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Trip Generation Study of Transit-Oriented Developments in Miami-Dade County

February 2014

Prepared for:
Miami-Dade County Metropolitan Planning Organization

Center for Urban Transportation Research
University of South Florida
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Trip Generation Study of Transit-Oriented Developments in Miami-Dade County

Final Report

Prepared for:

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Disclaimer

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Miami-Dade County Metropolitan Planning Organization.

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16. Abstract

This study aimed to collect quantitative data on trip generation patterns and estimate the reduction in automobile trips obtained in transit-oriented developments (TODs) in Miami-Dade County. This project addressed the trip generation aspects of TODs. Dadeland South and Brickell in the Metrorail corridor in Miami-Dade County were selected and studied. These two sites were chosen based on the diversity and intensity of surrounding land uses and feasibility for conducting the study. The activity of the development was examined at the land use level, and the internal trips were estimated via intercept interviews within the development. The results of the observed trip generation data were compared with private vehicle counts at the cordon line of the study. The internal trip capture analysis from both TOD study sites in Miami-Dade County showed high internal trip capture rates for TODs. This study verified that the ITE internal trip capture procedure overestimates the trip generation of mixed developments. In addition, it was verified that the methodology proposed in NCHRP Report 684 provided an improved estimate of the traffic impact for TOD over traditional internal trip capture methods. The information provided in this report can be applied during planning to assist in the prediction of traffic for developments similar to Dadeland South and Brickell. The percentages of outbound and inbound traffic can be considered for new TODs or mixed developments.

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Metric Conversion

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C

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This project was an opportunity for private companies to work together with academia to improve existing transportation systems planning processes and could not have been possible without the support of the property managers of the studied sites. Special thanks to First Service Residential for the collaboration provided for the Dadeland South study site.

Executive Summary

Sustainability is a major objective of land use and transportation planning in today's society. Recent policy trends seek to promote and maintain a sustainable living environment through land use development practices. Nationwide, land use policies seek increased development density, particularly within urban and suburban areas, that include complementary land uses in close proximity and transit accessibility, thereby decreasing automobile use. Such transit-oriented developments (TODs) can be used as role models for future developments.

This study aimed to collect quantitative data on trip generation patterns and estimate the reduction in automobile trips obtained in TODs in Miami-Dade County. This project addressed the trip generation aspects of TODs. This topic is of relevance to planners since it provides a baseline for improved design practices to accommodate complementary land uses in close proximity serviced by premium transit service. Two sites were studied in the Metrorail corridor in Miami-Dade County Dadeland South and Brickell as shown in Figure ES-1 and Figure ES-2, respectively.

Figure ES-1: Study Boundary for Dadeland South

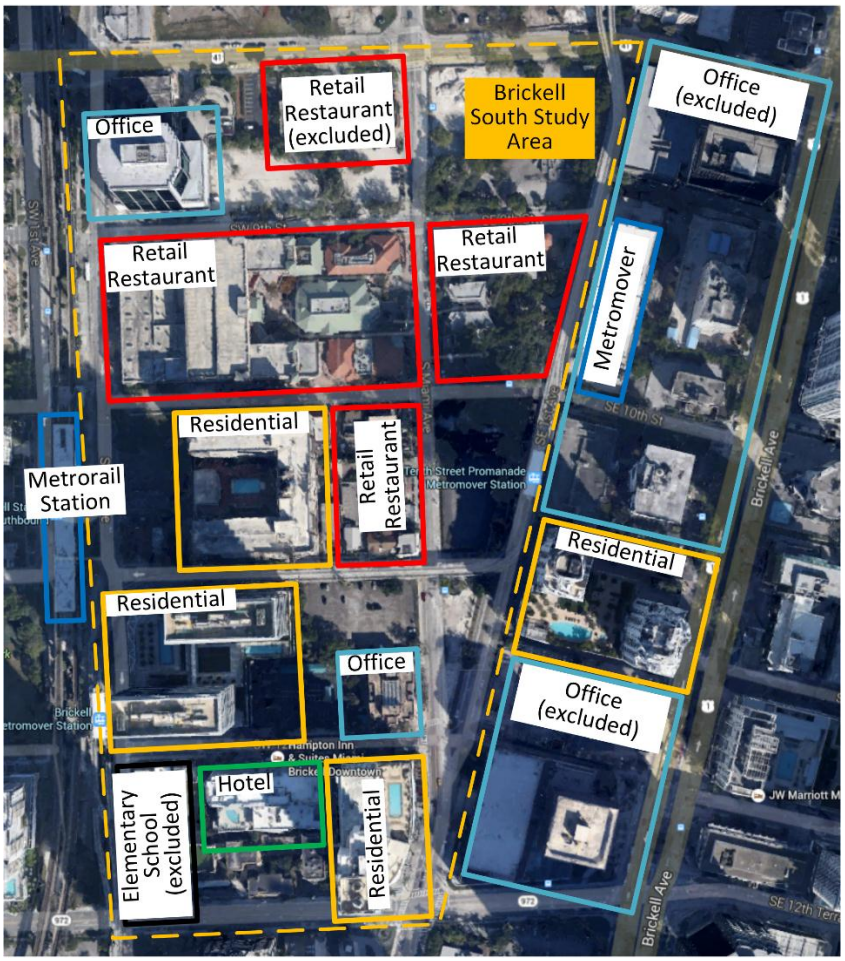

Figure ES-2: Study Boundary for Brickell

The sites were chosen based on the diversity and intensity of surrounding land uses and the feasibility of conducting the study. The study comprised several data elements including land use inventory, site activity, trip internalization behavior, and socio-economic data.

External trips by private vehicles were the main metric for the study since this measure is also used for traffic impact studies. To determine external trips, internal trips need to be subtracted. The activity of the development was studied at the land use level, and internal trips were estimated via intercept interviews within the development. The results of the observed trip generation data were compared with private vehicle counts at the cordon line of the study (see Figure ES-1 and Figure ES-2). The results of this procedure are summarized in Figure ES-3 and Figure ES-4. For Dadeland South, the activity of the on-site park-and-ride was accounted for in the analysis.

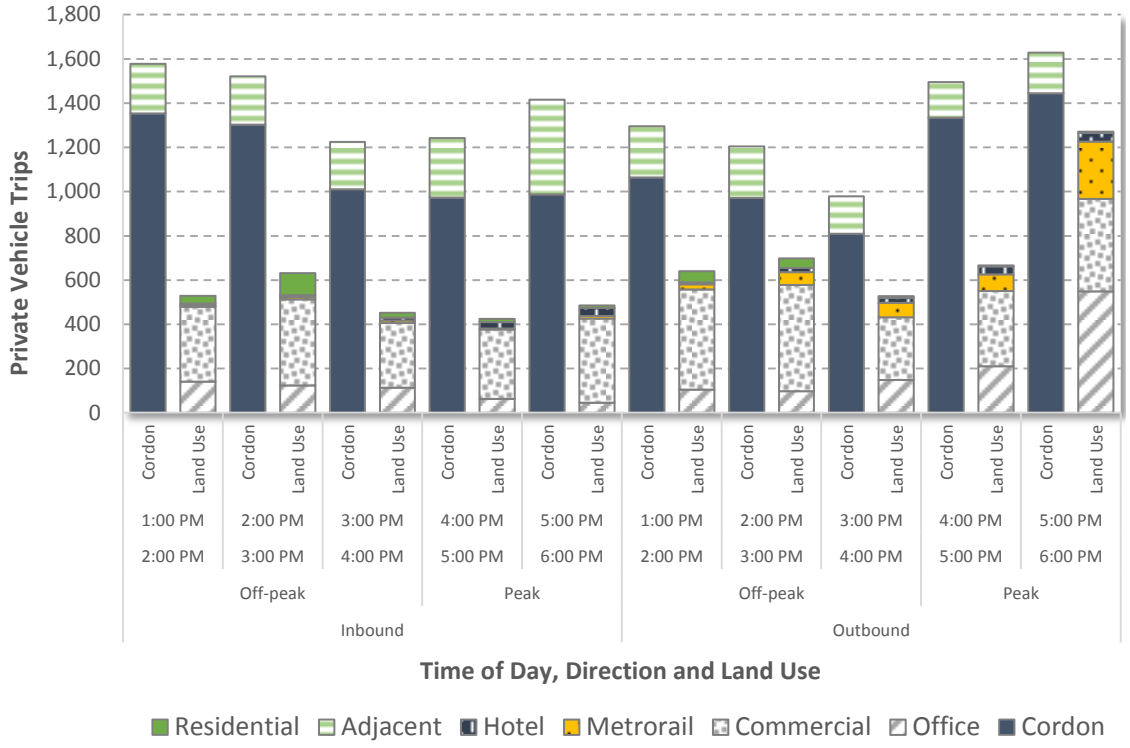

Figure ES-3: Study Results for Dadeland South

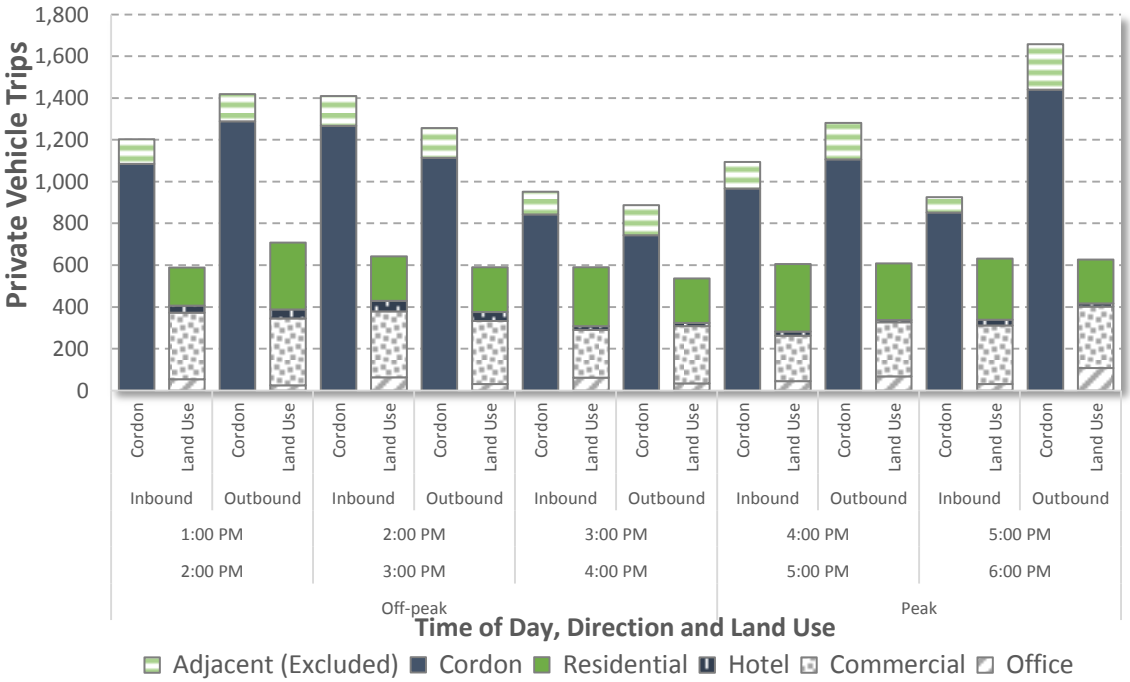

Figure ES-4: Study Results for Brickell

Findings on Trip Generation and Internal Trip Capture for Dadeland South

- Trip generation in Dadeland South was greatly dominated by commercial activity that occurred regularly during the day, accounting for 56 percent of all trips generated by the development. Of that, retail constituted the majority of the land use intensity at 88 percent of the total commercial gross leasable area, and restaurants constituted the 12 percent. Restaurant contributed with 16 percent of the commercial trips and retail with the remaining 84 percent.

- Office was the dominant land use in terms of area. During most of the data collection period, the impact of offices was no more than 25 percent of the total trips. During the PM peak hour, offices contributed to 32 percent of the trips generated in Dadeland South.

- Residential accounted for a peak in trip generation, at 11 percent of the total bi-directional trips for the development during the interval from 2:00–3:00 PM. During the next one-hour interval, the contribution for residential was 10, 6, and 3 percent, respectively, for the intervals starting at 3:00 PM, 4:00 PM and 5:00 PM.

- Dadeland South contained a park-and-ride facility that greatly contributed to the number of trips in/out of the study site boundary. The impact of such facility was moderate during most of the day (at most, 6%), but it increased to 13 percent of the total traffic during the PM peak period.

- The PM peak hour for Dadeland South was from 5:00–6:00 PM, presenting total bi-directional trip traffic of 2,626 vehicles, with a directional distribution of 30 percent entering and 70 percent exiting.

- During the off-peak hour, the estimated pass-through traffic varied from 27–42 percent of the cordon counts. During the peak, the pass-through traffic was estimated at 4 percent.

- The overall internal trip capture for Dadeland South for the off-peak period was 8 percent. For the outbound direction it was 7percent, and for the inbound direction it was 8 percent.

- For residential land uses during the off-peak period, it was estimated that 22 percent of the exiting trips were made to commercial destinations in the development. For commercial land uses, 1 percent of the exiting trips were headed to offices. For hotels, 30 percent of the exiting trips were headed to commercial land uses and 12 percent to on-site offices. For offices, 1 percent of the outbound trips were headed to on-site residential land uses, 11 percent to commercial establishments, and 3 percent to hotels.

- For inbound trips during the off-peak period, the distribution of entering or inbound trips per land use was estimated as follows: for residential, 2 percent of internal trips

came from on-site offices; for commercial, 3 percent came from residential, 2 percent from hotels, and 4 percent from offices; for hotels, 8 percent came from commercial and 18 percent originated at on-site offices; and for offices, 5 percent came from commercial and 2 percent from hotel.

- For the off-peak period, the proportion of outbound trips heading to external destinations by land use for residential was 78 percent, commercial 99 percent, hotels 57 percent, and offices 85 percent. For inbound trips, the proportion of external trips from the entering trips by land use was 98 percent for residential, 91 percent for commercial, 74 percent for hotel, and 93 percent for offices.

- During the peak period, the internal trip capture was 17 percent for outbound trips and 23 percent for inbound trips. The overall internal trip capture for the peak period was 19 percent.

- For outbound trips during the peak period, the distribution of exiting or outbound trips per land use was estimated as follows: for residential, 69 percent were headed to commercial and 11 percent to offices; for commercial establishments, 8 percent were headed to residential, 6 percent to hotels, and 6 percent to offices; for hotels, 22 percent were headed to commercial establishments; and for offices, 3 percent were headed to residential and 3 percent to commercial.

- Entering trips or inbound trips for the PM peak hour were distributed as follows: for residential, 58 percent came from commercial and 16 percent from offices; for commercial, 5 percent came from residential, 3 percent from hotels, and 3 percent from offices; for hotels, 44 percent came from commercial establishments; and for offices, 3 percent came from residential and 24 percent came from commercial.

- For the PM peak period, the proportion of outbound trips heading to external destinations by land use for residential was 21 percent, for commercial 80 percent, for hotels 78 percent, and for offices 94 percent. For inbound trips, the proportion of external trips from the entering trips by land use was 25 percent for residential, 89 percent for commercial, 56 percent for hotel, and 73 percent for offices.

Findings on Trip Generation and Internal Trip Capture for Brickell

- Trip generation in Brickell was greatly dominated by the commercial and residential activity regularly during the day. Restaurant contributed with 10 percent of the commercial trips and retail with the remaining 90 percent. Commercial trips accounted for 44 percent of all trips generated by the development, and 41 percent of the trips were from residential land uses.

- Office and commercial were the dominant land uses in terms of area. During most of the data collection period, the impact of office was no more than 25 percent of the total trips. During the PM peak hour, offices contributed up to 15 percent of the trips generated in Brickell.

- Residential accounted for a peak in trip generation, 34 percent in the interval from 3:00–4:00 PM. During the next hour interval, the contribution for residential was 34 and 28 percent, respectively, for the one-hour intervals starting at 4:00 PM and 5:00 PM.

- The PM peak-hour for Brickell was from 5:00–6:00 PM, presenting total bi-directional trip traffic of 2,002 vehicles, with a directional distribution of 50.2 percent entering and 49.8 percent exiting.

- During the off-peak hour, the estimated pass-through traffic varied from 10–16 percent of the cordon counts. During the peak, the pass-through traffic was estimated at 14 percent.

- The overall internal trip capture for Brickell for the off-peak period was 32 percent. For the outbound direction it was 32 percent, and for the inbound direction it was 33 percent.

- For residential land uses during the off-peak period, it was estimated that 97 percent of the exiting trips were made to commercial destinations in the development. For commercial land uses, 12 percent of the exiting trips were headed to office and 2513 percent to residential. For hotel, 2 percent of the exiting trips were headed to residential land uses. For offices, 25 percent of the outbound trips were headed to on-site residential land uses, 50 percent to commercial establishments, and 16 percent to external destinations.

- For inbound trips during the off-peak period, the distribution of entering or inbound trips per land use was estimated as follows: for residential, 8 percent of internal trips came from on-site offices and 35 percent from commercial; for commercial, 6 percent came from residential and 15 percent from offices; for hotel, 2 percent came from residential land uses; and for offices, 50 percent came from commercial and the rest being from external destinations.

- For the off-peak period, the proportion of outbound trips heading to external destinations by land use for residential was 91 percent, for commercial 63 percent, for hotels 98 percent, and for office 25 percent. For inbound trips, the proportion of external trips from the entering trips by land use for residential was 57 percent, commercial 79 percent, hotel 98 percent, and offices 50 percent.

- During the peak period, the internal trip capture was 21 percent for outbound trips and 21 percent for inbound trips. The overall internal trip capture for the peak period was 21 percent.

- For outbound trips during the peak period, the distribution of exiting or outbound trips per land use was estimated as follows: for residential, 9 percent were headed to commercial; for commercial establishments, 15 percent were headed to residential, 7 percent to hotels, and the rest to external destinations; for hotels, 54 percent were

headed to commercial establishments; and for offices, 13 percent were headed to residential, 25 percent to commercial and the rest to external.

- Entering trips or inbound trips for the PM peak hour were distributed as follows: for residential, 14 percent came from commercial and 4 percent from offices; for commercial, 8 percent came from residential, 5 percent from hotels, and the rest from external destinations; and for hotels, 55 percent came from commercial establishments.

- For the peak period, the proportion of outbound trips heading to external destinations by land use was 91 percent for residential, 46 percent for hotel, 78 percent for commercial, and 62 percent for offices. For inbound trips, the proportion of external trips from the entering trips by land use was 82 percent for residential, 78 percent for commercial, 45 percent for hotel, and 100 percent for offices.

Recommendations

- This study verified that the ITE internal trip capture procedure overestimates the trip generation on mixed-use developments (MXD). In addition, it was verified that the methodology proposed in NHRP Report 684, "Enhancing Internal Trip Capture Estimation for Mixed-Use Developments" [4] provided an improved estimate of the traffic impact for TOD over traditional internal trip capture methods. Therefore, it is recommended to use the NCHRP methodology for trip generation in future traffic impact studies.

- It is important to keep track of developments with desirable characteristics in order to perform trip generation studies. In this way, a local database that captures local behavior can be developed and applied to future developments.

- It is recommended that the surrounding theme of metro stations and transfer stations be master-planned to produce a seamless environment and that traffic going around an MXD instead of through it should be promoted.

- The information provided in this report can be applied by planners to assist in the prediction of traffic for developments similar to Dadeland South and Brickell. The percentages of outbound and inbound traffic can be considered for new TODs or MXD developments.

- It is recommended that the sample size be increased to obtain more reliable estimates for the parameters found in this project. It is recommended that data be collected not only through person interviews, but also through the use of online forms and location sensing such as Bluetooth.

Table of Contents

List of Figures

List of Tables

1 Introduction

Sustainability is a major objective of land use and transportation planning in today's society. Recent policy trends seek to promote and maintain a sustainable living environment through land use development practices. Nationwide, land use policies seek increased development density, particularly within urban and suburban areas, that include complementary land uses in close proximity and transit accessibility, thereby decreasing automobile use. Such transit-oriented developments (TODs) can be used as role models for future developments.

A TOD is a mixed-use residential and commercial area designed to maximize access to public transport and often incorporates features to encourage transit ridership. A TOD neighborhood typically has a center with a transit station or stop (train station, metro station, tram stop, or bus stop) surrounded by relatively high-density development, with progressively lower-density development spreading outward from the center. TODs generally are located within a radius of one-quarter to one-half mile (400 to 800 m) from a transit stop, as this is considered an appropriate scale for pedestrians, thus solving the "last mile" problem.

Miami-Dade County is at the forefront of multimodal development in Florida, providing rail, bus routes, and park-and-ride facilities in addition to tolls and expressways, to further enhance the mobility of its population. To meet desired multimodal planning goals, it is necessary to collect quantitative data on the trip generation patterns of successful TODs in the socio-economic context of Miami-Dade County. The collected data can be used to produce better assessments of automobile trip reductions by promoting TODs. Additionally, TOD-specific data can assist in improving the current transportation planning model data inputs.

This study aimed to collect quantitative data on trip generation patterns and estimate the reduction in automobile trips obtained in TODs in Miami-Dade County. The Center for Urban Transportation Research (CUTR) at the University of South Florida (USF) provided technical assistance to the Miami-Dade Metropolitan Planning Organization (MPO) in obtaining quantitative data to analyze and compute the trip generation rates of two successful TODs at the Dadeland South and Brickell sites in Miami-Dade County. This project accomplished the following three major objectives:

- Identify TODs in Miami-Dade County.
- Perform trip generation data collection and analysis at selected sites.
- Provide recommendations for the travel demand model with respect to TOD.

The collected TOD trip generation data and analysis can be used by the Miami-Dade MPO to enhance current transportation planning practices and multimodal infrastructure design.

This report is organized as follows: Chapter 2 presents a review of the most relevant work on internal trip capture studies and methodologies. Chapter 3 introduces the concepts of TOD and describes the procedure of data collection. Chapter 4 presents data collection

results and trip estimation for the selected sites. Chapter 5 contains conclusions and recommendations for the application of the data collected in this study.

2 Review of Related Studies

This section presents previous and ongoing studies and research initiatives in the area of trip generation, specifically on topics pertaining to internal capture. The area of trip generation is extensive and, in the case of mixed-use developments (MXDs), is often associated with TODs. This study focused on trip internalization in MXDs where the presence of a premium transit element was a requirement. Variations in land use mix and compactness were experimental factors among the study MXDs. This section introduces the concept of MXDs, followed by an overview of trip generation and internal trip capture. A review of the benefits of TODs and fundamental TOD characteristics is also provided. This section concludes with remarks and insights from the literature review process.

2.1 Trip Generation

Trip generation is the first step in the transportation demand modeling process (trip generation, trip distribution, mode choice, and trip assignment). Trip generation encompasses a set of methodologies aimed at predicting the trip-making decisions of transportation system users. These methods use characteristics of both land use type and users to obtain estimates of travel patterns across the transportation system (e.g., routes, volumes, and mode).

The mainstream applications of trip generation methods can be classified as system-wide methods and site-specific methods. System-wide methods, such as regional travel demand models, apply an analytical approach that uses transportation system user and land use information to predict the trips generated from and to a specific land use or zone in a transportation system. User information may include trip purpose, income, and age among others. Regional models require extensive survey data such as census and travel diaries, as in the case of the National Household Travel Survey (NHTS). Travel demand models are constantly evolving from trip-based isolated steps toward more elaborate methodologies that include linkage between the different model steps and activity-based trip-making behavior models. On the other hand, site-specific methods (e.g., traffic impact studies) are aimed at predicting the number of trip ends that a particular land use potentially generates. These methods consider only the characteristics of the land use (e.g., type, size, and time of day) as the explanatory variables of the trip generation process.

The preeminent source of data and methods for site-specific analyses is the Institute of Transportation Engineers' (ITE) *Trip Generation* [1]. Published, maintained, and updated by ITE, the *Trip Generation* provides trip rates and equations for an extensive set of land uses and includes trip data collected and analyzed over several decades on various land use types. Most of ITE's trip generation rates are predominantly based on the data collected from single-use, free-standing sites. Such trip rates are applicable only for typical individual, single-use, suburban types of development for which most travel occurs from (and to) outside the development, using the public road system. The application of the ITE's trip generation rates requires only land use characteristics representing the size of land use. For example, residential developments require residential units, hotels require number of rooms, and retail requires square footage. Because of this characteristic, the application of

the ITE methodology can be extended to different geographic locations. In addition, data for a specific land use can be updated or expanded when more land use trip generation data become available.

Because of the less stringent information requirements on input data, ITE's methods are the preferred alternative to estimate trip generation for new developments. ITE's method provides a common ground for transportation agencies and developers to estimate the traffic generated by new developments. Among the characteristics in favor of the ITE trip generation methods are:

- Single input for trip generation estimation in proportion to land use size
- Reproducible output for the same input
- No requirement for specialized equipment or software to be applied
- Widely accepted

The disadvantages of the ITE's method are based on some of same characteristics that make it useful. Because of the simplicity of the data input, it lacks explanatory power beyond the size of the land use. Another possible disadvantage is that, due to the prolonged lifecycle of the existing datasets (nearly 30 years), some of the data used to estimate trip rates may be outdated. For example, on-line services (e.g., banking, shopping) influenced some of the travel patterns from the 1980s and 1990s. In addition, some geographic-specific data are lost when all the data are aggregated at the national level. For instance, a transportation agency may be interested in data on multi-family residential developments in the southeast quadrant of the U.S. only.

Some of these data issues can be solved with business analytics tools that enable users to filter existing trip generation data according to their needs. An example of these tools is the cloud-based business system Online Traffic Impact Study Software (OTISS). OTISS provides access to the ITE trip generation database in the traditional way (e.g., equations and rates) and provides additional filtering by region, age of data, and land use size [2]. In addition, when updating trip generation data, it is important to collect metadata on the context surrounding the collected data. This will enable further initiatives on data mining and will enhance the quality for future trip generation estimates.

2.2 Mixed-Use Developments

ITE's *Trip Generation Manual* [1] refers to MXDs as multi-use developments, defined as a single real-estate project that consists of two or more ITE land-use classifications between which trips can be made without using the off-site road system. ITE description of MXDs includes:

- Planned as a single-real estate project
- Between 100,000 and 2 million sq. ft. in size
- Contains two or more land uses
- Not a central business district
- Not a suburban activity center

- Not an existing land use classification with potential for a mix of land uses such as shopping center, office park with retail, hotel with limited retail/restaurant space.

The Urban Land Institute (ULI) defines MXDs as developments with three or more revenue-producing uses integrated into a physically- and functionally-integrated development that conforms to a coherent plan [3]. In National Cooperative Highway Research Program (NCHRP) report 684, titled "Improving Method for Estimating Internal Capture for Mixed-use Developments," Bochner et al. [4] identify MXDs as physically- and functionally-integrated developments based on a single master plan with at least four complementary, interacting land uses that have internal pedestrian connectivity and shared parking (among at least some uses). For the purpose of this project, the term "mixed-use development" is used in general and will apply to multi-use developments. The acronym MXD is used throughout the report to represent mixed-use developments.

A key component to any MXD is the residential land-use element. The residential component can be integrated to the MXD in different ways depending on its type, density, and size. In suburban settings, single-family detached homes are frequently encountered as part of an MXD. Usually, single-family detached residential land uses have relatively low density, resulting in a sparse MXD with relatively long internal connection lengths when compared with other MXDs. It is also frequent to encounter isolated multi-family homes in MXDs. Multi-family homes can increase density and improve internal connectivity for MXDs, providing an intermediate level of integration. The most integrated residential components are the neo-traditional residential land uses consisting of low- to mid-rise apartments with ground-floor retail [5]. MXDs that include these residential land uses have the greatest potential to increase overall development density and offer an improved internal connectivity.

A related aspect that needs to be addressed when discussing MXDs is TODs. Although there is no universally-accepted definition for TOD, as stated by Cervero et al. [6], a TOD may be conceived as an MXD with a highly-integrated prime transit component. The American Public Transportation Association (APTA) defines a TOD as a compact MXD near new or existing transportation infrastructure that serves housing, transportation, and neighborhood goals. Along with trip generation, the other key performance metric indicator for a TOD is transit ridership. The *Trip Generation Manual* [1] leaves the TOD trip generation aspect as one of the areas for further research and improvements. TODs are the focus of this study, as they share many of the design features of MXDs. Bochner et al. [4] conducted internal trip capture studies at several locations, and two are often classified as TODs by various planning associations in the U.S.

2.3 Internal Trip Capture and Community Capture

Internal trip capture refers to those trips occurring among the various land uses of an MXD but that are not made on the major street system [1]. These trips are captured internally by the land uses in the development and do not impact the external road system. It is important to note that internal trips can be made either by walking or by bicycle or other vehicles, with the only restriction being that only internal transportation network are used.

The application of the internal trip capture concept is performed through internal trip capture (ITC) rates. ITC rates are defined as a percentage reduction that can be applied to the trip generation estimates for individual land uses to account for trips that are internal to the site [1]. Additional explanations on the concepts pertaining to internal trip capture, importance, usage, data collection procedure, and calculation are provided later in this document. The remainder of this section focuses on summarizing relevant work related to internal trip capture studies and other relevant trip generation work.

Current ITC rates-based studies were performed under the initiative of FDOT by Tindale-Oliver & Associates, Inc., in 1993 [7] and by Walter H. Keller, Inc., in 1995 [8]. The 1993 study produced ITC rates ranging from 28–32 percent for the PM period. The data from these studies were used to produce the current ITE ITC rates in the *Trip Generation Manual* [1]. Additional trip generation studies have been carried out by various states to serve different purposes. NCHRP Report 684 [4] provides an extensive review of internal trip capture studies, including the 1993 and 1995 studies. NCHRP Report 684 also contains reviews of the current trends in traffic impact analyses and MXD design at the national level. In addition to NCHRP 684, ITE provides links to finished and ongoing research on the subject of trip generation [9].

A study by Kittelson and Associates in 2008 [10] compared the methodology to estimate internal trip capture used by the Florida Standard Urban Transportation Modeling Structure (FSUTMS) with that of ITE for large MXDs. FSUTMS planning models can accommodate several localized conditions in the trip generation step (e.g., connectivity, project density, etc.). Internal trip capture rates were found to vary considerably based on the density of surrounding developments. Based on sensitivity analyses, the highest ITC rates (nearly 50%) were obtained in rural areas, whereas for downtown locations, the ITC rates were the lowest (close to 3%). Regional travel demand models (such as FSUTMS) potentially can be used to estimate internal trip capture. However, these are several difficulties associated with this approach. First, the spatial resolution of land-use representation in FSUTMS and most other travel demand models is at the Traffic Analysis Zone (TAZ) level. This resolution generally is not sufficient to identify the trips originating from (and destined for) specific developments/land uses unless very large communities are under consideration, as in the study by Kittelson [10].

Ewing et al. [11] collected trip-making patterns from six developments using data from the NHTS. In the study, Ewing pointed out the strengths and weaknesses of the ITE methodology for estimating internal trip capture and proposed a predictive statistical model based on hierarchical non-linear models. His model used household size, employment, gross land area of MXD, number of motorized vehicles per person in the household, employment within MXD, and some derived indicator of the proportion of individuals that live and work in the MXD. The proposed predictive model was tested using trip generation data of 22 sites, including some of the original ITE sites (e.g., Boca del Mar) and recently-studied sites (e.g., Mockingbird Station), as in the case of NCHRP Report 684 [4]. The performance measure of choice was the coefficient of determination (r^2) of the line described by observed vs. predicted trips. The ITE procedure had an r^2 of 0.81; Ewing's method's r^2 was 0.92. Ewing's

methodology was implemented into a spreadsheet and is hosted on the U.S. Environmental Protection Agency (EPA) website for download [12].

The method proposed by Ewing constitutes an alternative method to analyze trip-making behavior aspects including internal trip capture. It requires more inputs than the conventional ITE method for site impact analyses. Some of that information may not be readily-available at the design stage for new developments or may be subject to regional factors, thus causing variances in the application. This is especially important from the point of view of transportation agencies responsible for the review and approval for new developments.

In NCHPR Report 684, Bochner et al. [4] performed a comprehensive study to enhance the internal trip capture estimation procedure for the ITE methodology. Three MXDs were studied: Mockingbird Station, Atlantic Station, and Legacy Town Center. The data collection method employed was based on exit interviews and door counts. Site cordon counts were used to validate the collected data and calculation procedure. For the exit interviews, data collection personnel were placed at specific buildings or land uses, and trip information at the person level was collected. Data collection efforts were focused on interviews during peak hours. The reported internal trip capture rates for the AM peak period ranged from 11–31 percent. For the PM peak period, the internal trip capture rates ranged from 33–44 percent.

NCHRP Report 684 [4] also recommended several enhancements to ITE's estimation method and added more developments to the database. The improvements include:

- Addition of AM peak hour
- Expansion of land uses to six, adding restaurant, cinema, and hotel
- Estimation procedure that works in person trips and includes mode split (personal vehicle, transit, non-motorized) and vehicle occupancy
- Incorporation of the influence of proximity (walking distance between interacting land uses) on internal trip capture
- Enhanced data collection methodology to produce data needed to further add to the multi-use development trip generation database
- Data from three additional multi-use developments that also expand the variety of multi-use developments in the database

The recommended NCHRP method uses the same eight steps as the ITE trip generation estimation method but adds the proximity adjustment to the internal capture rates in Steps 5a and 5b. This process also works in person trips, so mode choice and vehicle occupancy can be reflected.

URS performed an internal trip capture study in four MXDs in Florida [13]. The study sites were located in the northeast area of Florida (FDOT District 2). Based on the study, URS estimated that the internal trip capture in the developments was 20 percent in the AM period and 30 percent in the PM period. One of the objectives of the study was to document home–work, home–retail, and retail–work interactions. The sites varied in size and land use

mix, including medical offices, retail, residential, and elementary schools, among others. The study used intercept interviews to obtain person-level information on internal trip capture. The study collected daily cordon counts and interview data. The number of interviews for daily internal trip capture estimation was substantial. The study data were used at the development level to validate the procedure and results obtained by this study.

For larger developments such as developments of regional impact (DRIs) [14], the concept of internal trip capture evolves to community capture. The term "community capture" applies to self-contained communities (new master-planned towns). The methods described in the ITE *Trip Generation Manual* are not recommended for DRI analyses. This project focuses on ITE methods that are applicable to small- to medium-scale MXDs. Often, small- to mid-size MXDs are part of small towns or DRIs. The current internal trip capture rates in use by ITE range from 61–253 acres. The largest community capture project in Florida is 26,000 acres (The Villages in Sumter, Lake and Marion counties). Substantial traffic monitoring, origin-destination (O-D) studies, trip generation studies, and evaluation of land uses mixes in the community and its surroundings are part of the community capture methodology.

2.4 Urban Infill Trip Generation Rates

The need from trip generation data varies across states based on their particular development patterns and trends. For newly-planned developments or for developments with suburban characteristics, ITE trip rates are applicable. For infill developments or redevelopments, ITE rates cannot be used. A study by Kimley-Horn for the California Department of Transportation [15] developed trip generation rates applicable for urban infill land uses. This is a developing subject and increases the potential to develop further trip generation studies for land uses immersed in urbanized environments. These rates are needed to evaluate redevelopment projects in decaying urban areas to promote high-density MXD developments on Central Business Districts (CBDs). From data collected at 27 sites, the study found that in general ITE trip rates tend to overestimate trip generation estimates.

2.5 Transit-Oriented Developments

Across the United States, in large cities and smaller metropolitan areas, new transit systems are being built to improve mobility, reduce congestion, and promote economic activity. To enhance the performance of the overall transportation network through transit investments, neighborhood or city development patterns should increase transit ridership. The strategy refers TOD, which is defined as

> a project or projects, in areas identified in a local government comprehensive plan that is or will be served by existing or planned transit service. These designated areas shall be compact, moderate to high density developments, of mixed-use character, interconnected with other land uses, bicycle and pedestrian friendly, and designed to support frequent transit service operating

through, collectively, or separately, rail, fixed guide way, streetcar, or bus systems on dedicated facilities or available roadway connections. [16]

TOD has attracted the interest of policy-makers, private businesses, environmentalists, real-estate developers, and other groups in recent times because it yields benefits. TCRP Report 102 [17] summarized the benefits of TOD, as shown in Table 2-1.

Table 2-1: Benefits of Transit-Oriented Developments

Class of Benefit	Public Sector	Private Sector
Primary	1. Increased ridership and farebox revenues 2. Joint development opportunities 3. Revitalized neighborhoods 4. Economic development	1. Increased land values, rents, and real-estate performance 2. Increased affordable-housing opportunities
Secondary	1. Less traffic congestion and VMT-related costs, such as pollution and fuel consumption 2. Increased property- and sales-tax revenues 3. Reduced sprawl/conserve open space 4. Reduced road expenditures 5. and other infrastructure outlays 6. Reduced crime 7. Increased social capital and public involvement	1. Increased retail sales 2. Increased access to labor pools 3. Reduced parking costs 4. Increased physical activity

TCRP Report 128 [18] explored the following fundamental TOD characteristics: (1) transit system and land use influences, (2) TOD ridership strategies, and (3) TOD resident/tenant characteristics. The results reported in TCRP Report 128 clearly show that automobile trips were reduced due to TODs in the four urbanized areas that were studied and that the ITE trip generation and parking generation rates underestimate automobile trip reduction for TOD housing.

A framework for TOD in Florida was developed in 2011 to provide planners, developers, elected officials, and the general public with a Florida-specific resource for TOD and transit planning considering three major factors: activity and accessibility, transit type, and community context. [19]

Cervero [20] conducted a survey of 17 TODs in 5 U.S. metropolitan areas and found that vehicle trips per dwelling unit with TOD housing projects were substantially below what the ITE's *Trip Generation Manual* estimates by 44 percent over a typical weekday period. Trip rates generally fell as neighborhood densities increased. According to the study, local officials should account for the lower automobile use of those residing in TOD housing through such measures as traffic impact-fee adjustments and reduced off-street parking requirements.

The study conducted for the Portland Metropolitan Region [21] showed favorable results for transit usage in the TODs along the light rail line and at the Belmont Dairy. The TOD AM peak-hour trip generation rates were not as low as the PM peak-hour rates. The rates of

TOD were well below the ITE AM peak hour rates of 0.62 for an apartment and 0.63 for a mid-rise apartment.

For the impacts of TODs on public transportation ridership, a research report published by FDOT [22] suggested that urban form does appear to exert some kind of influence. For that reason, it is worthwhile to further specify the relationship to ascertain how policy initiatives relating to TOD can support the goal to balance mode share in the direction of greater transit use.

2.6 Summary

- Traditionally, trip rates and single-regression equations based on single-use free-standing suburban sites have been the preferred method to perform trip generation estimation. Recent trends in MXDs have raised the need to improve existing trip generation methodologies, especially for TODs, to accommodate the effects of presence of a premium transit element and proximity among diverse land uses.

- As new business analytics tools are applied to transportation, new challenges arise. In the case of trip generation data, obsolescence may be an emerging issue. For some land uses, it may become necessary to collect additional data. It is recommended to analyze the life cycle of trip generation data and determine when more data are required and provide a quality metric for aging data.

- In Florida, two main internal trip capture methods or principles coexist. For site impact analyses, internal trip capture methods such as ITE's are the accepted practice. For large-scale MXDs (DRIs), which are generally self-contained developments, the community capture method should be used.

- Internal trip capture depends on several factors in addition to size and proximity. Density and surrounding environment have been cited as relevant factors. A set of methodological improvements is in place to accommodate proximity effects. The inclusion of additional factors in the ITE trip generation estimation procedure should gain the consensus of the great majority of users before implementation takes place. In addition, the required data should be simple to obtain or calculate at the development design stage.

- Initial trip capture rates from studies in 1993 [7] and 1995 [8] reported internal trip capture rates of 30–35 percent for the mid-day peak period and 28–32 percent for the PM peak period. Later studies, such as NCHRP Report 684 [4], reported internal trip capture rates varying from 11–33 percent for the AM period and 33–44 percent for the PM period. As more studies and data become available, the existing data and methodology become more reliable and can gain more credibility.

- TOD housing produced considerably less vehicle traffic than is generated by conventional development. One result is that auto trip generation is likely to be

overstated for TODs by using the ITE *Trip Generation Manual* method. New trip generation and parking guidance for TOD were recommended.

- The trip reduction benefits of TODs call for other development incentives, such as lower parking ratios, flexible parking codes, market-responsive zoning, streamlined project review and permitting processes, and investments in supportive public transit infrastructure.

3 Site Selection and Study Methodology

The study methodology covers the design aspects of the study. The two main design aspects include site selection and data requirements. Site selection was performed in conjunction with the project panel, and several MXDs with access to premium transit service were taking into consideration. To gain insight on the trip generation characteristics of TODs, it is necessary obtain data on the following aspects:

- Physical characteristics
- Activity level
- Trip internalization behavior
- Mode split
- Socio-economic characteristics

Physical characteristics of the development include a land use inventory, distance matrices, and number of parking spaces. The activity level of the development was measured by door counts for the establishments/buildings in the MXD. Trip internalization behavior, mode split, and socio-economic characteristics were obtained via person interviews.

This section provides details on the site selection process, data collection design methodology, and selection of socio-economic variables.

3.1 Site Selection

The candidate sites were developments located near Metrorail stations in Miami-Dade County. The original list of sites included:

- Dadeland South
- Brownsville
- Dadeland North
- South Miami
- Brickell
- Allapattah
- Santa Clara

The site selection process was made based on MXD characteristics such land use mix, compactness, and maturity. The selection process is summarized as follows.

3.1.1 Dadeland South

Dadeland South contains a mix of office, residential, and retail establishments that area in close proximity. The development was clearly defined for cordon counts by Kendall Drive and South Dixie Highway (US 1), as shown in Figure 3-1. Development of the Dadeland Station initially began with establishment of the station and the Datran office building as a joint development and then expanded in phases over the years. It contains three residential properties, retail, restaurants, office buildings, and two hotels.

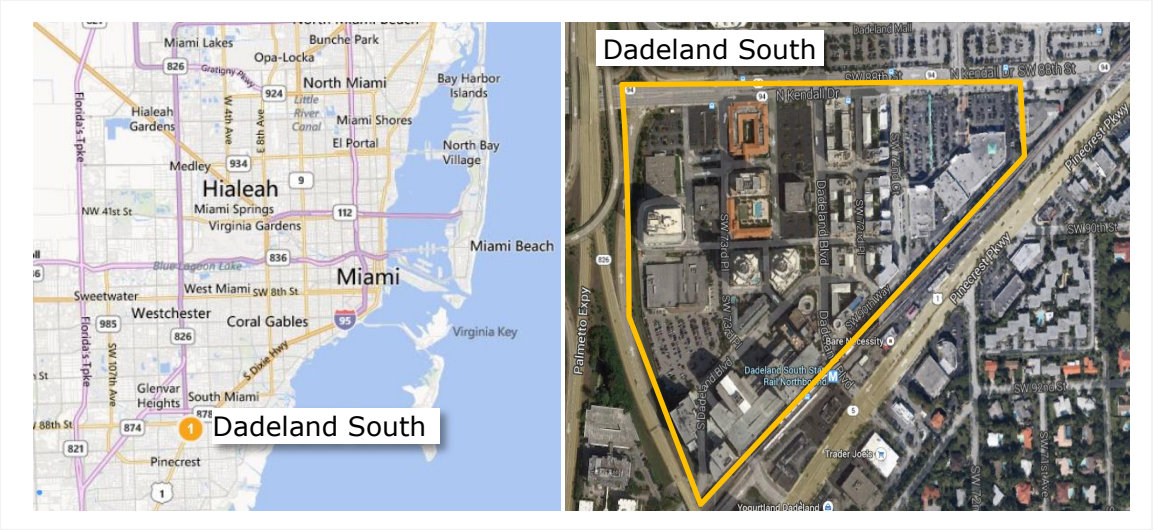

Figure 3-1: Overview of Dadeland South

3.1.2 Brownsville

Brownsville is an example of an urban revitalization project. It is a high-rise residential property with ground-floor retail, as shown in Figure 3-2. At the time of site selection, Brownsville had been recently established and could be considered for the study. It is expected that the area's dense residential development will attract more commercial developments to the surroundings.

Figure 3-2: Overview of Brownsville

3.1.3 Dadeland North

Dadeland North has a land use mix comprising hotel, office, residential, and retail land uses. The residential area is separated by a canal, which makes the development more scattered compared to Dadeland South (see Figure 3-3). For Dadeland North, the residential areas

located north of the Mall and the Metrorail station were considered for the study. Based on preliminary observations, there were some walking trips from the residential areas to the Metrorail station.

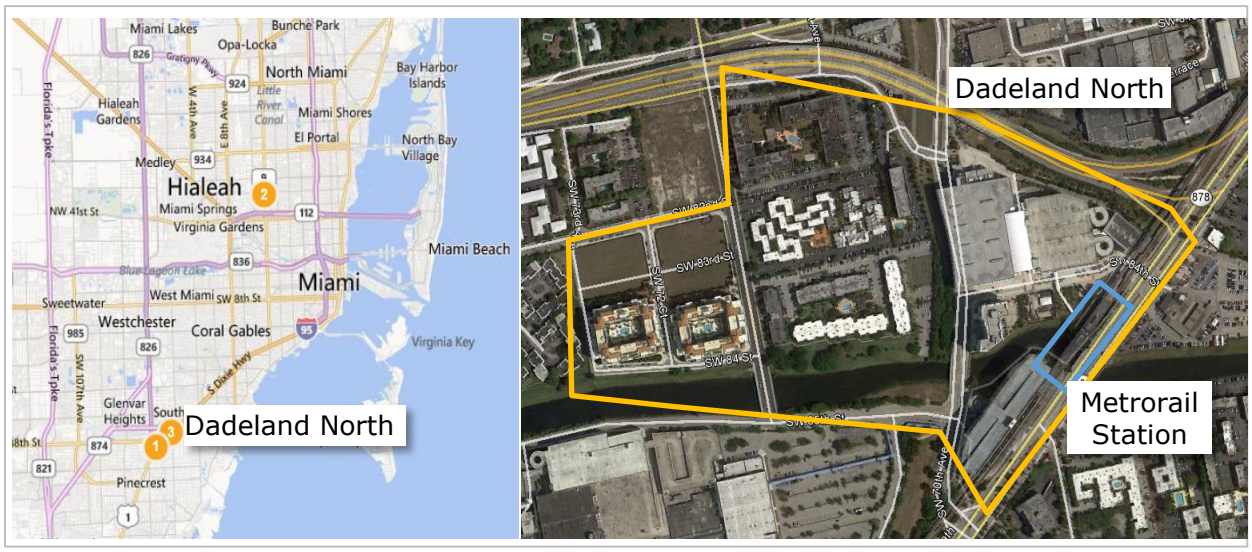

Figure 3-3: Overview of Dadeland North

3.1.4 South Miami

South Miami is an example of a transit-supportive neighborhood and contains a mix of commercial and residential land uses. It was noted that even when the neighborhood supports pedestrian activity, a significant portion of the Metrorail trips are transfers, either from the park-and-ride lot or connecting from other transit services. The structure of the neighborhoods surrounding the station includes a shopping mall with cinema and several multi-family buildings in the vicinity of the station (see Figure 3-4). The land uses, although in proximity, are separated by a major roadway (South Dixie Highway).

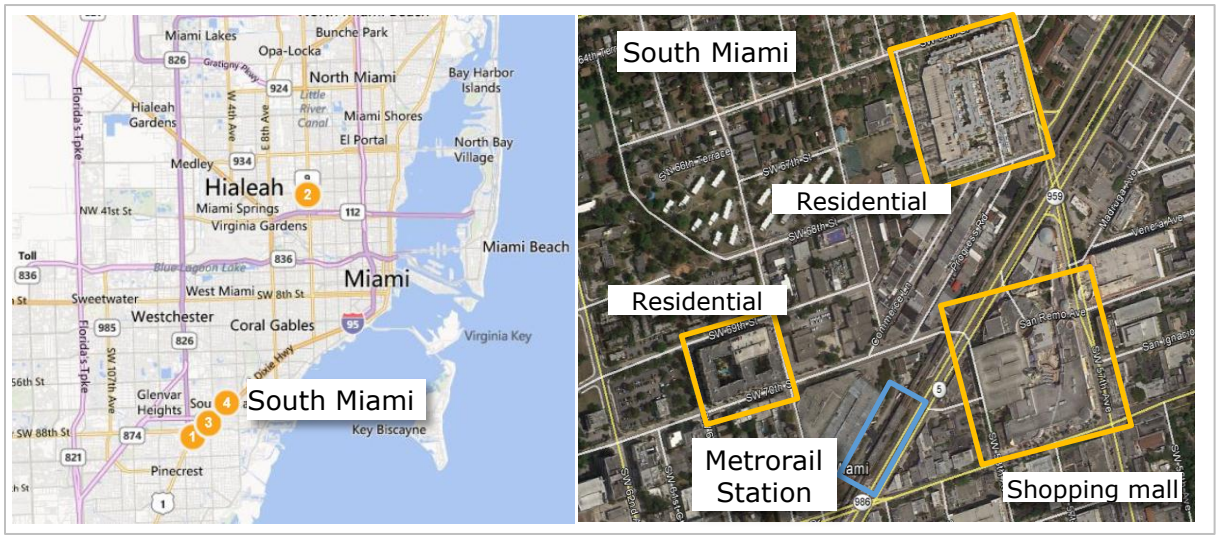

Figure 3-4: Overview of South Miami

3.1.5 Brickell

Brickell is an example of a mixed-income residential area for a transit-supportive neighborhood. As determined by the Advisory Group, this is very likely the land use pattern and the transit quality that will occur in future transit corridors and was strongly suggested as one of the study sites. The area is served by Metrorail and Metromover and contains a mix of high-rise residential buildings, offices, hotels, restaurants, and retail uses, as well as a major grocery shopping retailer. The boundaries of the Brickell Station area are presented in Figure 3-5.

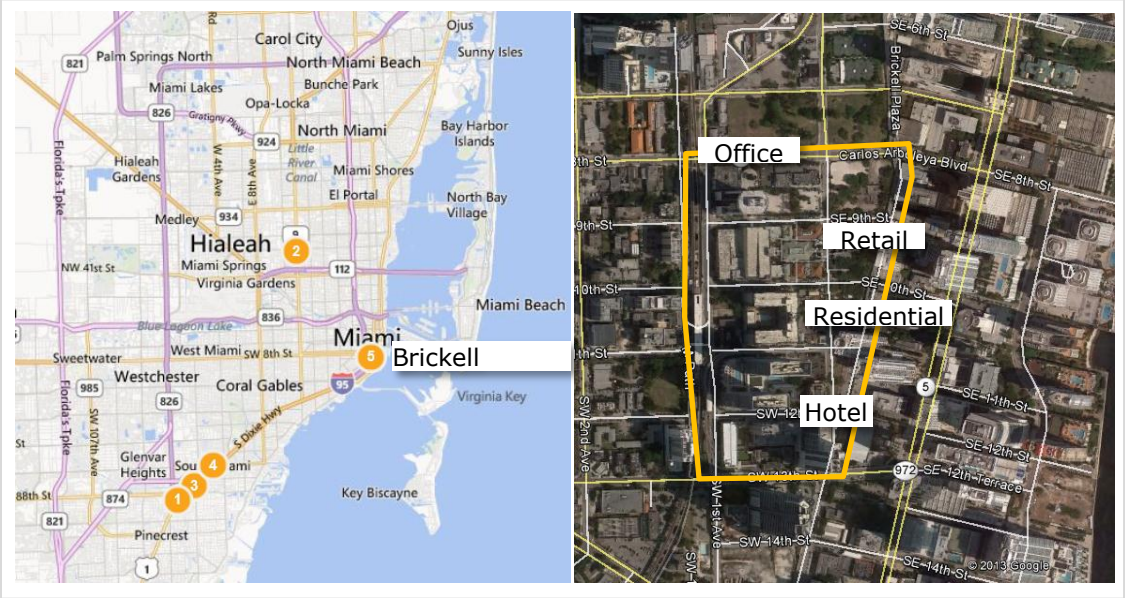

Figure 3-5: Overview of Brickell Station

3.1.6 Allapattah

The Allapattah Metrorail station is located in an urban infill area. The predominant land use in the transit core is residential. A housing complex is located in close proximity to the Metrorail Station (see Figure 3-6). The housing complex was built as a part of joint development project with Metrorail. The land use mix of the surrounding areas is dominated mainly by automobile sales lots, repair shops, and warehouses. The remaining residential units are detached homes. In general, the area is adjacent to the transit station but the MXD component is not present.

3.1.7 Santa Clara

The Santa Clara Metrorail station follows the Allapattah station in the southbound direction. Both were finished in the summer of 2004 as part of an aggressive joint development initiative by Miami-Dade Transit. A multi-family residential complex is located in close proximity to the station (see Figure 3-7). Besides the main residential component, the area has significant industrial warehouse land uses. The land use mix is limited within the first quarter mile from the station or transit core.

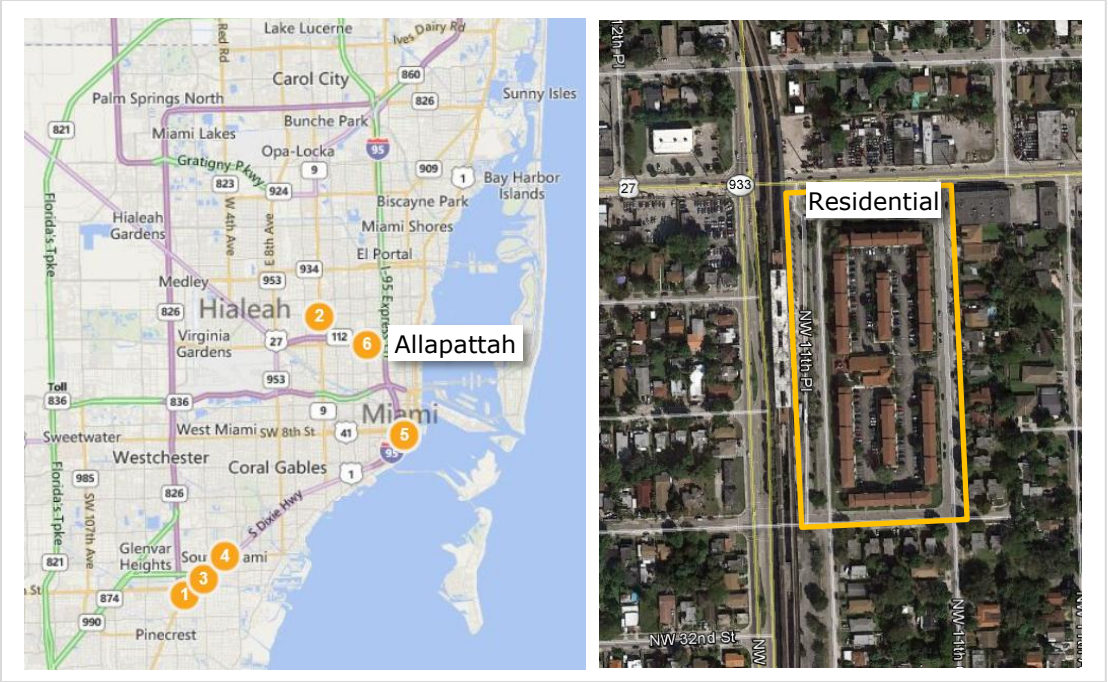

Figure 3-6: Overview of Allapattah Station

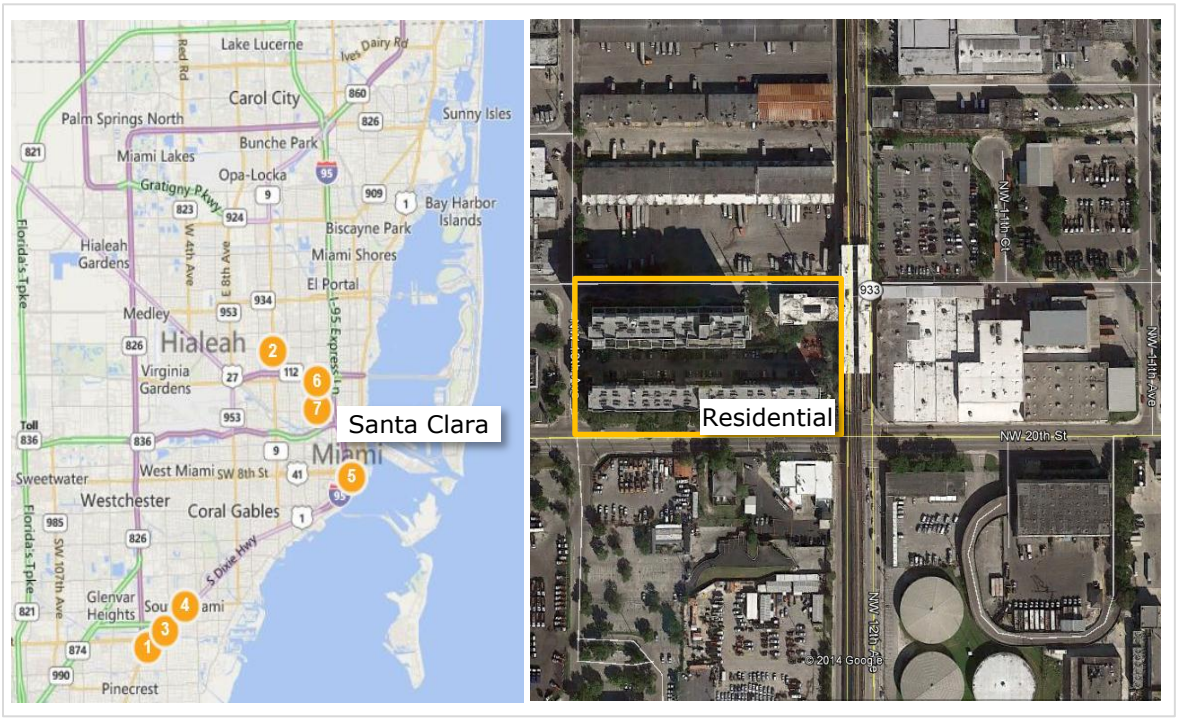

Figure 3-7: Overview of Santa Clara Station

3.1.8 Other Sites

The area of Naranja was suggested as a potential site due to its connectivity among amenities. However, there is currently no premium transit service in the area. It was noted that a significant portion of the developments in Naranja are being built. At its maturity, Naranja is expected to be a representative example of a mixed-use development.

3.1.9 Selected Sites

An advisory group was formed to guide in the selection of the study sites. The group was composed by members of the following organizations:

- Miami-Dade Transit
- Miami-Dade Regulatory and Economic Resources (RER)
- Miami-Dade County Planning & Zoning
- FDOT District 6 Planning Office
- Miami-Dade County Public Works
- Miami-Dade MPO
- Florida International University

A list of the candidate sites was presented to the advisory group. At the end of the meeting they discussed the pros and cons of the different sites. The group decided to focus on the sites that are most representative of a future growth scenario for the area and have a substantial land use mix. Dadeland South, Brickell, and South Miami were the top three sites having desirable characteristics. The selected sites were Dadeland South and Brickell. The main reason for site selection was a land use mix within 0.25 miles of the prime transit station. Dadeland South has a more compact land pattern, with offices and residential buildings as the dominant land uses. Brickell presents more of an infill environment, with a strong presence of high-rise residential buildings, retail uses, and restaurants as the dominant land uses for the selected area.

3.1.9.1 Dadeland South

Dadeland South station is located in a mixed-use development environment and is near another Metrorail station, Dadeland North. Based on the definitions of "A Framework for TOD in Florida" [23], the transit core is located within the first quarter mile around the station, the transit neighborhood is located in the second quarter mile around the transit core, and the transit-supportive area is on the outskirts, within one mile of the station. The data collection took place in the transit core area of the station (see Figure 3-8).

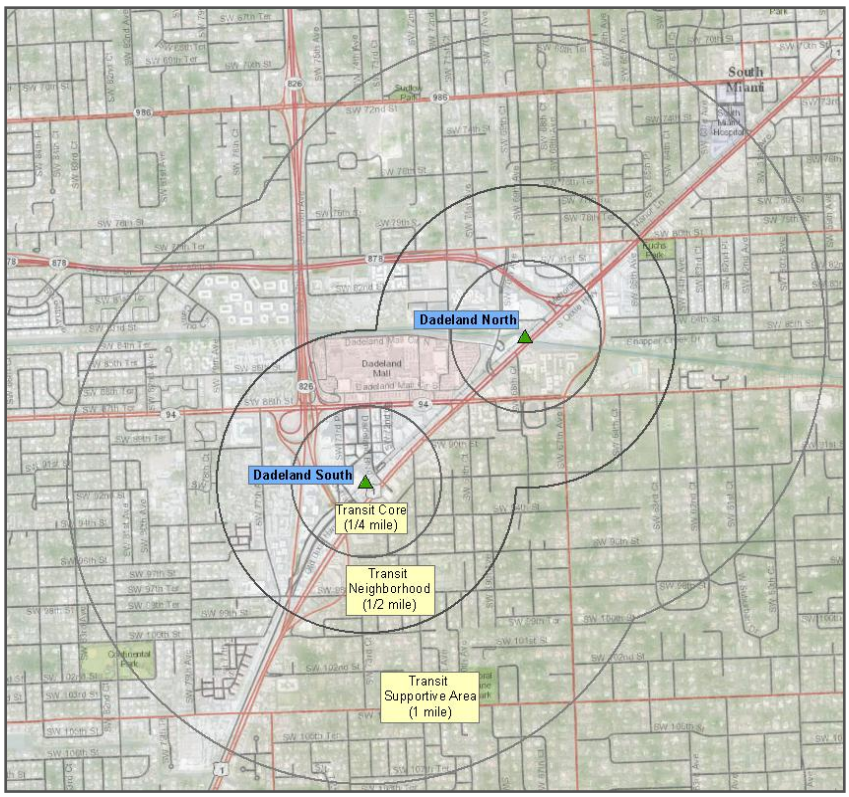

Figure 3-8: TOD in Dadeland South and North Station

3.1.9.2 Brickell

The Brickell Metrorail station is located in Downtown Miami and has a direct connection with the Miami Metromover system. The area located west of the surrounded by I-95 is predominantly residential, consisting of mostly low-rise, multi-family buildings with a few modern mid-rise residential areas close to the station (see Figure 3-10). The area east of the station contains a variety of land uses, including residential, retail, restaurants, hotels, and offices. Both Metrorail and Metromover serve the east areas of Brickell in addition to other high-quality transit.

Brickell was referenced as a Transit-Adjacent Development (TAD) in a previous study by Cervero et al. [6]. The reasons cited in the study to give Brickell this classification were the lack of comfortable sidewalks and the absence of ground-floor retail stores and services. Since the publication of Cervero's report in 2004, several new developments, such as the Mary Brickell Village, have been built, bringing more ground-floor retail to the area. In addition, the local government conducted several projects in the area that provide improved pedestrian access to the existing transit facilities.

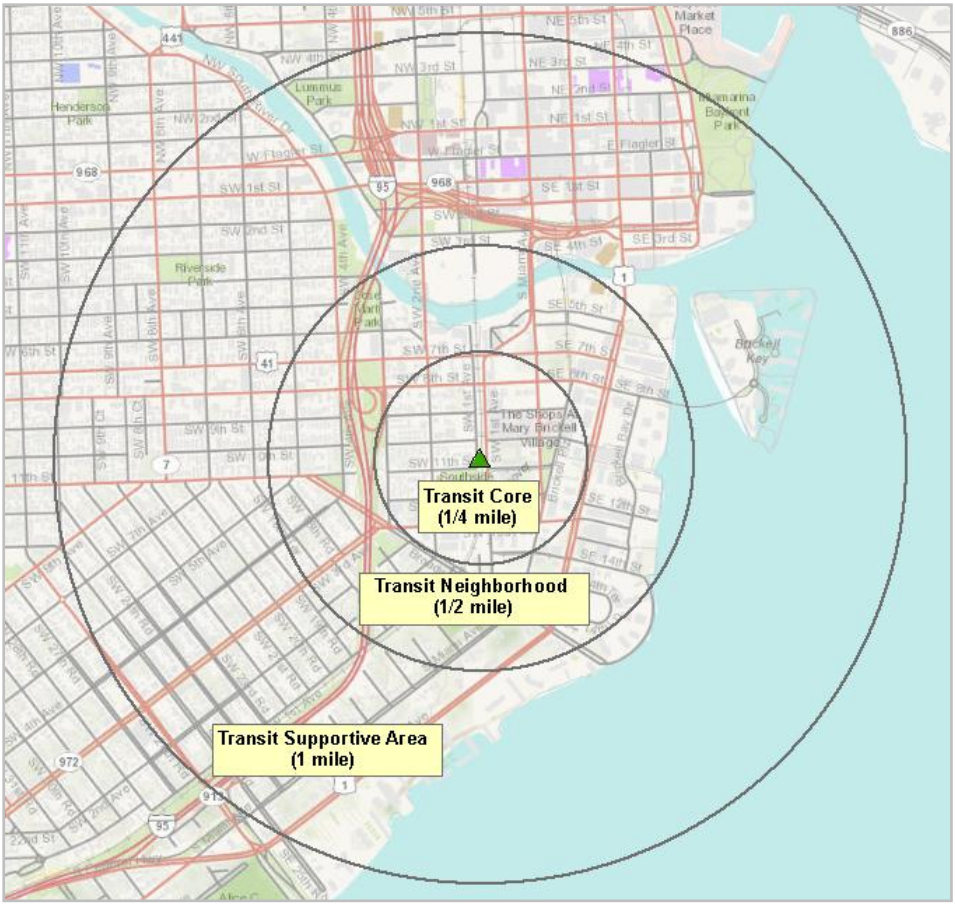

Figure 3-9: TOD in Brickell

3.2 Data Requirements

To understand the trip generation and internalization characteristics of TODs, it was necessary obtain field data on the following aspects:

- Physical characteristics of TOD
- Activity levels
- Trip Internalization behavior
- Mode split
- Socio-economic variables

Physical characteristics of the development include land use inventory in area/units, business hours, and TOD access point and door locations. If additional analyses, such as proximity (NCHRP Report 684 [4]), are to be performed, distance information may be collected and reported. However, this can be performed via a Geographic Information System (GIS) at any time. Door locations, particularly those with special conditions such as direct access to a street or drive-thru, must be documented. Other physical characteristics for the development can be collected for reporting purposes or for further analyses. A

comprehensive list of physical characteristics that can be collected for MXDs is provided in NCHRP Report 684 [4].

The activity level of the development was measured by door counts for the establishments/buildings in the TOD. Trip internalization behavior, mode split, and socio-economic were obtained via personal interviews. The suggested practice by ITE [1] and NCHRP Report 684 [4] consists of collecting survey information via entry/exit interviews. According to the lessons learned in NCHRP Report 684 [4], exit interviews tend to be more acceptable to business managers, since, from a business perspective, they do not want any impedance between a potential costumer and the business. Once a customer has left the business, it is more appropriate to proceed with the interviews.

The process of collecting activity levels, trip internalization behavior, and mode split is presented in Figure 3-10. Interviewers approach patrons as they exit from a location and ask questions regarding the previous and next trip, including mode. The previous-trip part of the interview yields inbound trip information for the establishment being exited; the second part yields outbound trip information. Interviewer skills, training, supervision, and form design are important factors for obtaining high-quality interviews. Forms for cordon counts, door counts, and interviews can be found in Appendix A.

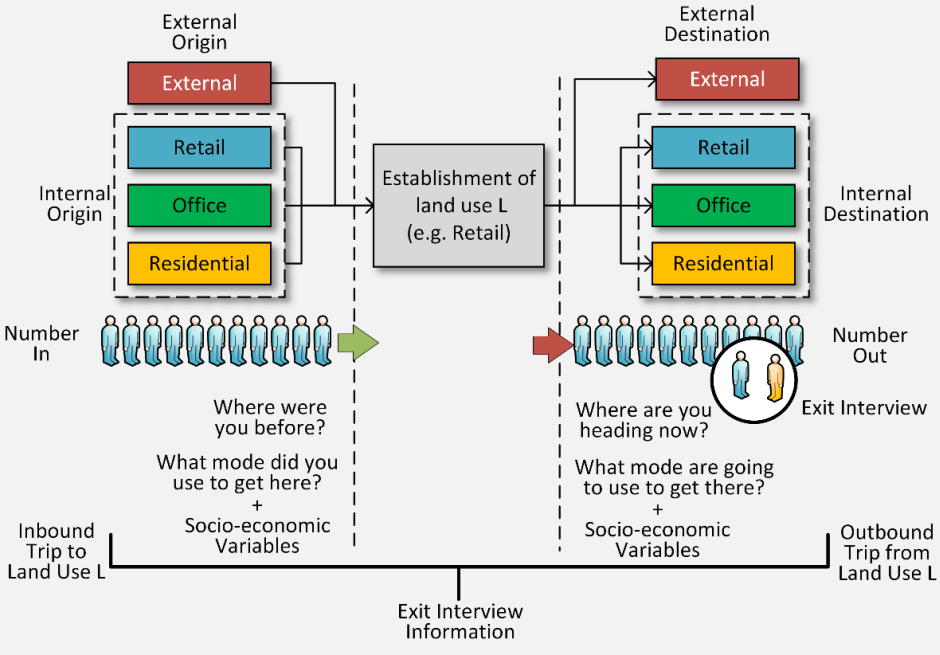

Figure 3-10: Overview of Interview Process

3.3 Selection of Socio-Economic Variables

Socio-economic variables are useful for incorporating the results of a study into transportation planning models. For this study, variables in use for travel demand modeling in SERPM were used. These variables were defined based on a previous transit survey

conducted aimed at refining the input variables for version 6.7 of the regional model (SERPM) [24]. The transit survey information was used to understand and model key transit travel patterns and behaviors. The transit survey fieldwork was performed from 2008 through 2010. The transit survey was mainly an on-board survey and was administered via the main transit modes use in the region, such as Metrobus, Tri-Rail, Metrorail, I-95 Express Bus, Broward County Transit, and Palm Tran.

The transit survey identified two main transit markets or users—the mobility-dependent market (MDM) and the commuter market (CM). It was found that zero-car households dominated the MDM, with dispersed travel patterns having walking as the primary access mode and an average trip length of 6.5 miles. On the other hand, car-owning households, with defined work destinations such as the Miami CBD and suburban employment areas, dominated the CM. Access mode for the CM was automobile, and the trip length ranged from 7.8 to 28.7 miles. The new model specification for transit in SERMP was divided based on the following segmentation:

- Zero-car households
- Households with workers greater than number of cars
- Household with workers less than or equal to the number of cars

In addition, the transit survey highlighted the importance of auto ownership as an explanatory variable for modal split was decreasing. Documentation on the calibration and validation of the SERPM model suggest that market segmentation based on the previous criteria seems to work well with respect to the transit model [24]. Data can be used at the individual level to validate trip generation models and trip lengths, and can be used to validate travel as trip generation. As part of the data collection, a manager/owner survey was conducted to collect zone data file (zdata) information such as:

- Number of dwelling units
- Percent of vacant units at the time of the study
- Percent of vacant non-permanently occupied at the time of the study

The final forms for cordon counts, door counts, and interviews can be found in Appendix A.

4 Data Collection Results

This section presents the results of the data collection process in the selected TODs of Dadeland South and Brickell. The results described in this section correspond to descriptive statistics on land use inventory, site activity, cordon counts, vehicle occupancy, trip generation, internal trip capture, and mode split. The results are contrasted with socio-economic variable data.

4.1 Dadeland South

Data in Dadeland South were collected on October 29, 2013, from 12:00–7:00 PM. Data collection consisted of interviews at the Metrorail station, exit interviews, and intercept interviews. The results are summarized in the following sections.

4.1.1 Land Use Inventory

The study area for Dadeland South is presented in Figure 4-1. It is comprised of three residential properties, two hotels, and several retail establishment and restaurants. Vehicle occupancy and person counts were collected at the boundaries of the study area.

Figure 4-1: Dadeland South Study Area

Adjacent office and retail land uses are shown in Figure 4-1. These land uses were excluded of the study due to feasibility reasons; however, they have an impact on the cordon counts. To account for such impact, the adjacent land uses were counted in order to identify the

though traffic in the main study site that is associated with these land uses. The land use inventory for the study area in Dadeland South is presented in Table 4-1. The occupancy of the residential units at the time of the study was more than 93 percent in all buildings. This number was obtained via interview with the property managers. The retail and restaurant space shown in Table 4-1 corresponds to occupied space. The study area also includes the park-and-ride of the Dadeland South Metrorail Station.

Table 4-1: Land Use Inventory for Dadeland South Study Area

Land Use Type	Size	Units
Hotel	478	d.u.
Office	1,012,587	sq.ft.
Residential	1,215	d.u.
Restaurant	31,887	sq.ft.
Retail	228,428	sq.ft.

4.1.2 Site Activity

Site activity was collected via door counts at the different establishments. For the entire site, the activity was captured via cordon counts. It is important to note that there is significant thru traffic in the study site. For this reason, the cordon counts do not reflect site activity exclusively. Figure 4-2 presents the cordon count locations for the Dadeland South study area. Data collection personnel were placed at the indicated locations. The cordon count data collection consisted of vehicle counts, vehicle occupancy, vehicle type (private, commercial, bus) and pedestrian counts.

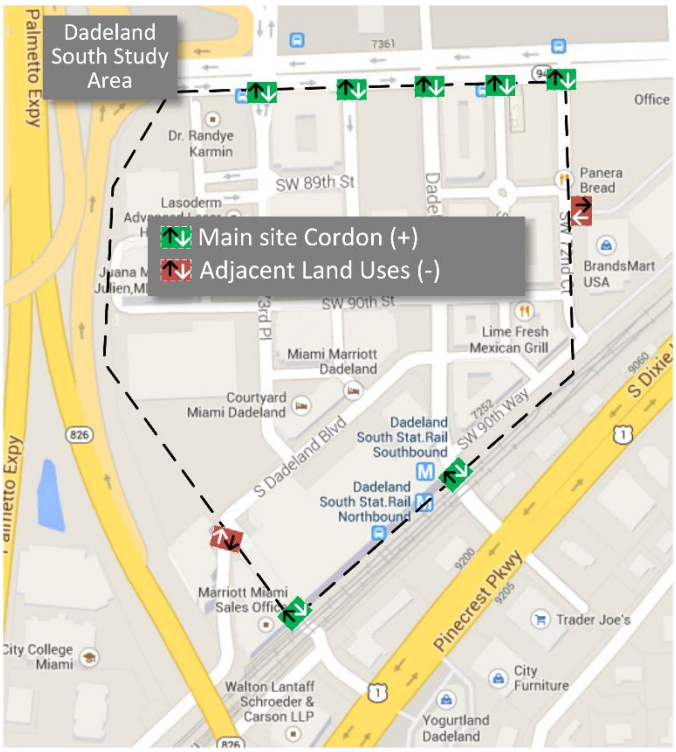

Figure 4-2: Dadeland South Site Cordon Counts

Figure 4-3 presents the site activity at Dadeland South for private vehicles. It presents cordon counts and subtracted cordon counts. The adjacent cordon counts were used to factor out the effect of other land uses adjacent to the study area in Dadeland South. This metric was chosen as the performance measure since it is compatible with the ITE trip generation methodology. The cordon counts reflect the overall site activity and thru traffic. It can be observed that the interval from 3:00–4:00 PM is the least active. The peak hour of the development in the PM is characterized by an increase in outbound trip counts. This is typically driven by office buildings and the Metrorail users exiting the park-and-ride.

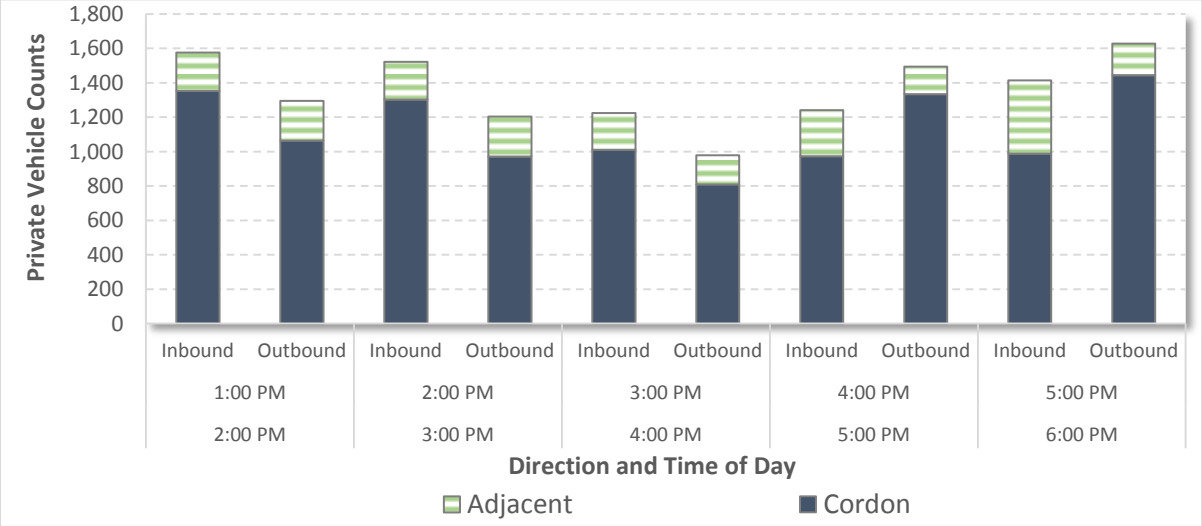

Figure 4-3: Dadeland South Site Activity Measured in Vehicle Counts

The internal site activity was measured by door counts at the different establishments at the site (see Figure 4-4). These counts are measured in person trips, which can be internal or external. Further details of the trips were estimated based on intercept interviews.

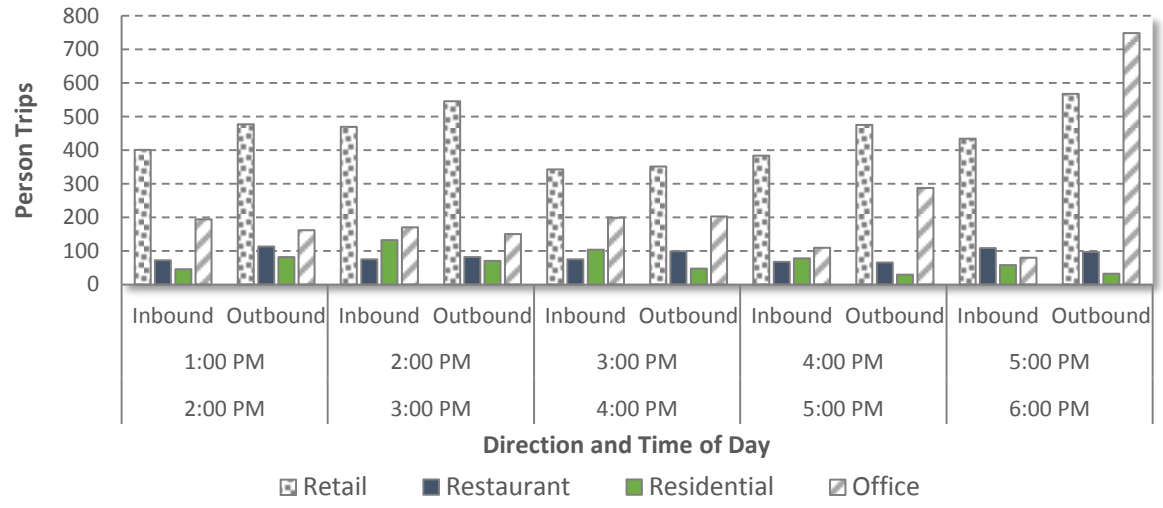

Figure 4-4: Dadeland South Site Internal Activity in Person Counts

Figure 4-4 shows the site activity in the form of person trips collected via door counts. The retail and restaurant trips were combined into a single category representing the commercial establishments to increase the sample size for interviews. The overall commercial land use was 260,315 sq.ft., with 12 percent (31,887 sq.ft.) of restaurants and 88 percent (228,428 sq.ft.) of retail. Site activity is dominated by commercial activity during most of the day. Offices were the dominant land use in terms of area. During most of the data collection period, the impact of offices was no more than 25 percent of the total bi-directional trips. During the PM peak hour, offices contributed to 32 percent of the bi-directional trips generated by the development. During the peak time, office outbound presented the peak activity for the PM period pattern of returning trips from work. Residential presented a peak in the interval from 2:00–3:00 PM, with 11 percent of the bi-directional trips generated by the development. During the next one-hour intervals, the contribution for residential was 10, 6, and 3 percent for intervals starting 3:00 PM, 4:00 PM and 5:00 PM, respectively.

4.1.3 Trip Generation and Internal Trip Capture

Person trips are used to obtain trip generation estimates and to capture the internal activity of the site. These trips are converted into cordon counts trips based on the interviews conducted at the site. The interview questionnaire can be encountered in Appendix A. As indicated in the methodology section, each interview leads to two trips (inbound and outbound). For Dadeland South the number of interviews was 138. This generated 276 potential trips. Not all the interviews contained useful information due to a number of reasons such as interviewer skills and quality of information provided by the interviewee. The effectiveness rate for the obtained number of trips was 92 percent. That is 92 percent of the 276 trips contained useful information. The data was analyzed using the procedure outlined in NCHRP Report 684 [4]. The results for outbound trips for off-peak period (1:00 PM to 4:00 PM) are presented in Table 4-2.

Table 4-2: Estimated Internal Trip Capture for Dadeland South for Outbound Trips for Off-Peak Period

Outbound From	To				External	Internal
	Residential	***Commercial***	***Hotel***	***Office***		
Residential		22%	0%	0%	78%	22%
Commercial	0%		0%	1%	99%	1%
Hotel	0%	30%		12%	57%	43%
Office	1%	11%	3%		85%	15%

Table 4-2 presents the analysis of internal trip capture based on interview data. The first row indicates that all for the trips exiting residential, 22 percent are expected to go to on-site commercial; the remaining 78 percent are expected to be external trips. For commercial establishments, 1 percent of the exiting trips are headed to on-site offices and the remaining 99 percent to external destinations. For hotels, 30 percent of the outbound trips are expected to go to on-site commercial and 12 percent to on-site offices, with 57 percent headed to external destinations. For offices, it was observed that 1 percent of the trips were made on-site residential land uses. The expected number of trips from offices to on-site commercial was estimated at 11 percent of the total exiting trips. The interaction of offices–

hotels for trips exiting offices was estimated at 3 percent. For offices, the number of external trips was estimated at 85 percent of the total exiting trips.

The results for inbound trips are presented in Table 4-3. This reflects internal trip capture behavior for trips entering the different establishments at the site. It can be observed that it is expected that for trips entering residential land uses, 2 percent are coming from on-site offices and 98 percent from external origins. For the case of commercial establishments, 3 percent of the entering trips are expected to come from on-site residential uses, 2 percent from hotels, and 4 percent from on-site offices; the remaining 91 percent are expected to be external trips. For trips entering hotels, 8 percent are expected to come from on-site commercial establishments and 18 percent from offices, with 74 percent coming from external destinations. For inbound offices, the percentages of internal trip capture are 5 and 2 for commercial and hotels, respectively. The trips coming to offices from external destinations were estimated at 93 percent of the inbound trips.

Table 4-3: Estimated Internal Trip Capture for Dadeland South for Inbound Trips for Off-Peak Period

Inbound To	From				External	Internal	Total
	Residential	***Commercial***	***Hotel***	***Office***			
Residential		0%	0%	2%	98%	2%	100%
Commercial	3%		2%	4%	91%	9%	100%
Hotel	0%	8%		18%	74%	26%	100%
Office	0%	5%	2%		93%	7%	100%

The summary of trip generation including internal trip capture for outbound trips during the off-peak period is presented in Table 4-4. The internal trip capture for outbound trips for the development was 7 percent, which was obtained by dividing the balanced internal trips (202) by the total trips generated by the development (2,692).

Table 4-4: Estimated Trip Generation for Outbound Trips for Off-Peak Period at Dadeland South

Outbound From	To		
	External	***Internal***	***Total***
Residential	161	45	206
Commercial	1,806	32	1,838
Hotel	59	44	103
Office	465	80	545
Total	2,490	202	2,692

The estimated trip generation and internal trip capture estimated for inbound trips during the off-peak period are presented in Table 4-5. The internal trip capture for inbound trips was 8 percent. The overall internal trip capture for Dadeland South was estimated at 8 percent for the off-peak period. This number was obtained dividing the total internal trips (inbound and outbound) by the total bidirectional trips.

Table 4-5: Estimated Trip Generation for Inbound Trips for Off-Peak Period at Dadeland South

Inbound To	To		
	External	***Internal***	***Total***
Residential	336	8	343
Commercial	1,446	134	1,580
Hotel	59	21	80
Office	526	39	565
Total	2,366	202	2,568

For the PM peak hour (4:00–6:00 PM) and outbound trips, the internal trip capture estimates are presented in Table 4-6. Based on the interviews, it was estimated that 69 percent of the trips leaving residential are headed to on-site commercial. For commercial outbound trips, it was estimated that 8 percent are going to on-site residential, 6 percent to hotels, and 6 percent to offices. For hotels, 22 percent of the outbound trips are going to on-site commercial during the peak hour; the remaining 78 percent are expected to go to external destinations. For trips exiting offices during the PM peak hour, 3 percent will go to residential, 3 percent to commercial, and the remaining 94 percent to external destinations.

Table 4-6: Estimated Internal Trip Capture for Dadeland South for Outbound Trips for PM Peak Period

Outbound From	To				External	Internal
	Residential	***Commercial***	***Hotel***	***Office***		
Residential		69%	0%	11%	21%	79%
Commercial	8%		6%	6%	80%	20%
Hotel	0%	22%		0%	78%	22%
Office	3%	3%	0%		94%	6%

The distribution of internal trips for the peak period for inbound trips is presented in Table 4-7. For residential land uses, 58 percent of the trips were coming from on-site commercial and 16 percent from offices; the remaining 25 percent were coming from external destinations. The substantial presence of offices in Dadeland South was observed; therefore, there were significant chances of encountering an increased office–residential interaction. For the commercial land use, the inbound trips were 5 percent coming from residential, 3 percent from hotels, and 3 percent from offices. For offices, the percentage of inbound trips coming from residential was 3 percent and from commercial 24 percent.

Table 4-7: Estimated Internal Trip Capture for Dadeland South for Inbound Trips for the PM Peak Period

Inbound To	From				External	Internal
	Residential	***Commercial***	***Hotel***	***Office***		
Residential		58%	0%	16%	25%	75%
Commercial	5%		3%	3%	89%	11%
Hotel	0%	44%		0%	56%	44%
Office	3%	24%	0%		73%	27%

Table 4-8 presents the trip generation estimates and balanced internal trips for the outbound direction during for the PM peak period. For outbound trips, the internal trip capture was 17 percent. Table 4-9 presents trip generation and internal trip capture for inbound trips. The internal trip capture for inbound trip was 23 percent. The overall internal trip capture rate for the development at Dadeland South during the peak period was 19 percent. These figures are compared in the next chapter with similar ones obtained from the ITE *Trip Generation* [1]. It can be observed that the trip generation is dominated by commercial and offices.

Table 4-8: Estimated Trip Generation for Outbound Trips for Peak Period at Dadeland South

Outbound From	To		
	External	***Internal***	***Total***
Residential	22	86	108
Commercial	1,332	325	1,657
Hotel	130	37	167
Office	1,164	76	1,240
Total	2,648	524	3,172

Table 4-9: Estimated Trip Generation for Inbound Trips for Peak Period at Dadeland South

Inbound To	From		
	External	***Internal***	***Total***
Residential	61	178	239
Commercial	1,263	149	1,412
Hotel	119	93	212
Office	285	104	389
Total	1,728	524	2,252

The Dadeland South detailed trip generation expressed in privately-owned vehicles is presented in Figure 4-5. The total cordon counts are presented by time of day. The pass-through traffic attributable to the adjacent land uses is accounted for and plotted on top of the cordon counts. The land use series express the contribution of each land use to the number of vehicles observed at the cordon counts.

In Figure 4-5, the difference between the cordon count and the generated trips are the pass-through trips. During the off-peak hour, the estimated pass-through traffic varied from 27–42 percent of the cordon counts. During the peak, the pass-through traffic was estimated at 4 percent.

It can be observed that the trip generation is dominated by commercial establishments having a nearly steady behavior during the data collection period. Offices became more active during the PM period, reflecting the typical return from work. Similarly, the Metrorail parking (park-and-ride) garage presented low activity in the early afternoon and became more active during the PM peak hour due to returning trips. The impact of this facility was moderate during most of the day—at most, 6 percent of the total bi-directional traffic—but it increased to 13 percent of the total traffic during the PM peak period.

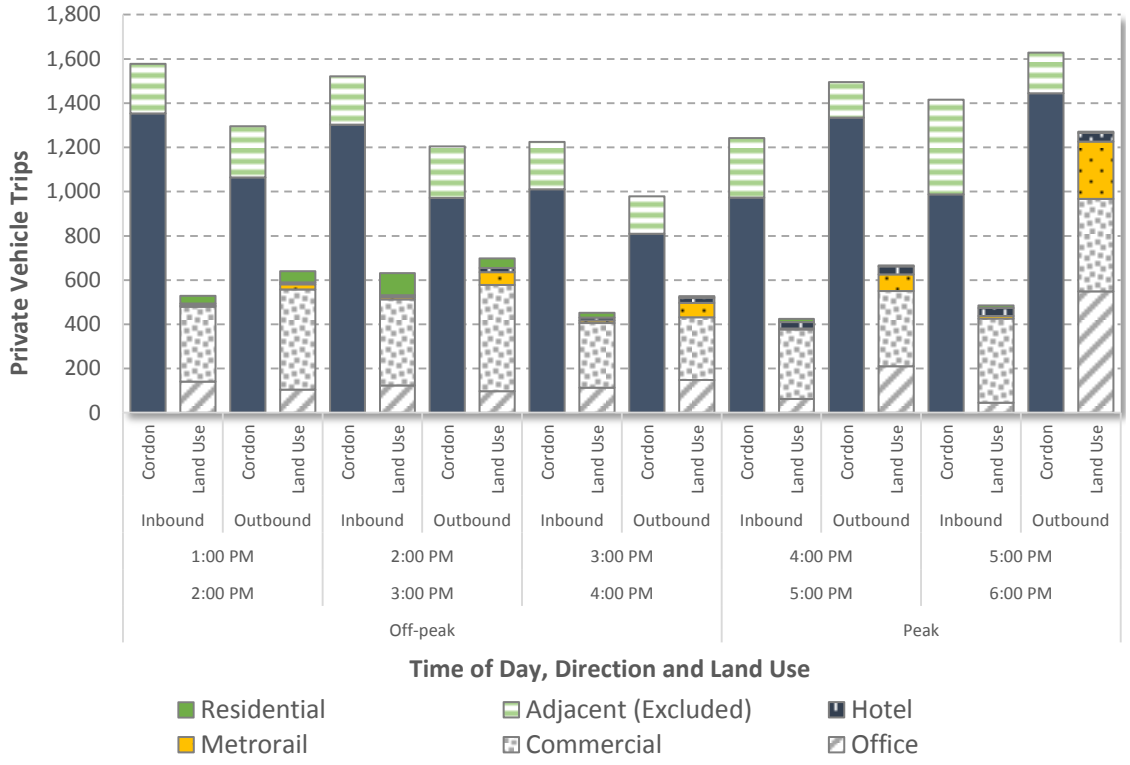

Figure 4-5: Dadeland South Trip Generation Distributions and Cordon Counts

4.2 Brickell

Data for Brickell were collected on November 19, 2013, from 1:00–6:30 PM. Data collection consisted of interviews at the Metrorail station, exit interviews, intercept interviews, and car counts. This section summarizes the results of the data collection.

4.2.1 Land Use Inventory

The study area for Brickell is presented in Figure 4-6, and is comprised of two residential properties, one hotel, one major shopping center, and several retail establishments and restaurants. Vehicle, occupancy, and person counts were collected at the boundaries of the study area.

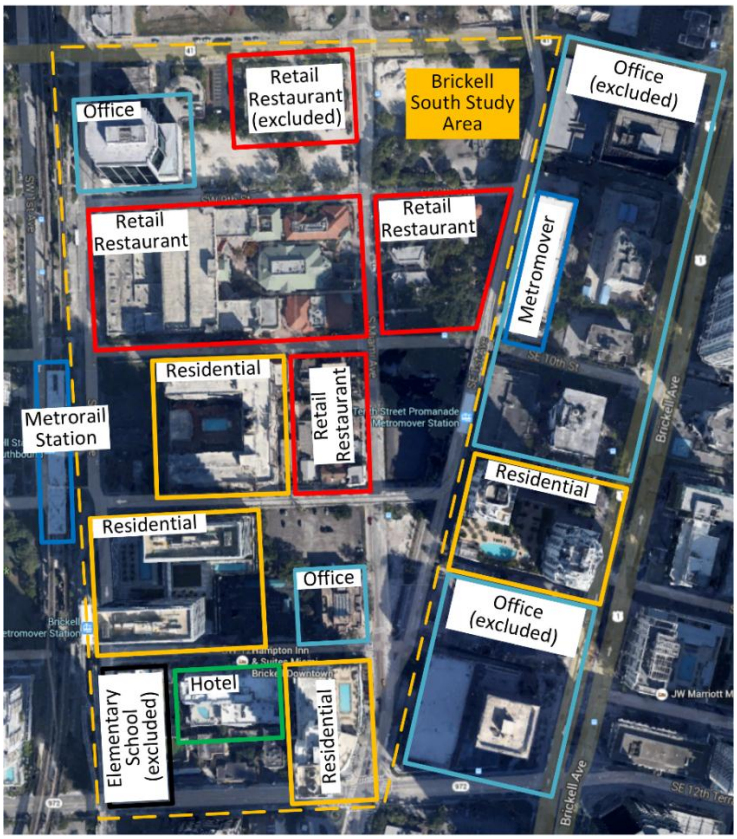

Figure 4-6: Brickell Study Area

The land use inventory for the study area in Brickell is presented in Table 4-10. The occupancy of the residential units at the time of the study was more than 80 percent in all buildings. The retail and restaurant space shown in Table 4-10 corresponds to occupied space. The study area also includes an elementary school, which was considered as office land use.

Table 4-10: Land Use Inventory for Brickell Study Area

Land Use Type	Size	Units
Hotel	183	d.u.
Office	511,993	sq.ft.
Residential	1,123	d.u.
Restaurant	11,717	sq.ft.
Retail	574,533	sq.ft.

4.3 Site Activity

Figure 4-7 presents the site activity obtained via door counts at the different establishments in the study area. The dominant land uses in the Brickell study area are commercial and residential. Most of the internal activity comes from the interaction of these two land uses in close proximity. The internal activity in person trips was converted into private vehicle trips at the boundary of the study area, with detailed information provided by the intercept interviews.

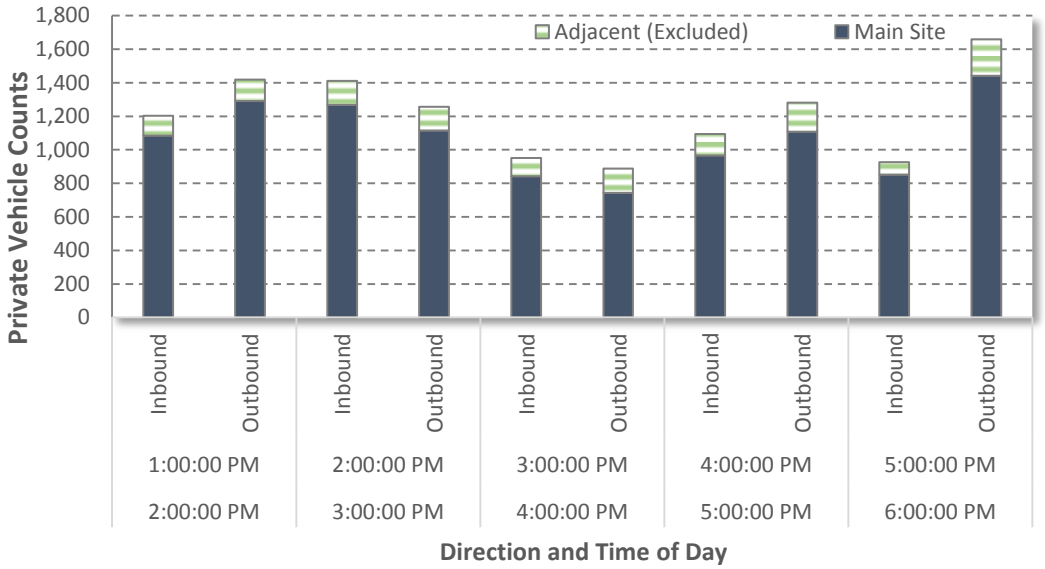

Figure 4-7: Brickell Site Activity Measured in Vehicle Counts

Trip generation in Brickell was greatly dominated by regular commercial and residential activity during the day. Restaurant contributed with 10 percent of commercial trips and retail with the remaining 90 percent. Commercial trips accounted for 44 percent of all trips generated by the development, and 41 percent of the trips were from residential land uses. Offices and commercial were the dominant land uses in terms of area. During most of the data collection period, the impact of offices was no more than 25 percent of the total trips. During the PM peak hour, offices contributed up to 15 percent of the trips generated in Brickell. Residential accounted for a peak in trip generation of 34 percent in the interval from 3:00–4:00 PM. During the next hour, the contribution for residential was 34, and for the one-hour intervals starting 4:00 PM and 5:00 PM, respectively, it was 28 percent.

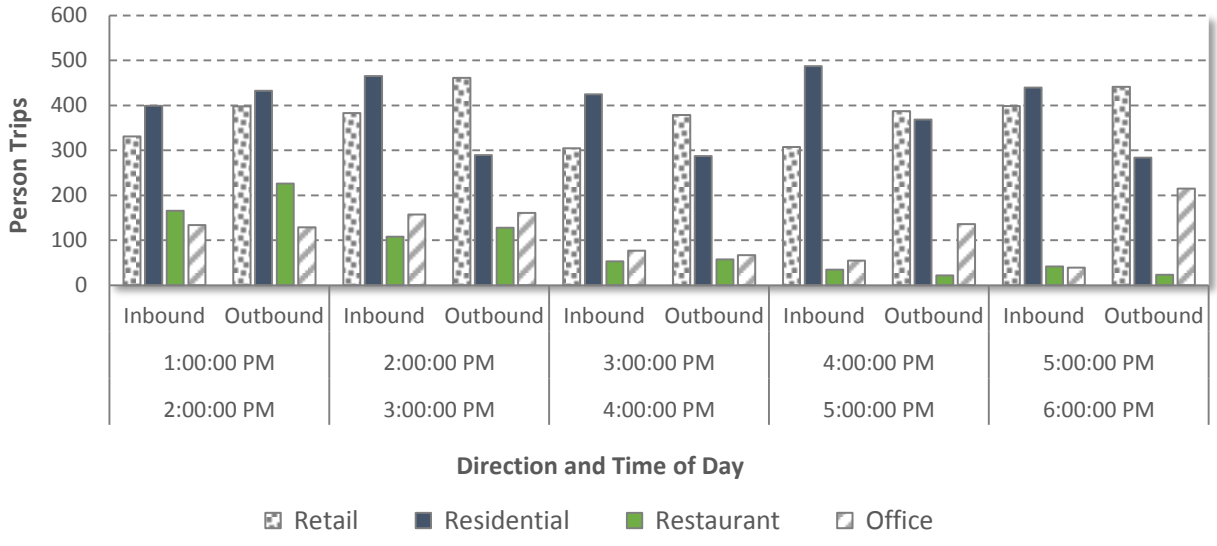

Figure 4-8: Brickell Site Internal Activity in Person Counts

4.3.1 Trip Generation and Internal Trip Capture

Trip generation and internal trip capture were estimated for the Brickell study area. The distribution for outbound trips for the off-peak period is presented in Table 4-11. It can be observed that, of the trips that exit residential, 9 percent go to on-site commercial establishments and the remaining 91 percent go to external destinations. A similar interpretation can be provided for the remaining land uses. Offices present the highest degree of interaction (50%) with on-site commercial establishments. This is due to the random nature of the sampling process. A larger sample size across several days would help smooth some apparently extreme values. However, the trip balancing step regulates extreme value since it selects the minimum number of trips between land use pairs during the internal trip capture procedure.

Table 4-11: Estimated Internal Trip Capture for Brickell for Outbound Trips for Off-Peak Period

Outbound From	To				External	Internal
	Residential	***Commercial***	***Hotel***	***Office***		
Residential		9%	0%	0%	91%	9%
Commercial	25%		0%	12%	63%	37%
Hotel	2%	0%		0%	98%	2%
Office	25%	50%	0%		25%	75%

The distribution for internal trips in the inbound direction for the Brickell area for the off-peak period is presented in Table 4-12. It can be observed that for trips entering to residential, it is expected that 35 percent will come from commercial land uses and 8 percent from office land uses. The remaining 57 percent are expected to come from external destinations. For commercial, it was estimated that 6 percent of the inbound trips will come from residential sites within the study area, 15 percent from on-site offices, and the remaining 79 percent from external destinations.

Table 4-12: Estimated Internal Trip Capture for Brickell for Inbound Trips for Off-Peak Period

Inbound To	From				External	Internal
	Residential	***Commercial***	***Hotel***	***Office***		
Residential		35%	0%	8%	57%	43%
Commercial	6%		0%	15%	79%	21%
Hotel	2%	0%		0%	98%	2%
Office	0%	50%	0%		50%	50%

The summary of trip generation including internal trip capture for outbound trips for the off-peak period is presented in Table 4-13. The internal trip capture for outbound trips for the development during the off-peak period was 32 percent, which was obtained by dividing the internal trips (734) by the total trips generated by the development (2,333). These figures are compared in the next chapter with similar ones obtained from the ITE *Trip Generation* [1].

Table 4-13: Estimated Trip Generation for Outbound Trips for Off-Peak Period at Brickell

Outbound From	To		
	External	***Internal***	***Total***
Residential	657	65	722
Commercial	764	450	1,213
Hotel	106	2	108
Office	72	218	290
Total	1,599	734	2,333

The estimated trip generation and internal trip capture estimated for inbound trips for the off-peak period is presented in Table 4-14. The internal trip capture for inbound trips for the development during the off-peak period was 33 percent, which was obtained by dividing the internal trips (734) by the total trips generated by the development (2,250). The overall internal trip capture rate for the development at Brickell during the off-peak period was 32 percent.

Table 4-14: Estimated Trip Generation for Inbound Trips for Off-Peak Period at Brickell

Inbound To	From		
	External	***Internal***	***Total***
Residential	486	379	865
Commercial	780	208	988
Hotel	104	2	106
Office	146	146	291
Total	1,516	734	2,250

The distribution for outbound trips for the peak period is presented in Table 4-15. It can be observed that of the trips that exited residential 9 percent go to on-site commercial establishments, and the remaining 91 percent go to external destinations. A similar interpretation can be provided for the remaining land uses. From commercial, 15 percent were headed to residential, 7 percent to hotels, and 78 percent to external destinations. Hotels presented the highest degree of interaction (54%) with commercial land use. A larger sample size across several days would help to smooth some apparently extreme values. It can also be observed that from offices, 13 percent of the trips were going to residential and 25 percent were going to commercial land uses, with the rest being external trips.

Table 4-15: Estimated Internal Trip Capture for Brickell for Outbound Trips for Peak Period

Outbound From	To				External	Internal
	Residential	***Commercial***	***Hotel***	***Office***		
Residential		9%	0%	0%	91%	9%
Commercial	15%		7%	0%	78%	22%
Hotel	0%	54%		0%	46%	54%
Office	13%	25%	0%		62%	38%

The distribution for internal trips in the inbound direction for the Brickell area for the peak period is presented in Table 4-16Table 4-12. It can be observed that for trips entering to residential, it is expected that 14 percent will come from commercial land uses and 4 percent from office land uses. The remaining 82 percent are expected to come from external destinations. For commercial, it was estimated that 8 percent of the inbound trips are coming from residential sites within the study area, 9 percent from offices, and 5 percent from hotels, with the remaining arriving from external destinations.

Table 4-16: Estimated Internal Trip Capture for Brickell for Inbound Trips for Peak Period

Inbound To	From				External	Internal
	Residential	***Commercial***	***Hotel***	***Office***		
Residential		14%	0%	4%	82%	18%
Commercial	8%		5%	9%	78%	22%
Hotel	0%	55%		0%	45%	55%
Office	0%	0%	0%		100%	0%

Table 4-17 provides the internal trip capture for outbound trips during the PM peak period of the Brickell area. It was 21 percent, which was obtained by dividing the internal trips (593) by the total trips generated by the development (2,775). This gives a clear idea of how good the MXD is in the Brickell area.

Table 4-17: Estimated Trip Generation for Outbound Trips for Peak Period at Brickell

Outbound From	To		
	External	***Internal***	***Total***
Residential	854	86	940
Commercial	1,018	293	1,311
Hotel	49	57	106
Office	261	158	418
Total	2,182	593	2,775

The trip generation using the ITE *Trip Generation* is discussed in the next chapter, which shows much higher trip generation than the observed counts.

The estimated trip generation and internal trip capture estimated for inbound trips during the peak period are presented in Table 4-18. It can be observed that during the PM peak period, trips that were entering offices were all coming from outside the boundaries of the development. The internal trip capture for inbound trips during the PM peak period was 21 percent, which was obtained by dividing the internal trips (593) by the total trips generated by the development (2,843). The overall internal trip capture rate for the development at Brickell during the PM peak period was 21 percent.

Table 4-18: Estimated Trip Generation for Inbound Trips for Peak Period at Brickell

Inbound To	From		
	External	***Internal***	***Total***
Residential	1,105	248	1,352
Commercial	894	248	1,142
Hotel	80	98	178
Office	171	0	171
Total	2,250	593	2,843

The detailed trip generation at Brickell expressed as privately-owned vehicles is presented in Figure 4-9. The total cordon counts are presented by time of day. The pass-through traffic attributable to adjacent/excluded land uses is accounted for and plotted on top of the cordon counts. The land use series expresses the contribution of each land use to the number of vehicles observed at the cordon counts. The difference between the cordon counts and the generated traffic is an estimation of pass-through traffic. During the off-peak hour, the estimated pass-through traffic varied from 10–16 percent of the cordon counts. During the peak, the pass-through traffic was estimated at 14 percent. The PM peak hour for Brickell was from 5:00–6:00 PM, indicating total bi-directional trip traffic of 2,585 vehicles, with a directional distribution of 36 percent entering and 64 percent exiting.

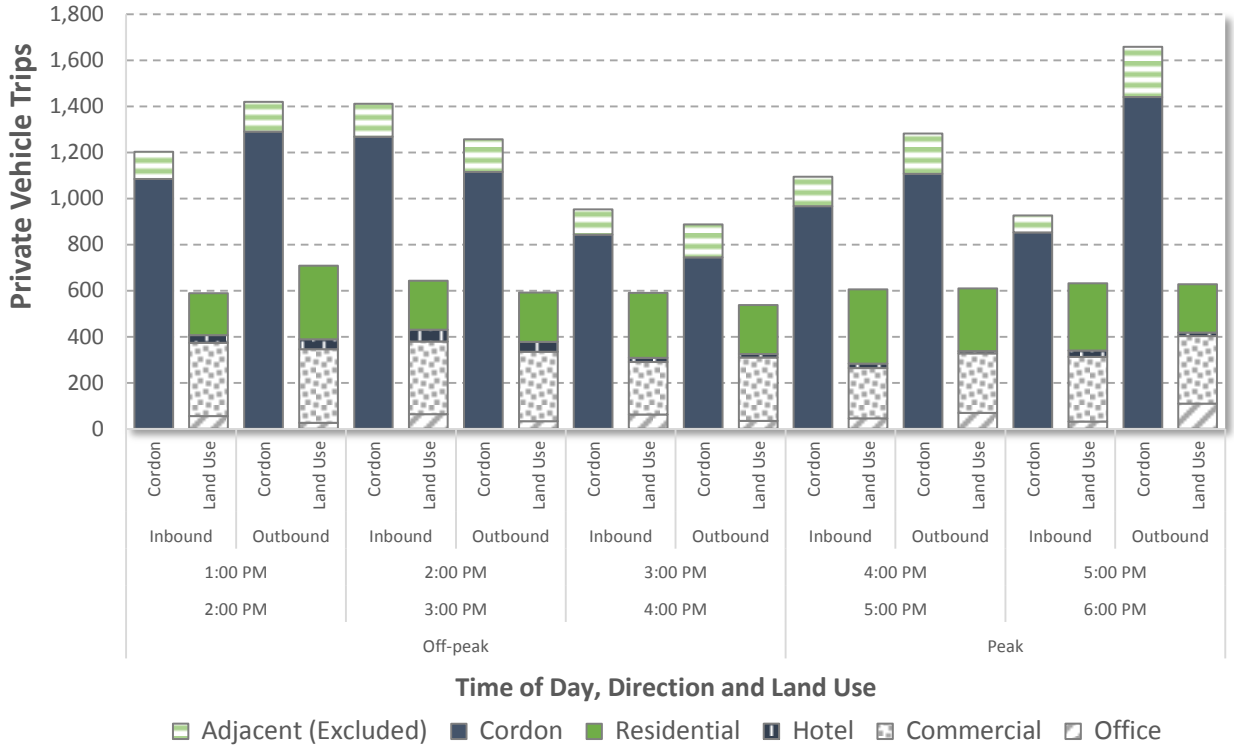

Figure 4-9: Brickell Trip Generation Distributions and Cordon Counts

5 Data Analysis and Discussions

This section presents the trip generation analysis of the study sites. Both sites selected for this study were analyzed using the traditional ITE internal trip capture method for MXDs and the most recent methodology suggested in NCHRP Report 684 [4]. The results of these methodologies are compared with field data.

5.1 Trip Generation

Three different methods were used for trip generation analysis. The first method consisted of estimating trip generation for each establishment and then summing the data for all the establishments assuming no interaction. This method is referred to as the ITE single land use method.

The second method is the traditional ITE internal trip capture methodology, which takes the single-use estimates and applies a correction percentage due to the presence of complementary land uses in close proximity. This method is referred to as ITE internal trip capture (ITE-ITC). The ITE-ITC has been traditionally used and accepted to predict trip generation in MXDs. Details on the ITE-ITC methodology can be found in the ITE *Trip Generation Manual* [1].

The third methodology used is the proposed in NCHRP Report 684 [4] for enhancing the internal trip capture estimates in MXDs. The NCHRP method divides the land uses into six categories—residential, restaurant, retail, office, hotel, and cinema. The methodology outlines the use of the maximum interaction between land uses based on all previous studies, followed by a trip-balancing procedure. The NCHRP methodology introduces a proximity adjustment to further adjust the internal trip capture rates for distant land uses.

The inputs for these methodologies are the land use inventory data presented in Tables 4-1 and 4-10. The results of the trip generation estimates for trip generation methodologies are shown in Table 5-1.

Table 5-1: Trip Generation Estimates Using Existing Methodologies

Site	Direction	Observed Trips	ITE Single Land Use	ITE ITC	NCHRP with Proximity	NCHRP w/o Proximity
Dadeland South	Inbound	1,057	1,683	1,421	1,011	1,007
	Outbound	751	2,678	2,416	1,918	2,002
	Bidirectional	1,808	4,361	3,837	2,929	3,009
Brickell	Inbound	925	2,010	1,644	1,575	1,446
	Outbound	948	2,271	1,905	1,852	1,707
	Bidirectional	1,873	4,281	3,549	3,427	3,153

The results of the different trip generation methods were compared with respect to field data obtained in this study. In this case the field data corresponded to observed trips which are assumed as the actual trip generation of the study site. For each prediction method, the

ratio of predicted trip generation and observed trips was obtained. If that ratio was greater than 1 (100%), then the method overestimated the observed trips. If the ratio was less than 1 (100%), then the method underestimated the observed trips. The best prediction should be close to 1 (100%). The results of the three expressed as percent of the observed trips are presented in Figure 5-1.

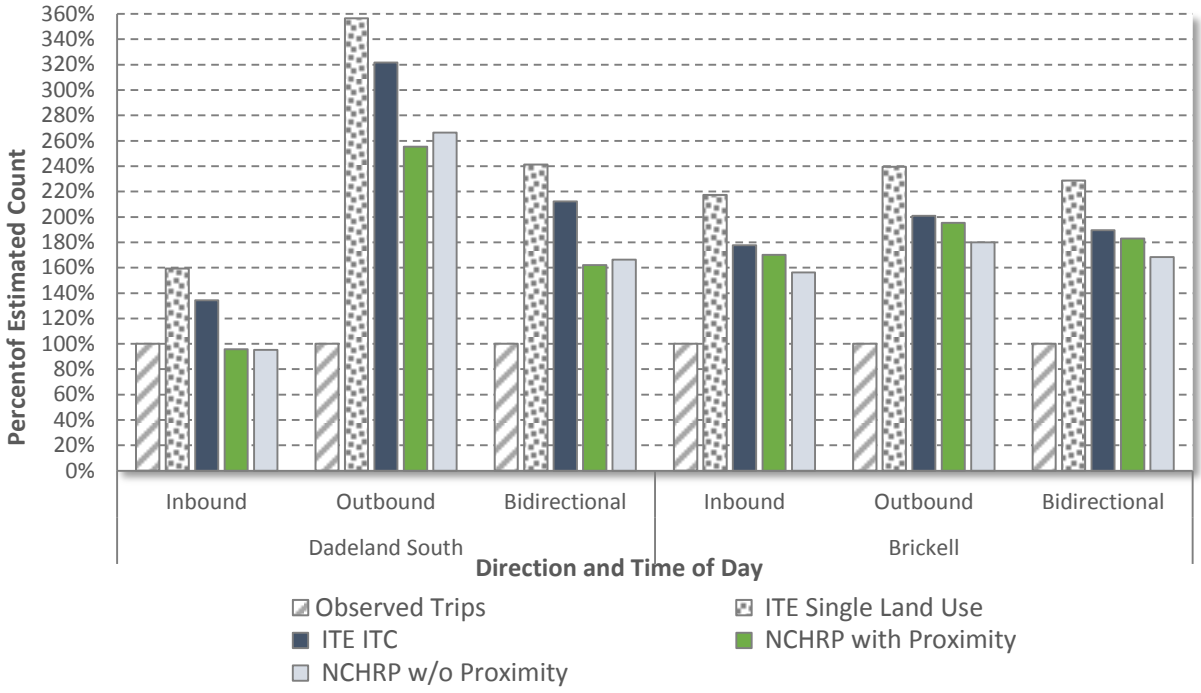

Figure 5-1: Comparison with Estimation Methods

In Figure 5-1, it can be observed that in general the ITE single land use estimate produced the most trips. This was the initial input for the rest of the methodologies, since these are intended to be correction factors to ITE single land use estimates. It can be observed that inbound trip generation for Dadeland South had the least single land use estimates predicted by the methodologies within a reasonable accuracy.

Although all of methods mostly overestimated the target trip generation from both sites, the accuracy of all the methods, including that of NCHRP, is dependent on the initial ITE single land use estimate. The NCHRP methodology provides a better estimate over the traditional ITE-ITC method. This was demonstrated from the comparison of results of trip generation estimates from both study sites.

6 Conclusions and Recommendations

This project addressed the trip generation aspects of TODs. This topic is of relevance for the planning practice since it provides a baseline for improved design practices to accommodate complementary land uses in close proximity serviced by premium transit service. Two sites were studied in the Metrorail corridor in Miami-Dade County. The sites were chosen based on the diversity and intensity of the surrounding land uses and the feasibility for conducting the study. The study comprised several data elements, including land use inventory, site activity, trip internalization behavior, and socio-economic data. The findings and recommendations for the study are provided in this section.

6.1 Findings on Trip Generation and Internal Trip Capture for Dadeland South

- Trip generation in Dadeland South was greatly dominated by commercial activity that occurred regularly during the day, accounting for 56 percent of all trips generated by the development. Of that, retail constituted the majority of the land use intensity at 88 percent of the total commercial gross leasable area, and restaurants constituted the 12 percent. Restaurant contributed with 16 percent of the commercial trips and retail with the remaining 84 percent.

- Office was the dominant land use in terms of area. During most of the data collection period, the impact of offices was no more than 25 percent of the total trips. During the PM peak hour, offices contributed to 32 percent of the trips generated in Dadeland South.

- Residential accounted for a peak in trip generation, at 11 percent of the total bi-directional trips for the development during the interval from 2:00–3:00 PM. During the next one-hour interval, the contribution for residential was 10, 6, and 3 percent, respectively, for the intervals starting at 3:00 PM, 4:00 PM and 5:00 PM.

- Dadeland South contained a park-and-ride facility that greatly contributed to the number of trips in/out of the study site boundary. The impact of such facility was moderate during most of the day (at most, 6%), but it increased to 13 percent of the total traffic during the PM peak period.

- The PM peak hour for Dadeland South was from 5:00–6:00 PM, presenting total bi-directional trip traffic of 2,626 vehicles, with a directional distribution of 30 percent entering and 70 percent exiting.

- During the off-peak hour, the estimated pass-through traffic varied from 27–42 percent of the cordon counts. During the peak, the pass-through traffic was estimated at 4 percent.

- The overall internal trip capture for Dadeland South for the off-peak period was 8 percent. For the outbound direction it was 7 percent, and for the inbound direction it was 8 percent.

- For residential land uses during the off-peak period, it was estimated that 22 percent of the exiting trips were made to commercial destinations in the development. For commercial land uses, 1 percent of the exiting trips were headed to offices. For hotels, 30 percent of the exiting trips were headed to commercial land uses and 12 percent to on-site offices. For offices, 1 percent of the outbound trips were headed to on-site residential land uses, 11 percent to commercial establishments, and 3 percent to hotels.

- For inbound trips during the off-peak period, the distribution of entering or inbound trips per land use was estimated as follows: for residential, 2 percent of internal trips came from on-site offices; for commercial, 3 percent came from residential, 2 percent from hotels, and 4 percent from offices; for hotels, 8 percent came from commercial and 18 percent originated at on-site offices; and for offices, 5 percent came from commercial and 2 percent from hotel.

- For the off-peak period, the proportion of outbound trips heading to external destinations by land use for residential was 78 percent, commercial 99 percent, hotels 57 percent, and offices 85 percent. For inbound trips, the proportion of external trips from the entering trips by land use was 98 percent for residential, 91 percent for commercial, 74 percent for hotel, and 93 percent for offices.

- During the peak period, the internal trip capture was 17 percent for outbound trips and 23 percent for inbound trips. The overall internal trip capture for the peak period was 19 percent.

- For outbound trips during the peak period, the distribution of exiting or outbound trips per land use was estimated as follows: for residential, 69 percent were headed to commercial and 11 percent to offices; for commercial establishments, 8 percent were headed to residential, 6 percent to hotels, and 6 percent to offices; for hotels, 22 percent were headed to commercial establishments; and for offices, 3 percent were headed to residential and 3 percent to commercial.

- Entering trips or inbound trips for the PM peak hour were distributed as follows: for residential, 58 percent came from commercial and 16 percent from offices; for commercial, 5 percent came from residential, 3 percent from hotels, and 3 percent from offices; for hotels, 44 percent came from commercial establishments; and for offices, 3 percent came from residential and 24 percent came from commercial.

- For the PM peak period, the proportion of outbound trips heading to external destinations by land use for residential was 21 percent, for commercial 80 percent, for hotels 78 percent, and for offices 94 percent. For inbound trips, the proportion of external trips from the entering trips by land use was 25 percent for residential, 89 percent for commercial, 56 percent for hotel, and 73 percent for offices.

6.2 Findings on Trip Generation and Internal Trip Capture for Brickell

- Trip generation in Brickell was greatly dominated by the commercial and residential activity regularly during the day. Restaurant contributed with 10 percent of the commercial trips and retail with the remaining 90 percent. Commercial trips accounted for 44 percent of all trips generated by the development, and 41 percent of the trips were from residential land uses.

- Office and commercial were the dominant land uses in terms of area. During most of the data collection period, the impact of office was no more than 25 percent of the total trips. During the PM peak hour, offices contributed up to 15 percent of the trips generated in Brickell.

- Residential accounted for a peak in trip generation, 34 percent in the interval from 3:00–4:00 PM. During the next hour interval, the contribution for residential was 34 and 28 percent, respectively, for the one-hour intervals starting at 4:00 PM and 5:00 PM.

- The PM peak-hour for Brickell was from 5:00–6:00 PM, presenting total bi-directional trip traffic of 2,002 vehicles, with a directional distribution of 50.2 percent entering and 49.8 percent exiting.

- During the off-peak hour, the estimated pass-through traffic varied from 10–16 percent of the cordon counts. During the peak, the pass-through traffic was estimated at 14 percent.

- The overall internal trip capture for Brickell for the off-peak period was 32 percent. For the outbound direction it was 32 percent, and for the inbound direction it was 33 percent.

- For residential land uses during the off-peak period, it was estimated that 97 percent of the exiting trips were made to commercial destinations in the development. For commercial land uses, 12 percent of the exiting trips were headed to office and 2513 percent to residential. For hotel, 2 percent of the exiting trips were headed to residential land uses. For offices, 25 percent of the outbound trips were headed to on-site residential land uses, 50 percent to commercial establishments, and 16 percent to external destinations.

- For inbound trips during the off-peak period, the distribution of entering or inbound trips per land use was estimated as follows: for residential, 8 percent of internal trips came from on-site offices and 35 percent from commercial; for commercial, 6 percent came from residential and 15 percent from offices; for hotel, 2 percent came from residential land uses; and for offices, 50 percent came from commercial and the rest being from external destinations.

- For the off-peak period, the proportion of outbound trips heading to external destinations by land use for residential was 91 percent, for commercial 63 percent, for hotels 98 percent, and for office 25 percent. For inbound trips, the proportion of external trips from the entering trips by land use for residential was 57 percent, commercial 79 percent, hotel 98 percent, and offices 50 percent.

- During the peak period, the internal trip capture was 21 percent for outbound trips and 21 percent for inbound trips. The overall internal trip capture for the peak period was 21 percent.

- For outbound trips during the peak period, the distribution of exiting or outbound trips per land use was estimated as follows: for residential, 9 percent were headed to commercial; for commercial establishments, 15 percent were headed to residential, 7 percent to hotels, and the rest to external destinations; for hotels, 54 percent were headed to commercial establishments; and for offices, 13 percent were headed to residential, 25 percent to commercial and the rest to external.

- Entering trips or inbound trips for the PM peak hour were distributed as follows: for residential, 14 percent came from commercial and 4 percent from offices; for commercial, 8 percent came from residential, 5 percent from hotels, and the rest from external destinations; and for hotels, 55 percent came from commercial establishments.

- For the peak period, the proportion of outbound trips heading to external destinations by land use was 91 percent for residential, 46 percent for hotel, 78 percent for commercial, and 62 percent for offices. For inbound trips, the proportion of external trips from the entering trips by land use was 82 percent for residential, 78 percent for commercial, 45 percent for hotel, and 100 percent for offices.

6.3 Recommendations

- This study verified that the ITE internal trip capture procedure overestimates the trip generation for MXD developments. In addition, it was verified that the methodology proposed in NHRP Report 684 [4] provided an improved estimate of the traffic impact for TOD over traditional internal trip capture methods. Therefore, the NCHRP methodology recommended to determine trip generation in future traffic impact studies.

- It is important to keep track of developments with desirable characteristics in order to perform trip generation studies. In this way, a local database that captures local behavior can be developed and applied to future developments.

- It is recommended that the surrounding theme of metro stations and transfer stations be master-planned to produce a seamless environment. In addition, traffic going around the MXD instead of through should be promoted. To the extent possible

arterials and major collector facilities should be designed outside of an MXD, more towards the perimeter boundary

- The information provided in this report can be applied to planning to assist in the prediction of traffic for developments similar to Dadeland South and Brickell. The percentages of outbound and inbound traffic can be considered for new TODs or MXD developments.

- It is recommended that the sample size be increased to obtain more reliable estimates for the parameters found in this project. It is recommended that data be collected not only in through person interviews, but also by using online forms and through location sensing such as Bluetooth.

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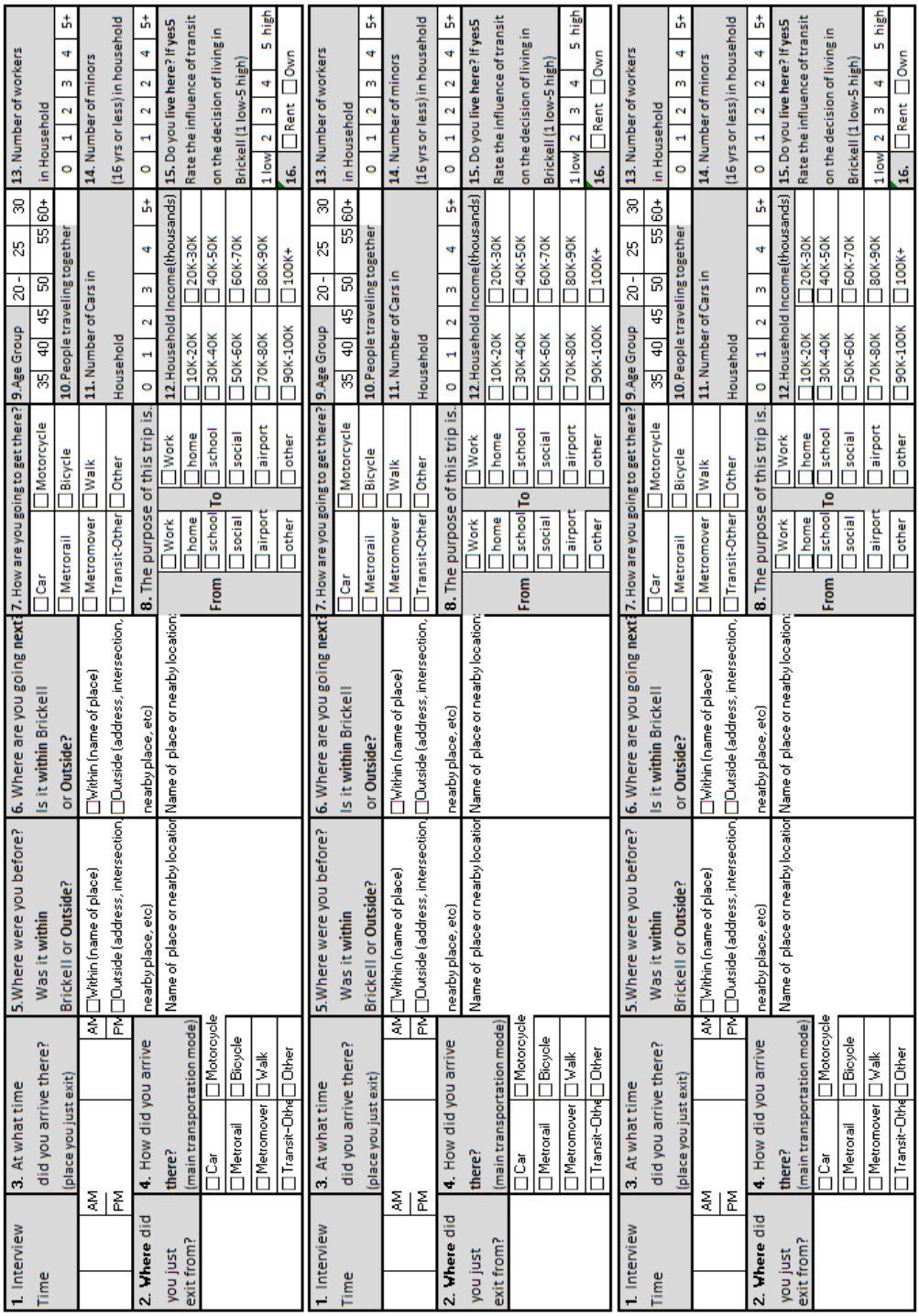
Appendix A: Forms

Intercept Interview Form



1. Interview Time
3. At what time did you arrive there? (place you just exit) AM PM
5. Where were you before? Was it within Brickell or Outside? ☐Within (name of place) ☐Outside (address, intersection, nearby place, etc)
6. Where are you going next? Is it within Brickell or Outside? ☐Within (name of place) ☐Outside (address, intersection, nearby place, etc)
7. How are you going to get there? ☐Car ☐Motorcycle ☐Metrorail ☐Bicycle ☐Metromover ☐Walk ☐Transit-Other ☐Other
9. Age Group: 20- | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60+
10. People traveling together: 0 | 1 | 2 | 3 | 4 | 5+
11. Number of Cars in Household: 0 | 1 | 2 | 3 | 4 | 5+
12. Household Income(thousands): ☐10K-20K ☐20K-30K ☐30K-40K ☐40K-50K ☐50K-60K ☐60K-70K ☐70K-80K ☐80K-90K ☐90K-100K ☐100K+
13. Number of workers in Household: 0 | 1 | 2 | 3 | 4 | 5+
14. Number of minors (16 yrs or less) in household: 0 | 1 | 2 | 3 | 4 | 5+
15. Do you live here? If yes5 Rate the influence of transit on the decision of living in Brickell (1 low-5 high): 1 low | 2 | 3 | 4 | 5 high
16. ☐Rent ☐Own

2. Where did you just exit from? 4. How did you arrive there? (main transportation mode) ☐Car ☐Motorcycle ☐Metrorail ☐Bicycle ☐Metromover ☐Walk ☐Transit-Othe ☐Other
8. The purpose of this trip is. From: ☐Work ☐home ☐school ☐social ☐airport ☐other To: ☐Work ☐home ☐school ☐social ☐airport ☐other
Name of place or nearby location:

1. Interview Time
3. At what time did you arrive there? (place you just exit) AM PM
5. Where were you before? Was it within Brickell or Outside? ☐Within (name of place) ☐Outside (address, intersection, nearby place, etc)
6. Where are you going next? Is it within Brickell or Outside? ☐Within (name of place) ☐Outside (address, intersection, nearby place, etc)
7. How are you going to get there? ☐Car ☐Motorcycle ☐Metrorail ☐Bicycle ☐Metromover ☐Walk ☐Transit-Other ☐Other
9. Age Group: 20- | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60+
10. People traveling together: 0 | 1 | 2 | 3 | 4 | 5+
11. Number of Cars in Household: 0 | 1 | 2 | 3 | 4 | 5+
12. Household Income(thousands): ☐10K-20K ☐20K-30K ☐30K-40K ☐40K-50K ☐50K-60K ☐60K-70K ☐70K-80K ☐80K-90K ☐90K-100K ☐100K+
13. Number of workers in Household: 0 | 1 | 2 | 3 | 4 | 5+
14. Number of minors (16 yrs or less) in household: 0 | 1 | 2 | 3 | 4 | 5+
15. Do you live here? If yes5 Rate the influence of transit on the decision of living in Brickell (1 low-5 high): 1 low | 2 | 3 | 4 | 5 high
16. ☐Rent ☐Own

2. Where did you just exit from? 4. How did you arrive there? (main transportation mode) ☐Car ☐Motorcycle ☐Metrorail ☐Bicycle ☐Metromover ☐Walk ☐Transit-Othe ☐Other
8. The purpose of this trip is. From: ☐Work ☐home ☐school ☐social ☐airport ☐other To: ☐Work ☐home ☐school ☐social ☐airport ☐other
Name of place or nearby location:

1. Interview Time
3. At what time did you arrive there? (place you just exit) AM PM
5. Where were you before? Was it within Brickell or Outside? ☐Within (name of place) ☐Outside (address, intersection, nearby place, etc)
6. Where are you going next? Is it within Brickell or Outside? ☐Within (name of place) ☐Outside (address, intersection, nearby place, etc)
7. How are you going to get there? ☐Car ☐Motorcycle ☐Metrorail ☐Bicycle ☐Metromover ☐Walk ☐Transit-Other ☐Other
9. Age Group: 20- | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60+
10. People traveling together: 0 | 1 | 2 | 3 | 4 | 5+
11. Number of Cars in Household: 0 | 1 | 2 | 3 | 4 | 5+
12. Household Income(thousands): ☐10K-20K ☐20K-30K ☐30K-40K ☐40K-50K ☐50K-60K ☐60K-70K ☐70K-80K ☐80K-90K ☐90K-100K ☐100K+
13. Number of workers in Household: 0 | 1 | 2 | 3 | 4 | 5+
14. Number of minors (16 yrs or less) in household: 0 | 1 | 2 | 3 | 4 | 5+
15. Do you live here? If yes5 Rate the influence of transit on the decision of living in Brickell (1 low-5 high): 1 low | 2 | 3 | 4 | 5 high
16. ☐Rent ☐Own

2. Where did you just exit from? 4. How did you arrive there? (main transportation mode) ☐Car ☐Motorcycle ☐Metrorail ☐Bicycle ☐Metromover ☐Walk ☐Transit-Othe ☐Other
8. The purpose of this trip is. From: ☐Work ☐home ☐school ☐social ☐airport ☐other To: ☐Work ☐home ☐school ☐social ☐airport ☐other
Name of place or nearby location:

Metro Inbound Interview Form

1. Interview	Please tell us about your previous two trips			5. Was that place your main	6. At what time did you arrive at **that place**		9.Number of cars in Household		12.The purpose of
Time	2. Where are you coming from?	3. How did you arrive		**trip start**? If not, could tell us		AM PM	0 1 2 3 4 5+		this trip is...
	Is it **within Brickell or outside?**	from **there**? (main trasnportation mode		your main **trip start**? Yes, Skip to 8	7. How did you get to **that place**?		10.Number of workers in Household		From / To
	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	0 1 2 3 4 5+		☐ work / ☐ work
	☐Outside (address, intersectio	☐ Car-Park Ride	☐ Walk	☐Outside (address, intersection,	☐ Car-Park Ride	☐ Walk	11. Household Income		☐ home / ☐ home
	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	☐ 10,000-20,000	☐ 20,000-30,000	☐ schoo / ☐ school
	Name of the place or location:	☐ Transit-Other	☐ Other	Name of the place or location:	☐ Transit-Other	☐ Other	☐ 30,000-40,000	☐ 40,000-50,000	☐ social / ☐ social
		☐ Motorcycle			☐ Motorcycle		☐ 50,000-60,000	☐ 60,000-70,000	☐ airpor / ☐ airport
		4. Number of people traveling together			8.Number of minors in household (16 or le		☐ 70,000-80,000	☐ 80,000-90,000	☐ other / ☐ other
		1 2 3	4 5+		0 1 2	2 4 5+	☐ 90,000-1000,00	☐ 100,000+	
13. **Residents of Brickell only:**	From 1 (low) to 5 (high) please rate the **influence of**				14.	Rent ☐	15. Age group		
transit in the decision of living in the Brickell Area		1(low) 2 3	4 5 (high)			Own ☐	-20 25 30	35 40 45 50 55 60	65+

1. Interview	2. Where are **you coming from?**	3. How did you arrive		5. Was that place your main	6. At what time did you arrive at **that place**		9.Number of cars in Household		12.The purpose of
Time	Is it **within** Dadeland South	from **there?**		**trip start**? If not, could tell us		AM PM	0 1 2 3 4 5+		this trip is...
	or **Outside?**			your main **trip start?** Yes Skip to	7. How did you get to **that place**?		10.Number of workers in Household		From / To
	☐Within (name of place)	☐ Car-Pick up	☐ Transit-Othe	☐Within (name of place)	☐ Car-Pick up	☐ Transit-Other	0 1 2 3 4 5+		☐ work / ☐ work
	☐Outside (address, intersectio	☐ Car-P&R Metro	☐ Motorcycle	☐Outside (address, intersection,	☐ Car-P&R Metro	☐ Motorcycle	11. Household Income		☐ home / ☐ home
	nearby place, etc)	☐ Car-P&R within DS	☐ Bicycle	nearby place, etc)	☐ Car-P&R within DS	☐ Bicycle	☐ 10,000-20,000	☐ 20,000-30,000	☐ schoo / ☐ school
	Name of the place or location:	☐ Car-P & R Out DS	☐ Walk	Name of the place or location:	☐ Car-P & R Out DS	☐ Walk	☐ 30,000-40,000	☐ 40,000-50,000	☐ social / ☐ social
		☐ Transit-Busway-Max	☐ Other		☐ Transit-Busway-Max	☐ Other	☐ 50,000-60,000	☐ 60,000-70,000	☐ airpor / ☐ airport
		4. Number of people traveling together			8.Number of minors in household (16 or le		☐ 70,000-80,000	☐ 80,000-90,000	☐ other / ☐ other
		1 2 3	4 5+		0 1 2	2 4 5+	☐ 90,000-1000,00	☐ 100,000+	
13. **Residents of Dadeland South only:**	From 1 (low) to 5 (high) please rate the **influence of**				14.	Rent ☐	15. Age group		
transit in the decision of living in the Dadeland South Area		1(low) 2 3	4 5 (high)			Own ☐	-20 25 30	35 40 45 50 55 60	65+

1. Interview	2. Where are **you coming from?**	3. How did you arrive		5. Was that place your main	6. At what time did you arrive at **that place**		9.Number of cars in Household		12.The purpose of
Time	Is it **within** Dadeland South	from **there?**		**trip start**? If not, could tell us		AM PM	0 1 2 3 4 5+		this trip is...
	or **Outside?**			your main **trip start?** Yes Skip to	7. How did you get to **that place**?		10.Number of workers in Household		From / To
	☐Within (name of place)	☐ Car-Pick up	☐ Transit-Othe	☐Within (name of place)	☐ Car-Pick up	☐ Transit-Other	0 1 2 3 4 5+		☐ work / ☐ work
	☐Outside (address, intersectio	☐ Car-P&R Metro	☐ Motorcycle	☐Outside (address, intersection,	☐ Car-P&R Metro	☐ Motorcycle	11. Household Income		☐ home / ☐ home
	nearby place, etc)	☐ Car-P&R within DS	☐ Bicycle	nearby place, etc)	☐ Car-P&R within DS	☐ Bicycle	☐ 10,000-20,000	☐ 20,000-30,000	☐ schoo / ☐ school
	Name of the place or location:	☐ Car-P & R Out DS	☐ Walk	Name of the place or location:	☐ Car-P & R Out DS	☐ Walk	☐ 30,000-40,000	☐ 40,000-50,000	☐ social / ☐ social
		☐ Transit-Busway-Max	☐ Other		☐ Transit-Busway-Max	☐ Other	☐ 50,000-60,000	☐ 60,000-70,000	☐ airpor / ☐ airport
		4. Number of people traveling together			8.Number of minors in household (16 or le		☐ 70,000-80,000	☐ 80,000-90,000	☐ other / ☐ other
		1 2 3	4 5+		0 1 2	2 4 5+	☐ 90,000-1000,00	☐ 100,000+	
13. **Residents of Dadeland South only:**	From 1 (low) to 5 (high) please rate the **influence of**				14.	Rent ☐	15. Age group		
transit in the decision of living in the Dadeland South Area		1(low) 2 3	4 5 (high)			Own ☐	-20 25 30	35 40 45 50 55 60	65+

Metro Outbound Interview Form

1. Interview	Please tell us about your next **two** trips →◯→◯			5. Is that place your **main destination**	6. How are you going		8.Number of cars in Household	11.The pupose of	
Time	2.Where are you going **next?** Is it **within** Brickell or Outside	3. How are you going **to get there?**		If not, could tell us your **main trip destination?** yes skip to 7	to get **there?** (your **main trip** destination)		0 1 2 3 4 5+ / 9.Number of workers in Household	this trip is... From	To
	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	0 1 2 3 4 5+	☐ Work	☐ Work
	☐Outside (address, intersecti	☐ Car-Park Ride	☐ Walk	☐Outside (address, intersection,	☐ Car-Park Ride	☐ Walk	10. Household Income	☐ home	☐ home
	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	☐ 10,000-20,000 ☐ 20,000-30,00	☐ schoo	☐ school
	Name of the place or location:	☐ Transit-Other	☐ Other	Name of the place or location:	☐ Transit-Other	☐ Other	☐ 30,000-40,000 ☐ 40,000-50,00	☐ social	☐ social
		☐ Motorcycle			☐ Motorcycle		☐ 50,000-60,000 ☐ 60,000-70,00	☐ airpor	☐ airport
		4. Number of people traveling together			7.Number of minors in household (16 or less		☐ 70,000-80,000 ☐ 80,000-90,00	☐ other	☐ other
		1 2 3 4 5+			0 1 2 2 4 5+		☐ 90,000-1000,00 ☐ 100,000+		
12. Residents of Brickell only: **transit** in the decision of living in the Brickell Area	From 1 (low) to 5 (high) please rate the **influence of**	1(low) 2 3 4 5 (high)			13. Rent ☐ Own ☐	14. Age group	-20 25 30 35 40 45 50 55 60 65+		

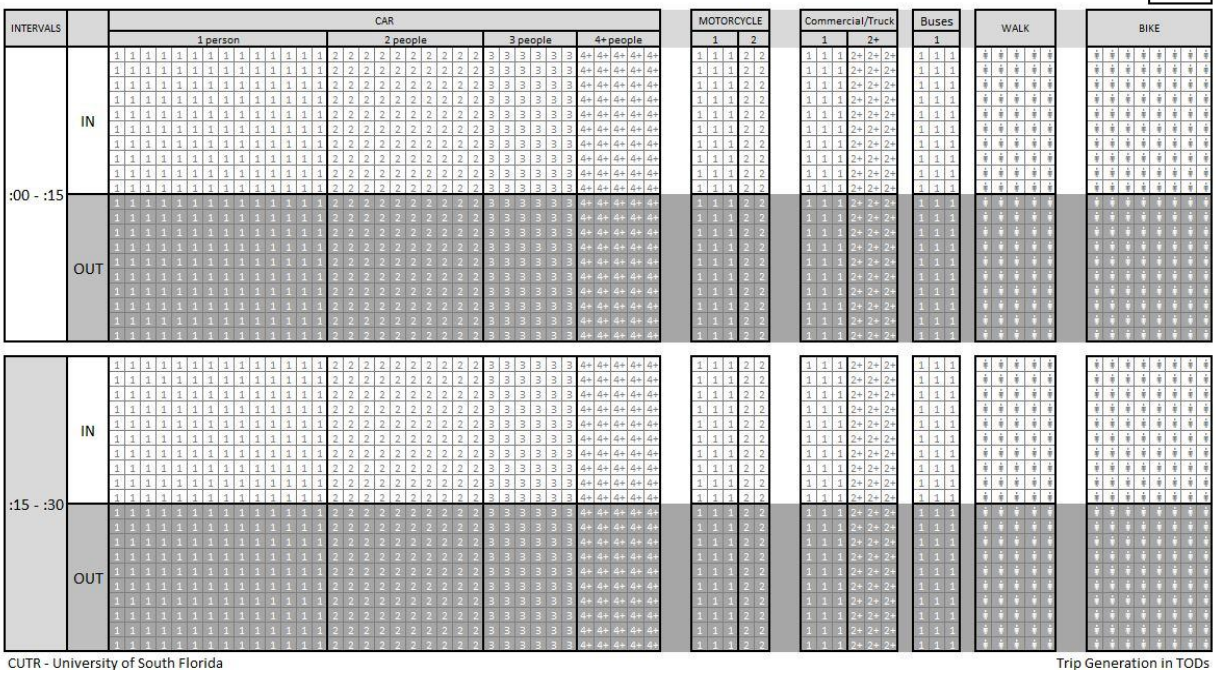
1. Interview	Please tell us about your next **two** trips →◯→◯			5. Is that place your **main destination**	6. How are you going		8.Number of cars in Household	11.The pupose of	
Time	2.Where are you going **next?** Is it **within** Brickell or Outside	3. How are you going **to get there?**		If not, could tell us your **main trip destination?** yes skip to 7	to get **there?** (your **main trip** destination)		0 1 2 3 4 5+ / 9.Number of workers in Household	this trip is... From	To
	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	0 1 2 3 4 5+	☐ Work	☐ Work
	☐Outside (address, intersecti	☐ Car-Park Ride	☐ Walk	☐Outside (address, intersection,	☐ Car-Park Ride	☐ Walk	10. Household Income	☐ home	☐ home
	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	☐ 10,000-20,000 ☐ 20,000-30,00	☐ schoo	☐ school
	Name of the place or location:	☐ Transit-Other	☐ Other	Name of the place or location:	☐ Transit-Other	☐ Other	☐ 30,000-40,000 ☐ 40,000-50,00	☐ social	☐ social
		☐ Motorcycle			☐ Motorcycle		☐ 50,000-60,000 ☐ 60,000-70,00	☐ airpor	☐ airport
		4. Number of people traveling together			7.Number of minors in household (16 or less		☐ 70,000-80,000 ☐ 80,000-90,00	☐ other	☐ other
		1 2 3 4 5+			0 1 2 2 4 5+		☐ 90,000-1000,00 ☐ 100,000+		
12. Residents of Brickell only: **transit** in the decision of living in the Brickell Area	From 1 (low) to 5 (high) please rate the **influence of**	1(low) 2 3 4 5 (high)			13. Rent ☐ Own ☐	14. Age group	-20 25 30 35 40 45 50 55 60 65+		

1. Interview	Please tell us about your next **two** trips →◯→◯			5. Is that place your **main destination**	6. How are you going		8.Number of cars in Household	11.The pupose of	
Time	2.Where are you going **next?** Is it **within** Brickell or Outside	3. How are you going **to get there?**		If not, could tell us your **main trip destination?** yes skip to 7	to get **there?** (your **main trip** destination)		0 1 2 3 4 5+ / 9.Number of workers in Household	this trip is... From	To
	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	☐Within (name of place)	☐ Car-Pick up/Dropoff	☐ Bicycle	0 1 2 3 4 5+	☐ Work	☐ Work
	☐Outside (address, intersecti	☐ Car-Park Ride	☐ Walk	☐Outside (address, intersection,	☐ Car-Park Ride	☐ Walk	10. Household Income	☐ home	☐ home
	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	nearby place, etc)	☐ Transit-Busway-Max	☐ Taxi	☐ 10,000-20,000 ☐ 20,000-30,00	☐ schoo	☐ school
	Name of the place or location:	☐ Transit-Other	☐ Other	Name of the place or location:	☐ Transit-Other	☐ Other	☐ 30,000-40,000 ☐ 40,000-50,00	☐ social	☐ social
		☐ Motorcycle			☐ Motorcycle		☐ 50,000-60,000 ☐ 60,000-70,00	☐ airpor	☐ airport
		4. Number of people traveling together			7.Number of minors in household (16 or less		☐ 70,000-80,000 ☐ 80,000-90,00	☐ other	☐ other
		1 2 3 4 5+			0 1 2 2 4 5+		☐ 90,000-1000,00 ☐ 100,000+		
12. Residents of Brickell only: **transit** in the decision of living in the Brickell Area	From 1 (low) to 5 (high) please rate the **influence of**	1(low) 2 3 4 5 (high)			13. Rent ☐ Own ☐	14. Age group	-20 25 30 35 40 45 50 55 60 65+		

Cordon Count Form

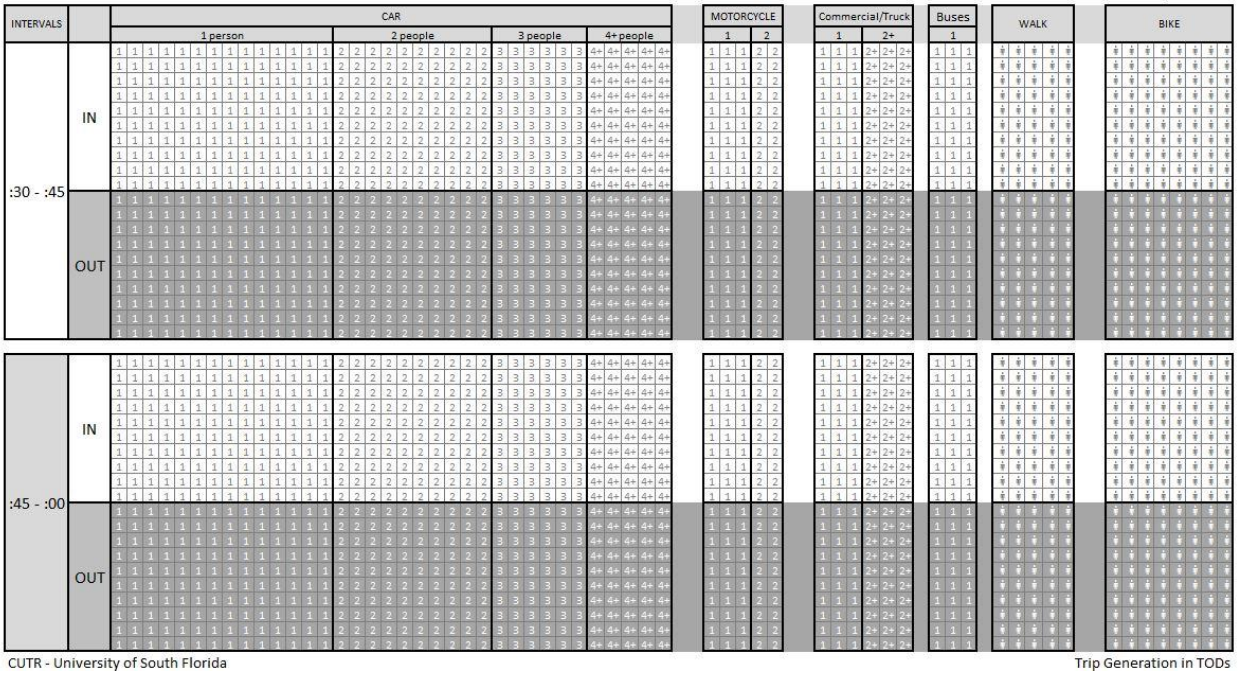
Counter Name: _____ Date: _____

Start Time: _____ Location: _____



Counter Name: _____ Date: _____

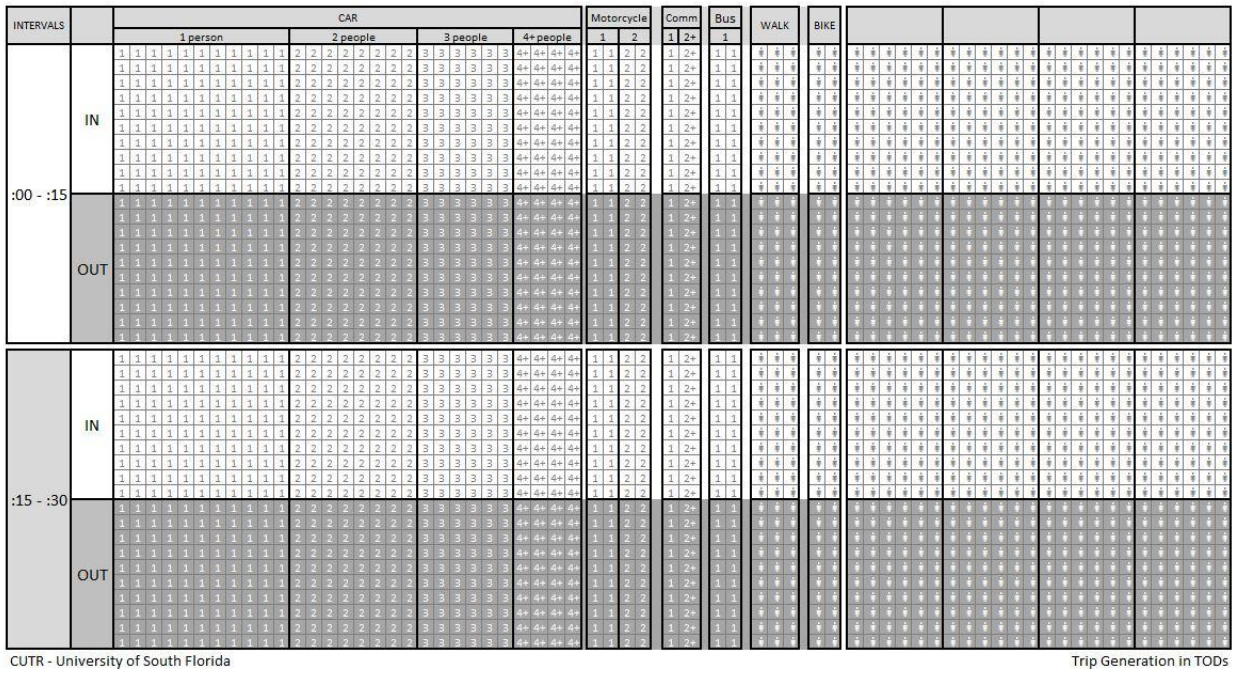
Start Time: _____ Location: _____



Cordon Count with Door Count Form

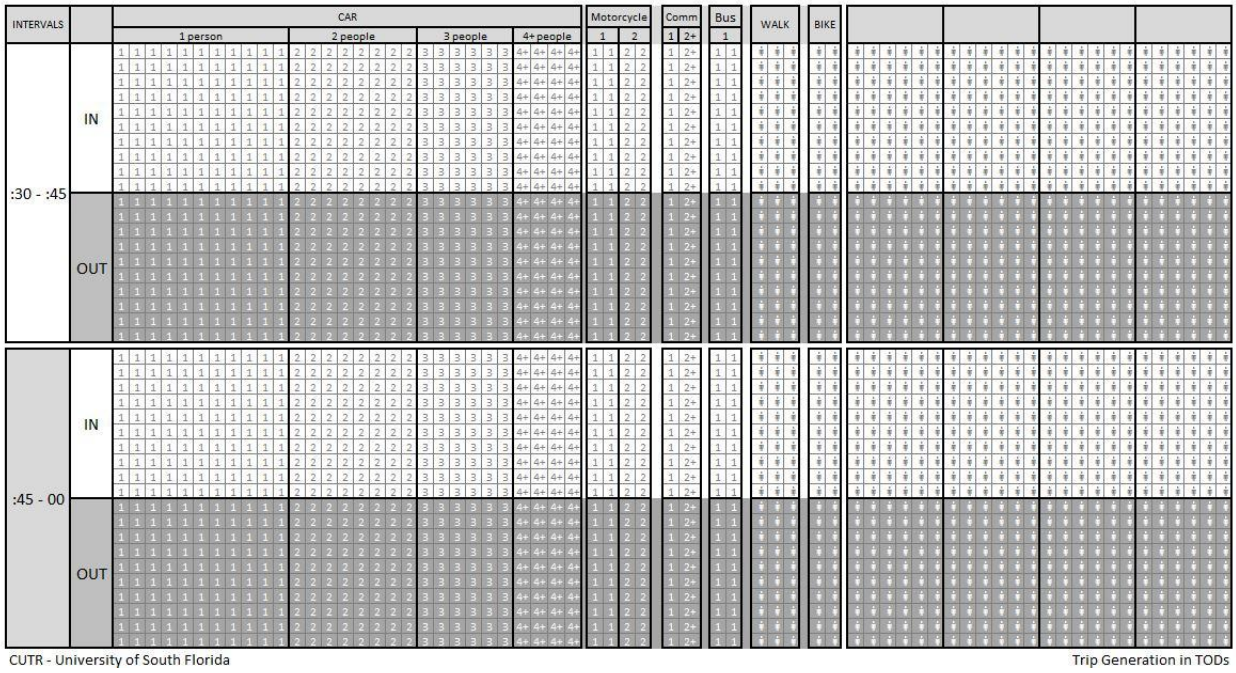
Counter Name: _____ Date: _____ Door Counts

Start Time: _____ Location: _____



Counter Name: _____ Date: _____ Door Counts

Start Time: _____ Location: _____



Column Door Count Form