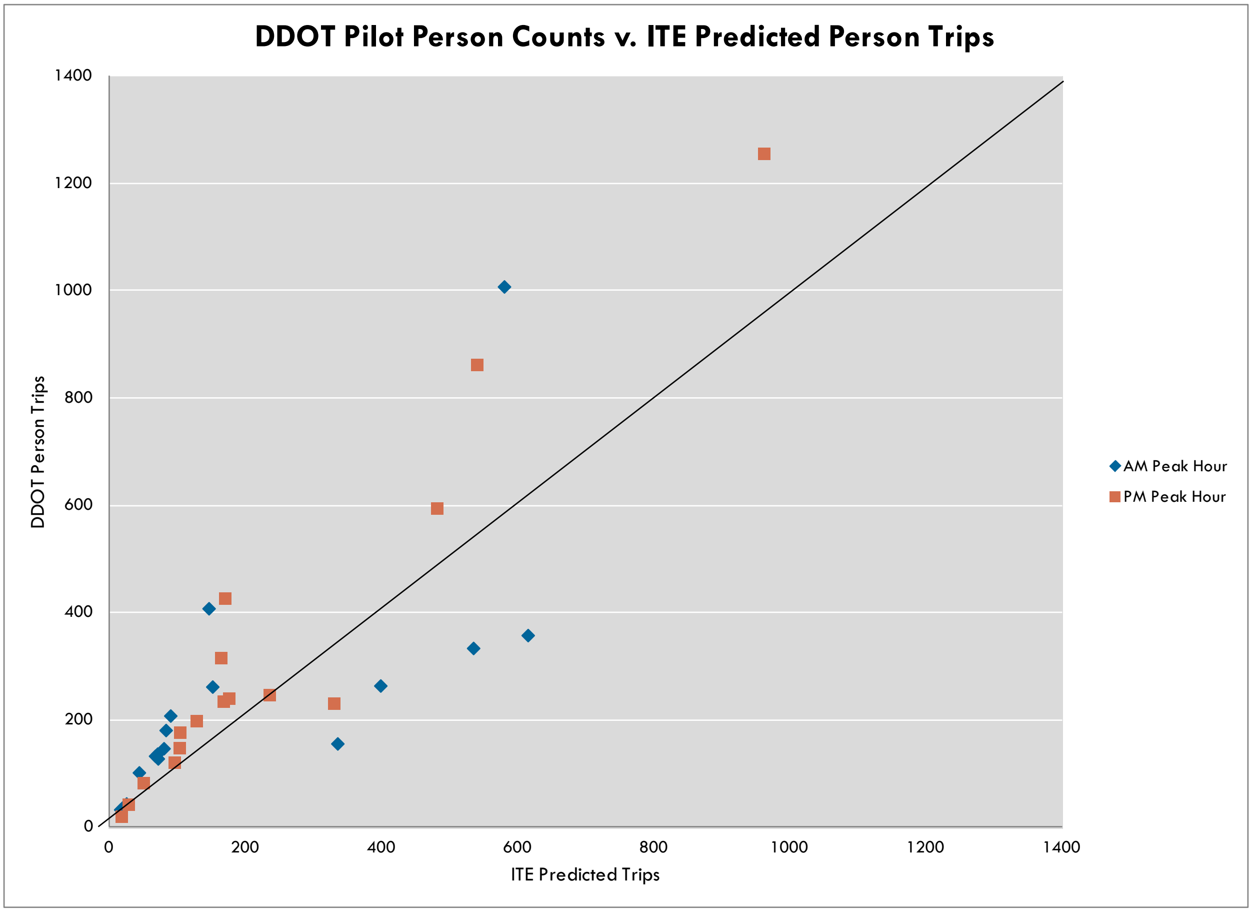


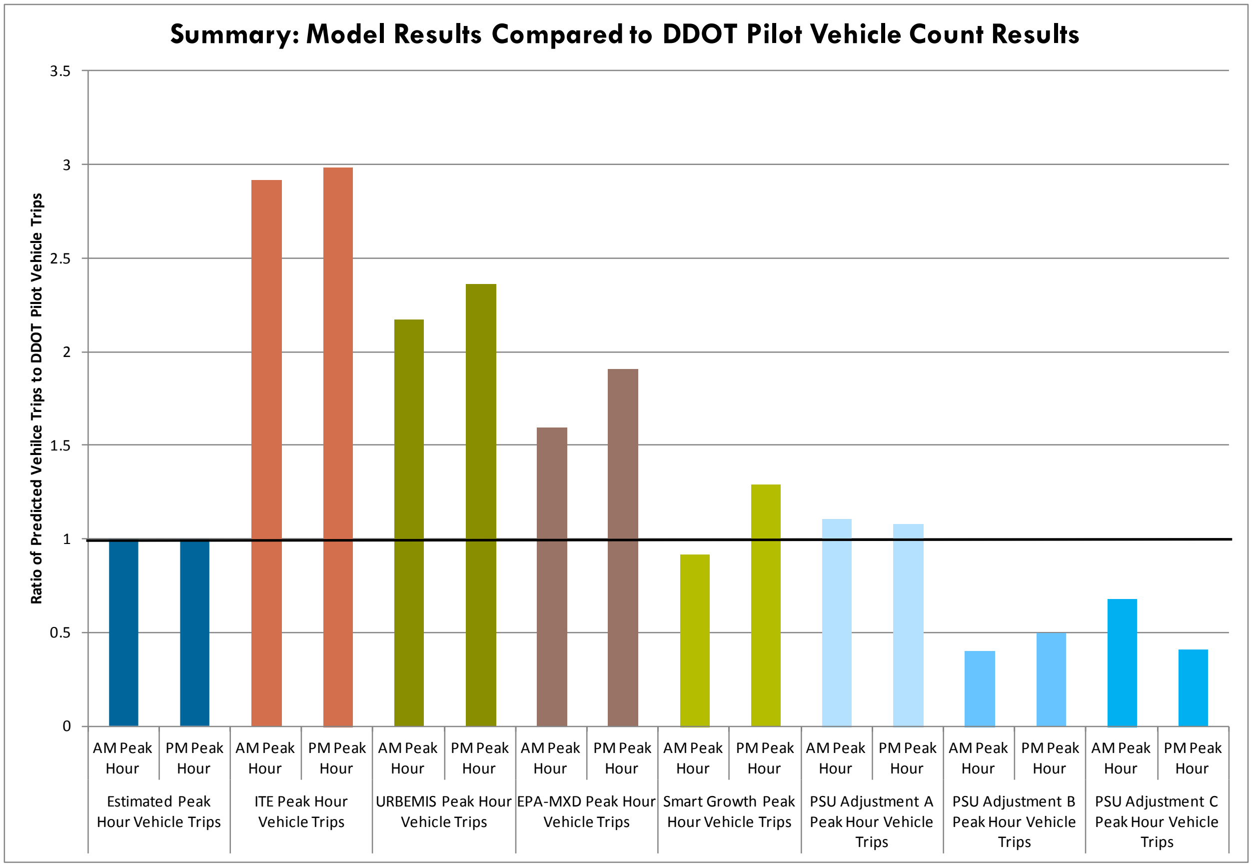
Figure 4. DDOT Project Person Counts v. ITE Predicted Trips*



*Applies factor of 1.13 persons per vehicle to predicted vehicle trips, based on the national average occupancy for journey to work trips. The JTW factor was chosen because the data collection effort focused on peak period, which tends to have a large representation of work trips.

Figure 5 shows vehicle trip predictions from the seven models applied. The results are presented as the ratio of model results to vehicle trip estimates based on the survey undertaken in this project. All of the alternative models adjust ITE rates based on "urban" characteristics and all get closer to the actual trip counts and mode splits observed in this project. However, the variability in this calibration suggests that a wholesale new approach, not just applying reduction factors to ITE rates, may be required to best address the issue.

Figure 5. Ratio of Model Results to DDOT Estimated Vehicle Trips



Conclusions and Next Step Recommendations

This effort confirmed that existing models, even if functionally reasonable, are not estimated on a sufficient dataset to make them useful for the task at hand. A large part of that is due to a paucity of data. Existing models tend to be built on limited travel survey data or, even more limited site-specific data. Conversely, ITE's 9th edition of *Trip Generation*, released in 2013, contains site-specific data from over 5,500 sites. Thus, to get a true representation of multimodal trip generation, particularly in urban areas, will ultimately call for substantially more data collection.

Through this study, DDOT has begun to build a dataset that begins to quantify what DDOT has known anecdotally and theoretically for some time, but for which local, supporting data has been lacking: that developments in the District generate different travel behaviors than those predicted by available trip generation tools. This project provided evidence of the sheer volume of trips and the lower number of vehicle trips generated by developments in the District. This newly-quantified understanding of travel behavior has clear impacts for DDOT's practice of development review and will assist in better understanding a proposed development's travel impacts in order to both lead to more appropriate mitigations and fewer inappropriate mitigations at the site level. More data is needed to further develop DDOT's understanding of urban trip generation and to create a more robust set of comparable sites for use when reviewing new developments.

DDOT’s ultimate vision for this project is to develop a robust database of urban, multimodal trip generation data from a variety of land uses and to produce statistically valid models capable of more accurately predicting trip generation. This project represents an important step along toward realizing that vision. Going forward, DDOT proposes several interim steps to reach this vision:

1. Additional data collection throughout the District, which can be collected by DDOT or required as part of DDOT’s development review process. There are opportunities to also link this data to other ongoing efforts at DDOT around residential parking studies and future transit development.
2. Create a national database through a coalition of peer jurisdictions and researchers. This will reduce the burden on any one city to produce enough data to estimate their own models. This is a recognized need in the industry and other cities and regions are already beginning to collect data.
3. Identify comparable site procedures so accurate comparisons can be made, once more data is available locally and/or nationally.
4. Develop and validate a model that predicts trip generation rates for various land uses and contexts. This step will require a robust dataset, as well as ongoing validation as new data is added.

1. Introduction

Study Purpose

There is a widespread belief that the available tools for estimating travel demand from urban development are not as accurate as they could be. The implications are 1) cities may be hindered in developing appropriate travel impact mitigations; 2) cities lack good information to communicate to existing residents regarding potential travel impacts of proposed development; and 3) cities, with better tools, would be able to make stronger, more relevant policy based on more reliable understanding of travel demand and development impacts.

To address this concern, the District Department of Transportation (DDOT) has undertaken a project to improve their understanding of urban, multimodal trip generation in Washington, D.C. DDOT is interested in the question of how trip generation is shaped by the relationship between land use and transportation infrastructure in heavily urbanized areas. The ultimate objective of the initiative is to develop a better suite of tools to understand development impacts so that appropriate mitigations can be made. The project documented here represents the intermediate step of developing a data collection methodology that captures multimodal trip-making behavior at the building level. Better data is foundational to creating a better process.

In a multimodal context, the most practical way to gather the required data is to conduct intercept surveys of people entering and exiting established developments. These sites would serve as proxy sites to determine trip impacts of new, similar development. A proposed development, or study site, would be compared to the proxy sites and an estimate of trip impacts, based on the trip impacts of existing proxy developments, would be made for the proposed development. The comparison can be made by estimating a model from data collected at the proxy sites or by using a cross-comparison when there are insufficient data to estimate a model.

The data collection methodology consists of site selection, a process for collecting context variables, and a person count and intercept survey strategy that captures total trip generation and allows trip generation estimation by mode. The data will help DDOT to better assess potential transportation impacts of new development throughout the District, ultimately providing guidance and the foundation for a bigger, perhaps national, data collection effort to estimate multimodal trip generation in urban contexts.

To date, DDOT has relied on a variety of data sources, including Institute of Transportation Engineers' (ITE) trip generation rates, Census data, and Washington Metropolitan Area Transit Authority (WMATA) Development-Related Ridership Survey data, when assessing the impact of new development on the transportation system. Even when taken together, these sources fail to provide a robust idea of a development's trip generation. ITE's *Trip Generation Manual*, long relied upon as the industry standard for predicting travel behavior, represents vehicle trip rates in areas with single-use, low density zoning and land uses, typically with limited or no pedestrian, bicycle and/or transit amenities. Thus, with very rare exceptions, ITE rates are only truly applicable in contexts where auto access is the dominant mode. ITE rates are only given for automobile trips and, *de facto*, assume most access and all impacts are due to automobile.

Washington, D.C., by contrast, is primarily dense and mixed-use, which, in combination with the availability of walking, biking, and public transit modes, represents a very different trip-making context.

This context is guaranteed to create fewer vehicle trips than ITE rates would predict and, quite possibly, more total trips overall (due to different trip-chaining patterns and greater density, for example). The limitations associated with ITE rates for this context are well understood, not least by ITE who is currently embarked on a process to improve the applicability of their practice guidance for urban and mixed use contexts. Census data also have limitations in that only journey to work trips are represented. Journey to work tends to have unique characteristics that are not necessarily representative of travel for other purposes. Thus, inference to other trip types cannot be made from census data. Finally, while the WMATA data provides local multimodal information, the data are out-of-date and were collected at limited sites. These sources are neither complete nor easily combined hence the need for the fresh perspective on trip generation that is herein documented.

This study developed a multimodal urban trip generation data collection methodology and piloted it at 16 sites in the District. These proxy sites were analyzed using several of the available tools for estimating travel impacts. The Comparative Results section shows how the tools fared in predicting actual trips and estimated vehicle trips based on data collected. DDOT envisions the eventual development of a model or models that will be applicable to urban areas across the United States, built with input data from across the United States. This pilot study represents a rigorous first step in realizing that vision.

The benefits of this project are multi-fold, addressing the concerns that prompted this study. First and foremost, this project produced detailed data on individual site trip generation that has not previously be available. This data allows the agency to better understand travel demand, which in turn allows for a better understanding of the potential transportation impacts of developments in the District. This will lead to more appropriate mitigations and fewer inappropriate mitigations at the site level. By quantifying observed behavior, this data can also assist in addressing traffic impact concerns from residents, decision makers, and other stakeholders. Similarly, the data could lead to better District-wide policy-making by more closely tying policies about mitigations to how residents make trips.

Understanding Trip Generation

As this project is concerned with travel impact analyses of proposed developments or land use changes, *trip generation* refers to trips that are “created” or “generated” at a site. Trip generation is estimated as a function of expected physical characteristics of the proposed development for the site. This is in contrast to trip generation for travel demand forecasting which relies on projected socio-demographic characteristics of a traffic analysis zone.

Travel impact analyses typically include a trip generation analysis component. The goal of the trip generation analysis is to determine a new development’s impact on the transportation network. If it is determined that the proposed development will adversely impact the existing transportation network, mitigations are usually required to accommodate the increased trips and avoid excessive congestion. There are many solutions to accommodate increased traffic associated with a given development, ranging from project-side solutions such as scaling back plans or increasing transportation demand management programming to local transportation network capacity increases, such as new lanes and turn pockets, and traffic signal adjustments.

The aim of travel impact analysis is to select mitigations that are commensurate with the anticipated level of impact by mode. Over-mitigating or mitigating for the wrong modal impacts may have unintended consequences beyond the site itself. For example, over-mitigating for automobile trips by providing additional infrastructure may ultimately induce additional auto trips. Further underscoring the importance of maintaining a multimodal view, increasing capacity of one mode is frequently done at the expense other modes. Thus, trip generation calculations constitute a critically important aspect of development planning.

Historically, and consistent with the ITE approach, the most common form of travel data collection for trip generation has been through simple vehicle counts. These can be automated, using pneumatic tubes, loop detectors, or other suitable technology, or manual, employing staff using manual counters who observe vehicles passing a point. Vehicle counts tend to be relatively low-cost and easy to implement. They can be very effective for providing estimates of vehicles accessing a site or crossing a cordon. It is worth noting that vehicle counting is so dominant that “trip generation” is often used synonymously with “automobile trip generation” i.e., frequently in travel impact analysis, “trip generation” refers specifically and only to vehicle trip generation.

In a context where most access trips are made by automobile, vehicle trips are a very good foundational estimate of total trips. In that context it is sufficient to count vehicles in order to estimate and mitigate the site’s travel impacts. Unfortunately, counting vehicles alone does not provide sufficient information for trip generation at urban or infill development sites. In the Washington, DC context where regionally only 41% of commute trips are made by car, truck, or van,[1] on average using proxy vehicle counts for trip generation would suggest more than twice as many auto trips would be generated than actually are. At the same time, counting only vehicle trips would undercount actual trips generated at the site by 60%, on average.

At development sites with limited or no parking it is not possible to count vehicles accessing the site – drivers will be parking at nearby garages or on the street and the trips cannot reliably be associated with the development. Vehicle counts may not allow for determination of the type of vehicle; it doesn’t allow the surveyor to note the number of people traveling in the vehicle, nor does it include those who travel by transit or bicycle, or who walk to a site. The alternative is to count persons entering and exiting the site. This is the most effective way to understand trips generated at a specific site.

There are multiple approaches to collecting person counts, with the simplest and most universally applicable being that an individual watches an entrance to a site and manually records all persons entering and existing. Other approaches include video, which allows for a manual count in a compressed amount of time as the tape can be played back at a higher speed, and sensors that are used in pedestrian traffic counts. If a building has an automated key card entry, that data could be used to determine person trip counts much like transit agencies use payment systems to determine system activity. Unlike with payment data key card data entry can only account for parties, hence groups of two or people can only count as one. These automated methodologies tend to seem more intrusive and use more expensive and specialized equipment, rendering them somewhat inaccessible in comparison to automated vehicle counts.

Knowing only vehicle trips or knowing only person trips are both insufficient for impact analysis and mitigation in a multimodal context. It is imperative to also know the mode split. Knowing the different mode usage allows the city to determine the impact of a given site in comparison to existing capacity across multiple modes. When creating future estimates using these data, appropriate mitigations can thus be made to accommodate increased use of any mode.

---

[1] US Census Bureau. American Community Survey 5-year Estimates 2008-2012.

Report Organization

This report documents the process of this project, with the objective of providing reasonable guidance so that others may replicate the effort. Particularly, in the section on data collection implementation we include efforts that were tested and then rejected. The intention is to provide maximum value as others undertake similar efforts.

The report is divided into sections detailing previous research on the topic, the design and implementation of this pilot data collection effort, and trip predictions from several trip generation models. Conclusions provide steps for future development of a universal urban trip generation approach. Appendices include the proposed data collection methodology for future efforts, communications and information materials, site details, data collection instruments, and summaries of the data.

2. Review of Previous Studies

A comprehensive review of previous trip and parking generation studies was undertaken to inform this project. Additional attention was placed on literature connecting trip making and mode choice with the built environment, even if the studies in question were not specifically about trip generation. Understanding built environment effects on travel behavior will be critical for later model development and informs the selection of context variables in data collection. To be relevant, the work had to address place-based, rather than person- or household-based trip generation. An obvious example of the former is described in ITE's *Trip Generation Manual* and of the latter, any regional household travel survey. Person- and household- based trip generation, typically used for regional travel demand, rely on demographic factors for forecasting; when reviewing proposed developments, demographics necessarily remain unknown, hence the model must predict on the basis of physical characteristics of the proposed development.

This literature review covers the academic and grey literature that pertains to place-based trip generation models, data collection for those models, and a review of the key context variables that affect trip generation and mode split. It includes a summary of trip generation models in use or recently developed. Appendix A provides a full bibliography.

Multimodal Trip Generation Data Collection

Few cases involving site-level data collection have been explicitly documented, but those that have universally involve a count and intercept survey [5],[7],[8],[9],[10], frequently conducted in tandem with just counts at doors with an exclusive access characteristic –e.g. from a garage or directly from a transit station [11].

Schneider et al., for their study of trip generation and smart growth, used a count and intercept survey [5]. The survey included up to 10 questions depending on branching related to earlier questions and the need for clarification. For example, to deal with the question of how to tabulate those who traveled by multiple modes, the surveyor asked clarifying questions such as “Walked all the way?”. The survey instrument included check boxes for all modes that the interviewee used to access a site. Mode classification could then be done in post-processing, eliminating surveyor bias in determining the “primary” mode of travel. Similarly, Clifton, Currans and Muh used a combination of long and short surveys and counts [7]. They opted for a longer survey instrument with up to 24 questions on their long form and just four on their short form with a response rate of 19% for the long survey. The longer survey captured demographic information (age, gender, household car/vehicle/transit pass ownership), “mode attitudes” (respondent would rate statements such as “walking here is safe and comfortable.”), and time and money spent in a location. The response rate for the short survey was higher, but not specified. Finally, in a study looking at infill-development sites in California, Kimley-Horn and Associates used a similar methodology [8]. Intercept surveys had up to 15 questions, and preliminary results show that the return rate was between 7 and 20%. This methodology is also recommended as a way of capturing multimodal trip generation at infill sites by the National Cooperative Highway Research Program (NCHRP) Report 758 [12].

Related studies focus primarily on internal capture. NCHRP Report 684 is an example; it also relies on counts and intercept surveys and its data collection field guide requires surveyors to ask and record answers to 7 to 12 questions about mode, origin and destination [9].

One of the variations across these studies is the interview-capture rate, but it is unknown if the different response rates were due to refusals or simply due to different staffing levels and/or the different lengths of time required for each survey to be completed.

Context Variables

A number of studies have focused on the impact of the built environment on trip generation and other travel behavior. The key indicators for travel behavior identified in this review are density, land-use mix, parking price and availability, and the quality of non-automobile modes. Studies in this section generally find correlations in consistent directions but different degrees for different variables. Travel behavior is measured as vehicle miles traveled (VMT) or vehicle hours traveled for private vehicles [13],[14],[15],[16],[17],[18],[19],[20],[21],[22],[23], mode share or propensity to use a given mode [1], [24], [25], [26] or number of trips generated [4],[8],[27],[28],[29],[30]. Table 2 below summarizes the studies considered in this section.

Table 2. Context Variable Studies

Category	Factor	Relevant and Recent Studies
Density	Density	▪ Zhang et al., 2012 [13] ▪ Ewing and Cervero, 2010 [23] ▪ Ewing et al., 2013 [16] ▪ Handy et al., 2013 [4]
Land Use Mix	Land use mix	▪ Ewing et al., 2011 [1] ▪ Ewing et al., 2013 [16] ▪ Boucher et al., 2011 [9] ▪ Ewing and Cervero, 2010 [23] ▪ Frank et al., 2011 [14] ▪ Zhang et al., 2012 [13]
	Jobs/population diversity	▪ Ewing et al., 2011 [31] ▪ Ewing et al., 2013 [16]
Parking Pricing and Availability	Parking availability	▪ Lund et al., 2004 [32] ▪ Cervero, 2006 [33] ▪ Cervero and Arrington, 2008 [30] ▪ Cervero et al., 2010 [34] ▪ Weinberger et al., 2012 [35]
	Parking cost	▪ Kelley and Clinch, 2005 [36] ▪ Right Size Parking Model, 2013 [37] ▪ Frank et al., 2011 [14] ▪ Kuzmyak and Vaca, 2005 [25] ▪ Shoup, 1997 [31] ▪ Shoup and Willson, 1992 [38]
Transit Quality	Frequency	▪ Right Size Parking Model, 2013 [37] ▪ Handy et al., 2013 [4]

		Evans, 2004 [39] Cervero, 2006 [33] Frank et al, 2011 [14]
	Availability	Chatman, 2006 [24] Podobnik, 2002 [40] Metropolitan Transportation Commission, 2006 [41]
	Stop density	Ewing et al., 2011 [1] Ewing et al., 2013 [16] Clifton et al., 2012 [7]
Walking Quality	Intersection density	Clifton et al., 2012 [7] Ewing et al., 2011[1] Chatman, 2006 [24] Ewing and Cervero, 2010 [23] Currans and Clifton, 2014[6] Chatman, 2006 [24]
	Block length	Zhang et al., 2012 [13]
	4-way intersections	Chatman, 2006[24] Cervero, 2006 [33] Lund et al., 2004 [32] Ewing et al., 2011 [1] Ewing and Cervero, 2010 [23]
	Sidewalk coverage	Handy et al, 2013 [4] Frank et al., 2011 [14]
Biking Quality	Bike facility availability	Carr and Dill, 2003 [42] Guo et al., 2006 [43] Barnes et al., 2006 [44] Clifton et al., 2012 [7]

Density

Several researchers found correlations between residential and/or employment density – but not always both. For example, Zhang et al. (2012) found that residential density was correlated with a decrease in VMT in the four major metropolitan areas they studied, but that employment density was statistically related to VMT in just two of the four [13]. In a meta-analysis of research comparing the built environment and travel behavior, Ewing and Cervero (2010) found that household or population density had a negative correlation with VMT and a positive relationship with transit and walking trips[23]. Ewing et al. (2013) found that activity density, represented by the sum of employment and population, was statistically significant in predicting the use of transit or walking but not in predicting internal capture rates or driving. Instead, the number of jobs within various multimodal radii of the site were better predictors of driving [1]. Density is often incorporated in other variables, such as the "Smart Growth

Factor," a compound, or interactive, variable used in the Smart Growth Trip Generation Model by Handy et al. [4]. This variable is derived from site-level and environmental characteristics including residential and employment density, distance to the central business district, average building setback, the presence of metered parking, transit service frequencies and the percentage of the site area that is surface parking.

Land-Use Mix

Much like density, researchers have measured land-use mix in a variety of ways and measured different impacts on trips. Ewing et al. (2013) tested both the balance between employment and population as well as an entropy variable calculated from the variety of uses (such as retail, residential, industrial, etc.) *within* a mixed use development [16]. The entropy variable indexes the balance of uses between 0 (imbalanced) and 1 (balanced). In two studies, the team found the balance of jobs and population to be an important predictor of external walk trips and trip distance for external driving trips [16],[1]. Using the same dataset but considering both internal and external trips together, Ewing et al. (2013) found that land-use entropy was a factor in predicting the length of vehicle trips [16]. Another study found the ratio of jobs to population unimportant; instead finding the ratio of commercial to residential square footage to be a predictor of internal capture [9].

In addition to those looking at the relationship between land-use mix and walk trips, other researchers have focused entirely on the correlation between land-use mix and vehicle trips. Ewing and Cervero (2010) found the elasticity of VMT with respect to land-use entropy and jobs-housing balance to be -0.09 and -0.02 respectively [23]. Frank et al. (2011) calculated an entropy variable in a one-kilometer radius of a household location and found it to be a significant variable in a model that explained about 30% of the decrease in auto trips [14]. Zhang (2012) also used an entropy calculation at the Census tract or traffic analysis zone (TAZ) level – depending on data availability for the region – and found that it had a negative effect on VMT [13]. A final study reliably used an area's Walkscore©, an index measuring density of amenities that could be a proxy for land-use mix, as a predictor of walk trips [45].

Parking Pricing and Availability

Unlike with trip generation modeling efforts, no nationally applicable model has been created for parking pricing. Kelley and Clinch (2005) measured parking before and after a 50% increase in meter prices in Dublin, Ireland. They found that the price elasticity of demand of parking averaged -0.28 [36]. The Right Size Parking Project model, based on field data from 240 multifamily properties in Seattle, found that when parking price, as a percentage of average rent, increases, the number of observed vehicles per occupied residential unit in multi-family residential developments decreases [37]. Using household travel surveys, also in Seattle, Frank et al (2011) found that per-trip parking charges had a negative influence on VMT while transit price had a positive influence on VMT [14]. Kuzmyak and Vaca (2005) found multiple examples where parking pricing on its own or as part of a suite of transportation demand management (TDM) strategies reduced trip rates and/or parked cars [46]. The study did not draw overall conclusions about parking pricing elasticity. However, research on parking cash-out at workplaces shows consistent reductions in single occupant vehicle use [31],[38].

In addition to price, the overall availability of parking can drive mode choice – it is more burdensome to drive when one is not assured a parking space. Lund et al. (2004) found that free parking at work had a negative impact on transit use [32] and Cervero (2006) and Cervero and Arrington (2008) found that as the number of parking spaces per worker at offices increased, the number of transit trips decreased [33], [47]. The relationship is symmetrical; while greater parking availability is associated with more driving, decreasing available parking may lead to decreases in driving [34]. In particular, Cervero et al. (2010) found that reducing parking by 0.5 spaces per unit can lower peak demand for parking by 0.11 parked cars per unit in a suburban multi-family residential transit-oriented development (TOD)[34]. Looking at homes as well, Weinberger (2012) found that private parking availability at home was a predictor of private automobile trips to the transit rich Manhattan core [35]. Conversely, or complementarily, lack of private parking at the origin was a predictor of higher transit.

Transit Quality

The Right Size Parking project used a gravity measure of service frequency, taking into account proximity and frequency, as a measure of transit quality, and found an inverse relationship between frequency and parking usage (parking usage implies private vehicle trips) [37]. Transit frequency was also a component of the previously discussed Smart Growth Factor variable used by Handy et al. [4]. In a survey of studies of transit headway decreases, Evans (2004) finds an overall positive relationship between ridership and increased frequency [39]. Cervero (2006) also measured the effect of frequency on ridership by surveying workers at ten office locations in California, all within a half mile of a train station. In that study, frequency of a feeder bus service at the work end of the trip was one of the most significant predictors of transit mode choice. Generally, the research also found that those who worked near a train station were more likely to take transit than the general population, thus implying that proximity to transit is an important driver of mode choice [33]. Frank et al. (2011) used a weighted average of bus wait time, finding that as it increased, driving increased [14].

Others measured the quality of the transit environment by the presence of transit options. Looking at TODs in California, Chatman et al. (2006) found that those that live and/or work near a light rail station were less likely to commute by personal vehicle. However, the same work found that those living near a light-rail station were more likely to drive or take transit and less likely to walk for non-work trips. As the study focused on TOD development, it was not as concerned with transit quality specifically [24]. Podobnik (2002) found the opposite at Orenco Station in Portland: residents were more likely to drive to work and use transit or walk for non-work trips [40]. In both cases TOD sites had lower overall drive trips [24], [40]. Research by the Metropolitan Transportation Commission also found a positive relationship between the propensity to take transit and the presence of transit within a half mile of a household [41]. Arguably, the presence of transit is a necessary, if insufficient, condition for transit usage.

Another measure of transit availability is transit-stop density. Ewing et al (2011) found that transit-stop density per quarter mile was negatively associated with private vehicle trips and positively associated with transit and walk trips [1]. Looking at the same data set, Ewing et al. (2013) also found a positive association with transit trips if there was a bus stop within a quarter mile of work or home or transit within a mixed-use development [16]. This research did not find a link between transit availability and driving.

Finally, although Clifton et al. (2012) considered the number of transit corridors and high-frequency bus routes near a site as independent variables, they ultimately dropped this variable in favor of density measures which they found to be more robust [7].

Walking Quality

Intersection density is the most frequently considered variable to predict walking, and it is a good proxy for block length as well (e.g. [1], [7], [24]) The six-region model by Ewing et al. (2011) finds that intersection density is not only a good indicator of walking, but that transit trips increase with it as well, while driving trips decrease [1]. In a study of four major metropolitan areas, Zhang et al. (2012) found that as block size increased (thus decreasing intersection density), VMT increased [13]. In their 2010 meta-analysis, Ewing and Cervero calculated a weighted negative elasticity between intersection/street density and driving, and a positive one with walking and transit [23]. Currans and Clifton (2014) found that intersection density was the single best predictor of auto trip share in an analysis of household travel surveys in Portland, Seattle, and Baltimore [6]. However, in California, Chatman (2006) did not find intersection density to significantly predict trip types other than walking [24].

A similar factor to intersection density is the percentage of four-way intersections within a catchment area. Technically, this approach counts the percentage of intersections with four or more legs –i.e. a standard intersection (not a “T” or staggered intersection) wherein two streets cross but also more complex intersections where more than two streets cross in a non-standard grid. Chatman used the four-way classification but still measured density rather than overall proportion [24]. Cervero (2006) found the percentage of four-way intersections in an area was correlated with walk trips but not with trips by other modes [33]. In contrast, Lund et al. (2004) found that this factor did predict transit choice [32]. As noted above, Ewing et al. (2011) found that intersection density was a statistically significant predictor of transit trips, while the percentage of four-way intersections was a statistically significant predictor of walking and bicycling trips [1].

Finally, at least one study looked at sidewalk coverage, but found sidewalk coverage to be insignificant in predicting vehicle trips [14].

Bicycling Quality

In their survey of the literature, Heinen et al. (2010) found that there are myriad ways that researchers have evaluated the built environment and its impact on cycling trips, from the type of facility to the number of vehicular lanes on a road to the presence of stop signs and traffic lights [48]. One of the most common and relatively easy-to-measure variables is the presence of bicycle facilities. Carr and Dill (2003) found that the mileage of bicycle lanes in a city was correlated with Census journey to work bicycle shares [42]. The causality is unclear but the presence of bicycle facilities may be robust as a heuristic to predict mode shares. Guo et al. (2006) found bikeway density to increase cycling for “maintenance trips”[2] but did not find a corresponding drop in vehicle activity [43]. Similarly, looking at Census data on commute mode shares before and after the construction of cycling facilities, Barnes et al. (2006) found that areas near cycling facilities gained bicycle mode share when the facilities were built [44]. The Oregon Transportation Research and Education Consortium (OTREC) model, developed by Clifton et al. (2012), considered the length of available bicycling facilities in predicting trips as well, but ultimately found other factors to be better predictors. This seems to be an overall trend – researchers either did not consider bicycle facilities or potentially considered other measurements such as intersection density to be sufficient to model bicycling opportunities and thus trip generation.

Trip Generation Estimation Tools

Multiple tools that seek to provide trip and/or parking generation estimates for a variety of site types, have been developed in recent years. Most efforts are in response to the concern that ITE trip generation rates are not well suited to urban infill, transit-oriented development, smart growth, and

---

[2] “Maintenance trips” are maintenance shopping such as groceries, medical visits, or dropping off/picking up a passenger. For more information, please see [43] Guo et al. (2006), p. 9

other high density development types that are increasingly common. In spite of the critique, most, like the National Cooperative Highway Research Program's (NCHRP) Report 758 [12] and the California Smart-Growth Trip Rates Study [4], adjust ITE rates in an effort to better fit the different contexts. The tools are summarized in Table 3. Five of these models are tested against this project's data with results given in section Comparative Results. Some of these tools are predicated on original data collection, some on secondary sources such as national or municipal data collection or household travel surveys, while others incorporate results from other studies, adapting their parameter estimates and findings to the task at hand (see Table 3, below).

Table 3. Trip Generation Estimation Tools

Tool	Applicability	Dataset	Associated Publications	Input Summary	Output Summary
NCHRP Report 684 (2011) [9]	Mixed-use developments (at least three uses)	Intercept surveys and door counts at three mixed use developments in Florida, and one each in Dallas, Atlanta, and Plano (TX)	n/a	Square footage of multiple uses Proximity of uses (not required)	ITE-based vehicular trip reductions due to internal capture
EPA- MXD Trip Generation for Mixed-Use Developments (2010) [49]	Mixed-use developments	Travel surveys from 239 mixed-use developments in 6 urban regions in the US	▪ Ewing et al., 2011 [1] ▪ SANDAG, 2010 [2] ▪ Fehr & Peers model overview [3]	Multiple context variables Size of uses	ITE-based vehicular trip reductions ITE-derived transit trips ITE-derived walking trips Internally captured trips
SANDAG MXD Trip Generation for Smart Growth (2010) [2]	An adaptation of the EPA-MXD model. Used for Smart Growth developments in California	Based on the above		Multiple context variables Size of uses	ITE/*San Diego Traffic Generators* vehicular trip rates
California Smart Growth Trip Generation Rates (SGTG) (2012) [50]	Smart growth developments (particular criteria given)	Door counts and intercept surveys at 30 smart growth locations in California	▪ Handy et al., 2012 [4] ▪ Schneider et al., 2013 [5]	Multiple context variables Size of uses	ITE-based vehicular trip reductions

Tool	Applicability	Dataset	Associated Publications	Input Summary	Output Summary
URBEMIS2007 (2007) [51]	All	Based on previous research	- n/a	Context and programmatic variables Size of uses	ITE-based vehicular trip reductions
PSU Models A, B and C*	All	195 travel surveys from Oregon, Washington and Baltimore.	- Currans and Clifton, 2014 [6]	Simple lookup table of activity density OR multiple context variables	ITE-based vehicular trip reductions (Adjustments A, B and C) and trips by mode (Adjustment A only)
CAPCOA (2010) [52]	All	Based on previous research	- n/a	Context and programmatic variables Size of uses	Quantification of pollution mitigation due to transportation measures. Could be translated to trip reduction.
TRIMMS (2012) [53]	All	Based on previous research	n/a	Context and TDM programmatic variables	Social benefits including trip generation and reduction
Tripgenie (2012) [54]	All	Based on previous site-specific counts	n/a	Place type, land use	Trips by mode
NCHRP Report 758 (2013) [12]	Infill development (particular criteria given)	n/a – Methods recommendations rather than a model	n/a	Regional travel demand model data	ITE-based vehicular trip reductions

***Note: Model unpublished. Model name created for the purposes of this paper only.**

Literature Summary

The literature reviewed provides a comprehensive, if not exhaustive, look at research relevant to trip generation estimation. Only a few of the studies directly attempt to estimate trip generation. Many focus on the effects of particular variables on travel behavior. Generally, previous research shows consensus on the kinds of variables that matter even when researchers do not always find agreement on the particulars. There is little direct conflict though, as the disagreements tend to be on magnitude or statistical significance but not on the direction of the effect.

Several recent efforts have sought to improve on ITE's methodology by applying adjustment factors to the wealth of data that ITE has collected over the years. But it is worth noting that the problem of trip generation is not new [55], nor is the concern that ITE may not be appropriate for predicting trip generation in all contexts. A 1985 report by the Federal Highway Administration (FHWA), *Development and Application of Trip Generation Rates*, sought to complement the ITE methodology by incorporating rates based on location, auto occupancy and transit availability [56]. Other researchers, dating back almost 30 years, have offered alternatives while expressing their thinking that the standard approach is quite flawed and may need to be abandoned altogether [57],[58].

The primary conclusion of this review is that a good trip generation model should consider measures of density, transit availability and quality, parking availability, and walkability at a minimum. Other variables to consider are land-use mix and the quality of bicycling infrastructure. The exact form that these variables should take will be determined by future research.

The secondary conclusion is that the ITE approach is not problematic *prima facie*, but that relevant proxy sites for urban and infill development are lacking. Due to ITE's focus on suburban development over the last several decades, the organization has collected an impressive database from low-density settings. ITE reminds its users that "Data were primarily collected at suburban locations having little or no transit service, nearby pedestrian amenities, or travel demand management (TDM) programs." (p.1) As a result, urban sites are systematically under-represented among the ITE data. The source of this data is not ITE itself, in fact the *Trip Generation Manual* states that "ITE Headquarters conducted no original field surveys." (p.11) Rather, ITE describes its data sources as "…contributed on a voluntary basis by various state and local governmental agencies, consulting firms, individual transportation professionals, universities and colleges, developers, associations and local sections, districts and student chapters of ITE." (p.11) [59]

Finally, the literature review also highlighted the extent to which accurate multimodal trip generation is at issue. The sheer volume of studies devoted to the topic show that policy-makers have a critical interest in accurately estimating trip behavior. While regional efforts such as municipal models or even national efforts like the US Census strive to create good data on travel patterns, site-specific multimodal trip generation remains an outstanding issue to date.

3. Field Methodology

The fieldwork for this project required communications with building owners and developers, a process for site selection, development of a data collection strategy encompassing both trip making and context variables, field testing the system, and making final adjustments. The procedures are documented in this section. Appendix B, Recommendations for Future Data Collection, represents the culmination of lessons learned during the field portion of the project.

Data Collection Strategy

DDOT sought to create a data collection methodology that would produce standardized and thus comparable data across multiple sites. Moreover, data collection methods had to be replicable to create and populate a database of site-specific multimodal trip generation that could be used to estimate the trip generation of future developments. This format is analogous to ITE's widely understood and accepted database of vehicle trip generation. Based on this objective for the project, the general discussion of trip generation found in the introduction, and the review of previous studies, the following criteria guided our data collection strategy. The method had to:

- encompass a site-specific strategy;
- obtain counts of person trips and mode shares;
- be simple and streamlined to ensure accuracy and usability for the larger study; and
- be replicable.

Given these criteria, a review of best practices, and relying on relevant team experience, the research team, in conjunction with DDOT, decided upon the data collection strategy described here in detail. The strategy includes site selection, collection of relevant context data, and, finally, a person count and mode estimation approach. The latter methodology utilizes door entrance/exit person counts to quantify the total number of person trips to a site. The door counts are complemented by an intercept survey to determine the modes by which people arrive. This allows the ultimate dataset to reflect person trips by mode at the sites.

Site Selection

Mid-rise residential properties were identified as a focus for this study because DC is currently seeing a great deal of this type of development. To gain perspective on the diversity of development in the District of Columbia, additional factors included [within development] mix of uses, transportation options, parking alternatives, size of the development, age and location context. The list below details the characteristics required of the sites; Table 4 shows the ideal versus realized factors:

- **Mix of uses:** A sampling of properties that represented both 100% residential developments as well as predominantly residential with ground floor *neighborhood-serving* retail was desired. While properties that included destination retail were generally avoided, one such destination was ultimately included in the sample. The final sample comprised seven sites that were 100% residential and nine sites with some kind of ground floor retail activity. Appendix C lists the surveyed properties and some key characteristics of each.
- **Transportation options**: Properties located in areas with a rich abundance of transportation options were desired. Generally this meant a proximate Metrorail station as well as significant bus connections, a grid street layout, and bicycle services and networks.

- **Parking alternatives**: Properties, both with and without on-site parking facilities were desired. Four sites without parking were selected.
- **Significant size**: A target of 75 units or greater was set. Ultimately, the average number of units was 218. The smallest building has 49 units and the largest 448.
- **Diversity of ages**: The initial sample of properties included those developed in recent years as well as mid-century and older properties. The team targeted properties that had been occupied for a minimum of three years to ensure residents had a generally established travel pattern.
- **Not hyper-urban**: Properties within the Central Business District were eliminated from the pool of eligible properties. These "hyper-urban" locations represent a unique context not typical of the majority of development projects in the District.

Based on these general criteria, a database of approximately 100 properties was identified. The Washington, D.C. Economic Development Inventory provided a foundation of 81 eligible properties. The Economic Development Inventory was augmented with 20 additional properties selected for their compatibility with the criteria. The additional sites were identified on the basis of professional judgment and local expert knowledge.

To improve the odds of success, these additional criteria were applied in selecting the final list of sites targeted for this data collection effort:

- **Supportive owners**: Though DDOT is legally entitled to survey on public sidewalks, cooperation from building owners was considered to offer an efficiency advantage. Therefore, properties where owners have previously been involved in and/or supportive of smart growth efforts in the city and collaboration with city agencies were preferred.
- **Properties under common management**: Several of the properties are under common management and communication, outreach, and notification were considered essential elements to reduce resistance and concern about the data collection effort. To gain efficiency in communication, properties under a common management company were prioritized. Working with fewer management entities increased the ability to quickly inform and allay any concerns about the data collection effort.
- **Geographically clustered**: To facilitate collection of other area data such as alternative transportation resources, distance from the urban core, and other factors, properties within common neighborhoods were also prioritized. The areas where surveying occured are shown in Figure 6.
- **Supportive local entity**: The presence of an informed and supportive Business Improvement District organization or similar entity was also deemed an advantage as this group could intervene in the event of any misunderstanding or conflict.

The application of these various criteria resulted in targeting the pilot data collection effort in four general areas of the District of Columbia (see Figure 6):

- **Petworth/Georgia Avenue** – four properties in this sub-area were sampled.
- **Columbia Heights** – three large properties were sampled in this sub-area
- **Navy Yard/Capitol Riverfront** – five properties were sampled in this sub-area
- **NoMa** – four properties were sampled in this sub-area.

Figure 6. Site Locations

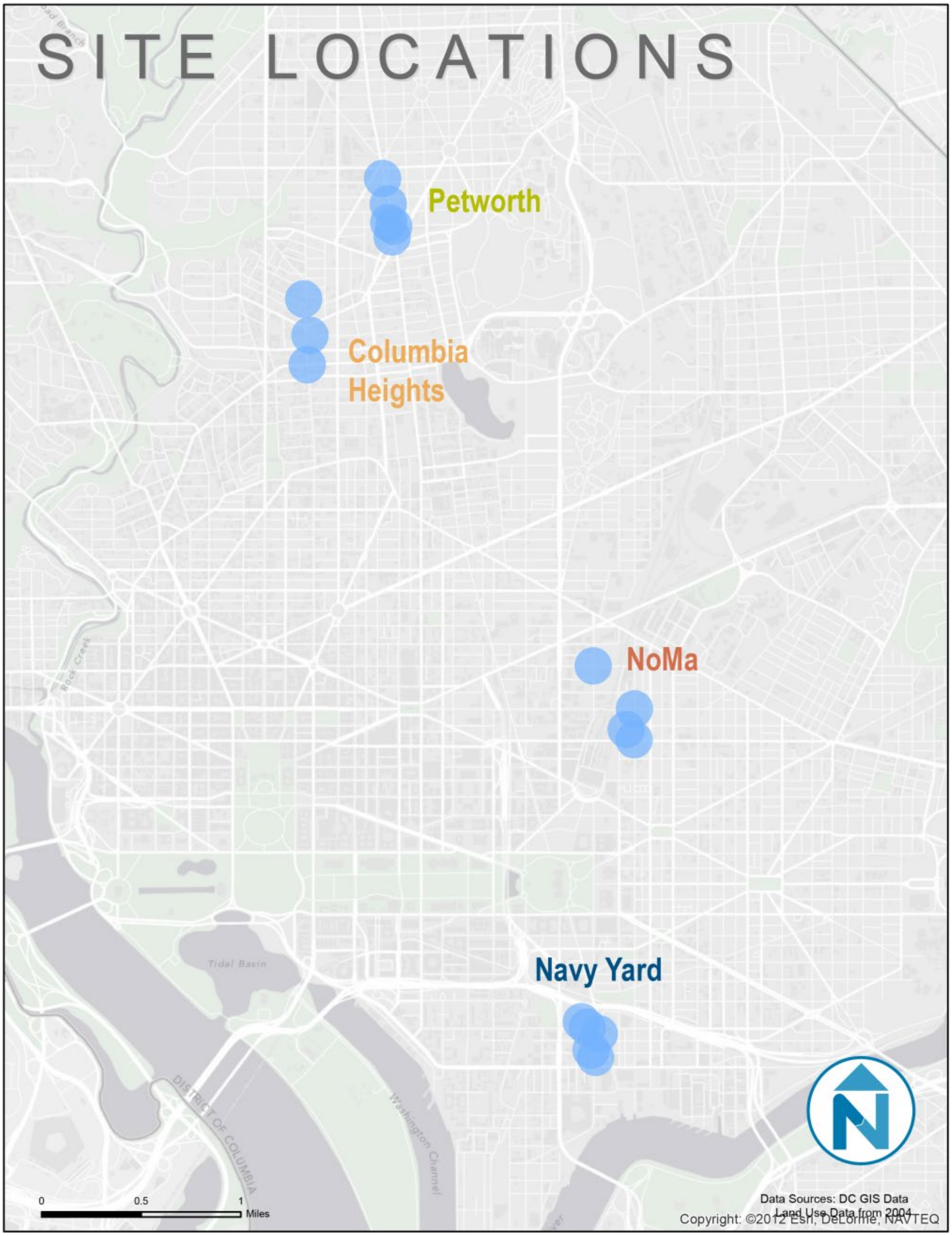


Table 4. Site Selection Criteria

Factor	Ideal	Realized
Mix of uses	Exclusively residential or local serving ground floor retail	6 of the sample sites were 100% residential and 9 contained ground floor retail.
Transportation options	Proximate Metrorail station as well as significant bus connections, a walkable grid of streets, and bicycle services and networks	All properties had a mix of transportation options nearby.
Parking alternatives	Mix of amount of parking provided	3 sites had no dedicated parking
Significant size	75 Units or greater	Average number of units was 233. The smallest building has 49 units and the largest 448
Diversity of ages	Minimum of three years	All at least three years old
Not hyper-urban	Avoid CBD	No sites in the CBD
Properties under common management	Grouped to the extent possible	Almost all the properties (12/16) were managed by different individuals working with the same entity.
Supportive owners	Owners had been contacted and expressed support	Owners were generally supportive. Property managers were not.
Geographically clustered	Clustered to the extent possible	The 16 pilot sites are contained within four study areas
Supportive local entity	Supportive BID	BID supportive, where such an entity exists

Support from Building Management

The project team was able to gain support from building owners, but was less successful in obtaining cooperation from specific building managers. Some of the speculation as to why this might have been the case includes acknowledgement that priorities of owners and managers are not the same, and that owners will generally have past experience with the city, either in the form of BIDs or through the development process while operators are more concerned with day to day management.

In any case, best practice dictates that every effort should still be made to inform and engage the property managers. To that end, the project team took the following steps to enlist support:

- Created 1-page brochure explaining project (see Appendix D) for email and print distribution.
- Met with the DC Building Industry Association and the DC Economic Development Partnership to discuss outreach to property managers.
- Communicated and coordinated with local BID organizations.
- Went e-mail notification of data collection (see Appendix E).
- Provided telephone notification of data collection.

Data Collection Implementation

Site and Area Specific Data Collection

As discussed in the literature review, travel behavior, including number of trips and mode choice, is a function of land use and transportation infrastructure supply. Given these established relationships, a robust trip generation model is reliant on site and area specific data. Hence, site and area specific data were collected to appropriately contextualize the trip counts. While much of the data is available in municipal or national databases and does not change over time (such as location of a rail transit station or a parking garage), other context variables, including parking utilization and quality of bus stops, may be time-sensitive and not available from pre-existing sources. This study did not focus on selecting context variables to build a model. However, the literature review identified several variables that would be good context measures. Therefore, to allow maximum flexibility in future development of trip generation models, the team also collected area-specific data to supplement that available from pre-existing sources.

Site data were collected using the DC Economic Development Partnership database, Google Earth, Zillow.com, and the DC Taxpayer Service Center Real Property Database. The research team collected site data at all data collection locations. The site data collection included the following key variables.

- Area (neighborhood),
- Name of Project,
- Address,
- Construction type,
- Major use,
- Total square footage,
- Office square footage,
- Number of residential units,
- Retail square footage,
- Parking space count, and
- Number of doors by type.

Context data that could influence mode share and trip generation include:

- Bus shelter quality assessment
- Bicycle rack availability
- Bicycle rack utilization
- Parking utilization on-street

This information was collected within a quarter mile radius of the 11 sites visited in November and it has been compiled as a GIS shape file. It is important to document this information at the same or similar time as the trip generation data collection occurred so that the context would accurately match behavior. Thus, these data were collected while the team was on site gathering trip generation data.

Trip Generation Data Collection (Counts and Mode Share)

The final field collection was conducted in November and December 2013 and February 2014. Address information for the sixteen sites has been omitted in the report to protect privacy of the residents. Details corresponding to the sites are found in Appendix C.

Test Case Data Collection

The intercept survey methodology was field tested in early November 2013. The test site, located in the Navy Yard neighborhood, is similar to the pilot sites: primarily condominium residential with a small number of non-residential ground floor uses with separated street entrances. Parking is underground in a facility shared with an adjacent hotel. A Metrorail station is approximately one block away.

The field test was conducted for approximately one hour in the morning (8 a.m. to 9 a.m.) and one hour in the afternoon (5 p.m. to 6 p.m.). Four surveyors were deployed at the building: two at the main pedestrian/lobby entrance, one at the retail storefronts and one at the parking garage access/egress point.

Based on the Test Case data collection, modifications were made to field instructions as well as to the data collection forms. Lessons learned from the Test Case are noted in the discussion below.

Staffing and Cost

The effort included counts at 62 entrance points and required 13-17 field staff per day depending on the number of sites being collected and the size of the building. Up to four sites per day were collected in this study. During the November data collection staff included two supervisors in the field, and in December and February one supervisor. Supervisors had a deeper understanding of the project and were thus able to answer data collector questions as they came up, reorganize staff as necessary, and maintain data quality control.

The team calculated a “loaded” cost estimate of approximately **$800 per door**. This includes:

- Pre-data collection site visit
- Data collection by temporary workers at approximately $10/hour
- Site coordinator/data collector
- Basic digitization of written data

Timing

Data collectors counted and surveyed during peak hours of 7 a.m. – 10 a.m. and 4 p.m. – 7 p.m. for a total of six hours per day. Counts were made on a Tuesday, Wednesday, or Thursday in dry weather conditions on a day without a holiday, early school release, a significant regional vehicular crash, transit system shutdown, or other event that would cause irregular behavior and bias the counts. The ultimate survey rubric is presented in Appendix F.

Count and Survey Preparation

Before the survey day, the research team visited each site to determine points of entry for person-trips (including those by vehicle) and to inventory the location for possible efficiencies. For example, in addition to entering at street level, site visitors may also enter the building directly from a parking garage or transit station. Multiple entrances may also meet at a “funnel point” that is not necessarily an exterior entrance; such points are ideal locations for surveying as they capture multiple entrances. In some situations, counters could position themselves to see more than one door thus increasing the team’s efficiency.

Data Collection Instrument

Based on the test case, changes were made to simplify the data collection form. The original survey asked multiple questions regarding both arrival and departure mode and time. In addition, surveyors were asked to record the exact time of each interview. Given the attitude of persons surveyed with respect to the interruption, the idea of collecting information on two trips at one time was abandoned. The new survey asked only about the access or egress that was in progress when the subject was approached –i.e. someone entering the building was only asked about their arrival and not about their hypothetical departure, someone leaving was asked only about their departure and not about how they had earlier arrived. Noting the precise time of the survey was deemed unnecessary and time consuming; it appeared sufficient to gather information in 15-minute increments. Finally, a need was identified for a way to capture non-personal vehicle trips as distinct from personal vehicle trips. For example, individuals arriving or departing by taxi, Uber (or the like), car2go, Zipcar or other service should be noted as a “shared vehicle” trip rather than an “SOV” (single-occupant vehicle) trip as these vehicles demonstrate greater efficiency in utilization of curbside and garage space.

Door Counts

Surveyors counted the number of person trips entering and exiting each building by door. All counts were recorded in 15-minute intervals during the collection period. The goal was a full 3-hour dataset in each peak to capture the highest 60-minute period.

Intercept Surveys

People were intercepted as they entered or exited the building. Generally people were more receptive to the surveyors upon exiting a retail location so the surveyors were less likely to approach people entering a retail establishment, focusing, instead on those exiting. Interviewers surveyed quickly and efficiently. Each survey was limited to 20 seconds. Surveyors and counters indicated, on the data collection form, which doorway and/or funnel point was being surveyed. This ensured the samples and counts were clearly matched. A door leading from a garage into a building will likely have a higher percentage of drivers than another door leading onto a sidewalk, hence the importance of keeping accurate records.

Ultimately, the following three data collection instruments were employed. The actual forms are shown in Appendix G:

- **Door Count AND Interview Form** – for low-traffic locations where one person can both survey and count people
- **Door Count ONLY Form** – for high-traffic locations where one person is ONLY counting people, NOT interviewing them
- **Interview ONLY Form** – for high-traffic locations where one person is ONLY interviewing people.

Other Observations

This section lists several additional, relevant observations that were made during the test case data collection.

Time of Day:

- Morning - during the morning collection period, a significant number of individuals were in a hurry, and did not want to be stopped for a survey, however brief. This does not affect counting but will yield a higher refusal rate for the survey portion of the study. Survey subjects were more willing to stop and answer questions in the evening.

Weather/season:

- Darkness/early sunset was an obstacle during the evening data collection. Data collectors should position themselves in well lit areas to ensure adequate comfort to subjects. Some subjects responded with fear when approached to answer the survey in the evening hours with waning daylight. Reflective vests or other measures to increase visibility may be a benefit for both survey administrators and respondents. Provisions should be made to ensure the safety of data collectors (e.g. pairing if necessary).

Volume:

- During the very busiest times, it may not be possible for an individual to both count and survey. Two surveyors, i.e. a counter and an interceptor should be stationed at high volume locations.

- A single surveyor appears to be adequate at retail and garage entrances. These have narrower portals that generally require queuing and have fewer entrances/exits at a time.

- For large format retail (e.g. a grocery store, big box, larger restaurant, entertainment venue, etc.), two or more surveyors will be needed.

Engagement:

- Many individuals, either through body language, presence of headphones, or eye contact, made it clear that they were not interested in engaging. The team’s recommendation is that regardless of body language, a single verbal attempt at engagement should be made in all cases.

- The engagement script should be as short as possible. It could include a statement of identification, an explanation of the project, and quickly coming to the point.

- Some subjects responded negatively/defensively to the script “… did you drive here today?” or “… will you drive to your next destination?” Surveyors should modify question according to context and most likely trip mode (e.g. are you taking Metro/walking/taking the bus/driving/biking to your next destination?).

4. Data Collection Results

Determining Generation and Modal Split

As discussed in the methodology section, this study used a combination of door counts and intercept surveys to get trip counts and estimate mode splits for trip generation rates at each site. Surveyors and counters recorded data at 15 minute increments for a predetermined "peak period" in the morning (7:00 a.m. – 10:00 a.m.) and evening (4:00 p.m. – 7:00 p.m.). The ratio of counts to surveys is used as an expansion factor to derive an estimate of person trips by mode by door. These are then aggregated to form a total for each site. The expansion factors are specific to each door/funnel point, meaning that the number of people interviewed at a particular door is given a factor weight so that the sum of weighted surveys equals the door count. The sum of the door counts equals the site count. This accounts for the fact that a door closer to the Metro station is likely to have a higher share reporting Metro as their main mode, while a door to a parking garage would have a higher share of vehicle trips.

The highest volume hour, comprised of four consecutive fifteen minute periods, defines the peak hour. It is not necessarily the same for each site. For example it could occur from 8:00am to 9:00am or just as easily from 7:45 a.m. to 8:45 a.m.. The mode shares, calculated over the entire three hour period are applied to the peak hour to determine the mode splits. Using the mode share for the peak period, rather than the hour, accounts for many potential irregularities in mode share that could be due to unobserved factors.

Traditional response rates that identify the percentage of solicited travelers who agreed to participate in the intercept survey were not tracked during data collection. However, a survey completion rate that compares the number of people surveyed to the number of people counted indicates that high rates of survey completion. Survey completion rates across the sites generally ranged from the mid-70 percent to mid-90 percent range, with an average completion rate of 77 percent.

This section summarizes the data collected. While some analysis is included, it is important to bear in mind that the sample is small and, far from being a statistical sample, it was deliberately stratified to encompass a variety of use and data collection contexts. Generalizations of the data with the goal of statistical inference are not warranted.

Figure 7 shows peak hour person counts by site. Note that counts are generally higher in the evening peak than the morning, except at the sites which are exclusively residential. In Figure 7, and the graphs that follow, the properties are grouped by their land use characteristics.

Figure 7. Peak Hour Person Counts by Site

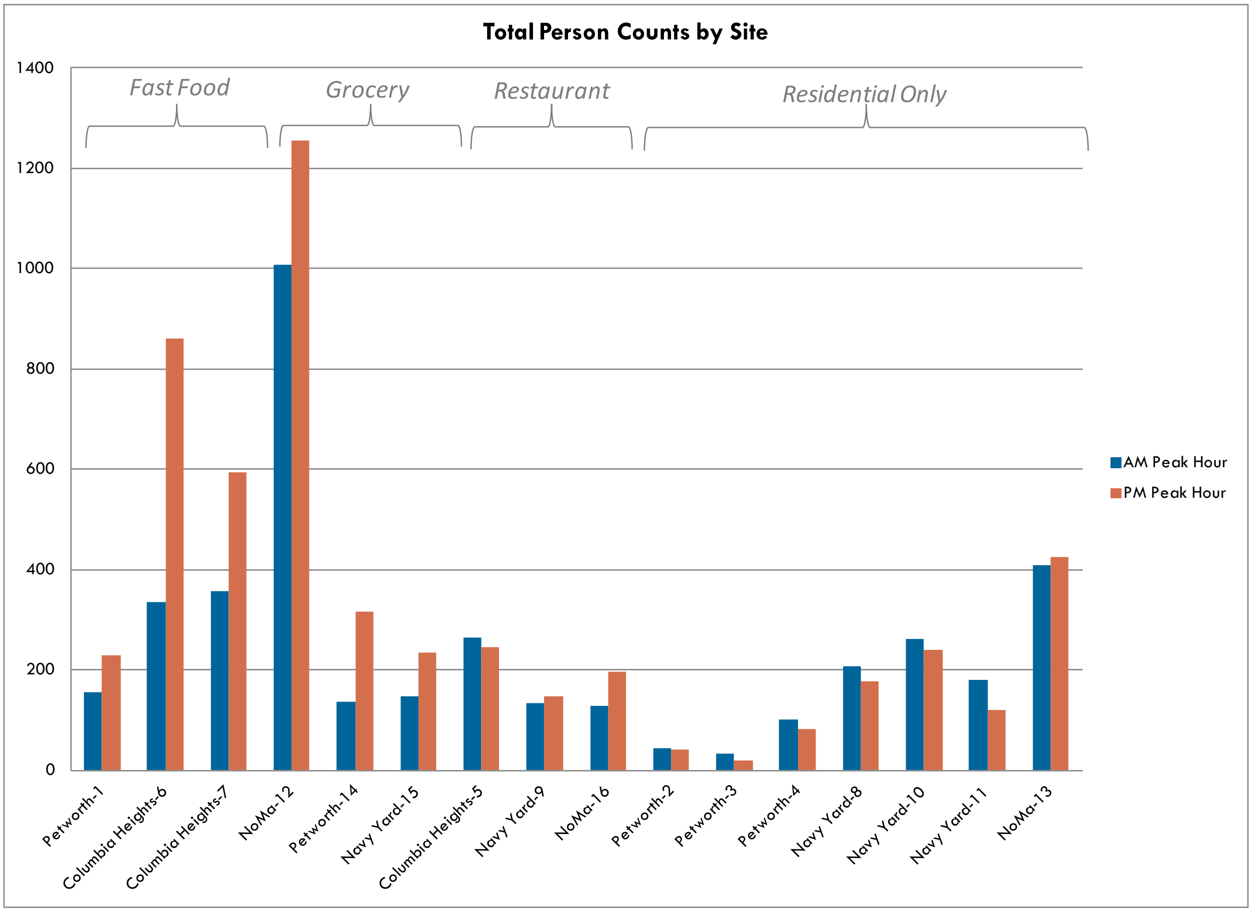


Figure 8 and Figure 9 compare mode share by site, which reflect similar morning and evening patterns.

Figure 8. DDOT Pilot Counts AM Peak Mode Share

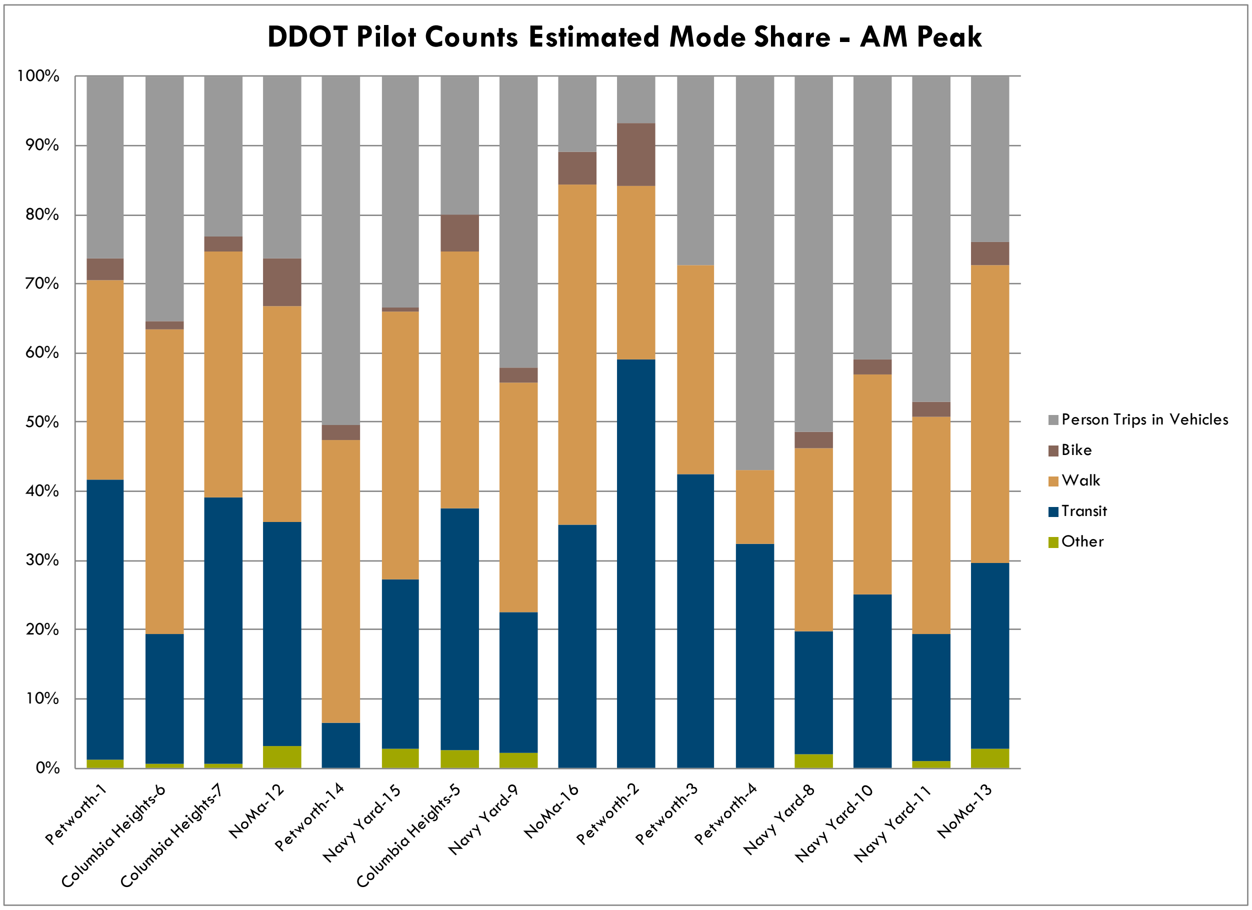
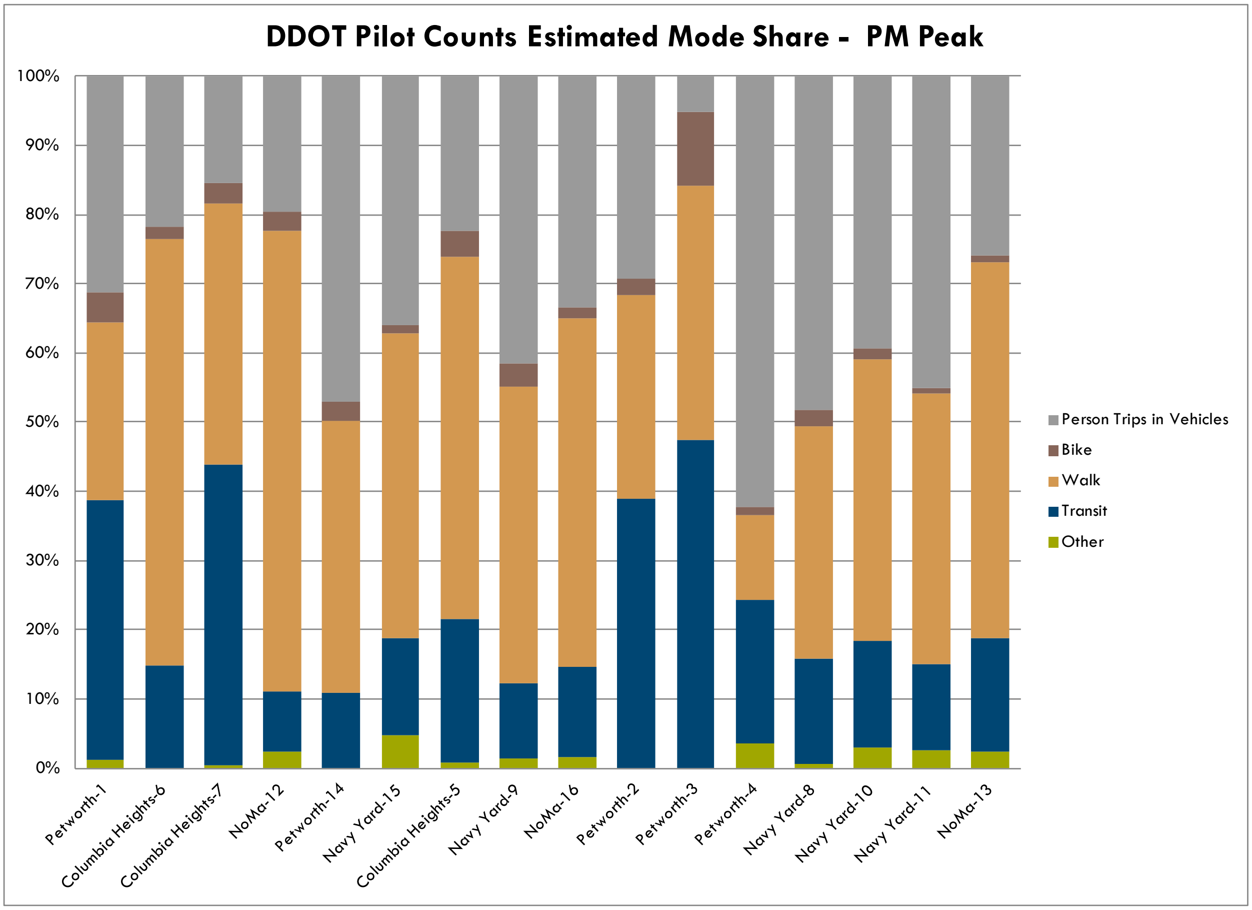


Figure 9. DDOT Pilot Counts PM Peak Mode Share

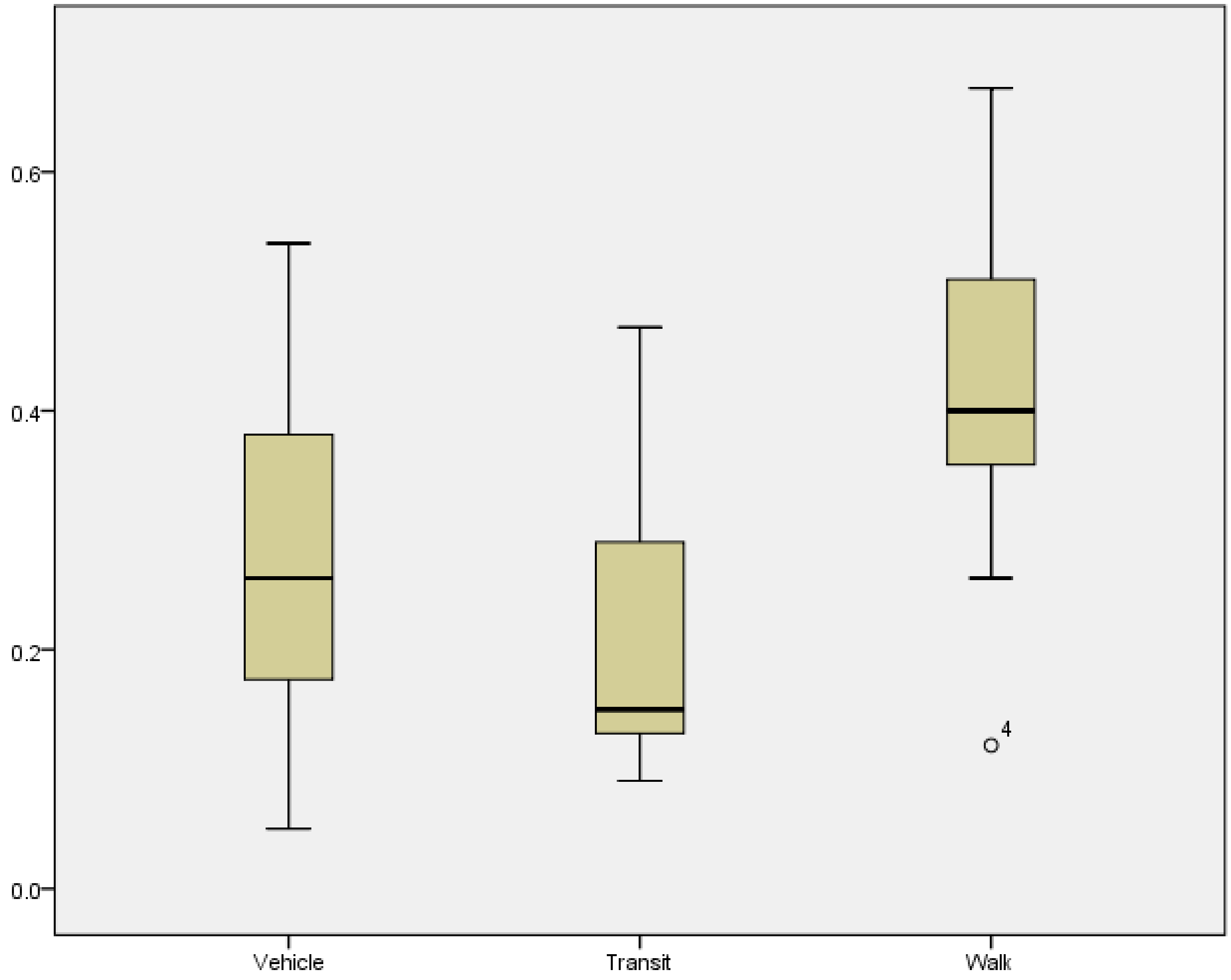


Perhaps not surprisingly, walking proved to be the dominant mode of travel with a median value for the afternoon peak at the sixteen sites of 41% and a maximum of 67%. As shown in the box diagrams of Figure 10, private vehicle followed with a median of 23% and maximum of 54%. Transit is also very close with a maximum of 47%, but a lower median at only 15%. The very compressed lower end of the transit boxplot indicates that transit usage at about half the sites is in a small range (in fact, between 11% and 16%) but the upper portion shows a much greater variation with transit shares ranging from 21% to 47%.

Consistent with findings reported in the literature review, we found transit and vehicle trips are traded off more strongly than vehicle and walk trips with correlation coefficients of -0.6 and -0.5 respectively. That is to say, the correlation between transit trips and private vehicle trips is greater than is the correlation between walking trips and private vehicle trips. As transit trips increase, private vehicle trips decrease sharply; as walk trips increase, private vehicle trips decrease but not as precipitously. This finding suggests that transit and drive trips are substitutes while walk trips are complementary to both transit and driving.

As will be discussed in greater detail in the next section, the preliminary conclusions that can be drawn from this effort serve to truly underscore the importance of the greater project contemplated. The high level of variability by seemingly similar sites indicates the idiosyncrasies of travel and the importance of developing a large enough database that will allow for modeling of multiple contexts. For example, in the case of the Petworth-4 study site, the inordinately high number of auto trips is due to the fact that the building's garage is open to the public; not all of the people parking there were accessing the building. Once a larger data collection is completed correction factors can be added to take account of these differences.

Figure 10. Box Plot of Estimated DDOT Mode Share (PM)



5. Comparative Results

Trip Generation Model Comparison

In this section we discuss five existing approaches to estimating trip generation and compare the predicted results of these models with the trip generation counts and mode shares that we estimated based on our field observations. The five approaches were selected on the basis of accessibility, availability of documentation and the context in which the model itself is applied. The models are the following:

1. The ITE *Trip Generation Manual* 8th Edition **(ITE)**.
2. URBEMIS Trip Generation Module 2007, which is the most recent version of a tool developed for California air pollution control districts to calculate the expected air quality impact of development proposals. **(URBEMIS)**
3. The EPA-MXD multi-use analysis method developed for the United States Environmental Protection Agency **(EPA-MXD)**.
4. The California Smart-Growth Trip Generation Model developed to estimate multimodal trip generation rates for proposed smart-growth land use development projects in California (**SGTG**).
5. Three models based on PhD work at Portland State University (**PSU Models)**

With the obvious exception of the ITE predictions, all the tools pivot from ITE trip generation. That is, they use ITE output as an input and adjust ITE trip generation based on a variety of identified "trip reduction factors", such as density, mixed land uses, transit service, TDM programs and other site characteristics. Throughout this section we differentiate between "estimated" trips based on DDOT's original data collection and "predicted" trips which are model outputs from the five models we compare.

ITE

The ITE *Trip Generation Manual* is a compendium of vehicle counts taken at project sites across the United States. The compendium is unique as a crowd-sourced project that pre-dates the internet but it is somewhat limited in that ITE had, for many years, stipulated an interest in single-use, low density sites. Unfortunately, ITE rates are often applied in contexts where ITE explicitly suggests alternative approaches. Our results, presented below, corroborate the concern that development proposals for sites in dense urban areas, but assessed using ITE rates, are assumed to produce more vehicular trips than are likely to be realized. The projects are then frequently rejected or else over-mitigate for personal vehicles.

Below we present the assumptions used to develop ITE model vehicle trip predictions for the 16 study sites. The model output and comparisons to estimated trips by site follow; rates are from *Trip Generation Manual 8th Edition*.

Applying the ITE Model to Sites in DC

Because ITE's rates are based on single-use development, we make the following assumptions with respect to the data and the application of the ITE rates, shown in Table 5 and Table 6 below.

Table 5. ITE Codes and Model Assumptions

Code	Use	Overall Modeling Notes
222	High-Rise Apartment	▪ Bank use – used Drive In Bank (912) rather than Walk-In Bank (911) due to the number of studies for each (~26 v. 3) ▪ Used Bank (912) for Cleaners and FedEx. No data for cleaners, only one data point in Texas for FedEx stores. ▪ All ITE rates for peak hour of adjacent street traffic unless otherwise noted
310	Hotel	
863	Electronics Superstore	
850	Supermarket	
912	Bank	
932	High-Turnover Sit Down Restaurant	
933	Fast-Food Restaurant	
936	Coffee/Donut Shop	

Table 6. Assumptions Made in Applying the ITE Model

Site	ITE Codes	Notes
Petworth-1	222/863/932/933	▪ Assumed 1/3 retail square footage restaurant, 1/3 fast-food sandwich restaurant, 1/3 electronics store ▪ Restaurant + electronics store closed AM
Petworth-2	222	
Petworth-3	222	
Petworth-4	222	
Columbia Heights-5	222/912/932/936	▪ Assumed retail square footage 1/3 cleaners and 1/3 high-turnover restaurant, 1/3 café ▪ Note: Restaurant closed AM, Cleaners closed PM
Columbia Heights-6	222/912/932/936	▪ Assumed retail square footage 1/8 for each retail outlet ▪ Based on available data and use pattern assumptions, used bank ITE code for bank/cleaners and small package shop ▪ Restaurant closed in AM ▪ Liquor store closed in AM, used high-

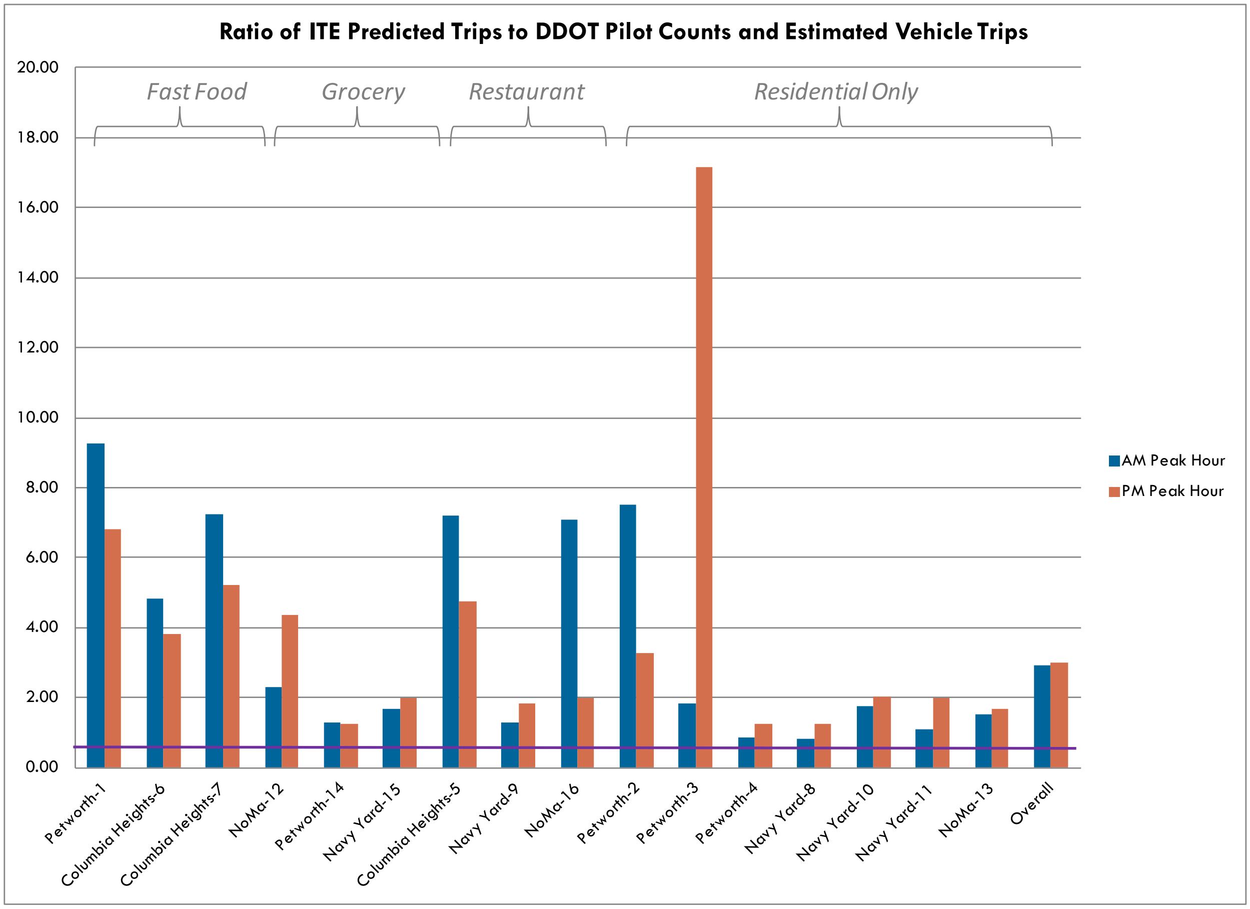
Site	ITE Codes	Notes
		turnover restaurant in absence of relevant ITE code
Columbia Heights-7	222/932/912/933/936	▪ Assumed 1/7 retail square footage for each use. ▪ Bank closed in PM, all restaurants except one closed AM
Navy Yard-8	222	
Navy Yard-9	222/936	
Navy Yard-10	222	
Navy Yard-11	222	
NoMa-12	222/850/310/933	▪ Use sizes derived from a variety of sources.
NoMa-13	222	
Petworth-14	222/850	
Navy Yard-15	222/932	▪ Liquor store closed in AM, used high-turnover restaurant in absence of relevant ITE code
NoMa-16	222/932	

Results

Although ITE estimates vehicle trips, there is an assumption that vehicle and person trips are related. In this study, on average, ITE vehicle trip predictions under-estimate person trips by about 50%, suggesting an average vehicle occupancy of 1.5 persons/vehicle. A 1.5 persons/vehicle occupancy is consistent with the National Household Travel Survey which reports a weighted vehicle occupancy of ~1.67 persons/vehicle for all trip purposes. However, journey to work trips are expected to dominate in the peak period and the national average vehicle occupancy for JTW is 1.13, suggesting a significant under-estimate of total person trips. This phenomenon is illustrated in Figure 13.

Figure 11 shows the ratio of ITE predicted private vehicle trips to observed private vehicle trips. The bold, purple line on the graph lies at the value one (1) indicating a perfect, hypothetical correspondence between ITE predictions and field observations. Bars that exceed the line represent ratios greater than one, indicating that ITE over-predicted vehicle trips, while those below the bar, less than one, indicate that ITE under-predicted vehicle trips.

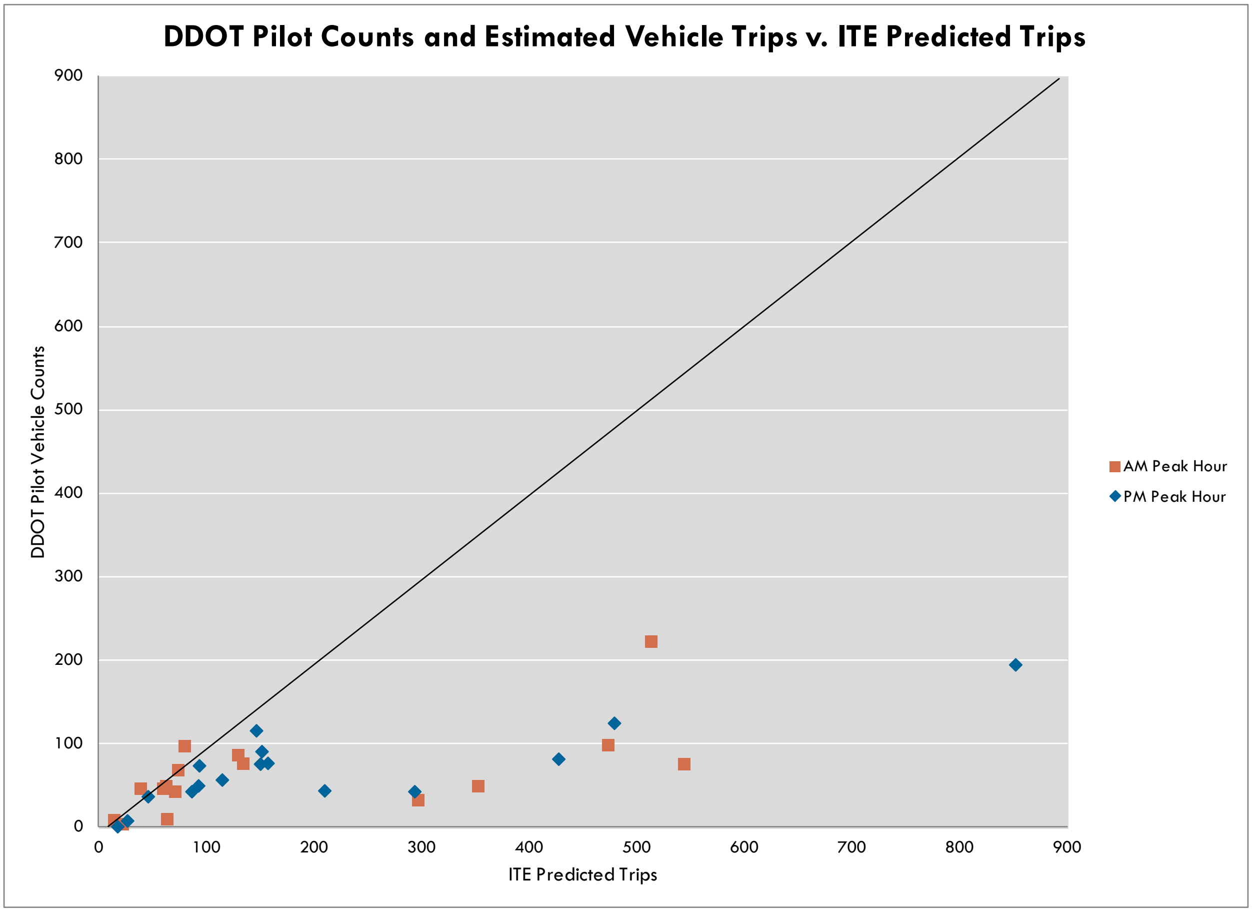
Figure 11. Ratio of ITE Predicted Trips to DDOT Estimated Vehicle Trips



For most sites, ITE over-predicts the number of vehicle trips. Navy Yard-8 and Petworth-4 are exceptions, however both buildings have garages that are accessible by members of the general public, thus the high number of personal vehicle trips could be due to the parking lot function rather than to the residential use. Petworth-1 and Columbia Heights-6 had very low vehicle mode shares in both the morning and evening. Petworth-3 also stands out – due to its overall low trip count, the mode split estimate is relatively unreliable (see Figure 9).

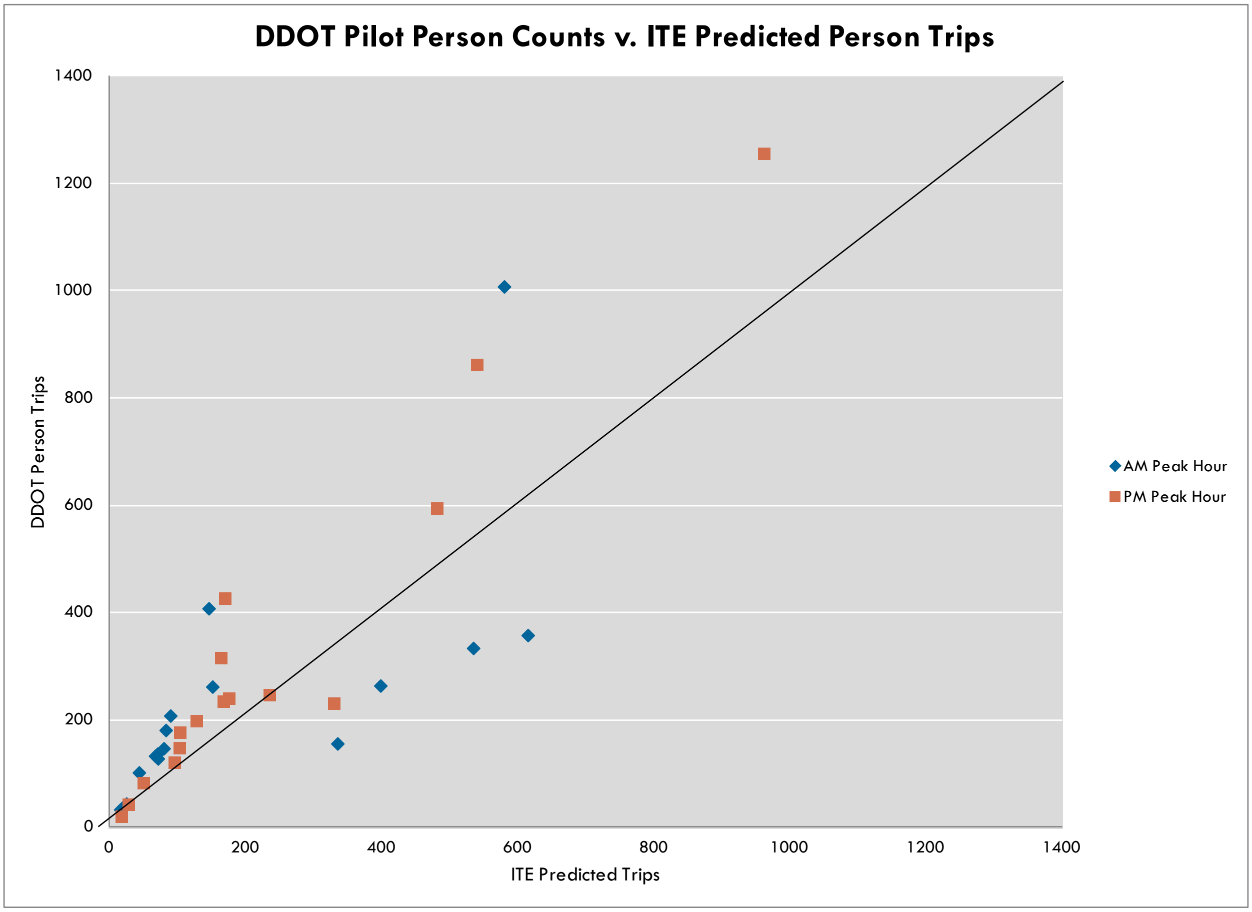
On average ITE over-predicts vehicle trips at the pilot sites by about 196% in the morning and 198% in the evening.

Figure 12. DDOT Estimated Vehicle Trips v. ITE Predicted Trips



The scatter plot shown in Figure 12 presents another view of the data. Points above the angled line represent sites where the estimated trip counts were higher than ITE predictions; points below the line are sites where ITE's predictions exceed the estimated trips There is no obvious pattern in the data except that ITE predictions are consistently above the locally estimated trips. The lack of a clear relationship leaves ample room for developing hypothesis underscoring the need for additional research.

Figure 13. DDOT Person Counts v. ITE Predicted Person Trips*



*Assumes vehicle occupancy of 1.13

Figure 13 shows that ITE consistently under-predicts person trips overall. Although there are a few outliers, the model generally does not account for the increased person trip activity in a highly urbanized environment. Interestingly, the outliers of Columbia Heights-6, Columbia Heights-5, and Petworth-1 all have higher ITE counts associated with higher square footage of Fast Food (933) and/or Coffee/Donut Shop (936), which have very high morning trip rates (43.87/1000 ft^2 and 117.23/1000ft^2, respectively). These busy establishments in suburban environments may have more spread out demand in urban environments where more options for these uses are available to the consumer. With one exception, ITE under-predicted trips for all purely residential uses. This pattern suggests that urbanites not only make more trips to retail and food outlets, they may access their home or visit others at home more frequently than those in a more isolated suburban environment with longer trip lengths.

URBEMIS

The California Air Resources Board developed the urban emissions model (URBEMIS) to quantify and evaluate emissions from development projects in California. URBEMIS outputs are in the form of pollutant levels, which are a function of VMT.

Using an average trip length, the URBEMIS trip generation module converts estimated VMT to number of trips and applies trip reduction credits for urban context variables such as land use mix, pedestrian and bicycle facilities, and transit quality. The reductions given as a result of these factors are based on third party research showing the effects of these variables on VMT and/or trip reduction. Finally, the reduction credits are applied to ITE estimates to develop a trip generation estimate that considers the development context.

The URBEMIS 2007 version, which is the currently disseminated software[3], uses ITE trip rates from the 7th Edition of the *Trip Generation Manual* to calculate the baseline raw trips [60]. Data needs for URBEMIS are relatively high, however sources for these data are easily found from Census, GoogleEarth, and publically available GIS data such as Census Topologically Integrated Geographic Encoding and Referencing (TIGER) data or state-wide databases.

As URBEMIS does not provide diurnal output, peak hour results shown here are derived by applying ITE peak hour percentages to the URBEMIS daily output. The results are minimally inconsistent as URBEMIS outputs are based ITE's 7th Edition and the peak hour factors are from the 8th Edition of the *Trip Generation Manual* [61].

Results

Figure 14 compares the project data to URBEMIS predictions. On average URBEMIS predictions are closer than ITE predictions to field results with over-prediction of vehicle trips closer to 117% in the morning peak but still quite high at 136% of the evening peak.

In particular, URBEMIS vehicle trip predictions for residential buildings are slightly under the estimates, with NoMa-13 coming very close to a one to one ratio. Petworth-3 evening data is an outlier in that its URBEMIS estimate was many magnitudes higher in the evening because observed vehicle trips were very low. However, these results are promising and indicate that URBEMIS adjustments to ITE come closer than ITE alone to estimating vehicle trips for single use properties.

---

[3] URBEMIS as linked from the ITE "Other Resources" page: http://www.ite.org/tripgeneration/otherresources.asp

Figure 14. Ratio of URBEMIS Vehicle Trips to DDOT Estimated Vehicle Trips

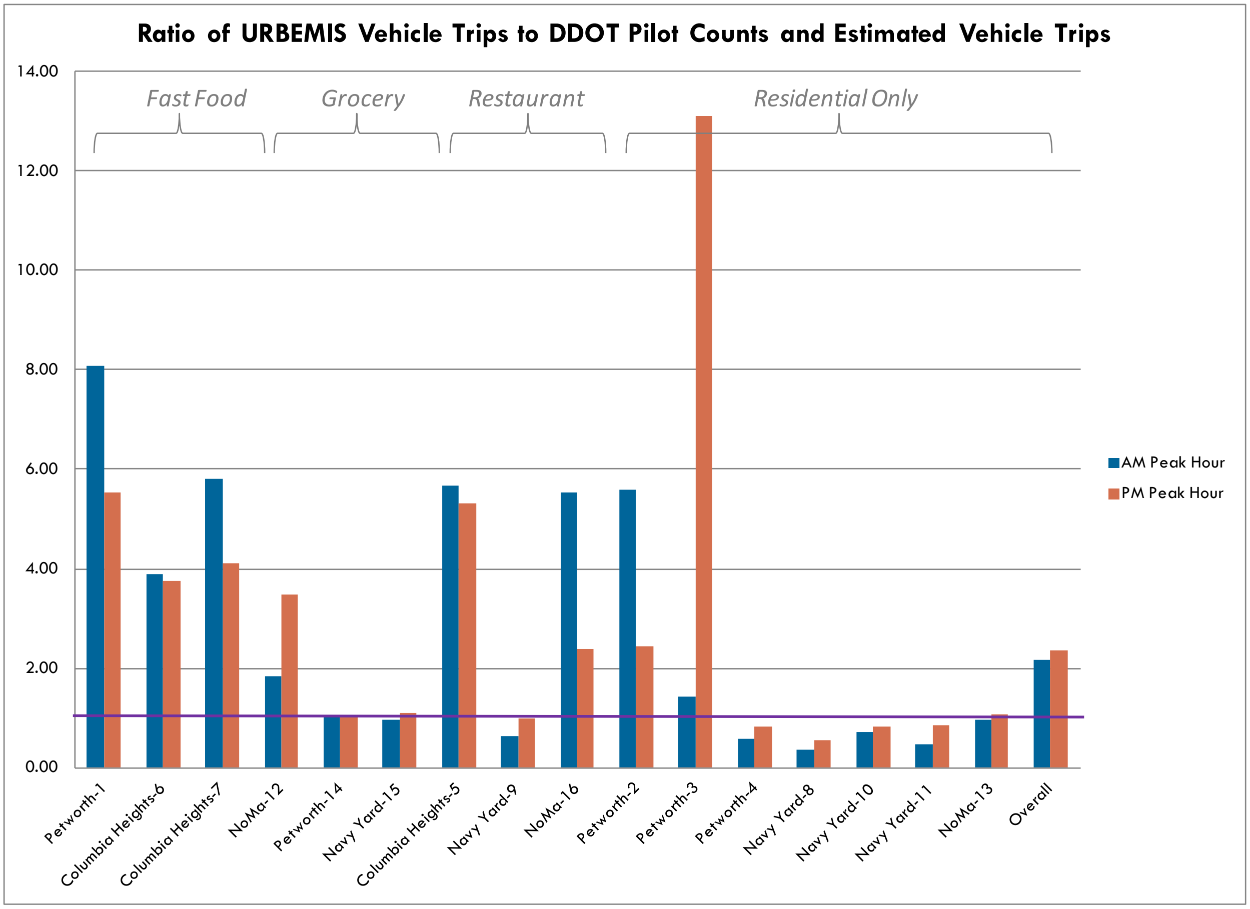
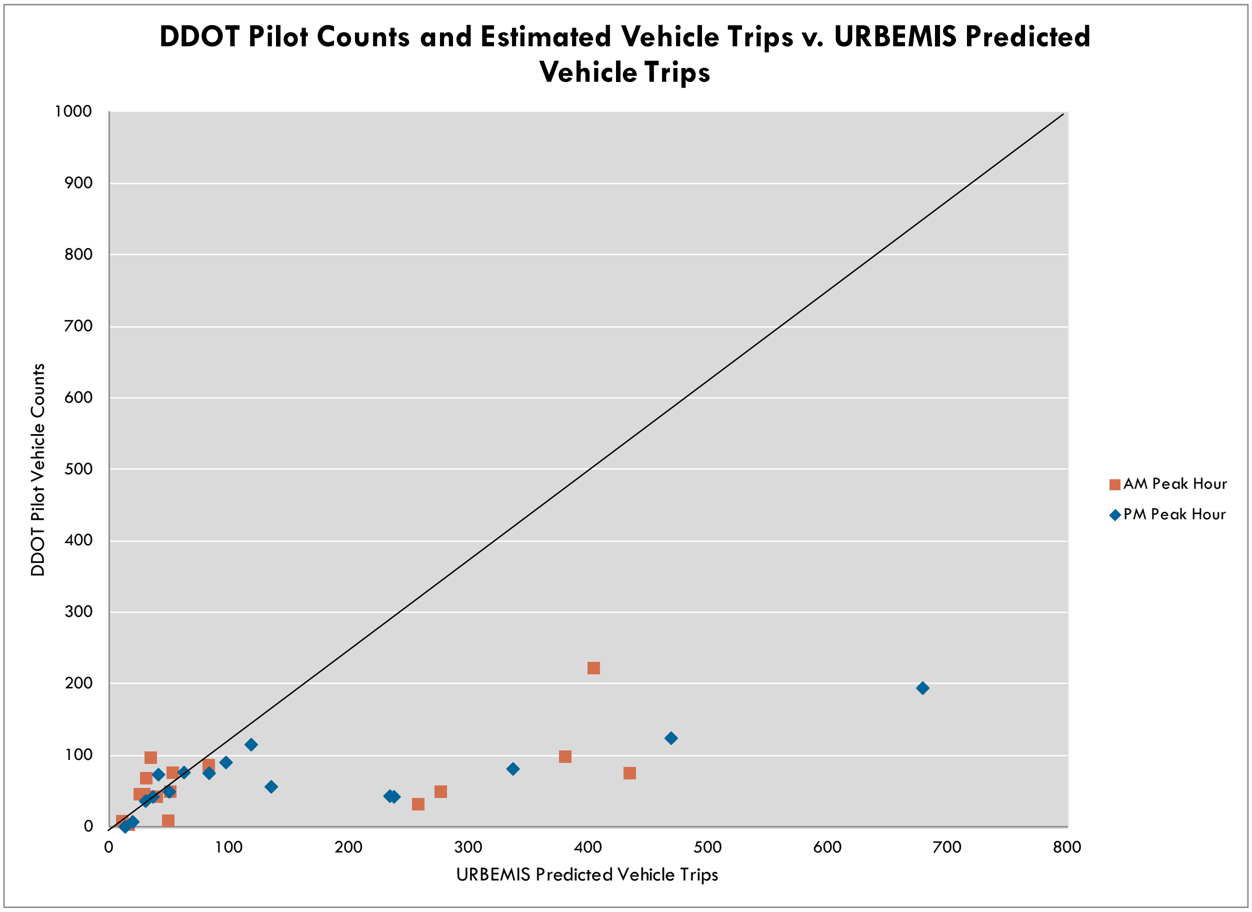


Figure 15, below, shows that DDOT estimates are below URBEMIS predicted trips.

Figure 15. DDOT Estimated Vehicle Trips v. URBEMIS Predicted Vehicle Trips



EPA-MXD

The Environmental Protection Agency Mixed Use Development model (EPA-MXD) is based on research published in Ewing et al. (2010). It is estimated based on observations from 239 mixed-use (or multi-use) developments in the urban areas of Atlanta, Boston, Houston, Portland (OR), Sacramento, and Seattle. The tool has been adopted and in some cases adapted by multiple regions in California, Washington, New Mexico, and Virginia [57].

The EPA-MXD spreadsheet tool uses context variables such as intersection density and jobs-population balance to calculate vehicle, transit, and walking trips, based on ITE estimates. However, the ITE estimates used in the model are slightly different from those calculated earlier in this study, as the model limits the number of uses that can be used as inputs. For example, ITE Code 222, High-Rise Apartment, which was used to develop the ITE predictions, is not an option – the user instead must select from “High-Rise Condominium” (232) or “Multi-Family” (220).

Results

Though we apply the model to the DDOT data, the EPA-MXD is actually poorly suited to the current context. First, the model is designed to estimate trips across a minimum five-acre site which accounts for all development in the catchment area, including the proposed development for which travel impacts are being considered. Assuming a city block is about 300 ft long, this is about two and a half city blocks. The proposed method for single site analysis is to apply the model at a suitable geography with, and then without, the proposed development. The difference in those results should yield the expected impact due to the development. Unfortunately, the detailed land use data necessary to do so was unavailable for this project.

Results shown in Figure 16 and Figure 17 are therefore provisional and differ from the “correct” results by an internal capture factor. Note that the larger (150+ units) and purely residential buildings performed well in the model as compared to the smaller Petworth-3 (49 units) and Petworth-2 (75 units). Somewhat surprisingly for a model that is meant to be robust to internal capture, for sites with multiple uses, the model generally over-predicted vehicle trips by factors of 91% and 122% in the morning and evening peak periods.

Figure 16. Ratio of EPA-MXD Vehicle Trips to DDOT Estimated Vehicle Trips

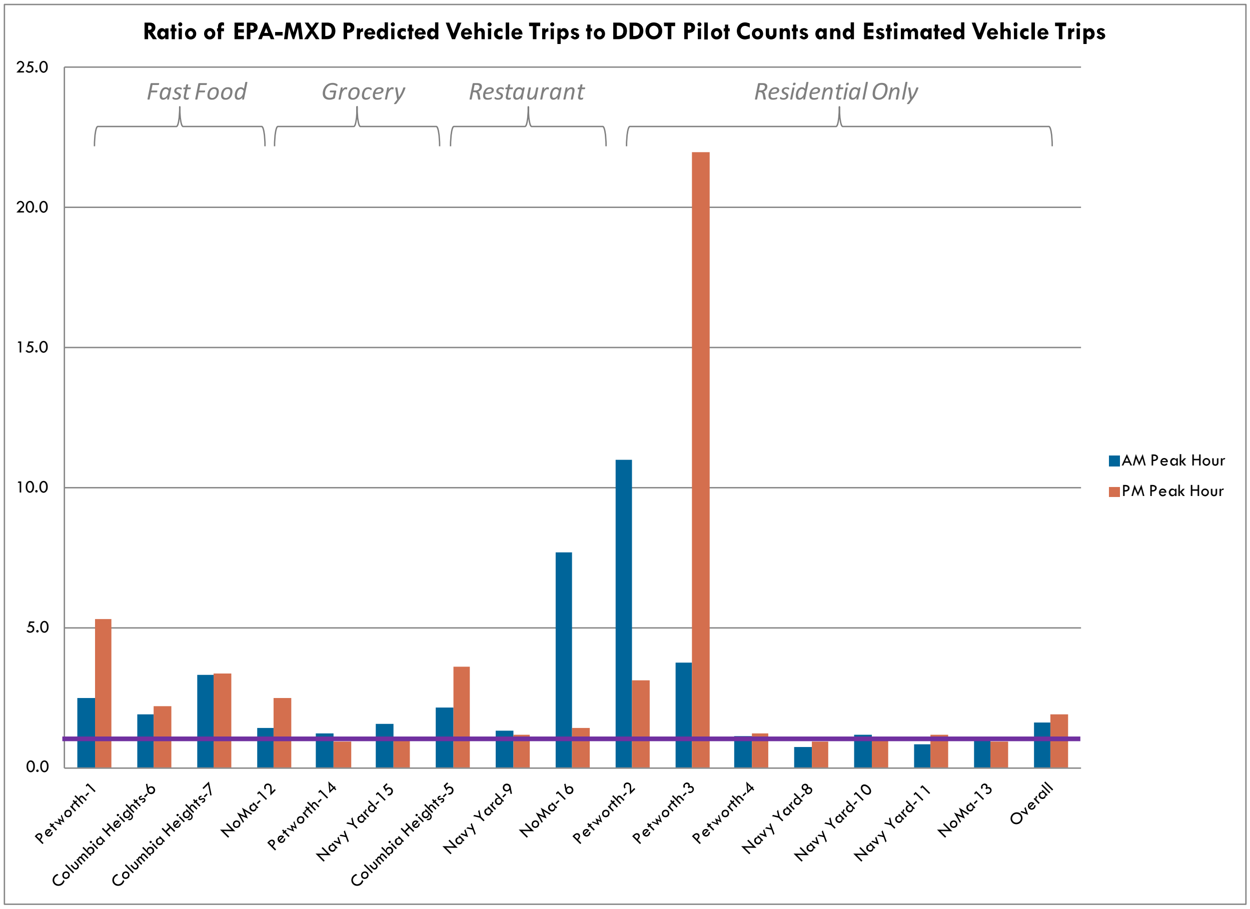


Figure 17. DDOT Estimated Vehicle Trips v. EPA-MXD Predicted Vehicle Trips

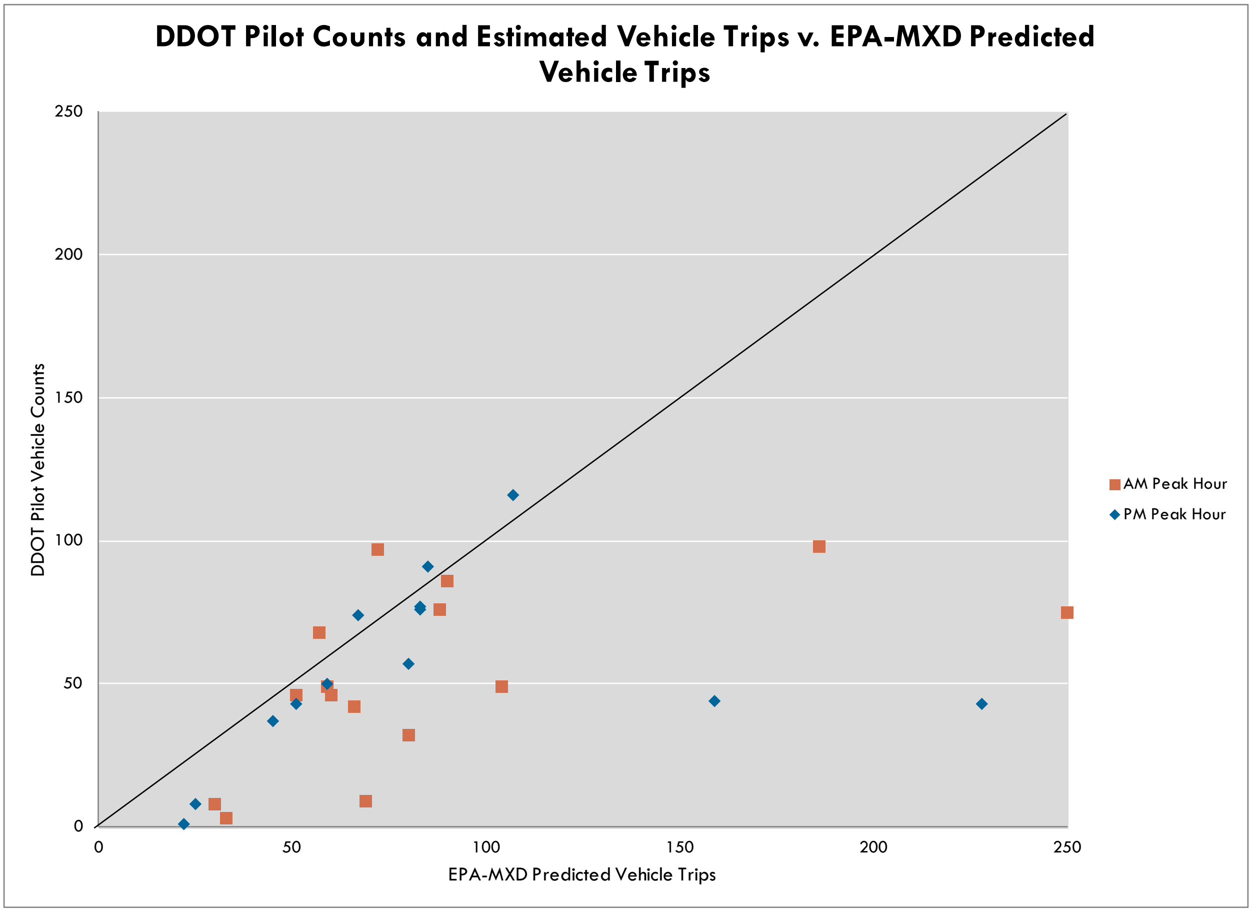


Figure 18 shows the EPA-MXD results for walking trips compared to the project study walking trips. Except for a few instances, the model estimates are close to the observed counts. Overall, the model underestimated walk trips by 42% in the morning and 52% in the evening. EPA-MXD also provided transit trips, underestimating them in almost all cases (Figure 19).

Figure 18. Ratio of EPA-MXD Walking Trips to DDOT Estimated Trips

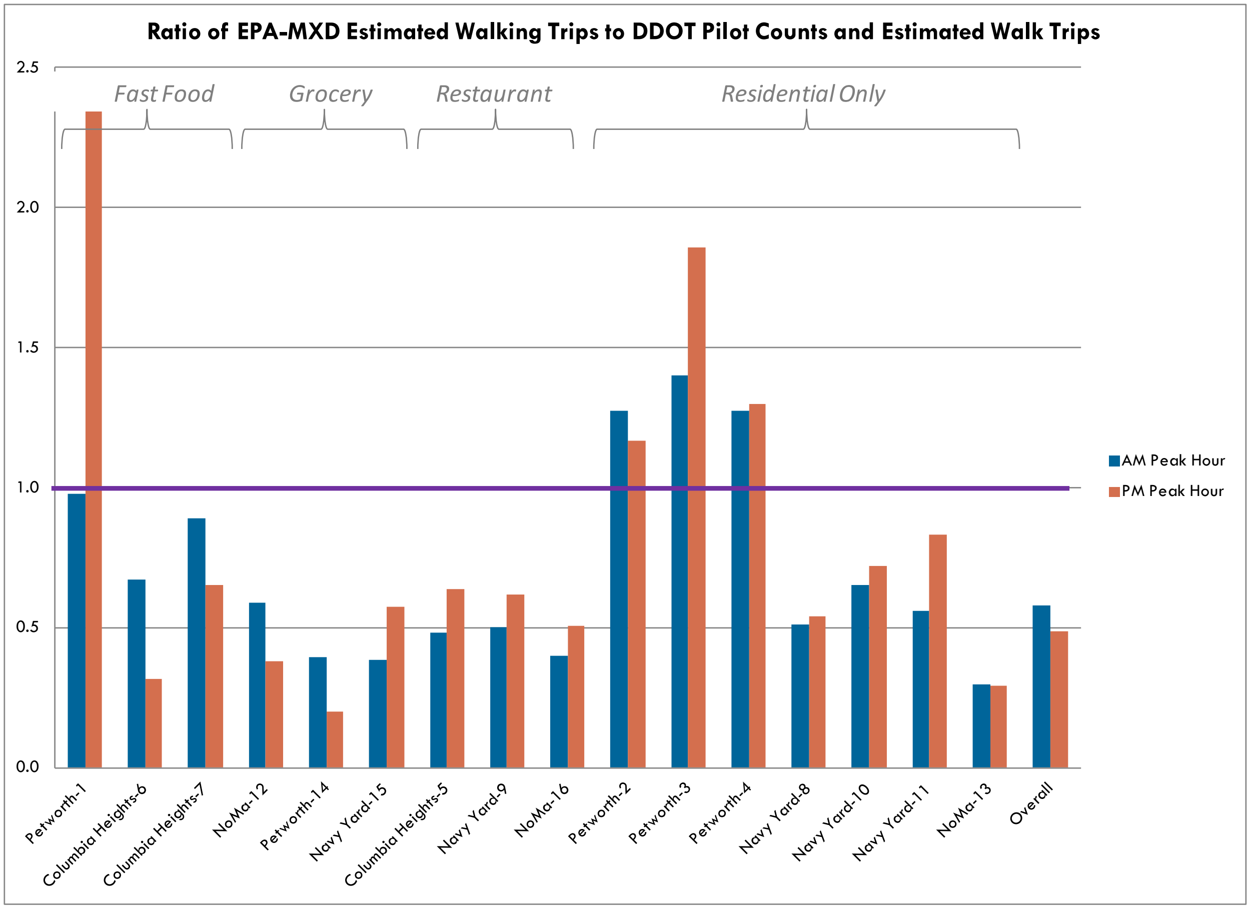


Figure 19. Ratio of EPA-MXD Transit Trips to DDOT Estimated Trips

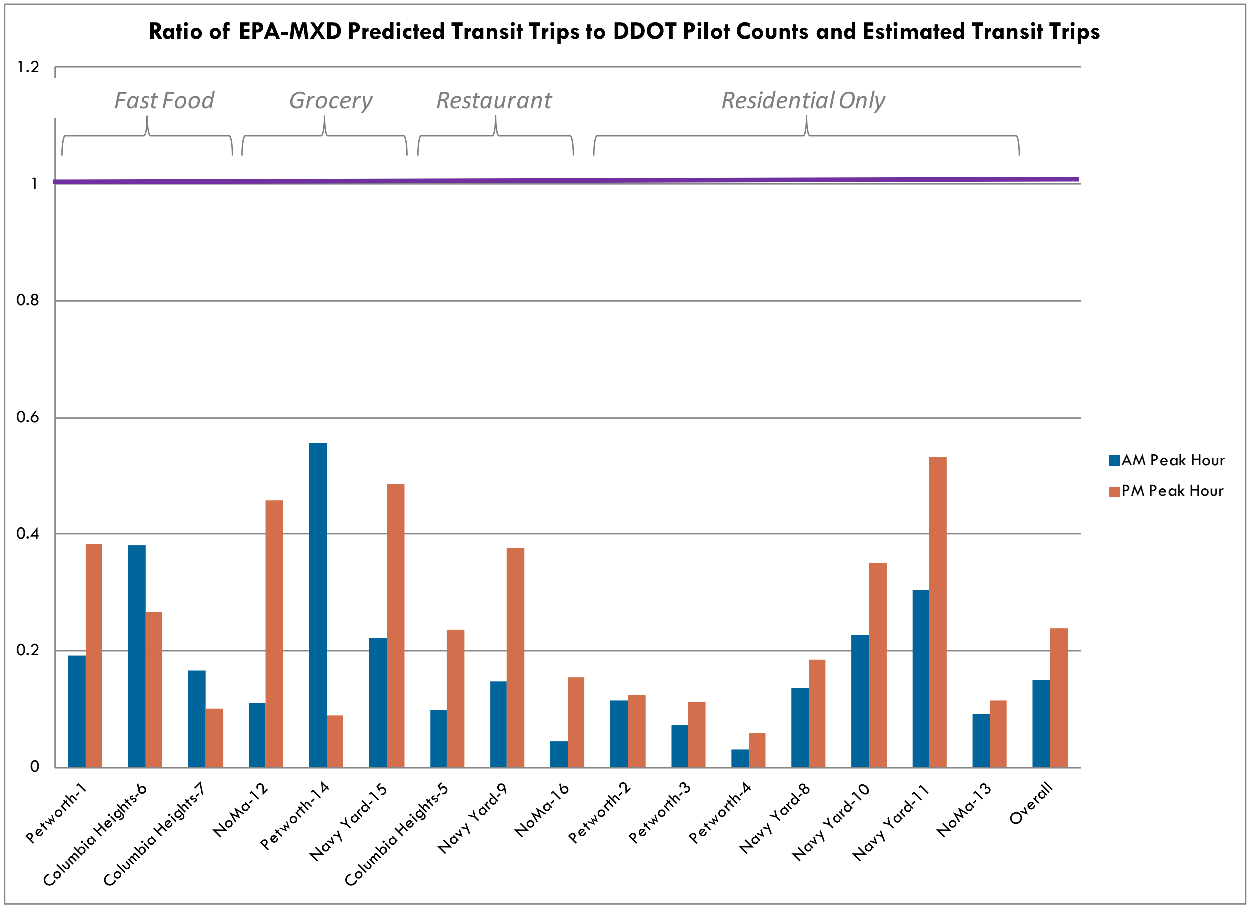
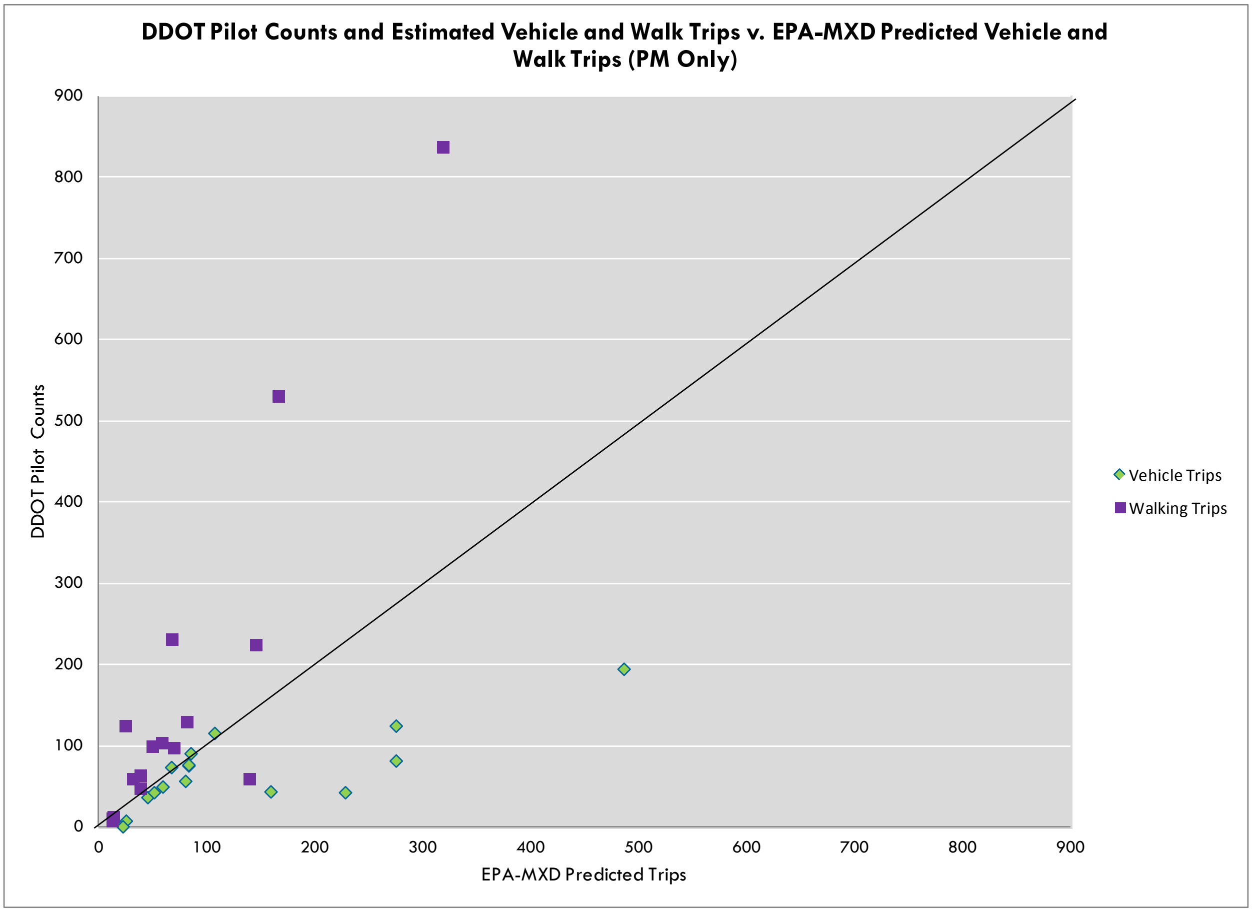


Figure 20 shows walking trips and vehicle trips as compared to the EPA-MXD model predictions. There is a stronger correspondence between predicted and estimated walking trips than vehicle trips. However, this model still over-predicts vehicle trips and under-predicts trips by other modes.

Figure 20. DDOT Project Estimated Vehicle and Walk Trips v. EPA-MXD Estimated Vehicle and Walk Trips (PM Only)



Smart Growth Trip Generation

Smart Growth Trip Generation (SGTG) is a methodology and spreadsheet tool that estimates vehicle, transit and walking trip generation rates at smart-growth developments. The SGTG project team collected trip-generation data at 30 smart growth sites in California. Comparing their field data to ITE trip generation rates and stratifying by various context variables, the team created a model to adjust ITE trip generation rates based on the context variables considered. The model relies on a blended “Smart Growth” variable which derives from eight site-level and context factors. This includes population, jobs, distance to CBD, average building setback, the presence of metered parking, transit service frequency and the percentage of the site devoted to parking. Trip generation is then estimated using a linear regression model of the form:

$$adjustment\ factor = a + b_1 * SMG + b_{2i} * landUse_i$$

Where a and b_i are estimated parameters, SMG is the smart growth composite variable and land use is a vector of zero/one variables indicating membership in a land use class –“i” indexes land use.

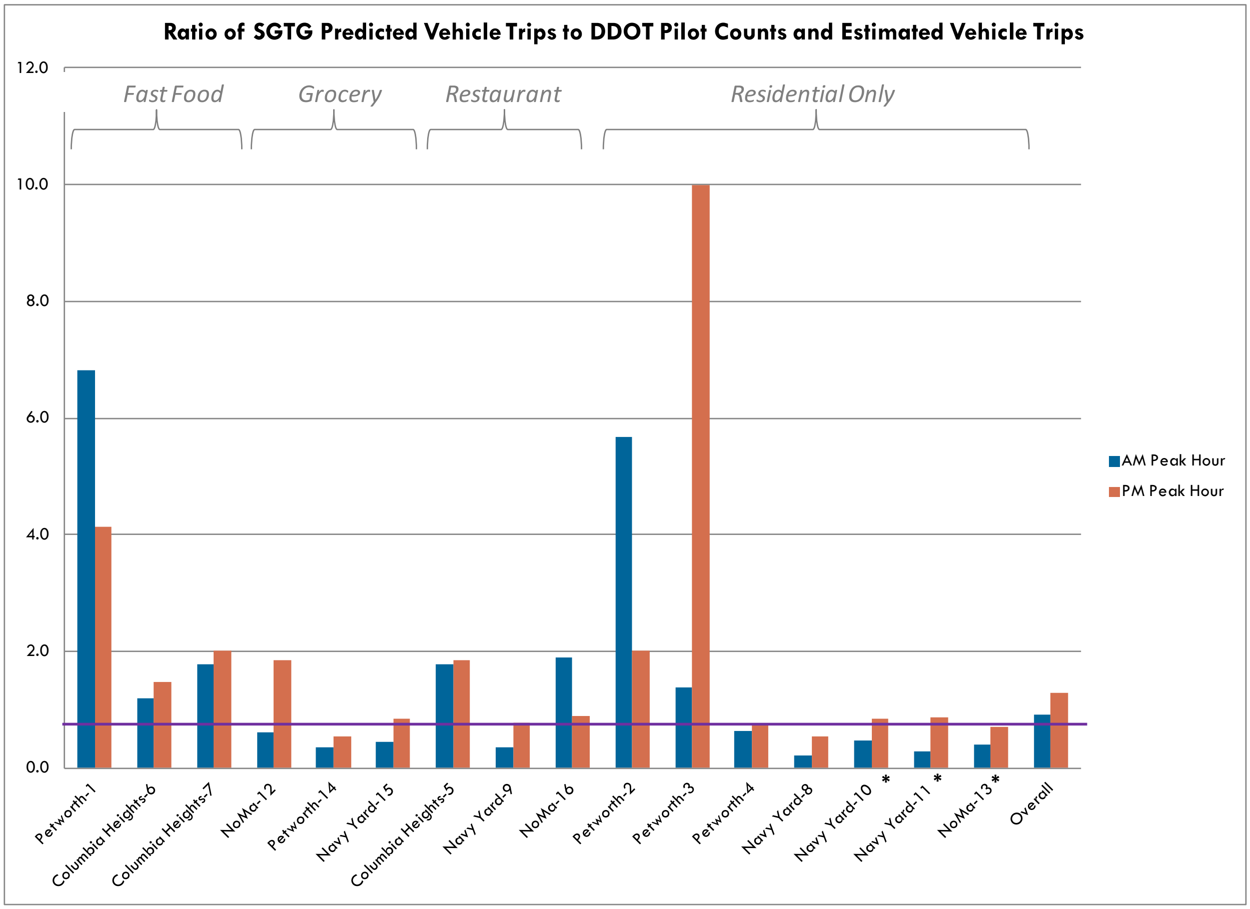
The model spreadsheet tool applies the calculated adjustment factor directly to ITE-predicted trips.

The model report notes that in addition to using the Smart Growth model to determine whether a site is suitable for this analysis, the model is also only applicable for single-use sites or single land uses that are part of multi-use sites. For the 16 sites in the DC region, six of the single use sites did not meet the Smart Growth criteria and all mixed use sites technically did not either, thus only three sites are actually consistent with the SGTG requirements. The model documentation warns that for sites that do not meet criteria, the SGTG may overestimate the ITE rate adjustment. As discussed in the next section, that warning seems to be borne out.

Results

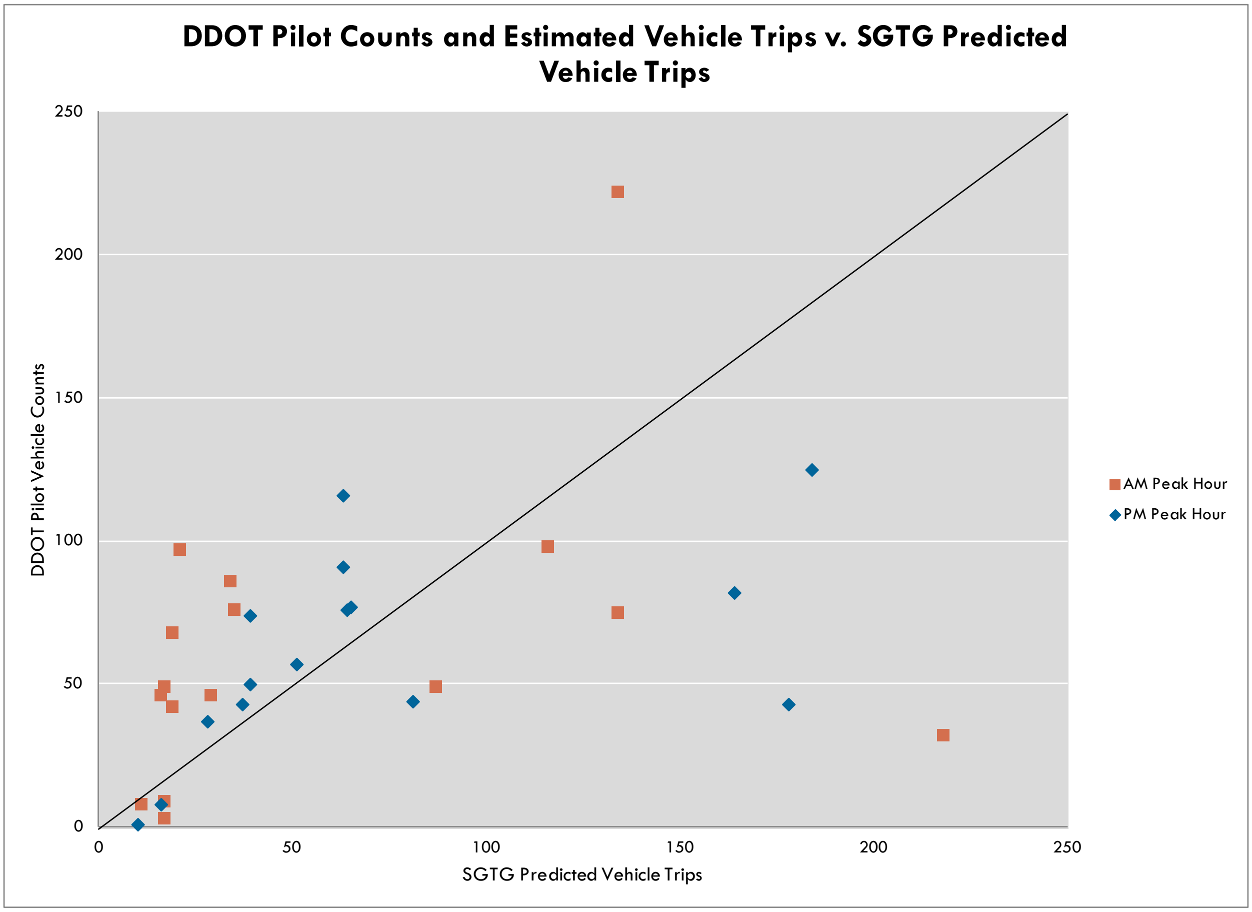
Figure 21 and Figure 22 show the number of observed vehicle trips as compared to the results of the SGTG model. Although the results vary widely, the overall number of trips predicted is similar to what was observed. Generally, vehicle trip rates were much higher in the morning than the model predicted, while the evening trips were closer to the SGTG results. The use does not appear to play a role in how closely the results matched here. In addition, the sites that did not meet the smart growth criteria would be expected to have ratios higher than one, but that is only true for about half of the observations.

Figure 21. Ratio of SGTG Predicted Vehicle Trips to DDOT Estimated Vehicle Trips



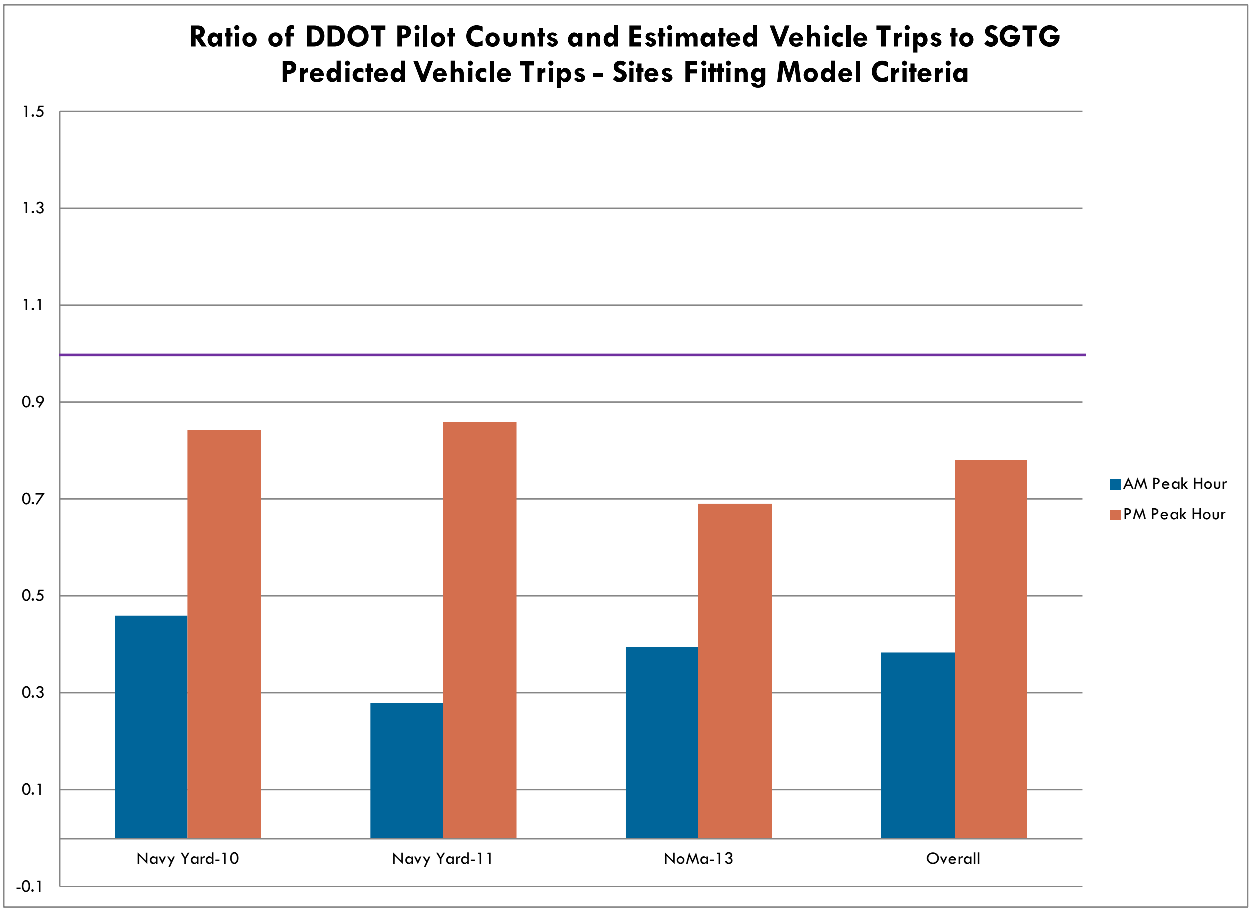
* Indicates sites that did fit the model criteria.

Figure 22. DDOT Estimated Vehicle Trips v. SGTG Predicted Vehicle Trips



Looking only at sites that fit the SGTG model criteria, Figure 23 shows that the model consistently under-predicted vehicle trips in the DDOT context: Navy Yard-10, Navy Yard-11, and NoMa-13. Although the model under-predicted morning trips by 62%, it was much closer for the evening, under-predicting by just 22%.

Figure 23. Sites Fitting SGTG Model Criteria



PSU Models

Clifton and Currans developed a suite of models based on travel surveys from Oregon, Washington and Baltimore. There are three different models, titled Adjustment A, B, and C. Using the National Household Travel Survey, the PSU models first convert ITE vehicle trips to person trips, then a second process divides the person trips into modal shares yielding a new set of vehicle trips and transportation impact estimates.

The person trip calculations are based on general land use category and trip characteristics such as time of day. The authors concluded that activity density was a simple and appropriate proxy variable for the urban environment for each general land use category. However, they note that the performance of this model was not high, and that vehicle occupancy is likely more strongly correlated with another variable not included in their analysis. These occupancy rates are applied to ITE estimates to calculate ITE "person trips" to each site.

Adjustment A estimates trips by mode based on mode shares developed for different urban density ranges. Calculating trips by mode is as simple as calculating density within a half mile buffer of the site and then using a lookup table to estimate mode share. That mode share is then applied to a person trip number modeled from ITE-predicted vehicle trips.

Adjustments B and C are models that give the odds that an individual will travel by car for a given trip. Adjustment B is based on intersection density, while Adjustment C looks at other land use variables such as distance from the CBD and whether the site is near a TOD. Rather than adjusting ITE directly, the adjustments are applied to the person trips derived from applying the vehicle occupancy models to ITE rates.

The advantage to these models is that their data requirements are relatively few and the data required are fairly accessible.

Results

Overall, Adjustment A of the three models gave the closest results for vehicle trips despite being the least complex.

Figure 24. Ratio of PSU A Estimated Vehicle Trips to DDOT Estimated Vehicle Trips

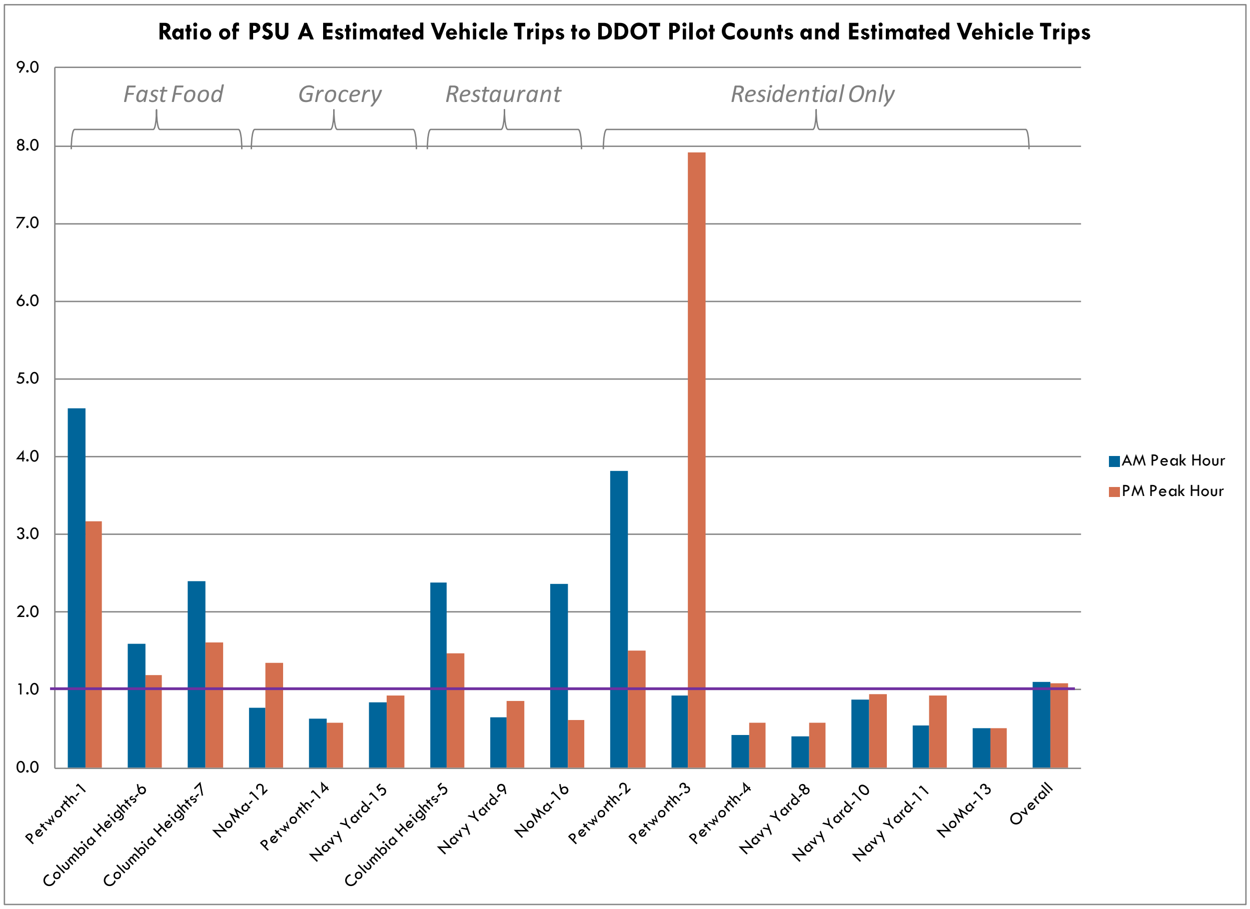
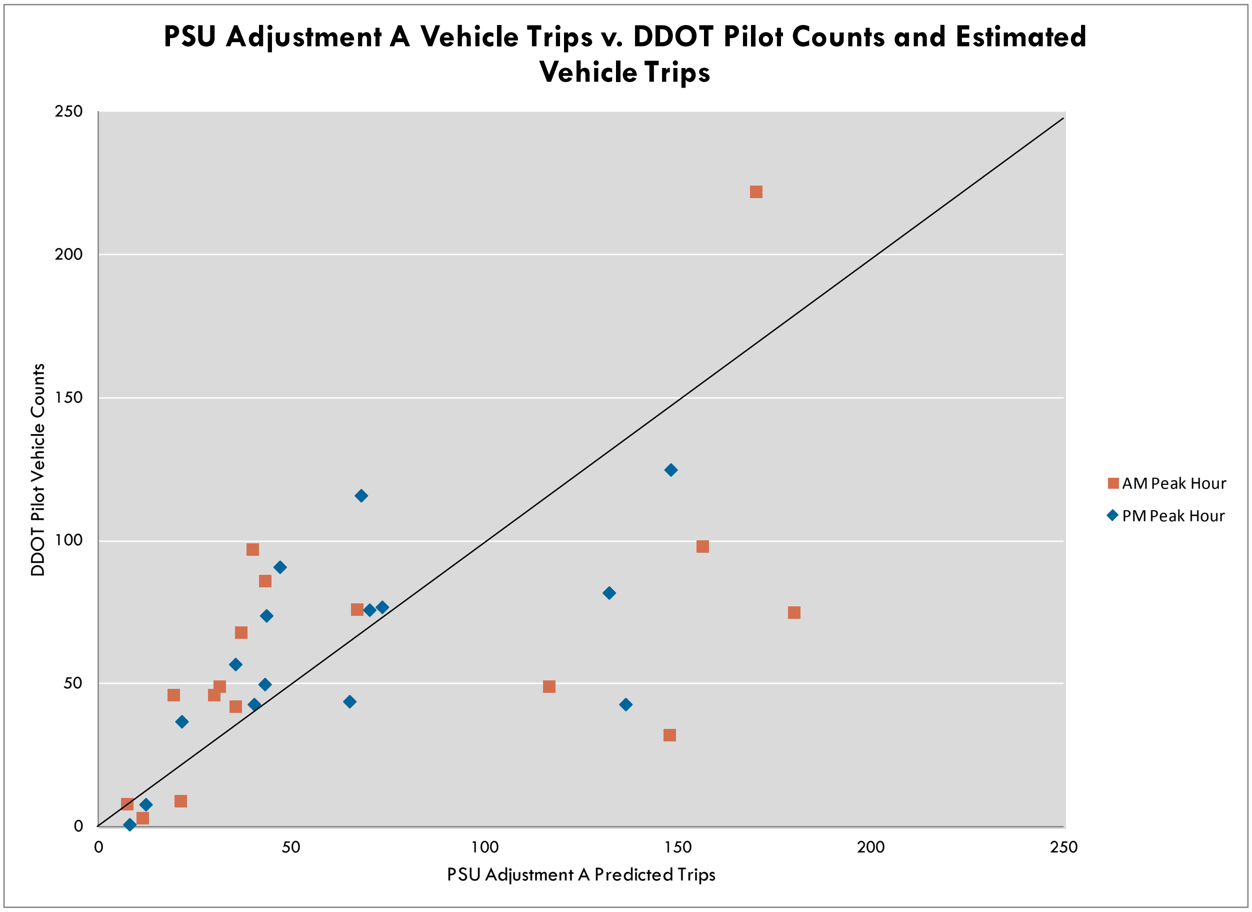


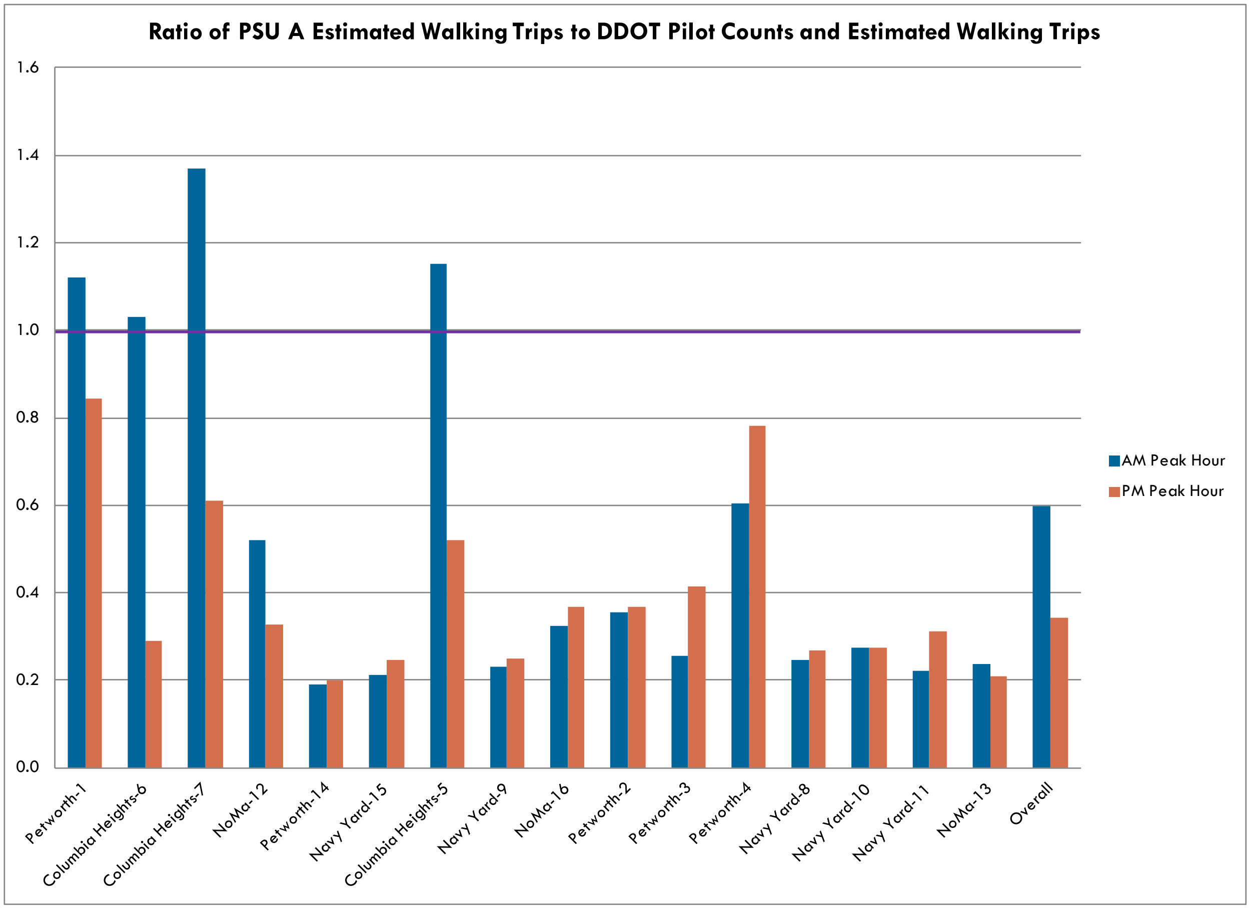
Figure 24 shows that Adjustment A of the model generally over-predicted vehicle trips, but by a small margin of 11% and 8% for the morning and evening peak hour, respectively. Figure 25 shows that both morning and evening results do not have a clear pattern, although the lower counts do seem to be clustered around a trendline.

Figure 25. PSU Adjustment A Vehicle Trips v. DDOT Estimated Vehicle Trips



In contrast, the model under-predicted walk trips (Figure 26) by 40% and 66%, respectively.

Figure 26. Ratio of PSU Adjustment A Estimated Walking Trips to DDOT Estimated Walking Trips



For this model it was also interesting to compare the predicted mode share to the observed. Figure 27 below shows PSU Adjustment A walk mode share (light blue) compared to observed walk mode share (dark blue), which is higher in almost all cases.

Figure 27. PSU Adjustment A Walk Share Compared to DDOT Estimated Walk Share

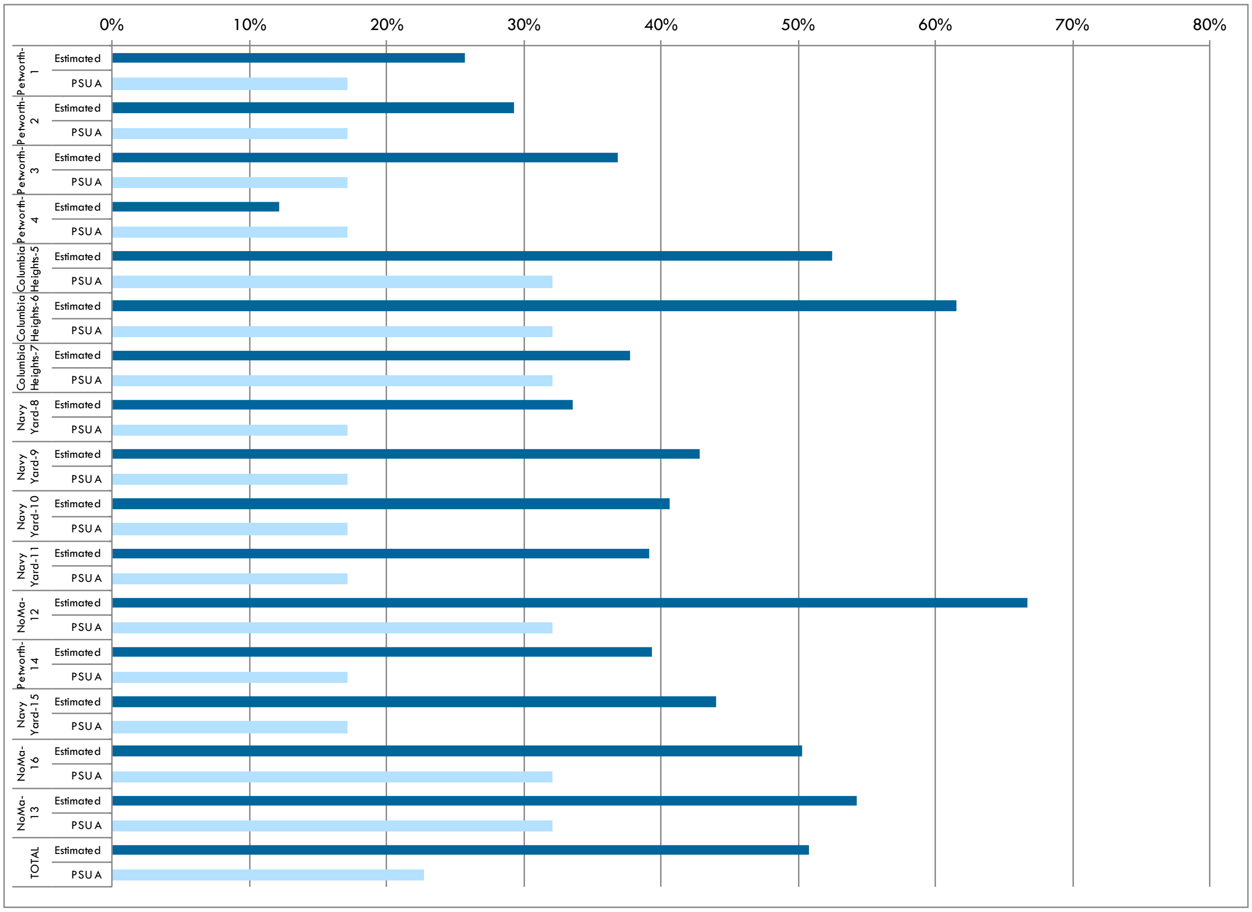


Figure 28 shows that the PSU Adjustment B model under-predicted vehicle trips for many sites – overall under-predicting by 60% of trips in the morning peak and 51% in the evening peak. Figure 29 shows that estimated vehicle trips are generally higher than the predicted.

Figure 28. Ratio of PSU Adjustment B Estimated Vehicle Trips to DDOT Estimated Vehicle Trips

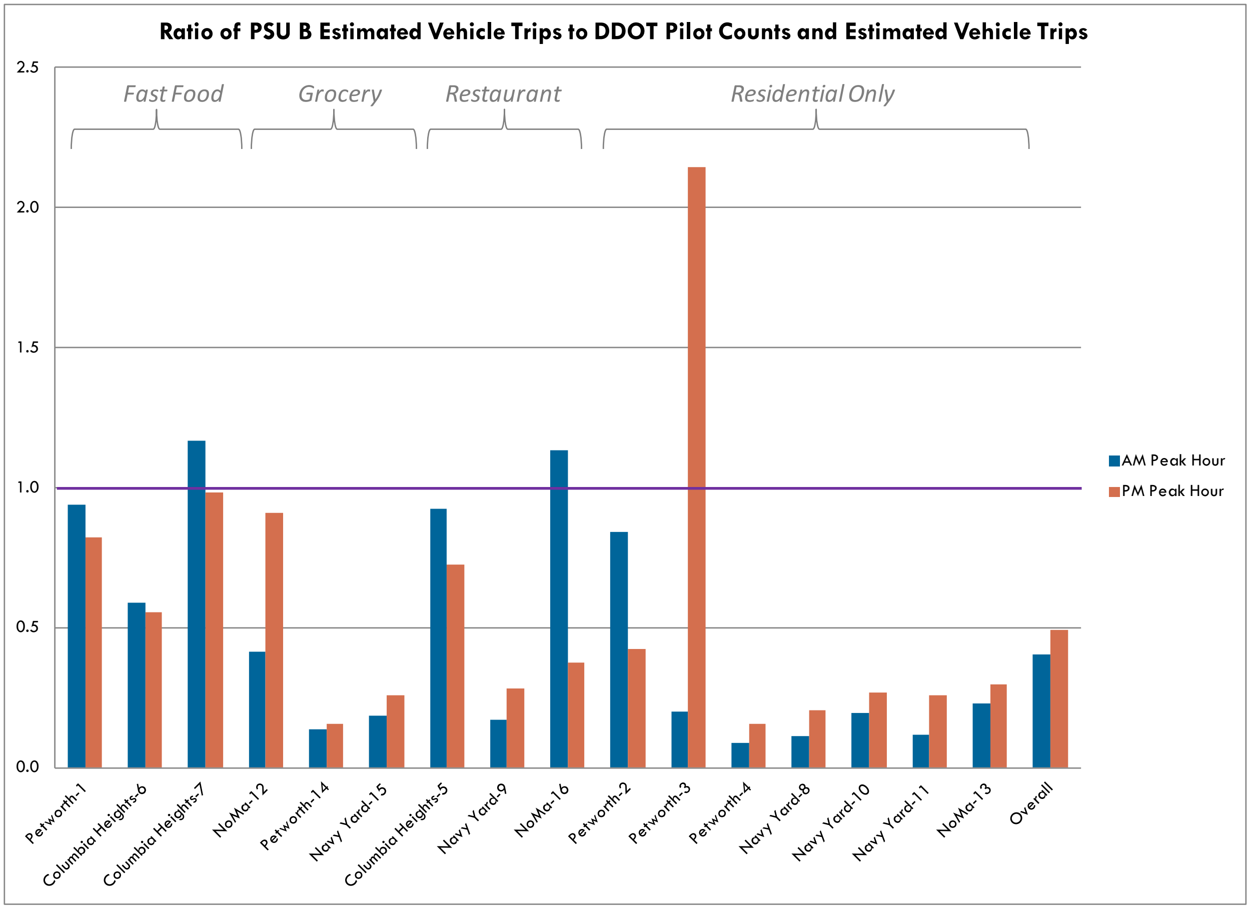


Figure 29. PSU Adjustment B Vehicle Trips v. DDOT Estimated Vehicle Trips

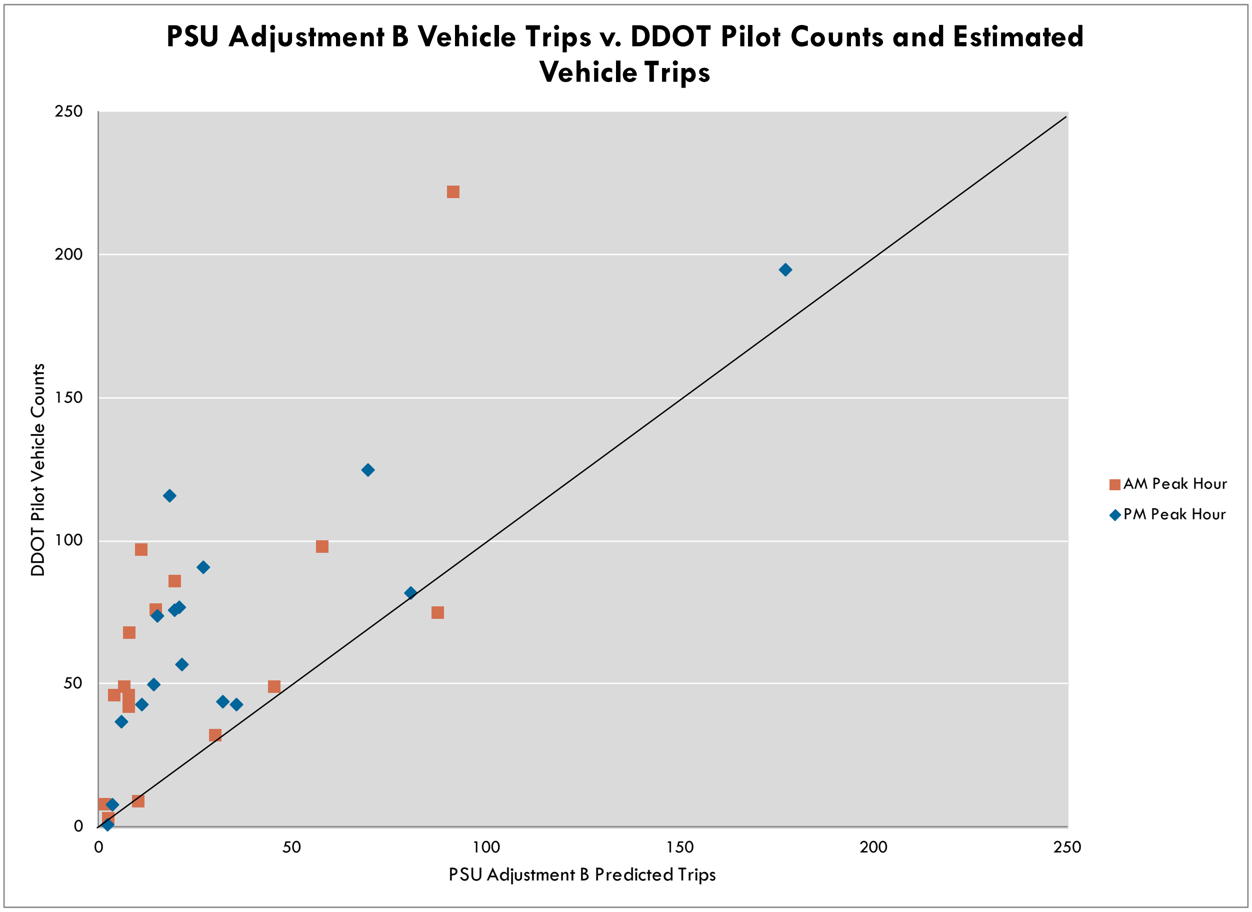


Figure 30 shows that Adjustment C provides a closer fit, but it underestimates vehicle trips by about 59% in the evening and 32% in the morning peak hour.

Figure 30. Ratio of PSU C Estimated Vehicle Trips to DDOT Estimated Vehicle Trips

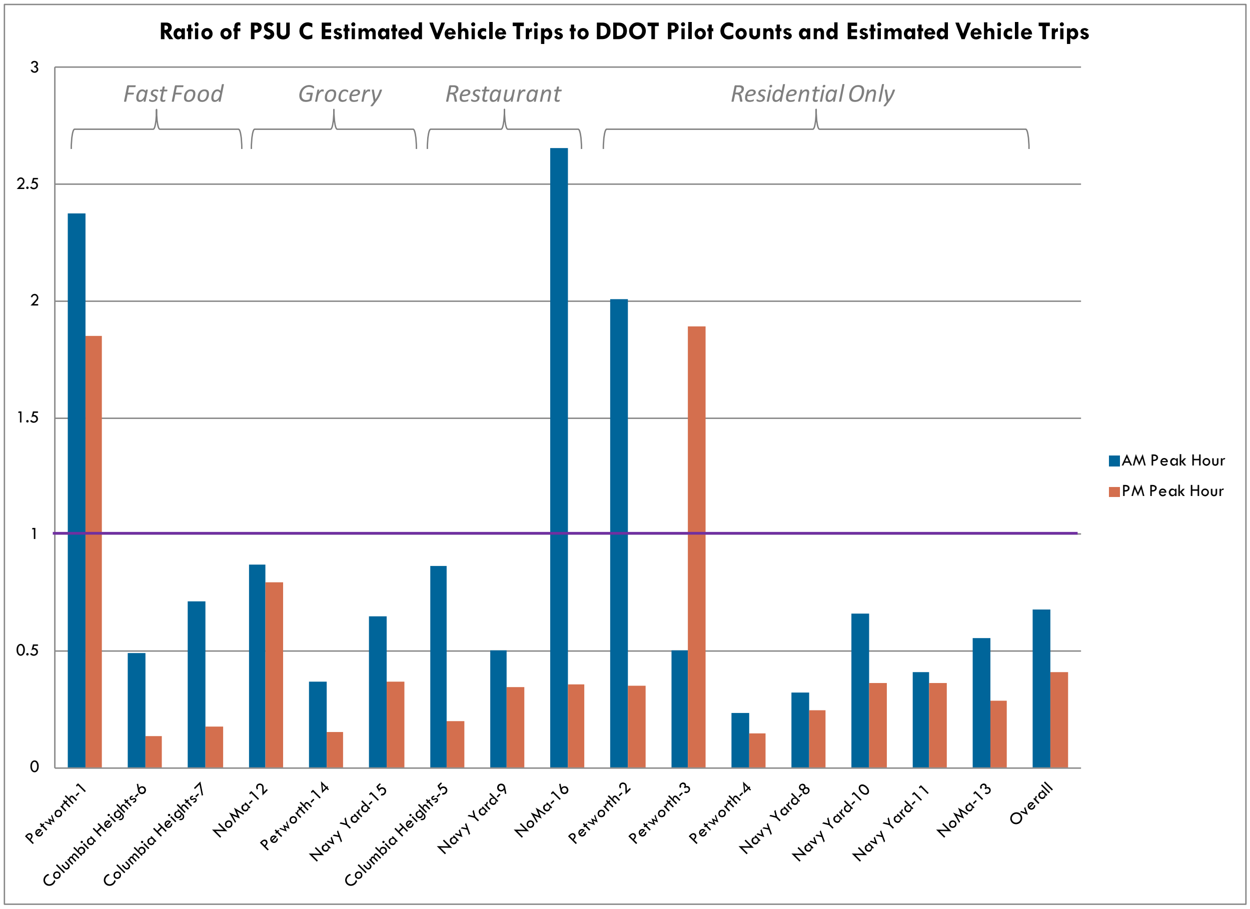
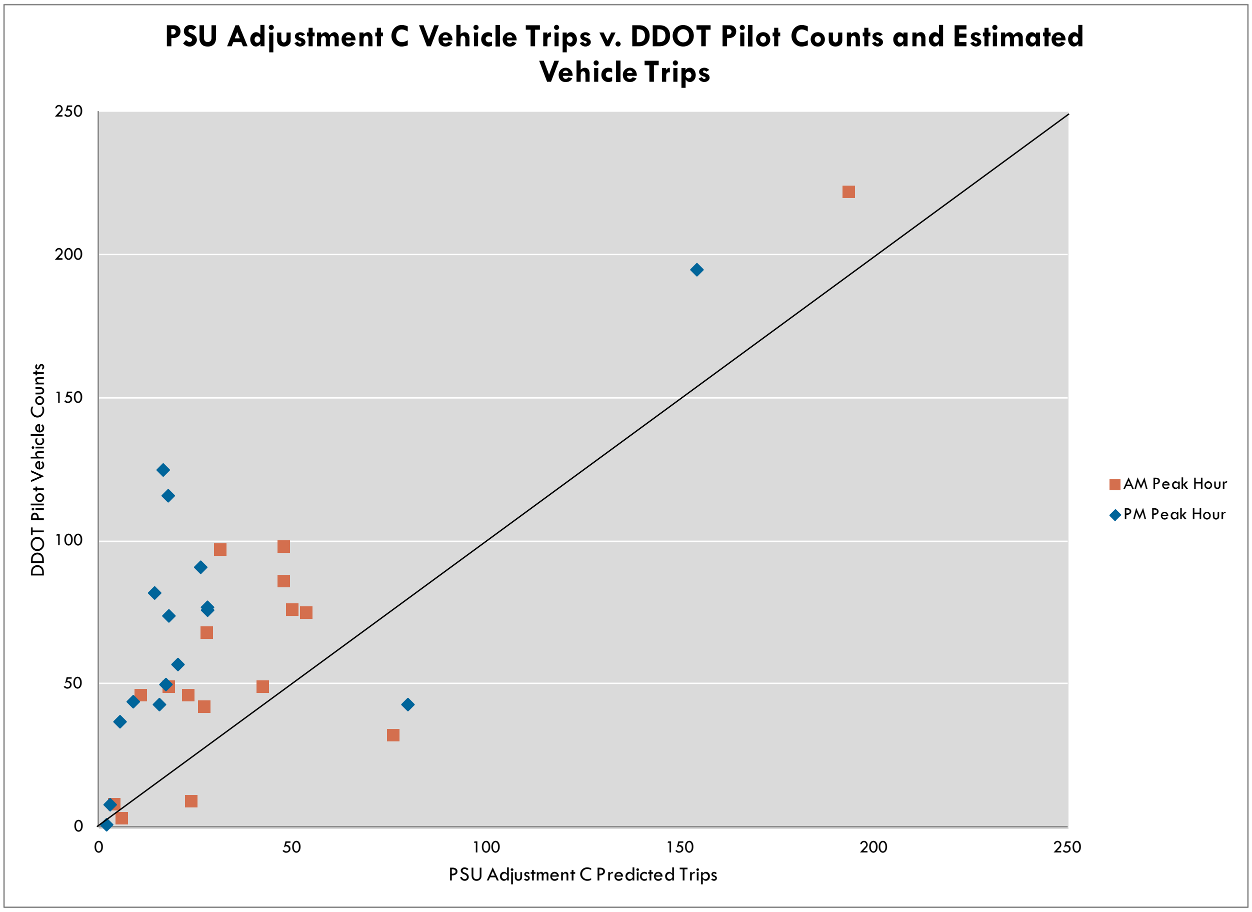


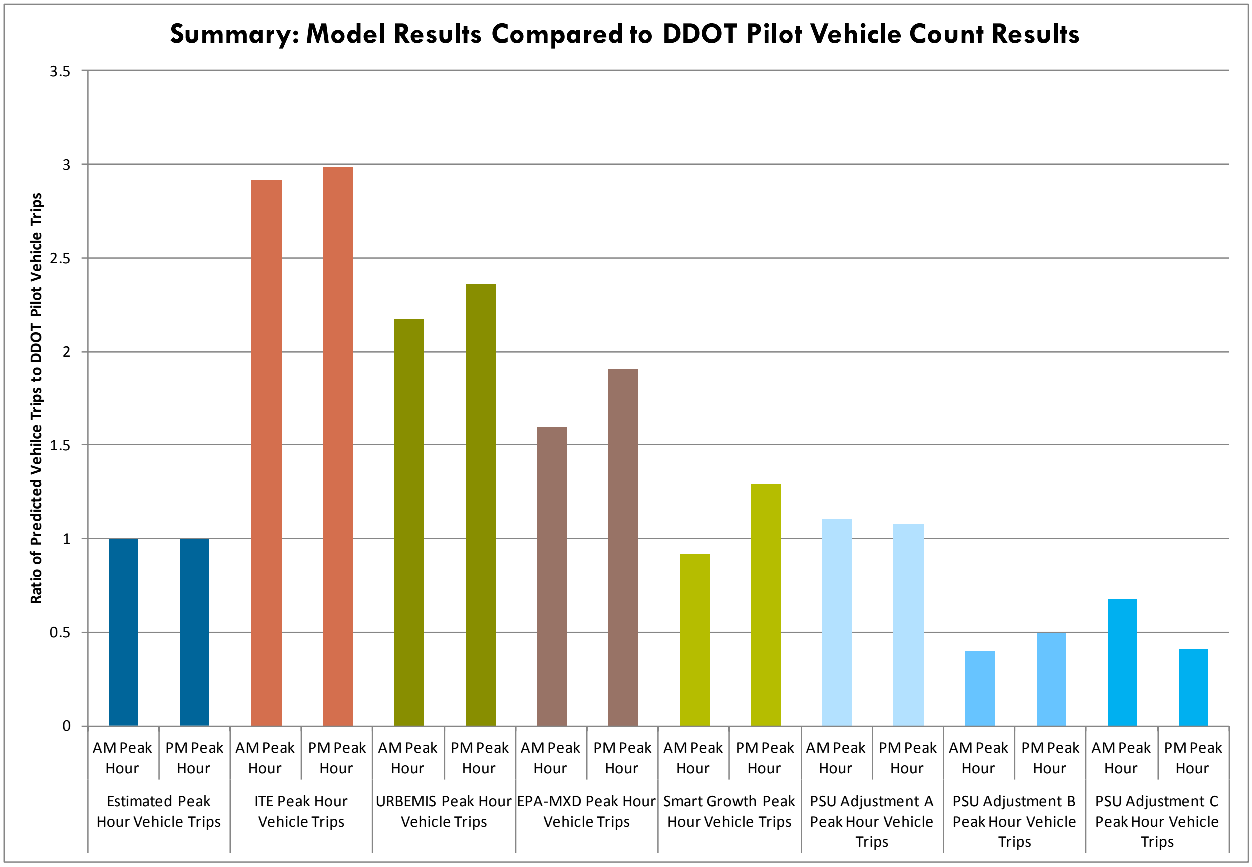
Figure 31. PSU Adjustment C Vehicle Trips v. DDOT Estimated Vehicle Trips



Summary

Figure 32 shows overall results from the seven models. Data are presented as the ratio of predicted vehicle trips from each model to the vehicle trips estimated from the field work.

Figure 32. Ratio of Model Results to DDOT Estimated Vehicle Trips



The overall finding that ITE under-predicts urban trips is consistent with the team's expectation. The finding that ITE over-predicts vehicle trips is also consistent. The array of models currently available predict slightly better than ITE but all do so by applying reductions to baseline ITE predictions. Since there is no theoretically compelling argument to suggest that single-use, suburban data would systematically translate to multi-use urban contexts, the finding underscores the importance of developing better tools to predict vehicle trips as well as trips by other modes. Furthermore, to adequately plan trip impacts in urban environments, trip generation must go beyond auto trips to include impacts on a broad set of travel modes.

6. Next Steps and Conclusion

Through the development and testing of a multimodal, building-level data collection methodology, this study was able to confirm and begin addressing a gap in the ability of DDOT (and other urban transportation agencies) to estimate the transportation impacts of proposed land development projects. This study confirmed that existing models, even if functionally reasonable, are inadequate for predicting multimodal trip generation in urban contexts and that this results in significant gaps between observed and predicted results. Results from the pilot data collection indicate that relying on ITE *Trip Generation Manual* and models derived from it will over-count vehicle trips and the under-count trips by all other modes. The pedestrian impacts of new development is particularly notable in this context given that almost all trips by non-automobile modes begin as walking trips.

A large part of shortcomings of the existing models is due to a paucity of data. Existing models tend to be built on limited travel survey data or, even more limited site-specific data. Conversely, ITE's 9th edition of the *Trip Generation Manual*, released in 2013, contains site-specific data from over 5,500 sites. Thus, to get a true representation of multimodal trip generation, particularly in urban areas, will ultimately call for substantially more data collection. To facilitate that data collection, this study developed a clear, reproducible methodology for urban trip data collection capable of standardizing data collection processes nationwide. Such a methodology is essential for consistent data collection, especially in complex urban environments where travel behavior is often characterized by its complexity, variability, and multimodality.

The outcomes of this study, particularly once better quantified after further data collection, support and can expand DDOT's multimodal planning focus. First and foremost, this project has provided an initial dataset that quantifies what DDOT has known anecdotally and theoretically for some time, but has lacked supporting evidence in some cases: that developments in the District generate different travel behaviors than those predicted by available trip generation tools. . As a result, DDOT can begin to better understand travel demand and from there, better assess impacts across modes. The finding that developments in the District generate significantly more pedestrian trips than previously quantified gives DDOT data to support existing policy-based approach to mitigating impacts in the pedestrian realm. Equally importantly, better data on vehicle trips will help to avoid over-mitigating for personal vehicle trips. This, in turn, will help to further develop the District's multimodal transportation system. Additionally, a fuller understanding of a development's impacts can also assist in addressing traffic impact concerns from residents, decision makers, and other stakeholders. Finally, the research could lead to better District-wide policy-making by basing mitigations and policies about mitigations on how residents are actually making trips.

DDOT's ultimate vision for this project is to develop a robust database of urban, multimodal trip generation data from a variety of land uses and to produce statistically valid models capable of more accurately predicting travel impacts. To get there, DDOT envisions several interim steps.

Local data collection. Collect additional data from a wide range of land-uses throughout the District. Additional data can be collected by integrating trip generation requirements into transportation impact studies (referred to as Comprehensive Transportation Reviews) as part of DDOT's development review process, by integrating trip generation data collection into performance monitoring reports, and by utilizing local funding sources to fund data collection by DDOT. The geographies and land uses collected will be driven by development trends in the District.

DDOT is preparing for a new round of locally-funded data collection in fiscal year 2015, focused on hotels, large-format retail, and high-rise residential. The geographies of interest will be similar to those in this study: growing, higher-density neighborhoods outside of the central business district. The residential uses studied in that project will be targeted to overlap with sites studied in a parallel study looking at parking utilization at residential sites. There may also be opportunities to link data collection to other, broader DDOT efforts, such as the planned streetcar expansion and new parking initiatives, to help trace the impacts of those projects over time.

This step also includes building the underlying database architecture needed for collecting and storing data. PSU has developed an app to assist with their data collection and DDOT is interested in adapting or developing a similar app for this methodology.

National effort. Build a coalition of peer cities and jurisdictions to contribute data to a centralized database. Trip generation data collection is costly and time consuming; however, the burden can be shared across multiple partners and data can be aggregated for mutual benefit. Broadening the base may require modifications to the methodology proposed here in order to ensure that the methodology functions in other contexts or to allow additional questions to be added to the surveys in response to local data collection needs. As an example, San Francisco has already begun data collection using a modified draft version of DDOT's methodology with additional questions about trip chaining and trip length in response to local regulatory needs.

In addition to data collection, DDOT would like to create a peer city researcher group to support and expand the data analysis around this effort. The group could meet periodically to discuss study designs and analysis ideas. DDOT has had conversations with several researchers already and host two meetings, one in person at the TRB Annual Meeting in 2014 and one online in April 2014, to introduce this effort to cities and researchers. The peer city researcher group could expand on those meetings.

Comparable site procedures. Until models can be developed (pending adequate data and model development), determine a process for using data from comparable sites to estimate impacts from proposed developments. This process will involve a combination of contextual and site variables and professional judgment. The literature review done for this project identified likely variables of interest.

Model development and ongoing data validation and integrity. As the database reaches critical mass, models that predict expected trip generation rates for various land-use types can be developed. Once there are models developed, it will be necessary to perform periodic data validation tests to ensure that the models are accurately reflecting observed travel behavior. This may require refinement of context variables to be collected along with site-specific travel behavior information. Additionally, data will need to be continually collected to ensure that the database remains fresh and reflects current travel behavior. Potential emerging datasets such as cell phone data may be utilized.

The work reported in this document represents an important first step in closing the identified gap between ill-equipped trip generation tools and the reality of travel behavior in urban, multimodal contexts. DDOT is committed to continuing this effort until a robust and uniform data set has been developed that will provide the basis of developing new tools to better estimate the transportation impacts of new urban and/or infill development.

APPENDICES

Appendix A. References

[1] R. Ewing, M. Greenwald, M. Zhang, J. Walters, M. Feldman, R. Cevero, L. Frank, and J. Thomas, “Traffic Generated by Mixed-Use Developments-Six-Region Study Using Consistent Built Environmental Measures,” *J. Urban Plan. Dev.*, vol. 137, no. 3, Sep. 2011.

[2] SANDAG, “Trip Generation for Smart Growth: Planning Tools for the San Diego Region,” SANDAG, San Diego, California, 2010.

[3] Fehr & Peers, “MXD Method,” *Cool Connections*. .

[4] S. L. Handy, K. Shafizadeh, and R. J. Schneider, “Final Report: California Smart-Growth Trip Generation Rates Study,” California Department of Transportation, University of California, Davis, Mar. 2013.

[5] R. J. Schneider, K. Shafizadeh, B. R. Sperry, and S. L. Handy, “Methodology to Gather Multimodal Trip Generation Data in Smart-Growth Areas,” presented at the Transportation Research Board 92nd Annual Meeting, 2013.

[6] K. M. Currans and K. J. Clifton, “Improving Vehicle Trip Generation Estimation for Urban Contexts: Using Household Travel Surveys as a Method to Adjust ITE Trip Generation Rates,” *Submitt. Rev.*, Feb. 2014.

[7] K. J. Clifton, K. M. Currans, and C. D. Muhs, “Contextual Influences on Trip Generation,” Nov. 2012.

[8] Association of Bay Area Governments (ABAG), Kimley-Horn and Associates, and Economic & Planning Systems, “Trip-Generation Rates for Urban Infill Land Uses in California. Phase 1: Data Collection Methodology And Pilot Application - FINAL REPORT,” Kimley-Horn and Associates, Phase 1, Apr. 2008.

[9] B. Boucher, K. Hooper, B. Sperry, and R. Dunphy, “NCHRP Report 684: Enhancing Internal Trip Capture Estimation for Mixed-Use Developments,” Transportation Research Record: Journal of the Transportation Research Board, 684, 2011.

[10] R. L. Steiner, “Trip Generation and Parking Requirements in Traditional Shopping Districts,” *Transp. Res. Rec.*, vol. 1617, pp. 28–37, 1998.

[11] R. Weinberger, M. Kodransky, J. Karlin-Resnick, A. Gauthier, and Z. Gyarmati, “Parking Guidebook for Chinese Cities,” Institute for Transportation and Development Policy, New York, NY.

[12] J. Daisa, M. Schmitt, P. Reinhofer, K. Hooper, B. Boucher, and L. Schwartz, “NCHRP Report 758: Trip Generation Rates for Transportation Impact Analyses of Infill Developments,” Transportation Research Record: Journal of the Transportation Research Board, Washington, D.C., 758, 2013.

[13] L. Zhang, J. Hong, A. Nasri, and Q. Shen, “How built environment affects travel behavior: A comparative analysis of the connections between land use and vehicle miles traveled in US cities,” *J. Transp. Land Use*, vol. 5, no. 3, pp. 40–52, 2012.

[14] L. Frank, M. Greenwald, S. Kavage, and A. Devlin, “An Assessment of Urban Form And Pedestrian and Transit Improvements As An Integrated GHG Reduction Strategy,” Washington State Department of Transportation, WA-RD 765.1, Apr. 2011.

[15] R. Cevero and M. Duncan, “Which Reduces Vehicle Travel More: Jobs-Housing Balance or Retail-Housing Mixing?,” *J. Am. Plann. Assoc.*, vol. 72, no. 4, Autumn 2006.

[16] R. Ewing, M. Greenwald, M. Zhang, M. Bogaerts, and W. Greene, “Predicting Transportation Outcomes for LEED Projects,” *J. Plan. Educ. Res.*, Apr. 2013.

[17] L. Bailey, “Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil,” American Public Transportation Association, Washington, D.C., Jan. 2007.

[18] D. Shoup and M. Manville, “Parking, People and Cities,” *J. Urban Plan. Dev.*, vol. 131, no. 4, Dec. 2005.

[19] H. Fang, “A discrete–continuous model of households’ vehicle choice and usage, with an application to the effects of residential density,” *Transp. Res. Part B Methodol.*, vol. 42, no. 9, pp. 736–758, Nov. 2008.

[20] D. Brownstone, “The Impact of Residential Density on Vehicle Usage and Energy Consumption,” *J. Urban Econ.*, vol. 65, no. 1, pp. 91–98, Jan. 2009.

[21] A. Bento, M. Cropper, A. Mobarak, and K. Vinha, “The Impact of Urban Spatial Structure on Travel Demand in the United States,” World Bank, Mar. 2003.

[22] P. Emrath and F. Liu, “Vehicle Carbon Dioxide Emissions and the Compactness of Residential Development,” *Cityscape J. Policy Dev. Res.*, vol. 10, no. 3, 2008.

[23] R. Ewing and R. Cevero, “Travel and the Built Environment: A Meta-Analysis,” *J. Am. Plann. Assoc.*, vol. 76, no. 3, 2010.

[24] D. Chatman, “Transit-Oriented Development and Household Travel: A Study of California Cities,” California Department of Transportation, University of California, Los Angeles, Aug. 2006.

[25] J. R. Kuzmyak and E. Vaca, “Transit Cooperative Research Program Report 95, Traveler Response to Transportation System Changes: Chapter 13 – Parking Pricing and Fees,” 2005.

[26] R. Weinberger, M. Seaman, C. Johnson, and J. Kaehny, “Guaranteed Parking - Guaranteed Driving: Comparing Jackson Heights, Queens and Park Slope, Brooklyn shows that a guaranteed parking spot at home leads to more driving to work.,” Transportation Alternatives, Oct. 2008.

[27] A. Khattak, J. Stone, W. Letchworth, B. Rasmussen, and B. Schroeder, “Traditional Neighborhood Development Trip Generation Study,” North Carolina Department of Transportation, North Carolina, NCDOT 2003-13, Jan. 2004.

[28] R. Cervero and G. B. Arrington, “Vehicle Trip Reduction Impacts of Transit-Oriented Housing,” *J. Public Transp.*, vol. 11, no. 3, 2008.

[29] A. Khattak and D. Rodriguez, “Travel behavior in neo-traditional neighborhood developments: A case study in USA,” *Transp. Res. Part Policy Pract.*, vol. 39, pp. 481–500, 2005.

[30] G. B. Arrington and R. Cevero, “TCRP Report 128: Effects of TOD on Housing, Parking and Travel,” Transportation Research Record: Journal of the Transportation Research Board, 128, 2008.

[31] D. C. Shoup, “Evaluating the Effects of Parking Cash Out: Eight Case Studies,” University of California Transportation Center, University of California Transportation Center, Working Paper, Sep. 1997.

[32] H. Lund, R. Cevero, and R. Willson, “Travel Characteristics of Transit-Oriented Development in California,” Caltrans, Final Report, Jan. 2004.

[33] R. Cevero, “Office Development, Rail Transit, and Commuting Choices,” *J. Public Transp.*, vol. 9, no. 5, 2006.

[34] R. Cervero, A. Adkins, and C. Sullivan, “Are Suburban TODs Over-Parked?,” *J. Public Transp.*, vol. 13, no. 2, 2010.

[35] R. Weinberger, “Death by a Thousand Curb-cuts: Evidence on the effect of minimum parking requirements on the choice to drive,” *Transp. Policy*, vol. 20, pp. 93–102, 2012.

[36] J. Kelly and J. Clinch, “Temporal variance of revealed preference on-street parking price elasticity,” *Transp. Policy*, vol. 16, no. 4, pp. 193–199, Aug. 2009.

[37] Center for Neighborhood Technology, “Right Size Parking Project - Technical Memo,” King County Metro Transit, Feb. 2013.

[38] D. Shoup and R. Willson, “Employer-Paid Parking: The Problem and Proposed Solutions,” The University of California Transportation Center, Berkeley, CA, 119, Aug. 1992.

[39] J. Evans, “TCRP Report 95: Traveler Response to Transportation System Changes - Chapter 9: Transit Scheduling and Frequency,” Transportation Research Record: Journal of the Transportation Research Board, 95, 2004.

[40] B. Podobnik, “The Social and Environmental Achievements of New Urbanism: Evidence from Orenco Station,” Lewis and Clark, Nov. 2002.

[41] Metropolitan Transportation Commission, “Characteristics of Rail and Ferry Station Area Residents in the San Francisco Bay Area: Evidence from the 2000 Bay Area Travel Survey,” Metropolitan Transportation Commission, Sep. 2006.

[42] T. Carr and J. Dill, “Bicycle Commuting and Facilities in Major U.S. Cities,” *Transp. Res. Rec.*, vol. 1828, pp. 116–123, 2003.

[43] J. Guo, C. Bhat, and R. Copperman, “Effect of the Built Environment on Motorized and Nonmotorized Trip Making: Substitutive, Complementary, or Synergistic?,” *Transp. Res. Rec.*, vol. 2010, pp. 1–11, 2007.

[44] G. Barnes and K. Thompson, “A Longitudinal Analysis of the Effect of Bicycle Facilities on Commute Mode Share,” *Transp. Res. Rec.*, 2006.

[45] R. Weinberger and M. Sweet, “Integrating Walkability into Planning Practice,” *Transp. Res. Rec.*, vol. 2322, pp. 20–30, 2012.

[46] J. R. Kuzmyak and E. Vaca, “Transit Cooperative Research Program Report 95, Traveler Response to Transportation System Changes: Chapter 13 – Parking Pricing and Fees,” 2005.

[47] R. Cevero and G. B. Arrington, “Vehicle Trip Reduction Impacts of Transit-Oriented Housing,” *J. Public Transp.*, vol. 11, no. 3, pp. 1–17, 2008.

[48] E. Heinen, B. van Wee, and K. Maat, “Commuting by Bicycle: An Overview of the Literature,” *Transp. Rev.*, vol. 30, no. 1, pp. 59–96, Jan. 2010.

[49] “Trip Generation Tool for Mixed-Use Developments - EPA Website,” Environmental Protection Agency.

[50] “Smart Growth Trip Generation - UC Davis Website,” UC Davis.

[51] T. Rimpo, “URBEMIS 2007,” Rimpo and Associates, 2007.

[52] B. Lee, “Quantifying Greenhouse Gas Mitigation Measures: A Resource for Local Government to Assess Emission REductions from Greenhouse Gas Mitigation Measures,” California Air Pollution Control Officers Association, Aug. 2010.

[53] “Trip Reduction Impacts of Mobility Management Strategies,” Center for Urban Transportation Research, University of South Florida.

[54] ARUP, “TripGenie: Context Sensitive Trip Generation Rates,” 2012.

[55] A. Sosslau, A. Hassam, M. Carter, and G. Wickstrom, “NCHRP Report 187: Quick-Response Urban Travel Estimation Techniques and Transferable Parameters,” Transportation Research Board, 1978.

[56] J. Mehra and R. Keller, “Development and Application of Trip Generation Rates,” US Department of Transportation, Federal Highway Administration, FHWA/PL/85/003, 1985.

[57] P. O. Barnard and R. E. Brindle, “A Review and Critique of Current Methods Used to Predict Traffic Generation with Some Accompanying Suggestions on Alternative Approaches,” *Transp. Plan. Technol.*, vol. 11, no. 4, pp. 273–288, 1987.

[58] F. A. Reid, “Critique of ITE Trip Generation Rates and an Alternative Basis for Estimating New Area Traffic,” *Transp. Res. Rec.*, vol. 874, pp. 1–5, 1982.

[59] Institute of Transportation Engineers (ITE), *Trip Generation Manual, 9th Edition, Volumes 1, 2 and 3*. 2012.

[60] Institute of Transportation Engineers (ITE), *Trip Generation Manual, 7th Edition, Volumes 1, 2 and 3*. 2003.

[61] Institute of Transportation Engineers (ITE), *Trip Generation Manual, 8th Edition, Volumes 1, 2 and 3*. 2008.

Appendix B. Recommendations for Future Data Collection

While lessons learned in the mini-pilot and detailed earlier were incorporated into the main data collection, additional insight was gained throughout the project. This section reproduces the Data Collection Field Guide, an intermediate product in this project, as the field guide accurately comprises lessons learned in the execution of this project. The Data Collection Field Guide has been reviewed by industry peers for incorporation and adoption into a national effort to gather urban trip generation data.

These field instructions describe how to collect data that can be used to develop the model. The focus is on how many trips, by what modes, begin or end at a study site.

For the purposes of this document, *trip generation* refers to person trips that are associated with a given land use. At the site level, this data is pivotal for a variety of planning purposes. The purpose of collecting data according to the approach outlined below is to later develop robust methodologies for estimating trip generation, by mode, in urban contexts.

The instructions provided here were developed for and from the fieldwork performed in the DDOT Urban Trip Generation Pilot Project. These instructions describe the fieldwork required to collect data on trip generation by mode. Site context data collection, such as proximity to transit, number of residences, and range of uses, is not included in this section.

Methodology Overview

To accurately and practically estimate person trips by mode, a survey approach is used to estimate the number of people accessing a site (universe), and their mode choices. The methodology detailed here uses a simple combination of door counts ("counts") and intercept surveys ("surveys") to do that.

A key element of the methodology is its relative simplicity. The accurate collection of these data involves the cooperation of a large number and wide range of people, from those coordinating the study to those answering survey questions. In the testing stages of this project we found that elements of the data collection meant to improve the system, such as attempting to document all travel modes used for a given trip rather than the most immediate, outweighed their benefits. We have retained essential features, thus the field instructions provided in this memo balance "ideal" statistical conditions with true field conditions, resulting in robust data on which to estimate trip generation for land uses in urban contexts.

Pre-Survey Work and Staffing

There are six elements to laying ground work prior to launching the actual trip generation data collection:

1. **Property Access and Permission.** The study coordinator or participating municipality should contact the property manager to inform them of the study and to obtain permission to stand on the property. If this permission is not granted, the study coordinator should determine the extent of the property line and plan to position surveyors in the public right-of-way. If permission is not obtained and the site proves too difficult to survey from the public sidewalk a substitute site should be considered.
2. **Preliminary Site Survey:**

   a. *Number and location of all doors.* Doorways are not always obvious. For example, secondary pedestrian entrances outside garages may not be marked or clear. Note that those traveling by modes other than personal vehicle may also use garage entrances, thus requiring a survey data entry form. Survey personnel must be stationed at every point of access and egress, hence every entrance must be known and accounted for.
   b. *Traffic Levels.* Doors with high pedestrian traffic may need two or more staff members to both count and survey those entering and exiting. Conversely, those with very low levels of traffic may be handled by one person who can both count and perform the intercept survey.
   c. *Business Hours*. Establishments such as banks and restaurants have very different hours of operation. Staffing plans must take account of open and closed hours.
3. **Staffing Plan**.
   a. *Staff Level*. Information from the preliminary site survey will dictate how many counters and surveyors will be required at a given site for the time periods to be studied. At least one “relief” surveyor must be on hand to rotate among the door locations, filling in for breaks and/or for any other reason that a substitution should be made.
   b. *Staff Location/Vantage Point*. Field staff should be directed to stand in an appropriate place for accurate data collection, imposing the least disruption at the site. Optimal location will be determined primarily based on the site survey but may also rely on input from the property manager or other entity.
   c. *Quality Control*. For quality control, the plan should also incorporate a supervisor who is able to travel between count sites and answer questions and confirm the field staff are correctly soliciting and recording data.
   d. *Accountability.* This plan should be documented as a quality assurance measure. It is frequently the case that a question will arise regarding the data collection, but after the fact (e.g. during data entry) and it is imperative to know which staff has been assigned to which locations.
4. **Data collection instrument(s).** Depending on the number of people required at each door, staff will need different types of forms. Three forms were developed in the DDOT Urban Trip Generation Pilot Study. One form is for person counts only, one is only for the intercept survey, and there is one for both person counts and surveys that would be used by the surveyor stationed at a low volume door who is responsible for both the count and survey.
5. **Practice Survey with Field Personnel.** It is important that field staff understand the overall goal of the data collection, which is to determine person counts by mode for a given site. The study coordinator should also stress the importance of clear documentation. Field staff should also be trained in the following:
   a. *Survey:* How to approach and engage the survey subject, asking “How did you get here today (for those entering a site)/How are you getting to your next destination (for those leaving).” Appropriate variations are acceptable; in particular, surveyors with a good understanding of the information to be gathered should put the interview in their own words in order to increase their confidence in approaching potential interviewees. The study coordinator should practice this with field staff.
   b. *Count:* All individuals, no matter the age/intent, should be counted. This is described in more detail later in this document.

6. **Optional: Survey/Count Pilot.** The entity coordinating the study may want to do a small field test, with field supervisors, before a full day of data collection. This will help identify potential problems and provide an opportunity to address them.

Study Schedule and Timing

Scheduling Data Collection

There are many events that can impact travel choices. The following conditions should be considered in determining when and where to schedule data collection. Note that this list endeavors to be comprehensive, but the study team should consider other local variables as well.

- Weekend days, holidays, and school vacations should be avoided unless there is a specific reason to study those days.
- On Mondays or Fridays travel schedules before and after traditional work hours are more subject to change, likewise, businesses that stay open through the weekend are often closed on Mondays. Hence these days should also be avoided.
- Severe weather has a depressing effect on travel and it affects mode choice. Contingency dates should be scheduled and data collection cancelled on bad weather days.
- Darkness/early sunset is an obstacle in evening data collection in the winter months. Some subjects respond with fear when approached to answer the survey in the waning evening hours. Spring or fall data collection is therefore preferred. If data collection occurs in the winter, provisions should be made to ensure the comfort of respondents, for example, data collectors should position themselves in well lit areas to ensure adequate comfort to subjects. Provisions should also be made to ensure the safety of data collectors (e.g. pairing if necessary and use of reflective vests).
- Events that would cause anomalous travel such as street fairs, sporting events at local stadia or parades and/or construction projects that would affect travel should all be avoided.
- Travel choices will be in flux immediately before or after implementation of a major transportation policy and/or management change i.e. a transit system fare increase or a shift in parking management. Data should be collected AFTER such a change with a three to four week buffer allowed for normalization of travel.
- The study coordinator should also consider the comfort of surveyors. Without property manager permission, surveyors will be outside in the elements for long periods of time. Therefore, even mildly high or low temperatures can feel much more severe. These conditions can impact the quality of data as surveyors may be in extreme discomfort.

Timing

- Trip generation data should be collected at the peak hours of travel on the local network. Traditionally, these hours are between 7:00 a.m. - 10:00 a.m. and 4:00 p.m. - 7:00 p.m.[4] As this area of study emerges, practitioners may wish to study alternative peaks depending on mode, generator type, or other variables.

---

[4] ITE's *Trip Generation Handbook* considers peak hour of street traffic to occur between 7:00 a.m. and 9:00 a.m. in the morning and 4:00 p.m. and 6:00 p.m. in the evening.

Personnel

- For large sites with multiple doors requiring large staff, it is important to begin planning and coordinating with field staff at least two to three weeks in advance. It is helpful to plan and warn staff in advance of an alternate data collection day in the event of inclement weather or other sudden changes. The coordinator should have a way to communicate with all field staff on the day of the survey, either by phone or email.
- The staffing plan should also incorporate a supervisor who is able to travel between count sites or stay on site at a large/complex location and answer questions/confirm the field staff are correctly soliciting and recording data.

Materials and Professional Presentation

- Personnel will require the following materials in the field:
- **Traffic safety vest or other "official" apparel**. Potential interviewees are more likely to feel comfortable answering questions from someone who they perceive as "official" in some way.
- **Clipboard and multiple pens**. The DDOT Urban Trip Generation study put an official DC logo on the back of clipboards used in the field.
- **Signed letter from municipality or other study coordinator.** This letter should also include contact information for those who have questions or comments about the study.
- **Additional pages for notes/observations/comments**
- Finally, personnel should be encouraged to dress comfortably but professionally.

Survey/Count Sheets:

- There are three different survey/count sheets, to be used in the following situations:
- **Survey Only Form:** To be used in high-traffic locations where someone else is counting a door. This allows an interviewer to focus on surveying only.
- **Count Only Form:** For high-traffic locations where someone is surveying separately. For efficiency, where appropriate, a counter may watch multiple doors while separate staff survey at each door.
- **Survey and Count Form:** To be used in locations where one surveyor can count and survey at one location or for garages.

Data Collection

Collection of Context Variables

Travel behavior, including number of trips and mode choice, is a function of land use and transportation infrastructure supply. Given these established relationships, a robust trip generation model is reliant on site and area specific data. Hence, site and area specific data must be collected to appropriately contextualize the trip counts. While much of the data is available in municipal or national databases and does not change over time, such as location of a rail transit station or a parking garage, other context variables, including parking utilization and quality of bus stops, may be time-sensitive and not available from pre-existing sources. Time-sensitive data should be collected concomitantly with survey data.

Counts

As mentioned earlier, the methodology is designed to be simple and thus easy to understand and replicate, while also providing good data. However, questions may arise as to what really counts as a "trip." To avoid potentially biasing judgment calls in the field, the methodology assumes that every person should be counted whenever s/he crosses any entrance threshold of the building. Thus, the study established the rules below:

- Count all individuals, regardless of age
- Count all individuals entering and exiting a doorway. Keep a separate count of those entering and those exiting. All individuals entering and exiting includes people that may not seem like they are making a relevant trip, such as people:
  - taking a smoking break,
  - walking a dog,
  - delivering a package,
  - going for a jog, and
  - for any other reason.
- For vehicles with one or more passengers, the counter should record the driver and the passengers in separate columns.[5]
- Counters should use one of two forms, either the Count Only or Count and Survey Form, found in Appendix G.

Survey

Interviewers should attempt to survey as many people as possible.[6] As soon as one interview is complete, an interviewer should attempt to engage the next person entering or exiting the doorway. For those entering a building, the interviewer should focus on how the individual arrived at the site. For those exiting, interviewers should focus on how the individual plans on getting to his or her next destination. Multiple persons in the same traveling party should not be interviewed.

---

[5] Separating these two allows a comparison of vehicle trips as compared to person trips in vehicles.

[6] This survey approach is a concession to field conditions. A preferred approach from a statistical perspective would be to collect a systematic sample in which the first person is selected at random and every kth person is interviewed after that.

Consistent with the counting rules denoted above, anyone crossing the threshold should also be asked the intercept question. Those not actually taking a trip (but going for a smoke or walking the dog, for example) should be approached, asked about their trip and then recorded as not making a trip on the survey sheet.

There is no effective way to automate the mode choice data collection but there are options for automating data recording. In this project we used paper and pen but electronic tablets pads could be used as well. The obvious disadvantage of using paper revolves around subsequent data entry, yet in many ways paper is superior to the alternatives in its flexibility, stability and indifference to inclement weather.

Survey Question(s)

The information required is access or egress mode to/from the site. There are many ways to phrase the question and several opinions as to whether the question should be scripted or if the field staff should have latitude to phrase the question in a way most natural to them. Theoretical statistical principles suggest a script but field experience shows that respondent may react negatively to scripted questions, particularly if the surveyor seems uncomfortable with the phrasing or if the question comes across as stale and automated. In this case subjects are more likely to refuse and fewer data are collected. Scripting also precludes sensitivity to local customs. In some situations it may be more effective to ask “did you get here by car today?” and allow the respondent to say “yes” or “no, I took the bus.” In other situations, the better question would be open ended “How did you get here today?” Essentially these are the same question and the surveyor who is familiar with local language rhythms will be able to better connect with respondents by asking the local version and they will be able to stay fresh in their presentation if they can vary the way they ask.

Mode Choice

In an effort to maintain simplicity, field staff should be instructed to focus on an individual’s most immediate mode, barring the walk to a door from a car/bus/bicycle rack etc. [7] Based on previous experience, this methodology assumes that most individuals will answer with their primary mode of transportation. For example, trips to metrorail or bus should be noted (and would usually be reported) as trips attributable to these transit modes *rather* than as a walk trip. The walk portion of their trip is assumed as a component of accessing this mode.

However, for those who used two modes, for example cycling to a bus, the interviewer should record the mode associated with the site. If the bicycle is used between the site and the bus then the immediate mode is bike. If the person is traveling from the site by bus to access a commuter rail line then the immediate mode is bus.

Per the forms in Appendix G, modes should be marked as follows:

- **Drive Alone** – drove alone in a private vehicle
- **Carpool/High Occupancy Vehicle (HOV) Driver** – Driver of a private vehicle with one or more passengers

---

[7] Schneider (2012, 2013) approaches this in a slightly different way to categorize mode and with fewer categories (see “Trip Generation Data Collection Guidelines” p. 21). Ultimately, these types of decisions will depend on the categories incorporated into the central database as well as data that the municipality or other entity funding the survey wishes to include.

- **Carpool/HOV Passenger** – Passenger in a private vehicle with one or more passengers
- **Walk** – Walked to/from the site from/to last location
- **Shared Vehicle** – traveled in a Taxi/Uber/Zipcar etc. This is separate as these vehicles demonstrate greater efficiency in utilization of curbside and garage space
- **Bicycle** – Bicycled to/from the site from/to last location
- **Bus** –whether local, express or private
- **Rail Transit** – Including both light and heavy rail
- **Delivery –** UPS, FedEx, etc.
- **No trip** – i.e. someone taking a smoke break who is not traveling to another destination
- **Refused to answer** (not technically a mode but to be recorded)
- The survey also asked where those traveling by car parked. Interviewees are given three options:
- On-street
- Garage/Surface Lot On-Site
- Off-site other

Surveyors should use one of two forms, either the Survey Only or Count and Survey Form, found in Appendix G. An additional, abbreviated sheet detailing information for the interviewers is attached at the end of these instructions.

Missed Doors

For a variety of reasons, counts may miss doors – for example if field staff have a personal emergency or if the initial site survey did not identify all entrance/egress points. Field staff and/or supervisors should record these doors and time periods that were missed and return on a similar day (weather, day of week, season, etc.) to collect data.

Statistical Considerations

Developing trip generation models relies on statistical estimates and therefore requires that the data have been collected to meet the underlying statistical characteristics. The essential requirements for this type of work are that the subjects are randomly selected and independent from each other. It is essential that every subject and every trip has the same chance of being selected as any other subject or trip. Some possible problems include:

- **Deliberately or subconsciously preferencing a particular subset of the population.** Examples include preferring to approach only men or only women; preferring to approach people who have small children; avoiding people who are entering a particular store if surveying in a mixed use development; avoiding people (or being drawn to people) who “seem like” bike riders. Every effort must be taken to ensure that the surveyors do not allow personal preferences to interfere with good data collection. Instructions must be clear that the surveyor is to approach the next person, not the next friendly/approachable looking person.

- **Surveying multiple persons within a single travel group** –if people are traveling together their responses are not independent. It is also important to note that some modes may accommodate groups better than others. For example, relative to a person traveling by bicycle, a person traveling by car is more likely to be with someone else. Therefore, a car trip is likely to be reported more frequently than it should simply because the same car trip is twice as likely to be selected. Ideally information on the travel party size would be collected but this may prove too difficult in one effort.

- **Imputing or guessing at a mode when the subject has not been approached or refused to answer**. Even when the surveyor sees a person unlocking and riding away on a bicycle, if they have not been surveyed or they were surveyed and refused to answer, this information must not be recorded. It will result in over counting the modes that are obvious. To further illustrate: a person walking maybe be walking all the way to the final destination, walking to a transit stop, or walking to a car that is parked nearby, thus their mode cannot be inferred and they cannot be recorded. In this fashion, more bicycle trips will be recorded than is warranted.

While there are some biases which cannot be controlled –for example, users of a particular mode may be more responsive, the field design is structured to eliminate as much bias as possible. In some cases though, we have recommend what is likely to be effective even when it implies a small sacrifice in the statistical correctness.

Analysis and Reporting

Data analysis and reporting consists of two steps. An example aggregate spreadsheet is included as Appendix H.

Data Synthesis

Data entry can be one of the most extensive and costly elements of this process. Therefore it is important to set up a format and workflow beforehand to streamline the process. Counts and survey data for each site should be combined by site, but kept separated by door and time period. This will help with future data queries, for example comparing the peak hour of the generator to counts for the generator at the peak hour of traffic for the street.

Calculating Mode Split

Combining the count and survey data consists of three steps:

1. **Determine the surveyed mode share by door for the entire period of morning and evening data collection**. Using the three hour period helps to account for time periods with relatively few surveys that would otherwise skew the results
2. **This mode share is applied to the counts by door to calculate a weighted mode split for each door.** Calculating this by door mitigates potential data skewing from the location of doors – for example a door leading to a garage may have extremely high vehicle counts while another door right in front of a bus stop would have a high proportion of bus riders. It is important to apply the survey mode share by door to the counts by door to accurately represent these differences.
3. **Combine the counts by door to determine mode split for the site overall.**[8]

---

[8] Other studies have used gender (Schneider, 2012 and Clifton, 2012) to further eliminate any bias from surveyors. If the gender split of interviewees was different from the gender split of a door count, the analysts adjusted the calculated mode split accordingly.

It is important to note that the mode shares, calculated over the entire peak period are applied to the peak hour to determine the mode splits. Using the mode share for the peak period, rather than the hour, accounts for many potential irregularities in mode share that could be due to unobserved factors.

There are a few issues that could arise during this process. Suggested resolutions include:

- **Total number of surveys higher than counts at a given door.** Assume that the number of surveys is the count, as it is unlikely that surveyors spoke to someone who did not use the door. If a surveyor consistently turns in sheets wherein the number of people surveyed is higher than the number of people counted, the surveyor should be retrained to correctly record the data. Staffers at low volume doors who are responsible to both count and interview must be sure to include the full count –i.e. those who were interviewed along with those who were not interviewed in the count column.
- **Legibility**. Refer to the staffing plan to determine who worked at a particular door, and contact them with questions
- **Doors with no survey data**. If a door was missed in the data collection plan, return to the site to conduct an additional day of surveying.

Additional Data Collection Resources

Multiple entities have undergone similar studies that couple person counts with survey data to determine multimodal trip generation at a variety of sites. Although these studies have slightly different objectives, the core methodology and lessons learned remain the same. These studies include:

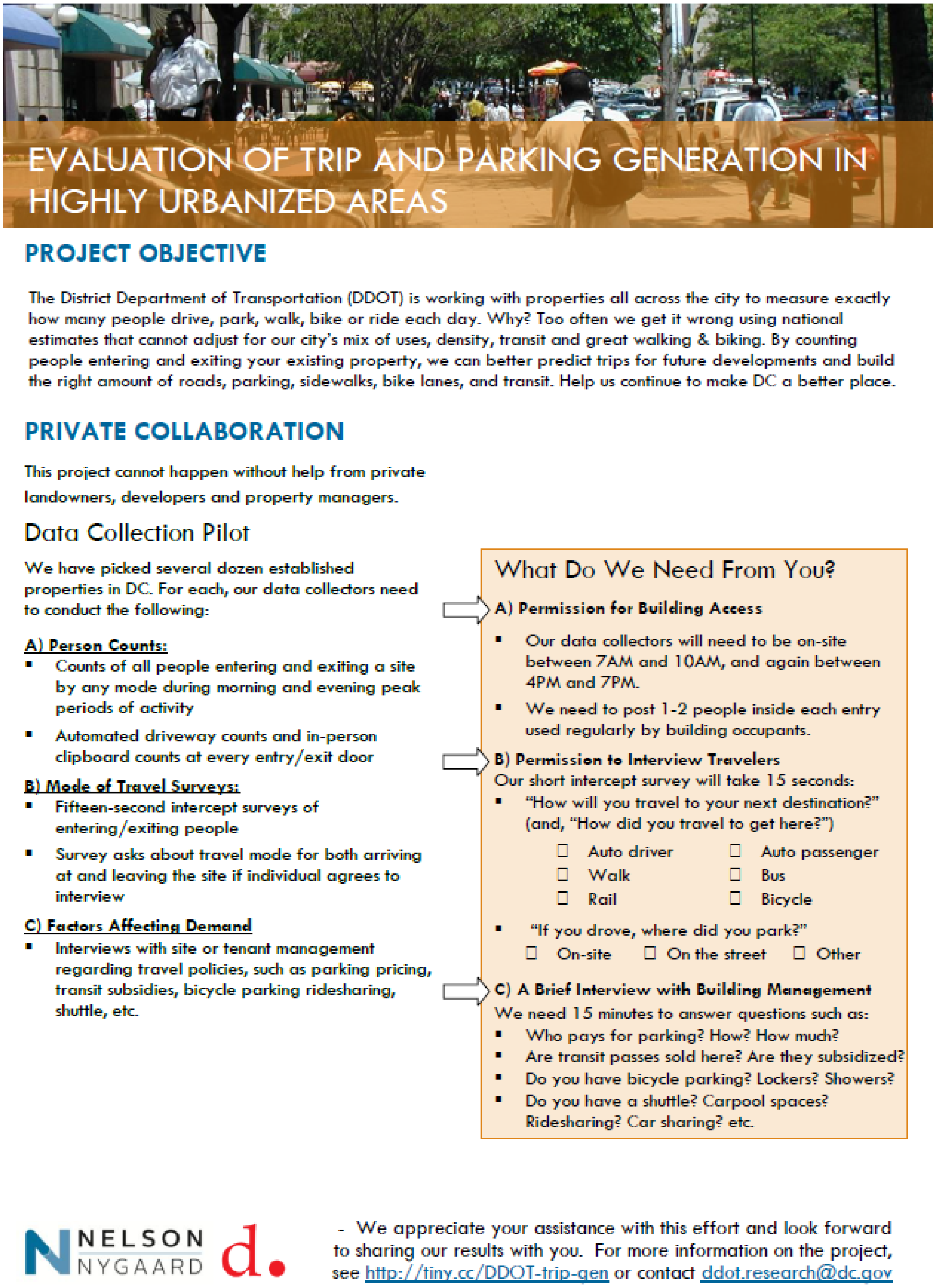
- Bochner, B.S., K. Hooper, B. Sperry, and R. Dunphy. (2011). Enhancing Internal Trip Capture Estimation for Mixed-Use Developments. *National Cooperative Highway Research Program (NCHRP) Report 684*. Retrieved from http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_684.pdf Accessed March 20, 2014.
- Clifton, K., C. Currans, and C. Muhs. (2012). Contextual Influences on Trip Generation: Final Report. *Oregon Transportation Research and Education Consortium*. Retrieved from http://otrec.us/project/407 Accessed August 27, 2013.
- Kimley-Horn and Associates, Inc., Economic & Planning Systems, Gene Bregman & Associates. (2009). Trip Generation Rates for Urban Infill Land Uses in California: Phase 2: Data Collection Final Report. *California Department of Transportation*. Retrieved from http://www.dot.ca.gov/newtech/researchreports/reports/2009/final_summary_report-calif._infill_trip-generation_rates_study_july_2009.pdf Accessed May 22, 2013
  - **See also:** Association of Bay Area Governments (ABAG), Kimley-Horn and Associates, Inc., Economic & Planning Systems,(2008). Trip Generation Rates for Urban Infill Land Uses in California: Phase 1: Data Collection Methodology and Pilot Application. *California Department of Transportation*. Retrieved from http://www.dot.ca.gov/newtech/researchreports/reports/2008/trip_generation_rates_urban_infill.pdf Accessed May 22, 2013.
- Schneider, R.J., K. Shafizadeh, B. Sperry, and S. Handy (2012) Methodology to Gather Multimodal Trip Generation Data in Smart-Growth Areas. Submitted to *Transportation Research Board.* Retrieved from http://docs.trb.org/prp/13-5108.pdf Accessed March 20, 2014

See also: Schneider, R.J., K. Shafizadeh, B. Sperry, and S. Handy (2013) Smart Growth Trip Generation Data Collection Guidelines – California Smart Growth Trip Generation Rates Study. Retrieved from http://downloads.ice.ucdavis.edu/ultrans/smartgrowthtripgen/Data_Collection_Guidelines.pdf March 20, 2014

Appendix C. Site Details

Sites	Major Use	Total SF	Residential Units	Retail SF	Parking	**Average daily weekday buses**	**Total capacity of bike racks within a quarter mile**
Petworth-1	Residential	165,000	161	17,000	145	840	97
Petworth-2	Residential	67,104	75	0	0	840	99
Petworth-3	Residential	40,000	49	0	25	840	99
Petworth-4	Residential	127,000	130	28,000	120	840	89
Columbia Heights-5	Residential	226,455	297	6,104	247	1344	69
Columbia Heights-6	Residential	243,000	228	21,000	161	1344	121
Columbia Heights-7	Residential	183,624	229	19,194	278	1482	99
Navy Yard-8	Residential	105,000	200	2,000	150	256	127
Navy Yard-9	Residential	479,093	448	0	372	256	119
Navy Yard-10	Residential	225,000	266	0	210	322	84
Navy Yard-11	Residential	284,900	246	0	0	204	106
NoMa-12	Residential	300,000	292	0	241	830	n/a
NoMa-13	Residential	678,000	432	0	0	558	n/a
Petworth-14	Residential	85,245	72	11,515	57	550	n/a
Navy Yard-15	Residential	239,408	237	6,000	199	346	n/a
NoMa-16	Residential	204,000	212	3,600	173	558	n/a

Appendix D. Project Brochure for Property Managers



EVALUATION OF TRIP AND PARKING GENERATION IN HIGHLY URBANIZED AREAS

PROJECT OBJECTIVE

The District Department of Transportation (DDOT) is working with properties all across the city to measure exactly how many people drive, park, walk, bike or ride each day. Why? Too often we get it wrong using national estimates that cannot adjust for our city's mix of uses, density, transit and great walking & biking. By counting people entering and exiting your existing property, we can better predict trips for future developments and build the right amount of roads, parking, sidewalks, bike lanes, and transit. Help us continue to make DC a better place.

PRIVATE COLLABORATION

This project cannot happen without help from private landowners, developers and property managers.

Data Collection Pilot

We have picked several dozen established properties in DC. For each, our data collectors need to conduct the following:

A) Person Counts:

- Counts of all people entering and exiting a site by any mode during morning and evening peak periods of activity
- Automated driveway counts and in-person clipboard counts at every entry/exit door

B) Mode of Travel Surveys:

- Fifteen-second intercept surveys of entering/exiting people
- Survey asks about travel mode for both arriving at and leaving the site if individual agrees to interview

C) Factors Affecting Demand

- Interviews with site or tenant management regarding travel policies, such as parking pricing, transit subsidies, bicycle parking ridesharing, shuttle, etc.

What Do We Need From You?

A) Permission for Building Access

- Our data collectors will need to be on-site between 7AM and 10AM, and again between 4PM and 7PM.
- We need to post 1-2 people inside each entry used regularly by building occupants.

B) Permission to Interview Travelers

Our short intercept survey will take 15 seconds:

- "How will you travel to your next destination?" (and, "How did you travel to get here?")

☐ Auto driver	☐ Auto passenger
☐ Walk	☐ Bus
☐ Rail	☐ Bicycle

- "If you drove, where did you park?"
  ☐ On-site ☐ On the street ☐ Other

C) A Brief Interview with Building Management

We need 15 minutes to answer questions such as:

- Who pays for parking? How? How much?
- Are transit passes sold here? Are they subsidized?
- Do you have bicycle parking? Lockers? Showers?
- Do you have a shuttle? Carpool spaces? Ridesharing? Car sharing? etc.

NELSON NYGAARD d.

- We appreciate your assistance with this effort and look forward to sharing our results with you. For more information on the project, see http://tiny.cc/DDOT-trip-gen or contact ddot.research@dc.gov

Appendix E. Email to Property Managers

Dear Property Owners and Managers,

In the coming days and weeks, representatives from the District Department of Transportation will be in your communities and outside your buildings collecting information on how residents, visitors and workers travel in various neighborhoods of the city. This information will help us better plan and predict necessary transportation services and systems in the city.

The survey consists of a single question asking people entering or leaving local buildings how they traveled to that destination, or will travel to their next one (e.g. by bus, metro, bike, walked, drove, etc.). Participation requires no more than 15 seconds.

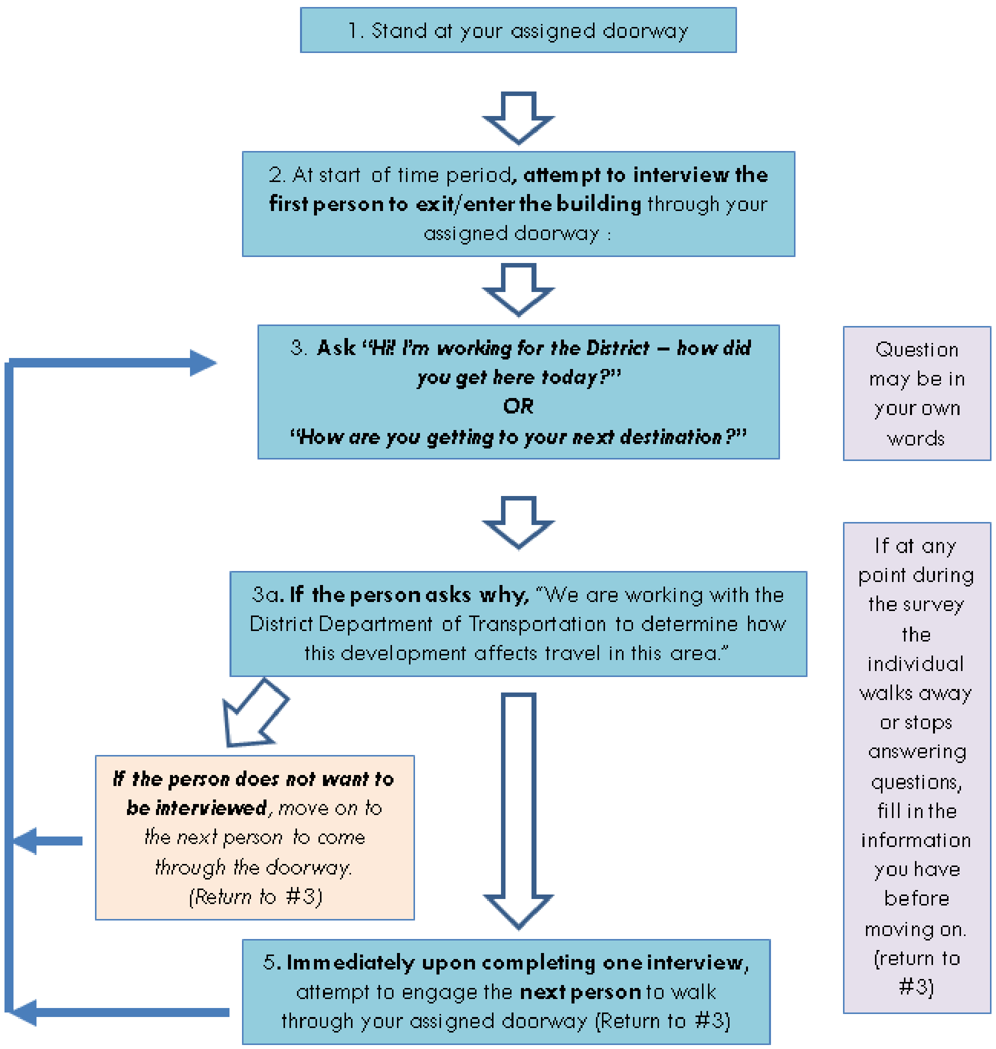
Surveyors will be on site during weekday morning and afternoon hours. Surveyors will be identifiable in yellow traffic vests and carrying a clipboard with the District Flag on it. They will be positioned on the sidewalk outside residential lobby doors, parking garage access points, and retail storefronts.

You can help this effort by informing your residents that the survey will be taking place and encouraging their participation. We would also appreciate it if you would grant permission for surveyors to administer the survey in the main residential lobby as this may decrease resident alarm or concern, especially in the darker evening hours.

Please do not hesitate to share any questions or concerns you may have about this research effort.

Sincerely,

Appendix F. Intercept Survey Plan



Intercept Survey Plan

1. Stand at your assigned doorway

2. At start of time period, **attempt to interview the first person to exit/enter the building** through your assigned doorway :

3. **Ask *"Hi! I'm working for the District – how did you get here today?"***
OR
"How are you getting to your next destination?"

Question may be in your own words

3a. **If the person asks why,** "We are working with the District Department of Transportation to determine how this development affects travel in this area."

If the person does not want to be interviewed, *move on to the next person to come through the doorway. (Return to #3)*

5. **Immediately upon completing one interview,** attempt to engage the **next person** to walk through your assigned doorway (Return to #3)

If at any point during the survey the individual walks away or stops answering questions, fill in the information you have before moving on. (return to #3)

Appendix G. Data Collection Forms and Sample

DRAFT Door Count AND Interview Form

For locations where one person can both survey and count people.

Please tally findings in the appropriate boxes below.

Location: ________________ Counter: ______________ Date ______________ Start Time: ____ : _____ am/pm

Minutes after Hour	Direction				Mode									If parked – where?		
		Door:	Door:	Door:	SOV	HOV driver	HOV pax	Walk	Shared vehicle	Bike	Bus	Metro	Rail	Garage	On-street	Other
:00 to :15	In															
	Out															
:15 to :30	In															
	Out															
:30 to :45	In															
	Out															
:45 to :00	In															
	Out															

DRAFT Door Count ONLY form

For high-traffic locations where one person is ONLY counting people, NOT interviewing them.

Please tally findings in the appropriate boxes below.

Location: _______________ Counter: _____________ Date _____________ Start Time: ___ : ____ am/pm

Minutes after Hour	Direction	Door:	Door:	Door:
:00 to :15	In			
	Out			
:15 to :30	In			
	Out			
:30 to :45	In			
	Out			
:45 to :00	In			
	Out			

DRAFT Interview ONLY form

For high-traffic locations where one person is ONLY interviewing people.

Please tally findings in the appropriate boxes below.

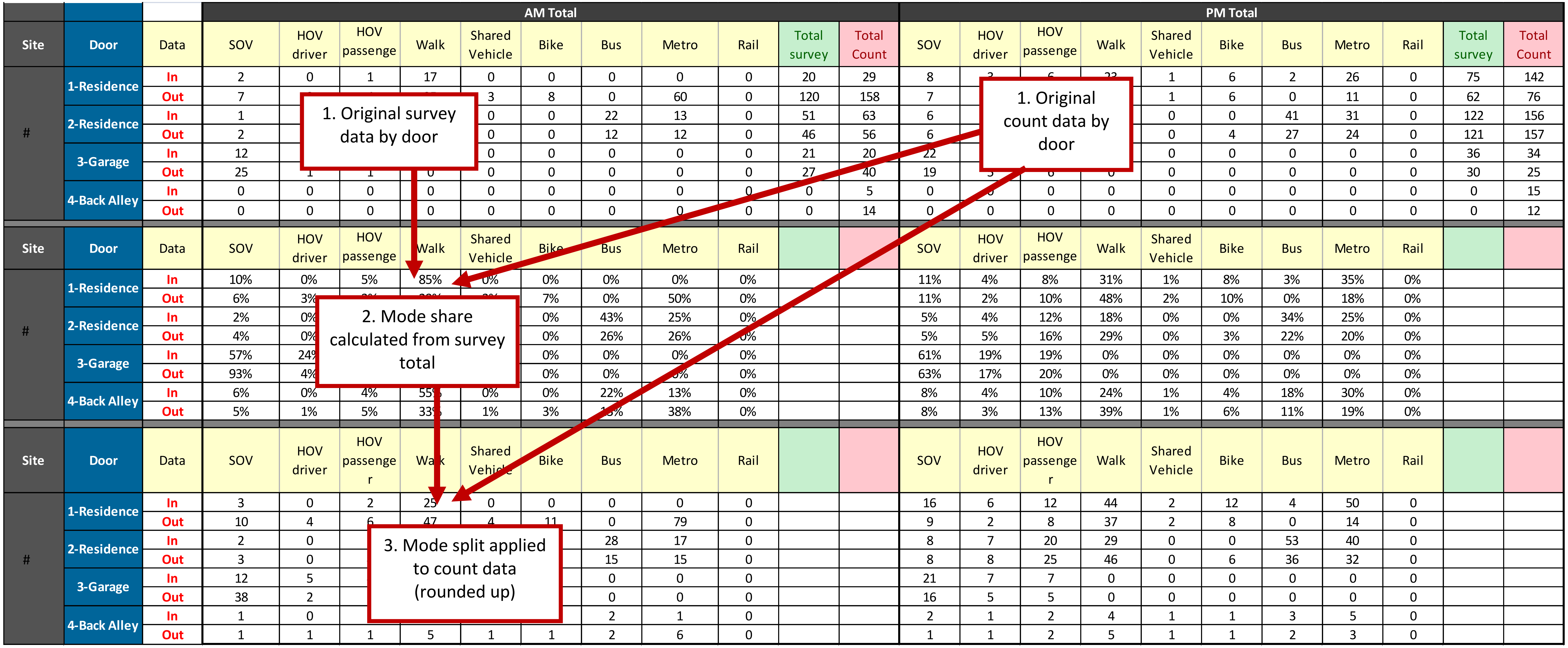
Location: ________________ Counter: ______________ Date ______________ Start Time: ____ : _____ am/pm

Minutes after Hour	Mode									If parked– where?		
	SOV	HOV driver	HOV pax	Walk	Shared vehicle	Bike	Bus	Metro	Rail	Garage	On-street	Other
:00 to :15												
:15 to :30												
:30 to :45												
:45 to :00												

Sample Completed Form

Location	XXXXXXXXX	Counter	XXXXXX	Date	XXXXXXXX										
Minutes after Hour	Direction			Mode										If park	
		Door:		Drive alone	HOV driver	HOV pax	Walk	Shared vehicle	Bike	Bus	Metro	Rail		Garage	On str
7:00 to :15	In	3					3								
	Out	4		1			1			2					
:15 to :30	In	1					1								
	Out	3				2	1								
:30 to :45	In	2		1			1								
	Out	8			1	3	2			1					
:45 to **8:00**	In	1													
	Out	9		1			4			1	1				
8:00 to :15	In	3					2				1				
	Out	10					9								
:15 to :30	In	2					1								
	Out	13				4	8				1				
:30 to :45	In	5		1			1								
	Out	11			2	4	2		1						
:45 to **9:00**	In	2					2								
	Out	3				1				2					
9:00 to :15	In	2				1	1								
	Out	10		3	1	3	2								
:15 to :30	In	6			1	1	2								
	Out	5					3		1						
:30 to :45	In														
	Out	1								1					
:45 to **10:00**	In	2					1								
	Out	3					2								

Appendix H. Sample Spreadsheet



			AM Total											PM Total										
Site	Door	Data	SOV	HOV driver	HOV passenge	Walk	Shared Vehicle	Bike	Bus	Metro	Rail	Total survey	Total Count	SOV	HOV driver	HOV passenge	Walk	Shared Vehicle	Bike	Bus	Metro	Rail	Total survey	Total Count
#	1-Residence	In	2	0	1	17	0	0	0	0	0	20	29	8	3	6	23	1	6	2	26	0	75	142
		Out	7	[illegible]	[illegible]	[illegible]	3	8	0	60	0	120	158	7	[illegible]	[illegible]	[illegible]	1	6	0	11	0	62	76
	2-Residence	In	1	[illegible]	[illegible]	[illegible]	0	0	22	13	0	51	63	6	[illegible]	[illegible]	[illegible]	0	0	41	31	0	122	156
		Out	2	[illegible]	[illegible]	[illegible]	0	0	12	12	0	46	56	6	[illegible]	[illegible]	[illegible]	0	4	27	24	0	121	157
	3-Garage	In	12	[illegible]	[illegible]	[illegible]	0	0	0	0	0	21	20	22	[illegible]	[illegible]	[illegible]	0	0	0	0	0	36	34
		Out	25	1	1	0	0	0	0	0	0	27	40	19	5	6	0	0	0	0	0	0	30	25
	4-Back Alley	In	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	15
		Out	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	12

Site	Door	Data	SOV	HOV driver	HOV passenge	Walk	Shared Vehicle	Bike	Bus	Metro	Rail			SOV	HOV driver	HOV passenge	Walk	Shared Vehicle	Bike	Bus	Metro	Rail		
#	1-Residence	In	10%	0%	5%	85%	0%	0%	0%	0%	0%			11%	4%	8%	31%	1%	8%	3%	35%	0%		
		Out	6%	3%	[illegible]	[illegible]	[illegible]	7%	0%	50%	0%			11%	2%	10%	48%	2%	10%	0%	18%	0%		
	2-Residence	In	2%	0%	[illegible]	[illegible]	[illegible]	0%	43%	25%	0%			5%	4%	12%	18%	0%	0%	34%	25%	0%		
		Out	4%	0%	[illegible]	[illegible]	[illegible]	0%	26%	26%	0%			5%	5%	16%	29%	0%	3%	22%	20%	0%		
	3-Garage	In	57%	24%	[illegible]	[illegible]	[illegible]	0%	0%	0%	0%			61%	19%	19%	0%	0%	0%	0%	0%	0%		
		Out	93%	4%	[illegible]	[illegible]	[illegible]	0%	0%	0%	0%			63%	17%	20%	0%	0%	0%	0%	0%	0%		
	4-Back Alley	In	6%	0%	4%	55%	0%	0%	22%	13%	0%			8%	4%	10%	24%	1%	4%	18%	30%	0%		
		Out	5%	1%	5%	33%	1%	3%	13%	38%	0%			8%	3%	13%	39%	1%	6%	11%	19%	0%		

Site	Door	Data	SOV	HOV driver	HOV passenger	Walk	Shared Vehicle	Bike	Bus	Metro	Rail			SOV	HOV driver	HOV passenger	Walk	Shared Vehicle	Bike	Bus	Metro	Rail		
#	1-Residence	In	3	0	2	25	0	0	0	0	0			16	6	12	44	2	12	4	50	0		
		Out	10	4	6	47	4	11	0	79	0			9	2	8	37	2	8	0	14	0		
	2-Residence	In	2	0	[illegible]	[illegible]	[illegible]	[illegible]	28	17	0			8	7	20	29	0	0	53	40	0		
		Out	3	0	[illegible]	[illegible]	[illegible]	[illegible]	15	15	0			8	8	25	46	0	6	36	32	0		
	3-Garage	In	12	5	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0			21	7	7	0	0	0	0	0	0		
		Out	38	2	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0			16	5	5	0	0	0	0	0	0		
	4-Back Alley	In	1	0	[illegible]	[illegible]	[illegible]	[illegible]	2	1	0			2	1	2	4	1	1	3	5	0		
		Out	1	1	1	5	1	1	2	6	0			1	1	2	5	1	1	2	3	0		

1. Original survey data by door

1. Original count data by door

2. Mode share calculated from survey total

3. Mode split applied to count data (rounded up)