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Trip Internalization in Multi-Use Developments

April 2014

BDK84-977-10

Final Report

PREPARED FOR:
Florida Department of Transportation

FDOT

Center for Urban Transportation Research
University of South Florida
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Disclaimer

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)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC

Technical Report Documentation

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Internal trip capture refers to how the number trips to and from a development are reduced by the proximity of complementary land uses within the development (e.g., residential to retail). Internal trips occur within the development and do not encumber the traffic flow on the public roadways connecting the development with the transportation network. Internal trip capture rates are used to estimate trip generation on mixed-use developments by adjusting the single land use estimates. These single land use estimates tend to overestimate the trip generation behavior for mixed-use developments. Accurate internal trip capture rate estimates and methodologies are necessary to improve the trip generation estimates for mixed-use developments. Nationwide, there have been efforts to enhance both the data availability and estimation methodologies to estimate internal trip capture rates. In this project, internal trip capture data from four mixed-use developments in Florida were collected and analyzed using a recently-enhanced internal trip capture methodology developed by the National Cooperative Highway Research Program (NCHRP). Results showed that the enhanced methodology produced generally more accurate estimates than those from the traditional ITE internal trip capture procedure. In the NCHRP methodology, the maximum unconstrained internal trip capture rates from land use pairs are chosen in mixed-use developments. Data collected in this project can potentially contribute with 33 percent of these unconstrained internal trip capture rates used in the enhanced methodology for internal trip capture estimation. A series of prediction tests was developed to assess the contribution of the unconstrained internal trip capture rates supplied by this study to the accuracy of the trip generation estimates. It was found that the use of the revised unconstrained internal trip capture rates based on the combined NCHRP and FDOT data improved the prediction capability in five out of eight test cases, with one test case tied. In addition to internal trip capture estimates, this project also collected transportation mode and internal trip length information. Guidance for improving the data collection process and estimation are also provided.</td></tr>
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Executive Summary

Internal trip capture refers to a reduction of trips from and to a development resulting from the proximity of complementary land uses within the development. Trips occur within the development rather than encumbering traffic flow on public roadways outside of the development. Nationwide, there have been efforts to enhance both the data availability and estimation methodologies to estimate internal trip capture rates. The Florida Department of Transportation (FDOT) contracted with the Center for Urban Transportation Research (CUTR) at the University of South Florida to conduct research aimed at obtaining additional quantitative estimates of internal trip capture need to improve current planning practices.

This research examines the internal capture rates of mixed-use developments in Florida in order to ultimately improve the accuracy of trip internalization estimation in the development review process. To achieve this goal, the objectives of the research focused on (1) obtaining additional detailed internal trip capture data for multi-use developments in Florida, (2) analyzing the characteristics of the internal trip capture process, and (3) contributing to the available data on internal trip capture.

Mixed-use developments vary in size, density, and land use composition. As part of this research, developments across Florida were reviewed, and those most representative of mixed-used development (MXD) were selected as candidates for further research. Typical candidate developments commonly contained a mix of interconnected land uses such as offices, restaurants, residential, and retail. Four MXD sites in Central Florida were selected for analysis, including Creekwood in Bradenton, South of Downtown Orlando (SODO) in Orlando, Lakeside Village in Lakeland, and Uptown Altamonte in Altamonte Springs. These sites included traditional suburban developments having single-family detached homes as the main residential component with commercial retail and services located adjacent to the major arterial serving the development and also compact MXDs having neo-traditional residential uses with ground-floor retail.

To prepare internal trip capture estimates, a detailed data collection process was required. The on-site data collection efforts for this study consisted of cordon vehicle counts, door counts, and brief interviews of people exiting various establishments within the development. Data were collected for both AM and PM peak hours. The main output of the data collection process was a set of internal trip capture data between different land uses within the MXDs. These data converted to internal trip capture rates between land uses are inputs for internal trip capture calculations that typically take place when producing trip generation estimates in traffic impact analyses for new developments.

The internal trip capture data from the subject sites were collected and analyzed using a recently-enhanced internal trip capture methodology documented in National Cooperative Highway Research Program (NCHRP) Report 684, “Enhancing Internal Trip Capture Estimation for Mixed-Use Developments.” The recommended estimation method from NCHRP Report 684 built on the Institute of Transportation Engineers (ITE) internal trip capture procedures contained in the second edition of its *Trip Generation Handbook*. The NCHRP method expanded the ITE internal trip capture procedure to cover both AM and PM peak periods, six primary land uses found at MXDs, and proximity of interacting land uses. In the NCHRP enhanced methodology, the maximum unconstrained internal trip capture rates were chosen to represent the interaction between pairs of land uses in mixed-use developments.

Results obtained through this FDOT research (referred to as FDOT 2014) verified that the enhanced NCHRP methodology produced more accurate estimates than the traditional internal trip capture procedure found in the ITE *Trip Generation Handbook*. Data collected for this FDOT research can potentially contribute to 33 percent of the maximum unconstrained internal trip capture rates for the PM peak period recommended by NCHRP Report 684 to enhance the methodology for internal trip capture estimation. The proposed revised unconstrained internal trip capture rates based on the combined FDOT 2014, NCHRP 684, and FDOT 1993 data are shown in Tables ES-1 through ES-4. These values show how much internal capture was achieved by the best balances between interacting land uses during the PM and AM peak periods. These values demonstrated the most unconstrained individual conditions observed at the selected 10 MXDs.

Table ES-1: Proposed Unconstrained Internal Trip Capture Rates for Outbound Trips for PM Peak Period

Origin Land Use From	Destination Land Use To					
	Office	**Retail**	**Restaurant**	**Residential**	**Cinema**	**Hotel**
Office	N/A	20%	4%	24%	0%	3%
Retail	2%	N/A	29%	26%	4%	5%
Restaurant	3%	41%	N/A	18%	8%	7%
Residential	4%	43%	24%	N/A	3%	4%
Cinema	2%	21%	31%	8%	N/A	4%
Hotel	0%	16%	68%	2%	14%	N/A

Table ES-2: Proposed Unconstrained Internal Trip Capture Rates for Inbound Trips for PM Peak Period

Destination Land Use To	Origin Land Use From					
	Office	**Retail**	**Restaurant**	**Residential**	**Cinema**	**Hotel**
Office	N/A	31%	30%	57%	6%	0%
Retail	8%	N/A	50%	10%	4%	2%
Restaurant	3%	29%	N/A	33%	3%	5%
Residential	6%	46%	16%	N/A	4%	1%
Cinema	1%	26%	36%	2%	N/A	2%
Hotel	1%	17%	71%	12%	15%	N/A

Table ES-3: Proposed Unconstrained Internal Trip Capture Rates for Outbound Trips for AM Peak Period

Origin Land Use From	Destination Land Use To					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	28%	63%	35%	N/A	0%
Retail	29%	N/A	14%	17%	N/A	0%
Restaurant	31%	14%	N/A	6%	N/A	8%
Residential	2%	16%	20%	N/A	N/A	0%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	75%	14%	9%	12%	N/A	N/A

Table ES-4: Proposed Unconstrained Internal Trip Capture Rates for Inbound Trips for AM Peak Period

Destination Land Use To	Origin Land Use From					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	4%	14%	3%	N/A	3%
Retail	32%	N/A	8%	39%	N/A	4%
Restaurant	23%	50%	N/A	20%	N/A	7%
Residential	33%	45%	16%	N/A	N/A	9%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	0%	0%	21%	0%	N/A	N/A

A series of prediction tests was developed and conducted in this research to assess the contribution of the internal trip capture rates supplied by this research to the accuracy of trip generation estimates. It was found that the combined data approach (NCHRP+FDOT 2014), which used an updated maximum unconstrained internal trip capture rates based on the expanded database of NCHRP and FDOT 2014, improved the prediction capability in five out of eight test cases, with one test case tied. The results of the tests are presented in Figure ES-1.

In Figure ES-1, the dotted line represents the observed bidirectional cordon counts (e.g., driveway counts) or 100 percent. The prediction errors are expressed as percentages of the observed cordon counts. Values greater than 100 percent represent overestimation of trip generation, and values below 100 percent represent under estimation. As shown in Figure ES-1, the traditional ITE single lane use rates and ITE internal trip capture (ITC) rates tend to significantly overestimate the bidirectional cordon counts of a MXD.

The estimation error was high for the estimators for SODO. This can be the result of several factors, such as unbalanced land use sizes/trip generation rates or overstated single land use rates. It was found that the major reason for a large estimation error was the actual number of trips generated from the specific big-box retail in SODO, which was much less than the number of trips computed using the ITE single land use rate for a big-box retail store.

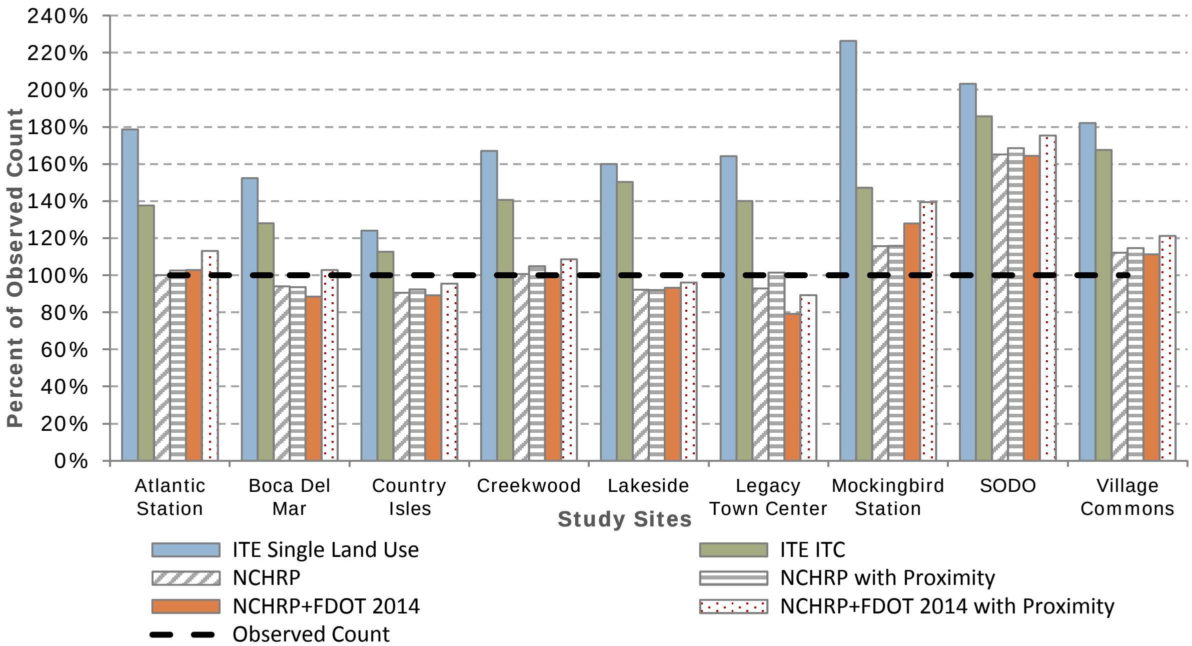

Figure ES-1: Comparison of Cordon Count Estimates (Bidirectional) Using Combinations of Internal Trip Capture Studies

Table ES-5 presents a summary of comparisons on bidirectional vehicle cordon counts estimates for nine selected study sites. The combined data approach (NCHRP+FDOT 2014) using the revised unconstrained internal trip capture rates shows improvement for vehicle cordon counts estimates than the NCHRP-only data approach, NCHRP (684), which uses the unconstrained internal trip capture rates based on the NCHRP-only data.

Table ES-5: Summary of Comparison on Bidirectional Vehicle Cordon Counts Estimates for Study Sites

Development	NCHRP(684)	NCHRP+FDOT 2014	Best Estimate
Atlantic Station	100%	103%	NCHRP
Boca Del Mar	94%	103%	NCHRP+FDOT 2014 with Proximity
Country Isles	92%	96%	NCHRP+FDOT 2014 with Proximity
Creekwood	101%	99%	NCHRP or NCHRP + FDOT 2014 (tie)
Lakeside Village	92%	96%	NCHRP+FDOT 2014 with Proximity
Legacy Town Center	101%	89%	NCHRP with Proximity
Mockingbird Station	116%	128%	NCHRP
SODO	165%	164%	NCHRP+FDOT 2014
Village Commons	112%	111%	NCHRP+FDOT 2014

FINDINGS FROM DATA COLLECTION OF INTERNAL TRIP CAPTURE

- Obtaining permissions from site managers and individual store managers of a mixed-use development to collect the data are the most time-consuming and the most important aspect of a detailed and successful trip internalization study. Training of supervisory personnel and survey crews also plays an important role of the trip internalization study to ensure data quality.
- The minimum data elements needed to perform an internal trip capture study are door counts and interviews for origin and destination locations. Mode split and other data can be collected for further clarification and analysis but are not necessary.
- Performing door counts at as many establishments as possible allows the capture of activity data at the site. This gives more flexibility on data analysis, since the survey data can be expanded to the entire MXD based on activity levels in the trip factoring step.
- The cordon counts of a study on mixed-use development should exclude pass-by traffic of a roadway passing through the development to ensure their accuracy.
- Interviewers should be located on sidewalks for exit interviews, where they have the potential to increase the representation of internal trips. Usually, people who are willing to give interviews on sidewalks within a development have more time to spare since they are headed to internal destinations. On the other hand, parking lot interviews can add balance and generalization to exit interviews.
- In this study, the chronology used in the exit interviews was reversed from the NCHRP order such that it matched the chronology of the trip. First, the interviewer asked for previous trip (inbound) information and, then, for information about the next destination. This significantly improved the collection of data regarding the inbound portion of the trip.

RESULTS OF INTERNAL TRIP CAPTURE STUDY

The internal capture rates for MXDs are usually arbitrarily selected for use throughout the jurisdiction. These rates are most typically in the range of 10 percent, but were found to range between less than 5 percent and more than 25 percent in most transit-oriented developments. Four MXD sites in central Florida were selected in this research project for data collection and analysis. Table ES-6 summarizes the internal capture rates ranging from 9–14 percent for the AM peak period and from 13–16 percent for the PM peak period for these four study sites.

Table ES-6: Summary of Internal Capture Rates for Four Study Sites on Mixed-Use Developments

Mixed-Use Development Site	AM Peak Period			PM Peak Period		
	Inbound	Outbound	Overall	Inbound	Outbound	Overall
Creekwood (Bradenton) - a suburban development with single-family detached residential units on the back end with front-end commercial.	15%	12%	14%	13%	15%	14%
SODO (Orlando) - a compact development with mid-rise residential, medical offices, a big-box retail grocery store, and a variety of ground-floor retail and restaurants.	12%	12%	12%	14%	13%	14%
Lakeside Village (Lakeland) - a lifestyle center (open shopping mall) with a movie theater, hotels, and a direct connection to an apartment complex.	7%	11%	9%	15%	16%	16%
Uptown Altamonte (Altamonte Springs) - combines existing residential, hotel, and shopping centers with new residential and a retail-themed town center.	17%	9%	12%	12%	15%	13%

The major results of this internal trip capture study are provided below.

- The overall internal trip capture rates of the four study MXD sites in Florida for the PM peak period range from 13–16 percent and from 9–14 percent for the AM peak period.

- The internal trip capture rate was higher for the PM peak period in compact developments such as SODO (14%) compared to large developments such as Boca Del Mar (8%). This was observed mainly in the land use pair of residential-retail.

- The overall internal trip capture rates for traditional suburban MXDs during the PM peak period in Florida with front-end commercial and back-end residential in large areas (i.e., Creekwood, 14%) were found to be comparable to those from compacted mixed-use developments (i.e. SODO, 14%).

- This research verified that the NCHRP enhanced internal trip capture method, which included the addition of three primary land uses (restaurant, cinema, hotel) found at MXDs, proximity of interacting land uses, and the use of maximum unconstrained internal trip capture rates, produced more accurate estimates than the previous ITE methods.

- In the NCHRP enhanced methodology, the maximum unconstrained internal trip capture rates were chosen per origin-destination (OD) pair of land uses to represent the maximum interaction between pairs of land uses in MXDs. Before this FDOT research, 93 percent of these rates used for internal trip capture estimation came from NCHRP data and 7 percent from FDOT 1993 data.

- When the internal capture data collected from this FDOT research were added to the existing data collected from the NCHRP 684 and FDOT 1993 studies, the updated maximum interaction rates for PM outbound trips comprised 64 percent NCHRP data, 33 percent FDOT 2014 data, and 3 percent FDOT 1993 data. The updated maximum interaction rates for PM inbound trips comprised 70 percent NCHRP data and 30 percent FDOT 2014 data.

- This FDOT research project produced revised maximum unconstrained internal trip capture rates for further improving the estimation of internal trip capture and the trip generation for an MXD.

- The combined data approach (NCHRP+FDOT 2014) using the revised maximum unconstrained internal trip capture rates improved the prediction capability of the existing data-method combination in five out of eight test cases, with one test case tied.

- The important results of this project were the verification of the NCHRP methodology and the generalization capabilities that can be achieved by the addition of the obtained FDOT 2014 data to previous NCHRP data to continue to improve accuracy of internal trip capture and trip generation for MXDs.

- It is important to note that the previous ITE internal trip capture rates produce significantly higher external trip generation rates for MXDs. The enhanced NCHRP method with the use of the revised maximum unconstrained internal trip capture rates based on NCHRP and FDOT 2014 datasets can significantly improve the prediction capability of internal tips capture for MXDs than those predicted from the previous ITE internal trip capture method.

- Proximity adjustments were used for large developments recommended in NCHRP Report 684 to reflect the interaction decay due to increased distance between land use pairs. This FDOT research project verified the benefit of using the proximity factors for large MXDs and provided a recommendation for when to use the NCHRP proximity factors based on results from the nine test cases in the study. It is recommended that the proximity factors be considered when the area of an MXD is greater than 55 acres.

RECOMMENDATIONS

- A repository of validation data for MXDs should be developed for use in evaluating the predictive capability of current internal trip capture methods. Data should consist of cordon counts, door counts, multimodal origin-destination interviews (as were collected in this study), land use inventory, and land use occupancy.

- Validation data from mixed-use sites should also be gathered and compiled in the same repositories. The same data should be collected, except for interview data. These data should be collected to provide test data to evaluate the predictive capability of current internal trip capture methods.

- More internal trip capture studies should be performed, keeping track of detailed land uses and distances between them. In this way, more land use categories can be added to an internal trip capture database.

- The sample for internal trip capture rates at the OD pair level should be expanded to include, for example, collected data on retail-residential land uses. Data collection personnel can be located at both ends. Reporting on these data should include establishment interviews, door counts, MXD cordon counts, a land use inventory, and a distance matrix.

- NCHRP Report 684 provided generic proximity factors to account for the reduction of internal trips due to the distance between interacting land uses in a large MXD. With the addition of the FDOT 2014 dataset, more proximity data from 3 sites to 7 sites are available for future research. This provides a good opportunity to improve upon the NCHRP 684 proximity adjustment estimation method or develop a new one using the new FDOT data plus the NCHRP data. A further understanding on proximity of land uses within an MXD and proximity of competitive land uses outside the MXD could potentially shed some light for further improvement on internal trip capture prediction capabilities of MXDs.

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1 Introduction

Internal trip capture refers to a reduction of trips from and to a development resulting from the proximity of complementary land uses within the development. Trips occur within the development rather than encumbering traffic flow on public roadways outside of the development. Nationwide, there have been efforts to enhance both the data availability and estimation methodologies to estimate internal trip capture rates. The Florida Department of Transportation (FDOT) contracted with the Center for Urban Transportation Research (CUTR) at the University of South Florida to conduct research aimed at obtaining additional quantitative estimates of internal trip capture need to improve current planning practices.

This research examines the internal capture rates of mixed-use developments in Florida in order to ultimately improve the accuracy of trip internalization estimation in the development review process. To achieve this goal, the objectives of the research focused on (1) obtaining additional detailed internal trip capture data for multi-use developments in Florida, (2) analyzing the characteristics of the internal trip capture process, and (3) contributing to the available data on internal trip capture.

Mixed-use developments vary in size, density, and land use composition. As part of this research, developments across Florida were reviewed, and those most representative of mixed-used development (MXD) were selected as candidates for further research. Typical candidate developments commonly contained a mix of interconnected land uses such as offices, restaurants, residential, and retail. Four MXD sites in Central Florida were selected for analysis including Creekwood in Bradenton, South of Downtown Orlando (SODO) in Orlando, Lakeside Village in Lakeland, and Uptown Altamonte in Altamonte Springs. These sites included traditional suburban developments having single-family detached homes as the main residential component with commercial retail and services located adjacent to the major arterial serving the development and also compact MXDs having neo-traditional residential uses with ground-floor retail.

To prepare internal trip capture estimates, a detailed data collection process was required. The on-site data collection efforts for this study consisted of cordon vehicle counts, door counts, and brief interviews of people exiting various establishments within the development. Data were collected for both AM and PM peak hours. The main output of the data collection process was a set of internal trip capture data between different land uses within the MXDs. These data converted to internal trip capture rates between land uses are inputs for internal trip capture calculations that typically take place when producing trip generation estimates in traffic impact analyses for new developments.

The internal trip capture data from the subject sites were collected and analyzed using a recently-enhanced internal trip capture methodology documented in National Cooperative Highway Research Program (NCHRP) Report 684, “Enhancing Internal Trip Capture Estimation for Mixed-Use Developments.” The recommended estimation method from NCHRP Report 684 built on the ITE internal trip capture procedures contained in the second edition of the Institute of Transportation Engineers (ITE) *Trip Generation Handbook*. The NCHRP method expanded the ITE internal trip capture procedure to cover both AM and PM peak periods, six primary land uses found at MXDs, and proximity of interacting land uses. In the NCHRP enhanced methodology, the maximum unconstrained internal trip capture rates were chosen to represent the interaction between pairs of land uses in mixed-use developments.

Results obtained through this FDOT research (referred to as FDOT 2014 in this report) verified that the enhanced NCHRP methodology produced more accurate estimates than the traditional internal trip capture procedure found in the ITE *Trip Generation Handbook*. Data collected for this FDOT research can potentially contribute to 30 percent of the maximum unconstrained internal trip capture rates for the PM peak period recommended by NCHRP Report 684 to enhance the methodology for internal trip capture estimation.

This report is organized as follows. Chapter 2 presents a review of the most relevant work on internal trip capture. Chapter 3 introduces the concepts of internal trip capture and describes the methodology to collect internal trip capture data. Chapter 4 describes the study sites for internal capture data collection and presents the internal trip capture estimates for each of the four selected study sites. Analysis and comparisons of the results from this study with those from other trip generation studies are presented in Chapter 5. Chapter 6 contains conclusions and recommendations for the application of the data collected in this study.

2 Summary of Related Studies

Much work has been done on the topic of trip generation; however, much less work is available regarding the internal trip capture of mixed-use developments. This chapter presents previous and ongoing studies and research initiatives in trip generation, specifically on topics pertaining to internal trip capture. While the studies of trip generation are extensive and, in the case of MXD, are often associated with transit-oriented developments (TODs), this study focused on trip internalization in MXDs where the presence of a transit element was not requirement. Variations in land use mix and compactness were variable factors among the study MXDs. The concept of MXDs is introduced, followed by an overview of previous research on internal trip capture urban infill trip generation.

2.1 Trip Generation

Trip generation is the first step in the four-step transportation demand modeling process (trip generation, trip distribution, mode choice, and trip assignment) and 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 found in the U.S. Census and travel diaries such as, the National Household Travel Survey (NHTS). Travel demand models are constantly evolving from trip-based isolated steps to 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 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 Handbook* [1]. Published, maintained, and updated by ITE, *Trip Generation* [2] provides vehicle trip generation 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 roadway system. The application of ITE’s trip generation rates requires only land use characteristics representing the size of the land use. For example, residential developments require residential dwelling units, hotels require number of rooms, and retail requires gross leasable area (square footage). Because the requirement for using this approach requires only one characteristic, the application of the ITE methodology can easily 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.

ITE's method in the *Trip Generation Handbook* [1] are the preferred alternative for estimating trip generation for new developments largely due to simple data requirements and provide a common ground for transportation agencies and developers. 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 of specialized equipment or software to be applied
- Widely accepted

The disadvantages of 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 life cycle 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) have influenced some travel patterns common in the 1980s and 1990s. In addition, some geographic-specific data are lost when all 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, such as the Cloud-based business system Online Traffic Impact Study Software (OTISS) [3]. 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. When updating trip generation data, it is important to collect metadata on the context surrounding the collected data to enable further initiatives on data mining and enhance the quality for future trip generation estimates.

2.2 Mixed-Use Developments

ITE's *Trip Generation Handbook* [1] refers to MXDs as multi-use developments, defined as single real-estate projects that consist of two or more ITE land-use classifications between which trips can be made without using the off-site road system. ITE provides further description for multi-use developments in its *Trip Generation Handbook* [1]:

- Planned as single-real estate projects
- Between 100,000 and 2 million sq. ft. in size
- Contain 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, or 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 [4]. NCHRP Report 684 [5] identifies 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 applies to what ITE defines as multi-use developments. The abbreviation 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 into an 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 within MXDs 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 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 [6]. The most integrated residential components have interactive mixed uses within same buildings—sometimes mid- to high-rise buildings. MXDs that include these residential land uses have the greatest potential to increase overall development density and offer an improved internal connectivity.

A development with aspects related to the MXDs is the transit-oriented developments (TODs). Although there is no universally-accepted definition of a TOD, Cervero et al. [7] state that 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. *Trip Generation* [2] identifies the TOD trip generation aspect as an area for further research and improvement. Although TODs are not the focus of this study, they share many of the design features of MXDs. NCHRP 684 [5] includes internal trip capture studies on several locations, two of which often are 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 within an MXD 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 by walking or by bicycle or other vehicles, with the only restriction being that only internal roads are used.

The application of the internal trip capture concept in trip generation is performed through ITE 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 internal to the site [1]. Additional explanations of the concepts pertaining to internal trip capture, such as 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 at the initiative of FDOT by Tindale-Oliver & Associates, Inc., in 1993 [8] and Walter H. Keller, Inc., in 1995 [9]. The 1993 study produced daily ITC rates ranging from 28–33 percent and PM ITC rates ranging from 7–24 percent. The data from these studies were used to produce the current ITE ITC rates in the *Trip Generation Handbook* [1]. Additional trip generation studies have been carried out by various states to serve different purposes but there are very few studies on internal capture at the development level. NCHRP Report 684 [5] provides an extensive review of internal trip capture studies, including the 1993 and 1995 studies, and also contains reviews of the current trends in traffic impact analyses and MXD design at the national level. In addition to NCHRP Report 684 [5], ITE provides links to finished and ongoing research on the subject of trip generation [10].

A study by Kittelson and Associates in 2008 [11] 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 [11].

Ewing et al. [12] collected trip-making patterns from six developments using data from the NHTS. The study identified 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. Ewing's 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 in NCHRP Report 684 [5]). 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; in Ewing's method, r^2 was 0.92. Ewing's methodology was implemented through a spreadsheet that is hosted on the U.S. Environmental Protection Agency (EPA) website and available for download [13].

The method proposed by Ewing constitutes an alternative method to analyze trip-making behavior aspects including internal trip capture. Notably, it requires more inputs than the conventional ITE method for site impact analyses not all of which are typically available at time of rezoning or development approval. This is especially important from the point of view of transportation agencies responsible for the review and approval of new developments.

In NCHPR Report 684 [5], Bochner et al. 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 (e.g., driveway 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 periods. The reported internal trip capture rates for the AM peak period ranged from 11–31 percent, and for the PM peak period, 33–44 percent.

NCHRP Report 684 [5] 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 provided in the ITE *Trip Generation Handbook* [1] 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.

2.4 FDOT District 2 Study

URS [14] performed an internal trip capture study in four MXDs 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 peak period and 30 percent in the PM peak 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 and collected daily cordon counts and interview data. The number of interviews for daily internal trip capture estimation was substantial, and 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) [15], 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 Handbook* [1] are not recommended for DRI analyses. This research focused 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 (OD) studies, trip generation studies, and evaluation of land uses mixes in the community and its surroundings are part of the community capture methodology.

Table 2-1: Bi-Directional Internal Trip Capture Rates from FDOT District 2 Study

Land Use Pair	Commercial-Residential	Residential-Office	Office-Commercial
Haile Plantation	61%	8%	31%
Magnolia Parke	75%	19%	6%
Palencia Site	60%	0%	40%
Tioga Site	70%	9%	21%

2.5 Urban Infill Trip Generation Rates

The needs from trip generation data vary across states based on their particular development patterns and trends. For new 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 [16] developed trip generation rates applicable for urban infill land uses. This study became NCHRP Report 758, "Trip Generation Rates for Transportation Impact Analysis of Infill Developments" [17]. Such 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, the standard ITE trip rates tend to overestimate trip generation estimates for infill developments. This is a developing area of study that would benefit from additional trip generation studies focused on land uses immersed in urbanized environments.

2.6 Summary

- Traditionally, trip rates and single variable regression equations based on single-use free-standing suburban sites have been the preferred method to perform trip generation estimation due to the widespread availability of the data and methodology. Recent trends in MXDs have highlighted the need to improve existing trip generation methodologies to accommodate the effects of proximity among diverse land uses.

- In Florida, two main internal trip capture methods or principles are commonly used. For site impact analyses, internal trip capture methods described in ITE's *Trip Generation Handbook* [1] and NCHRP Report 684 [5] are the accepted practice.

- Calculation of internal trip capture depends on several factors in addition to size and density; proximity and surrounding environment have been cited as relevant factors, and methodological improvements have been developed to accommodate proximity effects. The inclusion of these additional factors in the ITE trip generation estimation procedure described in the ITE *Trip Generation Handbook* [1] 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 reported daily internal trip capture rates of 28–33 percent and 7-24 percent for the PM peak period. Later studies, such as NCHRP Report 684 [5], reported internal trip capture rates varying from 11–33 percent for the AM peak period and 33–44 percent for the PM peak period. As more studies and data become available, the existing data and methodology become more reliable and can gain more credibility.

- 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 that the life cycle of trip generation data be analyzed to determine when more data are required and to provide a quality metric for aging data.

3 Internal Trip Capture Concepts and Data Collection Methodology

This chapter provides a general description of trip generation concepts, including trip generation estimation, internal trip capture, and pass-by trips. Data collection methodologies for internal trip capture studies are introduced, including study process, data requirement and data analysis. Lessons learned from this research project on internal trip capture data collection are also provided.

3.1 Trip Generation, Pass-by Trips, and Internal Trips

Trip-making behavior is a complex process and is subject to continuous study. The decision to make a trip depends on several factors, such as socio-economic attributes of the individual, the built environment, and transportation network characteristics. This research focused on the study of internal trip capture as a component of trip generation for MXDs. Data requirements include physical characteristics of a proposed development, such as land use type, which are generally available at the planning stage.

Data collection and data generalization are key requirements in developing trip generation rates using land use characteristics. Data collection involves obtaining trip counts that reflect the trip generation activity of the subject land use. Data transferability is related to the validity of the collected data and how well the estimated trip rates reflect or emulate the actual trip generation for the subject land use.

To accommodate these requirements, vehicle cordon counts for single-use free-standing sites have traditionally been used by ITE and others to derive trip generation rates. As such, trip generation rates in the current ITE *Trip Generation* [2] are based on an automobile-centered transportation system predominantly representing vehicle trips. These trip generation rates have been widely accepted since they reflect the need of individuals to make a defined trip to the land use of interest and the availability of the data and methodology.

ITE has refined its methodology and some of the existing trip generation rates over time to improve their applicability to traffic impact studies. In their pure form, trip rates derived from driveway cordon counts for single-use sites contain all types of trips that a land use potentially can generate (e.g., external, internal, pass-by, diverted). However, the traffic impact of a new development is measured only by the net new trips that the development generates. Thus, ITE's first refinement consisted of enhancing the ability of the ITE trip rates to predict net new traffic (see Figure 3-1) by incorporating pass-by trips. Details about the pass-by trip methodology can be found in Chapter 5 of the ITE *Trip Generation Handbook* [1].

Additional refinements or enhancements to the methodology are required for situations when two or more land uses are placed in close proximity within a master-planned development, as depicted in Figure 3-2.

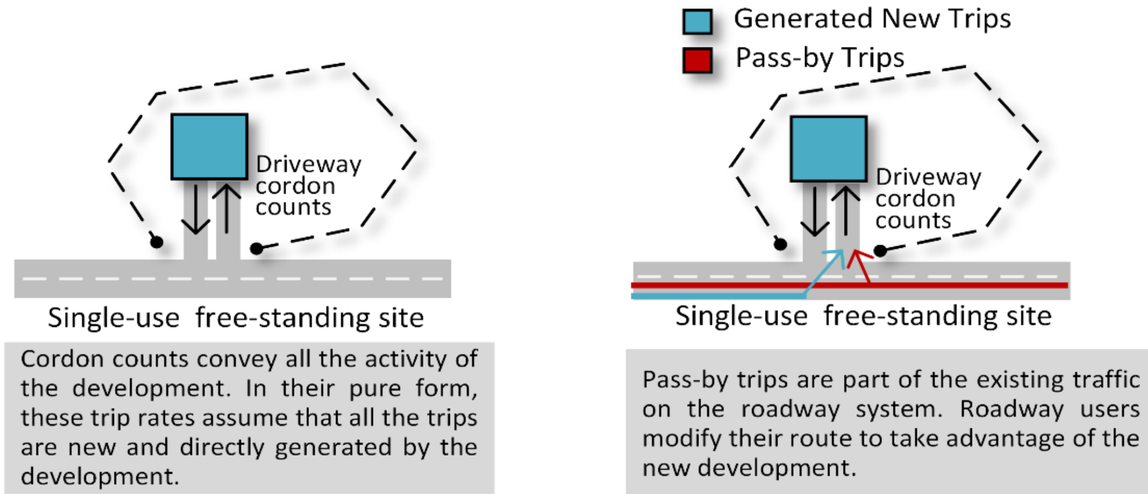


Figure 3-1: ITE Trip Rates and Pass-by Trips

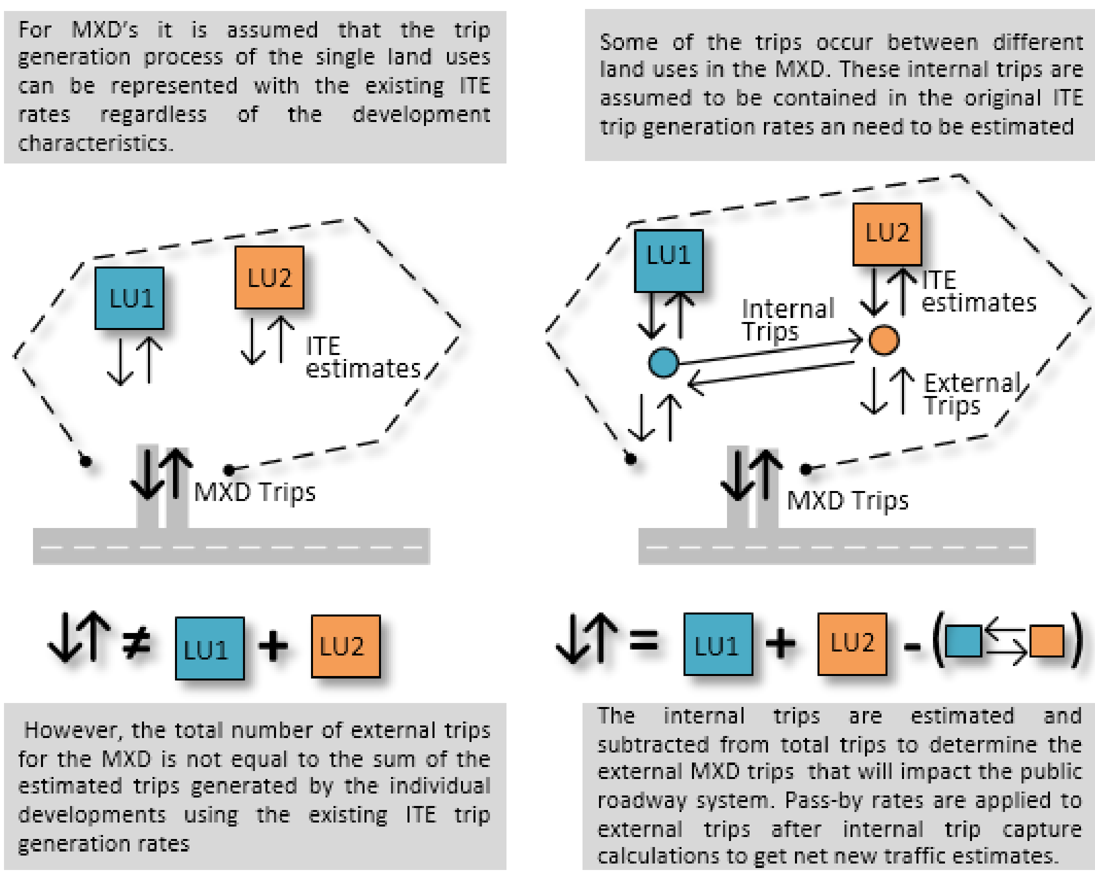


Figure 3-2: Internal Trip Capture Concepts

In cases where two or more interacting land uses are placed in close proximity within a master-planned development, net trips generated by the development as whole may not be equal to the sum of estimated trips generated by the individual land uses (calculated with the existing ITE trip generation rates). The key assumptions underlying ITE's the internal trip capture or pass-by trip procedure include the following:

1. Existing trip generation rates derived from driveway cordon counts reflect all trip types that a land use potentially can generate (e.g., external, internal, pass-by, diverted, walking, etc.) and are a function of the land use type, size, and time of day.

2. The trip generation characteristics for a single land use can be represented by the existing ITE rates regardless of the characteristics of the development in which it is located.

3. The trips between land uses of the same type in an MXD are excluded from the internal trip capture estimation procedure.

These assumptions are implicit in the application of the internal trip capture procedure. The internal trip capture procedure starts with the estimation of trip generation rates for individual land uses. Internal trip capture rates between land uses are then applied to obtain the trip distribution among land uses in the MXD. Finally, a trip balancing rule is applied to obtain internal/external trip capture estimates. The internal trip capture procedure, explained in detail below, is summarized in the following four steps:

1. Estimate trip generation for individual land uses.
2. Apply internal trip capture rate factors for trips entering (inbound) and departing (outbound) each land use (internal trip distribution).
3. Balance internal capture between sending and receiving land uses (balance internal trip making).
4. Calculate internal/external trips (external trip estimation).

The first two of the previously-mentioned assumptions apply to Step 1. First, the internal trip capture rates reflect all types of trips that are generated by a land use. Second, since these rates are applied to individual land uses in an MXD, it is implicitly assumed that development characteristics such as size will not affect trip generation for a particular land use. Based on these assumptions, the internal trips that occur between different land uses within an MXD need to be estimated and subtracted from the initial trip estimates (see Figure 3-2).

The third assumption is intended to keep a consistent trip estimation with the ITE trip generation rates. Trip generation of the same land use have the same purpose and is accounted for in the existing ITE rates. For instance, if there is a trip from retail to retail in a particular development, it may not exist or apply to another trip because there may be a different, perhaps larger, retailer that can supply the needs for these two trips. This also is explained by the assumption that states that the trip generation process depends on the land use type, size, and time of day.

The sum of trips estimated for individual land uses within an MXD using the methodology provided in the ITE *Trip Generation Handbook* [1] is expected to be greater than the external trips generated by the MXD as whole (e.g., per cordon or driveway counts). Once the internal trips are estimated then subtracted from the total number of trips for the individual land uses of the MXD, the resulting new external trip estimate can be compared with the MXD cordon counts. Further trip reductions can be obtained by applying pass-by rates to the external trip estimates.

Internal trip capture rates are estimated for both entering and exiting trips based on data collected via surveys. Single land use trip generation estimates from ITE are adjusted by applying an internal trip capture factor. These factors are published by ITE and can be found in Chapter 7 of the ITE *Trip Generation Handbook* [1]. Internal trips are estimated by land use pairs based on the unconstrained internal trip capture rates shown in Tables Table 3-1 and Table 3-2. These rates are based on observed data from three sites in Florida in 1993. A recent effort to contribute to the existing data on internal trip capture can be found in NCHRP Report 684 [5], including a proposed revision of unconstrained internal trip capture rates. Table 3-3 and Table 3-4 show examples of proposed unconstrained internal trip capture rates for the PM peak period.

Table 3-1: Unconstrained Internal Trip Capture Rates for Trip Origins within an MXD

From	To	Midday Peak Hour	PM Peak Hour, Adjacent Street Traffic	Daily
From Office	To Office	2%	1%	2%
	To Retail	20%	23%	22%
	To Residential	0%	2%	2%
From Retail	To Office	3%	3%	3%
	To Retail	29%	20%	30%
	To Residential	7%	12%	11%
From Residential	To Office	N/A	N/A	N/A
	To Retail	34%	53%	38%
	To Residential	N/A	N/A	N/A

Source: [1], Table 7.1

Table 3-2: Unconstrained Internal Trip Capture Rates for Trip Destinations within an MXD

To	From	Midday Peak Hour	PM Peak Hour, Adjacent Street Traffic	Daily
To Office	From Office	6%	6%	2%
	From Retail	38%	31%	15%
	From Residential	0%	0%	N/A
To Retail	From Office	4%	2%	4%
	From Retail	31%	20%	28%
	From Residential	5%	9%	9%
To Residential	From Office	0%	2%	3%
	From Retail	37%	31%	33%
	From Residential	N/A	N/A	N/A

Source: [1], Table 7.2

Table 3-3: Unconstrained Internal Trip Capture Rates Proposed by NCHRP for Outbound Trips for PM Peak Period

Origin Land Use From	Destination Land Use[1] To					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	20%	4%	2%	0%	0%
Retail	2%	N/A	29%	26%	4%	5%
Restaurant	3%	41%	N/A	18%	8%	7%
Residential	4%	42%	21%	N/A	0%	3%
Cinema	2%	21%	31%	8%	N/A	2%
Hotel	0%	16%	68%	2%	0%	N/A

[1] Corresponds to ITE Trip Generation *Handbook* Table 7.1: N/A signifies no data or interchanges within same land use categories that accounted for within trip generation rates.

Table 3-4: Unconstrained Internal Trip Capture Rates Proposed by NCHRP for Inbound Trips for PM Peak Period

Destination Land Use To	Origin Land Use[1] From					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	31%	30%	57%	6%	0%
Retail	8%	N/A	50%	10%	4%	2%
Restaurant	2%	29%	N/A	14%	3%	5%
Residential	4%	46%	16%	N/A	4%	0%
Cinema	1%	26%	32%	0%	N/A	0%
Hotel	0%	17%	71%	12%	1%	N/A

[1] Corresponds to ITE *Trip Generation Handbook* Table 7.1: N/A signifies no data or interchanges within same land use categories that accounted for within trip generation rates.

NCHRP Report 684 [5] was accompanied by an Excel spreadsheet workbook to automate the computations of internal trip capture. It is intended that the spreadsheet be used to perform computations. The proximity factors were introduced by the NCHRP Report 684 [5] to reflect the interaction decay due to increased distance between land use pairs. The proximity effects were also included into the same spreadsheet, the factors being from all land uses to residential and only applicable to the trip origin end; from office to retail or restaurant, applicable to both trip ends; and from residential to retail or restaurant, applicable at both trip ends. Table 3-5 and Table 3-6 show the NCHRP estimator with updated values in the ITE *Trip Generation Handbook* [1] with proximity adjustment factors for outbound and inbound trips, respectively. As explained above the highlighted cells in Table 3-5 and Table 3-6 are the factors that NCHRP developed to account for the proximity effects. The estimator—either automated or manual—was designed to have a cover sheet that contains all input and output of interest, with lookup data and intermediate computations on the subsequent spreadsheets.

Table 3-5: NCHRP Estimator Updated ITE *Trip Generation Handbook* Table 7.1 with Proximity Adjustment

Unconstrained Internal Trip Capture Rates for Trip Origins within a Multi-Use Development				Proximity Adjustment	
Land Use Pairs		Weekday			
		AM Peak Hour	PM Peak Hour	AM	PM
From Office	To Office	0%	0%	1.000	1.000
	To Retail	28%	20%	1.000	0.100
	To Restaurant	63%	4%	1.000	0.100
	To Cinema/Entertainment	0%	0%	1.000	1.000
	To Residential	1%	2%	1.000	0.100
	To Hotel	0%	0%	1.000	1.000
From Retail	To Office	29%	2%	1.000	1.000
	To Retail	0%	0%	1.000	1.000
	To Restaurant	13%	29%	1.000	1.000
	To Cinema/Entertainment	0%	4%	1.000	1.000
	To Residential	14%	26%	1.000	1.000
	To Hotel	0%	5%	1.000	1.000
From Restaurant	To Office	31%	3%	1.000	1.000
	To Retail	14%	41%	1.000	1.000
	To Restaurant	0%	0%	1.000	1.000
	To Cinema/Entertainment	0%	8%	1.000	1.000
	To Residential	4%	18%	1.000	1.000
	To Hotel	3%	7%	1.000	1.000
From Cinema/ Entertainment	To Office	0%	2%	1.000	1.000
	To Retail	0%	21%	1.000	1.000
	To Restaurant	0%	31%	1.000	1.000
	To Cinema/Entertainment	0%	0%	1.000	1.000
	To Residential	0%	8%	1.000	1.000
	To Hotel	0%	2%	1.000	1.000
From Residential	To Office	2%	4%	1.000	1.000
	To Retail	1%	42%	1.000	0.100
	To Restaurant	20%	21%	1.000	0.847
	To Cinema/Entertainment	0%	0%	1.000	1.000
	To Residential	0%	0%	1.000	1.000
	To Hotel	0%	3%	1.000	1.000
From Hotel	To Office	75%	0%	1.000	1.000
	To Retail	14%	16%	1.000	1.000
	To Restaurant	9%	68%	1.000	1.000
	To Cinema/Entertainment	0%	0%	1.000	1.000
	To Residential	0%	2%	1.000	1.000
	To Hotel	0%	0%	1.000	1.000

Adjusted Internal Trip Capture Rates for Trip Origins within a Multi-Use Development			
Land Use Pairs		Weekday	
		AM Peak Hour	PM Peak Hour
From Office	To Office	0.0%	0.0%
	To Retail	28.0%	2.0%
	To Restaurant	63.0%	2.0%
	To Cinema/Entertainment	0.0%	0.0%
	To Residential	1.0%	2.0%
	To Hotel	0.0%	0.0%
From Retail	To Office	29.0%	2.0%
	To Retail	0.0%	0.0%
	To Restaurant	13.0%	29.0%
	To Cinema/Entertainment	0.0%	4.0%
	To Residential	14.0%	26.0%
	To Hotel	0.0%	5.0%
From Restaurant	To Office	31.0%	3.0%
	To Retail	14.0%	41.0%
	To Restaurant	0.0%	0.0%
	To Cinema/Entertainment	0.0%	8.0%
	To Residential	4.0%	18.0%
	To Hotel	3.0%	7.0%
From Cinema/ Entertainment	To Office	0.0%	2.0%
	To Retail	0.0%	21.0%
	To Restaurant	0.0%	31.0%
	To Cinema/Entertainment	0.0%	0.0%
	To Residential	0.0%	8.0%
	To Hotel	0.0%	2.0%
From Residential	To Office	2.0%	4.0%
	To Retail	1.0%	4.2%
	To Restaurant	20.0%	17.8%
	To Cinema/Entertainment	0.0%	0.0%
	To Residential	0.0%	0.0%
	To Hotel	0.0%	3.0%
From Hotel	To Office	75.0%	0.0%
	To Retail	14.0%	16.0%
	To Restaurant	9.0%	68.0%
	To Cinema/Entertainment	0.0%	0.0%
	To Residential	0.0%	2.0%
	To Hotel	0.0%	0.0%

Table 3-6: NCHRP Estimator Updated ITE *Trip Generation Handbook* Table 7.2 with Proximity Adjustment

Unconstrained Internal Trip Capture Rates for Trip Destinations within a Multi-Use Development				Proximity Adjustment	
Land Use Pairs		Weekday			
		AM Peak Hour	PM Peak Hour	AM	PM
To Office	From Office	0%	0%	1.000	1.000
	From Retail	4%	31%	1.000	1.000
	From Restaurant	14%	30%	1.000	1.000
	From Cinema/Entertainment	0%	6%	1.000	1.000
	From Residential	3%	57%	1.000	1.000
	From Hotel	3%	0%	1.000	1.000
To Retail	From Office	32%	8%	1.000	0.100
	From Retail	0%	0%	1.000	1.000
	From Restaurant	8%	50%	1.000	1.000
	From Cinema/Entertainment	0%	4%	1.000	1.000
	From Residential	17%	10%	1.000	0.100
	From Hotel	4%	2%	1.000	1.000
To Restaurant	From Office	23%	2%	1.000	0.100
	From Retail	50%	29%	1.000	1.000
	From Restaurant	0%	0%	1.000	1.000
	From Cinema/Entertainment	0%	3%	1.000	1.000
	From Residential	20%	14%	1.000	0.847
	From Hotel	6%	5%	1.000	1.000
To Cinema/ Entertainment	From Office	0%	1%	1.000	1.000
	From Retail	0%	26%	1.000	1.000
	From Restaurant	0%	32%	1.000	1.000
	From Cinema/Entertainment	0%	0%	1.000	1.000
	From Residential	0%	0%	1.000	1.000
	From Hotel	0%	0%	1.000	1.000
To Residential	From Office	0%	4%	1.000	1.000
	From Retail	2%	46%	1.000	1.000
	From Restaurant	5%	16%	1.000	1.000
	From Cinema/Entertainment	0%	4%	1.000	1.000
	From Residential	0%	0%	1.000	1.000
	From Hotel	0%	3%	1.000	1.000
To Hotel	From Office	0%	0%	1.000	1.000
	From Retail	0%	17%	1.000	1.000
	From Restaurant	4%	71%	1.000	1.000
	From Cinema/Entertainment	0%	1%	1.000	1.000
	From Residential	0%	12%	1.000	1.000
	From Hotel	0%	0%	1.000	1.000

Adjusted Internal Trip Capture Rates for Trip Destinations within a Multi-Use Development			
Land Use Pairs		Weekday	
		AM Peak Hour	PM Peak Hour
To Office	From Office	0.0%	0.0%
	From Retail	4.0%	31.0%
	From Restaurant	14.0%	30.0%
	From Cinema/Entertainment	0.0%	6.0%
	From Residential	3.0%	57.0%
	From Hotel	3.0%	0.0%
To Retail	From Office	32.0%	2.0%
	From Retail	0.0%	0.0%
	From Restaurant	8.0%	50.0%
	From Cinema/Entertainment	0.0%	4.0%
	From Residential	17.0%	2.0%
	From Hotel	0.0%	2.0%
To Restaurant	From Office	23.0%	2.0%
	From Retail	50.0%	29.0%
	From Restaurant	0.0%	0.0%
	From Cinema/Entertainment	0.0%	3.0%
	From Residential	20.0%	11.9%
	From Hotel	6.0%	5.0%
To Cinema/ Entertainment	From Office	0.0%	1.0%
	From Retail	0.0%	26.0%
	From Restaurant	0.0%	32.0%
	From Cinema/Entertainment	0.0%	0.0%
	From Residential	0.0%	0.0%
	From Hotel	0.0%	0.0%
To Residential	From Office	0.0%	4.0%
	From Retail	2.0%	46.0%
	From Restaurant	5.0%	16.0%
	From Cinema/Entertainment	0.0%	4.0%
	From Residential	0.0%	0.0%
	From Hotel	0.0%	3.0%
To Hotel	From Office	0.0%	0.0%
	From Retail	0.0%	17.0%
	From Restaurant	4.0%	71.0%
	From Cinema/Entertainment	0.0%	1.0%
	From Residential	0.0%	12.0%
	From Hotel	0.0%	0.0%

As previously noted, the entering (inbound) and exiting (outbound) trips for each individual land use within an MXD are estimated separately using ITE trip generation rates. The internal trip capture procedure is applied from the standpoint of an origin or destination. Origin trip rates are applied to outbound trips estimates. For instance, if an office building has an estimate of 500 outbound trips, then, according to Table 7.1 in the ITE *Trip Generation Handbook* [1] as shown in Table 3-1, 23 percent (115) of them go to retail during the PM peak hour. Similarly, the destination rates are applied to inbound trip estimates. From the destination standpoint, if a retail land use has 400 trips inbound during the PM peak hour, then 2 percent (8) of them are coming from office, according to Table 7.2 of the *Trip Generation Handbook* [1], as shown in Table 3-2. These rates constitute the unconstrained internal trip distribution (see Figure 3-3).

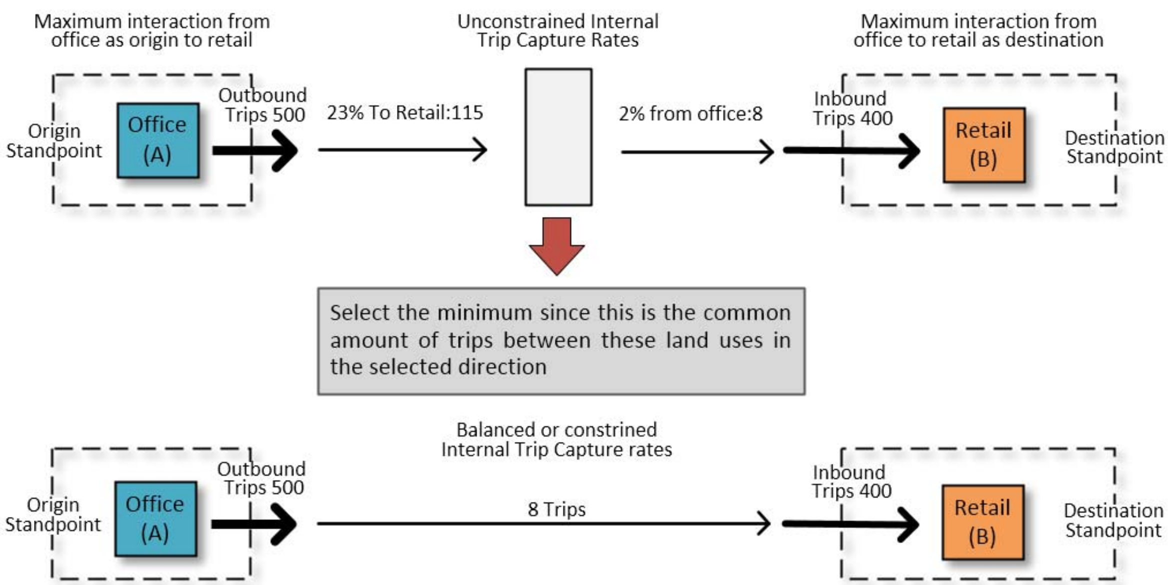


Figure 3-3: Trip Balancing in Tradition Internal Trip Capture Methodology

The unconstrained internal trip distribution represents the maximum potential interaction between two land uses. Not all trips exiting the origin may be received at the destination or vice versa; therefore, the highest common number (which is the lowest of the two unconstrained numbers) of trips between the two land uses should be chosen as the constrained or balanced trip distribution for the selected direction. Figure 3-3 presents an example of trip balancing for trips from office (land use A) to retail (land use B). The balancing initializes from office (land use A) as origin to retail as destination with 115 for trips. Balancing continues with retail as the destination (land use B) that has a total of 8 trips coming from office. Based on both calculations, 8 is the common interaction between these two land uses and is, therefore, selected as the number of balanced trips. The procedure is applied in the reverse direction to find the balanced internal trips from retail (land use B) to office (land use A). The same balancing procedure is applied for all land use pairs A-B to calculate the balanced internal trips. The internal trips by direction are subtracted from the single land use estimates to estimate the total external trips for the development under study. Additional documentation can be found in the ITE *Trip Generation Handbook* [1].

3.2 Internal Trip Capture Data Collection Methodology

The study methodology used in this research includes the design aspects analysis for a trip internalization study, including process, data, and analysis. This section covers aspects related to preparation and execution of a trip internalization study based on the experiences of this study. An overview of the minimum data requirement is provided as is a detailed explanation of the analysis process for internal trip capture data.

3.2.1 Internal Trip Capture Study Process

The process to conduct the internal trip capture study (data collection) used in this research is presented in Figure 3-4. Once a development was selected, permissions to conduct the study were obtained. Obtaining permission is a time-consuming process, but is critical for the success of the study and should not be overlooked.

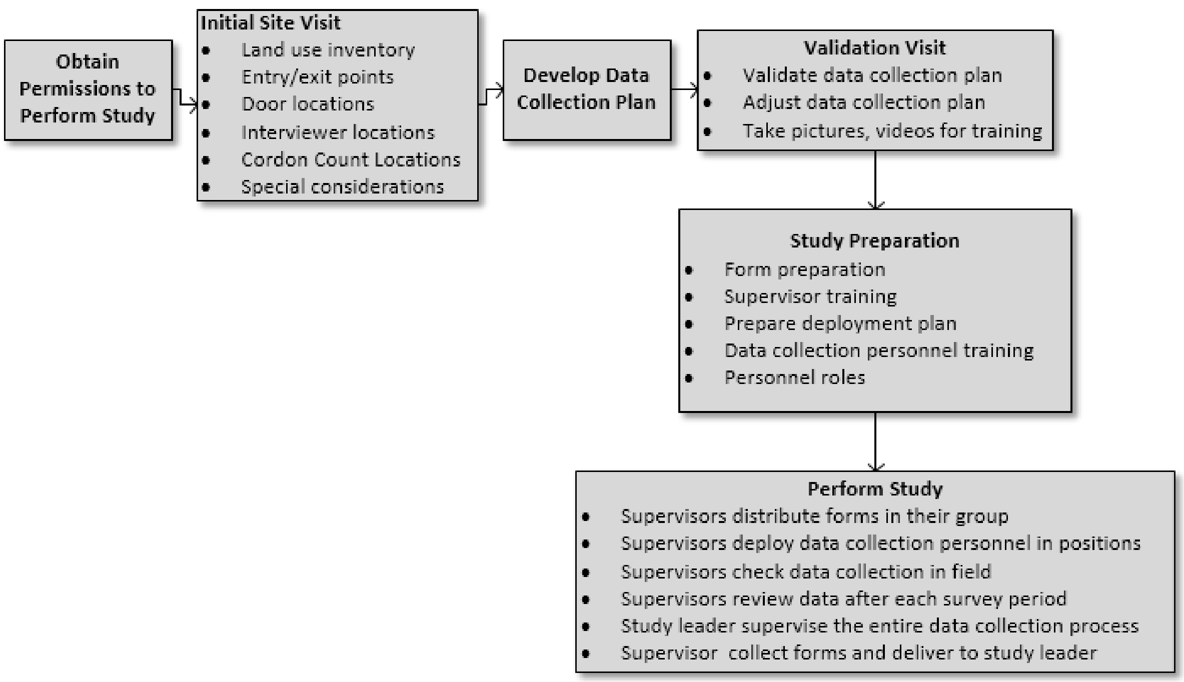


Figure 3-4: Internal Trip Capture Study Process

Permissions were obtained to access the common areas (sidewalks, parking lots) of the MXD where the interviews would take place. Big-box retailers often have stringent regulations about surveys conducted near their businesses, and the study leader had to identify the best location to conduct the interviews without being disruptive to the business. Even when general permission is obtained from property management to access the common areas of an MXD, individual establishments may not be aware of the study or that permission has been granted, so communication is important. Also, the project leader should identify cooperative (and uncooperative) business managers who will assist in planning interviewer locations and, thereby, minimize the chance of conflicts on the day of data collection.

An initial site visit was conducted to obtain a land use inventory for the entire site and to determine the occupancy and hours of operations for each establishments. In addition, the initial site visit was an opportunity to communicate with the establishment managers about the study date. During the initial site visit, the study leader identified cordon count locations and establishment entry/exit points, particularly those with direct connections to external roads, as counts on these locations can convey information on external trips without interviews. Establishments with high, medium, and low activity in the MXD were identified. The study leader also paid attention to special conditions such as through traffic, drive-through, illegal parking, etc., factors that can cause variations in the results of the study.

Based on the initial site visit, the study leader developed an initial data collection plan, establishing locations for counters and interviewers. After that, he/she validated the data collection plan by visiting the site several times, if necessary, and applying necessary adjustments. Photos and videos of the site were taken for training purposes.

Once the data collection plan was ready, the study leader prepared the final forms to be used in the study and selected a team of supervisors. Each supervisor was responsible for a group of up to 10 data collection positions. The study leader and the supervisors conducted data collection personnel training and assigned roles (e.g., counters, interviewers).

On the day of the study, the project leader distributed a form package to each supervisor that contained all the forms for the data collection positions assigned to that supervisor. The supervisors deployed the data collection personnel to their corresponding locations and checked for quality and completeness of the data.

Once the study was completed, each supervisor collected the forms from the data collection personnel, performed a final quality check, and delivered the forms to the study leader. The study leader had the responsibility to supervise the entire data collection process and make decisions or adjustments to the data collection plan. The study leader also addressed any concerns from the business manager that arose during the study.

3.2.2 Data Requirements

To gain insight on the trip generation and internalization characteristics of MXDs, it is necessary obtain field data on the following aspects:

- Physical characteristics of MXD
- Impact to roadway system
- Activity level
- Trip internalization behavior
- Mode split

Physical characteristics of the development include land use inventory in area/units, business hours, and MXD access point and door locations. If additional analyses such as proximity (NCHRP Report 684 [5]) 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 the street or drive-through, 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 [5].

The impact on the roadway system is measured via cordon counts (see Figure 3-5), which include both travel mode and persons. Ideally, the development will not have through roads such that the cordon counts reflect trips to and from the development only. Although this situation is desirable, it is difficult to encounter in reality. If through roads cannot be avoided, a through traffic estimation must be performed to obtain cordon counts associated with MXD activity. However, it must be understood that the accuracy of the internal trip data can be compromised by the through traffic estimate.

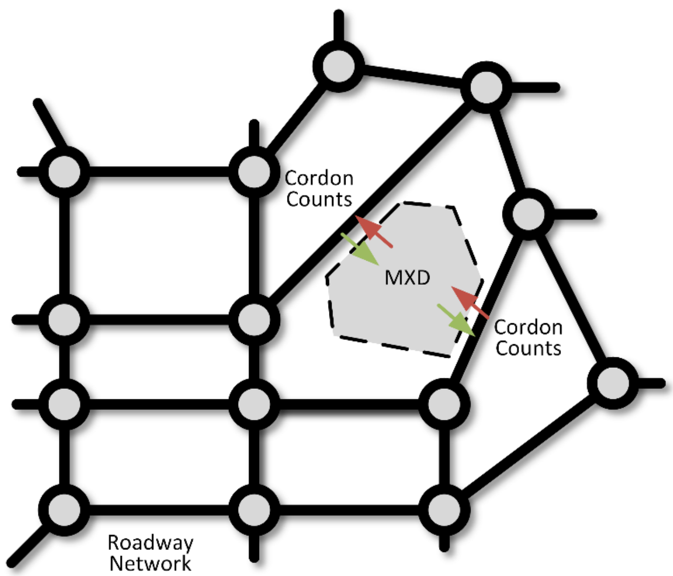


Figure 3-5: Cordon Counts as a Measure of Traffic Impact of MXD on Roadway Network

The activity level of the development is measured by door counts from each establishment/building in the MXD. Trip internalization behavior and mode split are obtained via personal interviews. The suggested practice in the ITE *Trip Generation Handbook* [1] and NCHRP Report 684 [5] consists of collecting survey information via entry/exit interviews. According to the lessons learned in NCHRP Report 684 [5], 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 acceptable to proceed with the interviews.

The process of collecting activity levels, trip internalization behavior, and mode split is presented in Figure 3-6. Interviewers approach patrons as they exit a location and ask questions regarding the previous trip and the 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 used in this study for cordon counts, door counts, and interviews can be found in Appendix A.

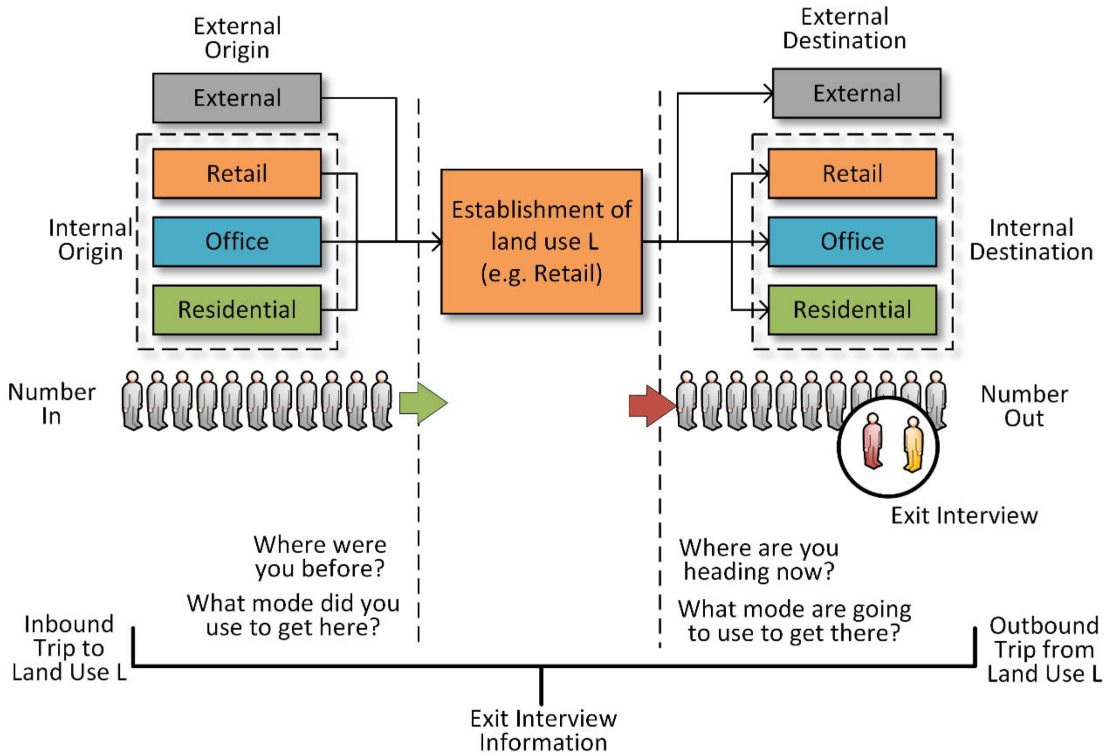


Figure 3-6: Data Collection on Activity Levels, Trip Internalization Behavior, and Mode Split

3.2.3 Data Analysis

The goal of collecting detailed internal trip capture field data is to gain insight on the interaction among the land uses within an MXD and how such insight can be generalized to predict internal and external trips for new MXDs.

Field data include both estimation data and validation data. Estimation data (e.g., door counts and interviews) are used to estimate the internal trip capture behavior in the MXD. Validation data (e.g., development cordon counts) are used to assess the prediction error of the internal trip capture estimates. In other words, the internal trip capture rate employs the activity levels of the MXD represented as door counts in an attempt to replicate the cordon counts.

Estimation data can be categorized as activity data and internalization data. Activity data are related to the actual trips to and from the establishments within the MXD (establishment door counts). Internalization data are collected via intercept surveys and yield distribution of trips (e.g., internal, external). The estimation procedure is performed via trip factoring.

Trip factoring is a correction process that is applied to the sample information so that it is applicable to the entirety of the MXD. Trip factoring uses activity data and internalization data to expand the survey data such that the overall trip generation attempts to match the observed cordon counts.

Note that not all establishments will be surveyed during an internal trip capture study for various reasons, including lack of permissions, type of establishment (e.g., banks), or economic feasibility. In addition, because internalization behavior is collected via interviews, not all patrons of an MXD are willing to give interviews and not all interviewers have high interview rates. Therefore, data collection is limited to a fraction of the activity of the MXD. Trip factoring expands the trip generation and trip internalization behavior of the portion of the MXD surveyed to the remaining portion of the MXD.

Trip factoring was applied at the land use level, as presented in NCHRP Report 684 [5]. To introduce the trip factoring procedure, it is necessary to define the basic parameters obtained from the data collection procedure as follows:

- N_{dir}^{L}: Aggregated door counts by land use L and by direction dir (in, out)
- S_{dir}^{L}: Number of trips in usable interview sample by direction dir and land use L
- $T_{dir,OD}^{L}$: Number of trips from interviews by direction dir from/to origin/destination land use OD (e.g., external, retail, office)
- A_{T}^{L}: Total area or units or land use L in the MXD
- A_{S}^{L}: Area or units of the land use L surveyed in the MXD

Where,

- L: {residential (res), retail (ret), restaurant(rst), office (off), hotel (hot), cinema (cin)}
- OD: {external , residential (res), retail (ret), restaurant (rst), office (off), hotel (hot), cinema (cin)}
- dir: {in, out}

The formulas for trip factoring adapted from NCHRP Report 684 [5] are presented in Figure 3-7 for the inbound and outbound directions. It can be observed that each trip is multiplied and an expansion factor is applied. The first expansion factor (N_{dir}^{L}/S_{dir}^{L}) is called the Interview factor; it expands the survey trip internalization behavior to all the door count activity of the surveyed fraction of the subject land use. The next expansion factor is the Area Expansion factor that extrapolates the trip generation and trip internalization behavior of the sample to all of the MXD, including establishments not surveyed in the study.

General Formula: $F^{L}_{dir,OD} = T^{L}_{dir,OD} \times \frac{N^{L}_{dir}}{S^{L}_{dir}} \times \frac{A^{L}_{T}}{A^{L}_{S}}$

Inbound: $F^{L}_{in,OD} = T^{L}_{in,OD} \times \frac{N^{L}_{in}}{S^{L}_{in}} \times \frac{A^{L}_{T}}{A^{L}_{S}}$

Outbound: $F^{L}_{out,OD} = T^{L}_{out,OD} \times \frac{N^{L}_{out}}{S^{L}_{out}} \times \frac{A^{L}_{T}}{A^{L}_{S}}$

Where,

$LandUse\ (L)$: {residential (res), retail (ret), restaurant(rst), office (off), hotel (hot), cinema (cin)}

$Origin - Destination\ (OD)$: {External , residential (res), retail (ret), restaurant (rst), office (off), hotel (hot), cinema (cin)}

$Direction\ (dir)$: {Inbound (in), Outbound (out)}

F: Expansion factor

T: Total

S: Surveyed sample

Figure 3-7: Trip Factoring Formula for Inbound and Outbound Trips

For example, for all retail in the development (land use $L = ret$), the areas of the retail establishment are surveyed, and counts performed can be aggregated in A^{ret}_{S} (e.g., 300,000 sq. feet). The total retail space in the MXD is denoted by A^{ret}_{T} (e.g., 500,000 sq. feet). For outbound trips, the customers exiting the establishment are counted and aggregated for all the surveyed retail into N^{ret}_{out} (e.g., 540 people). Since only a sample of the people exiting retail is surveyed, this number is denoted by S^{ret}_{out} (e.g., 50 interviews). In this case, S^{ret}_{out} denotes all the outbound trips from retail in the surveys (50 trips out). Among the surveys, there are people heading to external destinations, others going to on-site residential, and so forth. Depending on the destination land use, for the outbound case, these trips are denoted as $T^{ret}_{out,ext}$ (e.g., 38 trips) for trips outbound from retail to an external destination and $T^{ret}_{out,res}$ (e.g., 12 trips) for trips outbound from retail to on-site residential. A similar approach can be applied to other land uses in the MXD. A graphical representation of these terms for the outbound direction is presented in Figure 3-8.

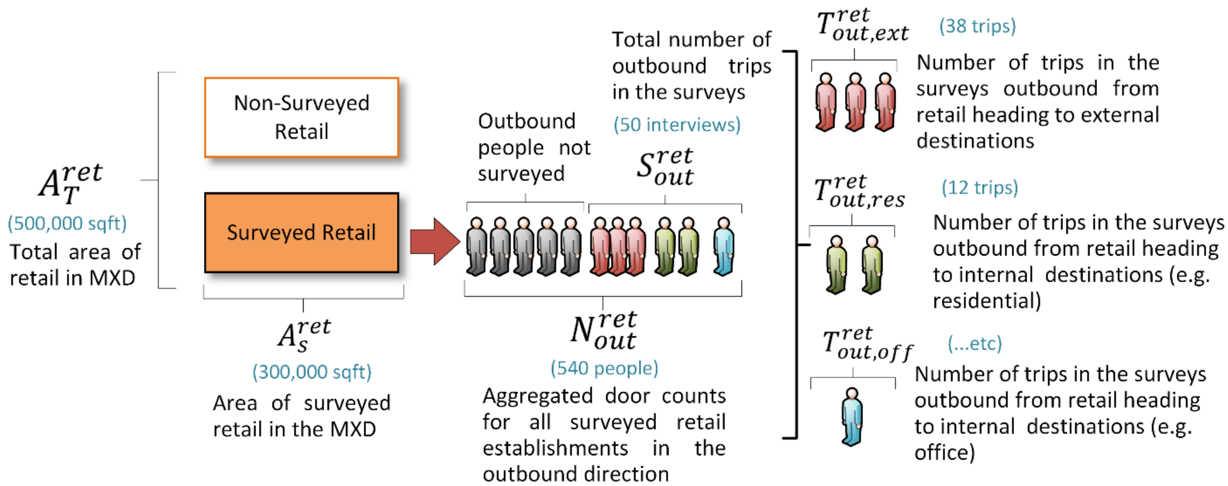


Figure 3-8: Trip Factoring Parameter Example for Outbound Trips

A similar case can be presented as an example for the inbound portion of the interview. For all retail in the development (land use $L = ret$), the areas of the retail establishment are surveyed, and counts are performed and can be aggregated in A_S^{ret} (e.g., 300,000 sq. ft.). The total retail space in the MXD is denoted by A_T^{ret} (e.g., 500,000 sq. ft.). For inbound trips, the customers entering the establishment are counted and aggregated for all the surveyed retail into N_{in}^{ret} (e.g., 620 people). Only a sample of the people exiting retail are surveyed and asked about their inbound trip. In ideal conditions, each exit interview will have an inbound trip; this number is denoted by S_{in}^{ret} (e.g., 50 interviews). In this case, S_{in}^{ret} denotes all the inbound trips to retail in the surveys (50 trips inbound). Among the surveys, there are people coming from external destinations, on-site residential, and so forth. Depending on the origin land use, for the inbound case, these trips are denoted as $T_{in,ext}^{ret}$ (e.g., 41 trips) for trips inbound to retail from external destinations, and $T_{in,res}^{ret}$ (e.g., 9 trips) for trips inbound to retail from on-site residential. A graphical representation of these terms for the outbound direction is presented in Figure 3-9.

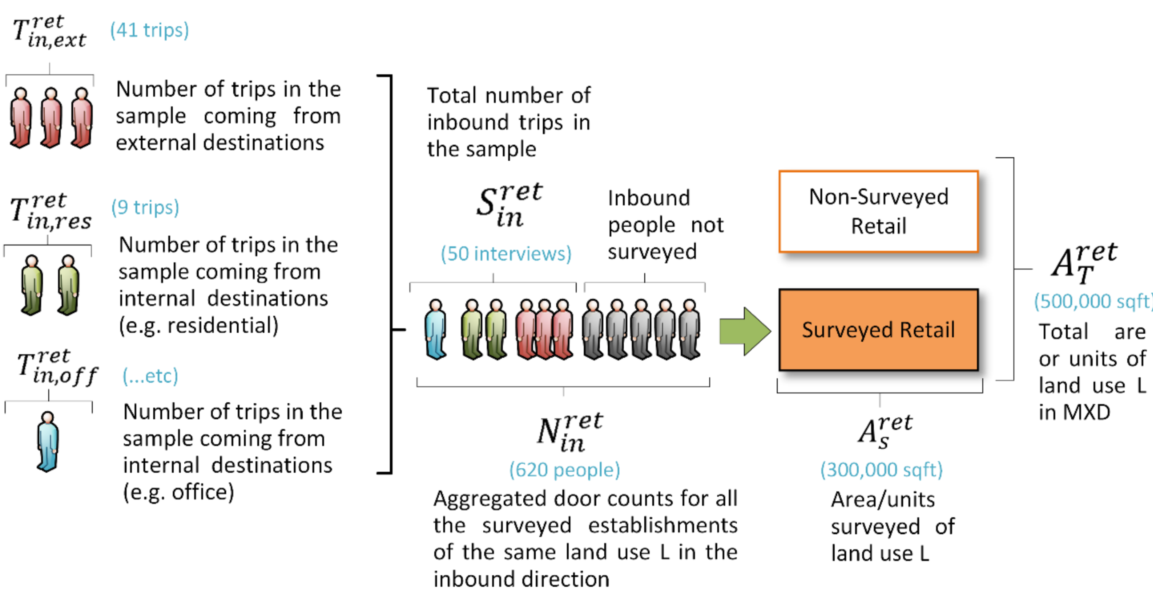


Figure 3-9: Trip Factoring Parameter Example for Inbound Trips

In summary, the procedure of analyzing trip internalization data beginning with raw data through to factored trips is presented in Figure 3-10. Each raw interview is split into two trips, an inbound and and outbound trip. These trips are summed by direction and by land use to obtain the total surveyed trips. The surveyed trips are further divided by direction land use of OD land use. These trips will be factored and reported in the final step. The surveyed trips by direction play a role in sample size and are used to calculate expansion factors along with door counts aggregated by direction and land use. Land use inventory and surveyed land use are used to calculate the Area Expansion factors. All the expansion factors and the surveyed trips by direction are factored or expanded to represent MXD totals. Factored trips are used for reporting and calculation purposes.

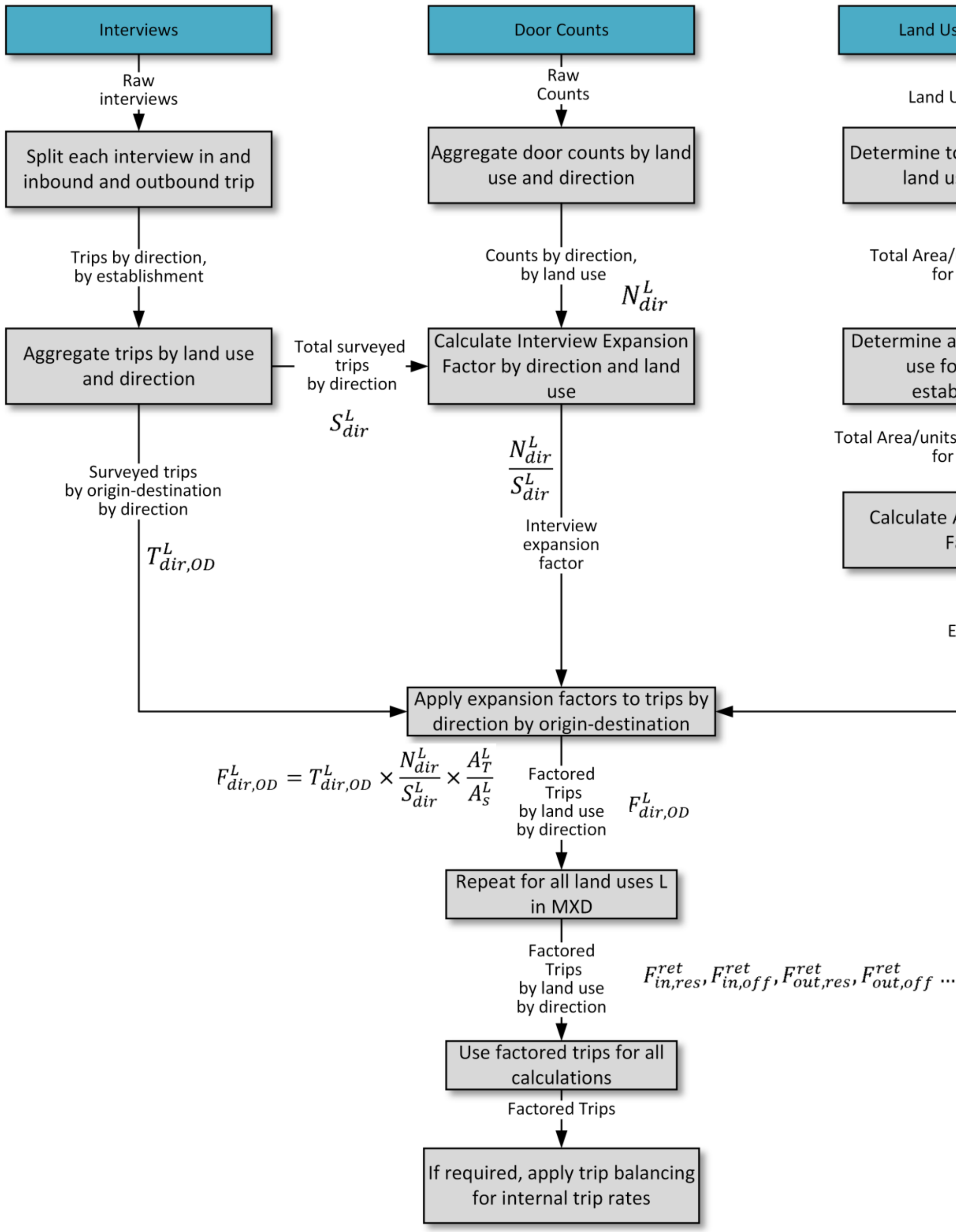


Figure 3-10: Analysis of Internal Trip Capture Data

To obtain valid internal trip capture rates, the factored trips should be corrected via a balancing procedure. The balancing procedure, as previously described, ensures that the number of trips outbound from land use A to land use B (A as origin) are equal to the number of entering trips to B coming from A (B as destination). If the survey procedure is highly sucessful (e.g., high interview rates and high-quality interviews), then these two numbers should be very close. Sampling errors and other factors may affect these quantities resulting in greater differences between the numbers. To produce a set of balanced trip matrices, it is necessary to find an appropriate way to adjust outbound and inbound trips so that these amounts adequately reflect the observed trip internalization behavior of the development. One option to obtain balanced trips is to average the inbound and outbound rates. However, in general, more reliability is associated with the direction with the larger sample size.

3.2.4 Lessons Learned

Based on the experiences of conducting internal trip capture procedures at the four sites in Florida, the most important lessons learned are the following:

- Obtaining permission to perform the study is key to performing a trip internalization study. This could take months to finalize. In some cases, it can involve signing agreements or contracts with the property management office of the site. Even when general permissions are given, individual stores may not agree to participate in the study. Communication with establishment managers is important for the success of the study.

- Several site visits during the time of data collection are recommended. The study leader should focus on key land uses, which will help in designing a data collection plan that captures the trip-making behavior in the MXD.

- The study should attempt to perform door counts at as many establishments as possible to capture the activity at the site and thereby limit expansion to internal trip capture.

- The study should be designed in accordance with data needed for the analysis step to obtain generalizable results. Since this analysis uses land use, data collection should be designed at the land use level as well. This means that an interviewer may approach a person at any location of the development to increase sample size for trip internalization behavior at the land use level. At the same time, it will prevent the study being biased towards particular land uses.

- Interviewers usually should be located on sidewalks for exit interviews but should interview people either leaving or about to enter a building door so they can be properly factored during the expansion process. This approach is recommended for obtaining more interviews, but it has the potential to increase the representation of internal trips. Usually, people who are willing to give interviews have more time to spare when walking on a sidewalk since they are traveling to internal destinations. On the other hand, parking lot interviews can add balance and generalization to exit interviews.

- Interviewers may have problems getting information for inbound trips; this problem was noted in NCRHP Report 684 [5]. Based on examination of the current data collection process, the sequence in which the interview was conducted can be a major cause of confusion. As suggested by ITE, the interviewer should first ask for information about the next trip and then ask for information about the previous trip. While this is clear for a transportation planning/traffic engineer practitioner, for an interviewer and interviewee it may be confusing. The suggested practice that was successfully incorporated into this study was to change the order of the interview such that it matches the chronology of the trip. First, the interviewer asked for previous trip (inbound) information and then for information about the next destination.

- A “divide and conquer” approach is recommended for quality control and deployment. The interviewers can be divided according to supervisor, and each supervisor is responsible for deployment and quality control of his/her data collection personnel, including breaks.

- Training and practice are an important part of the study, especially for interviewers. It helps to assign roles for field data collection; however, some adjustments may be necessary based on observed performance. If both AM and PM data collection will be conducted, it is recommended to schedule AM first to allow initial observation of interviewer performance. In this way, adjustments can be applied for the PM data collection that requires enhanced performance.

3.3 Stakeholders for Internal Trip Capture Data

The main outputs derived from the internal trip capture estimation procedure are external MXD trips and internal trip distribution. The external MXD trip data have several stakeholders. Counties, municipalities, and planning organizations can benefit from improved internal trip capture estimates for planning purposes. Developers can improve their building plans by incorporating features that promote more efficient use of the transportation system and, therefore, minimize their impact on the roadway network, which often is a financial benefit.

Internal trip distribution data can be useful for planners to provide improved development patterns that promote internal trips through land use synergy. Land use planners and transit agencies looking to promote TOD can establish land use policies that support complementary land uses in close proximity and, therefore, encourage mode shift and increased ridership.

4 Analysis Results of Internal Trip Capture for Study Sites

4.1 Creekwood

Creekwood was proposed in 1985 as a Development of Regional Impact (DRI) with a mixed-use land use pattern. As a DRI, Creekwood has been built in phases. The initial three phases comprised residential, commercial, office, and industrial land uses. Phases I and II were completed at the time of this study. The third phase has a build-out (completion) date of November 2018. The fourth phase of Creekwood involves the expansion of existing land uses and the inclusion of a hotel and has a build-out date scheduled for November 2019. The Creekwood DRI, divided by Interstate 75, is illustrated in Figure 4-1. The west side of the development contains commercial and residential land uses, and the east side contains hotel, office, and industrial land uses. For the purpose of this study, only the development to the west of I-75 was selected.

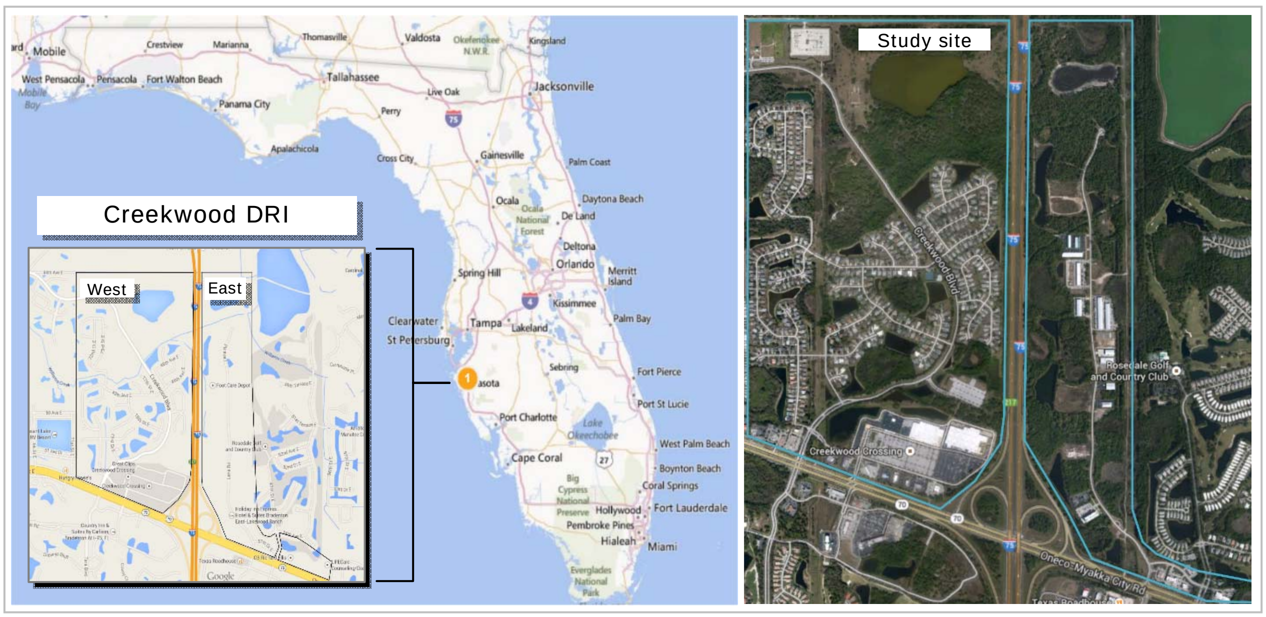


Figure 4-1: Overview of Creekwood DRI

4.1.1 Land Use Inventory

At the time of study, the commercial area contained two major apparel stores and a big-box home improvement retailer as the anchor establishments. Other commercial establishments with observed high activity levels were a fast food restaurant with a drive-through, a coffee shop with a drive-through, a fitness center, and a gas station with a convenience store. Additional commercial establishments included restaurants, dry cleaning establishments, hair salons, discount stores, a jewelry store, and furniture stores. The residential uses consisted of 592 dwelling units of single-family detached homes. A map of the land use distribution is presented in Figure 4-2.

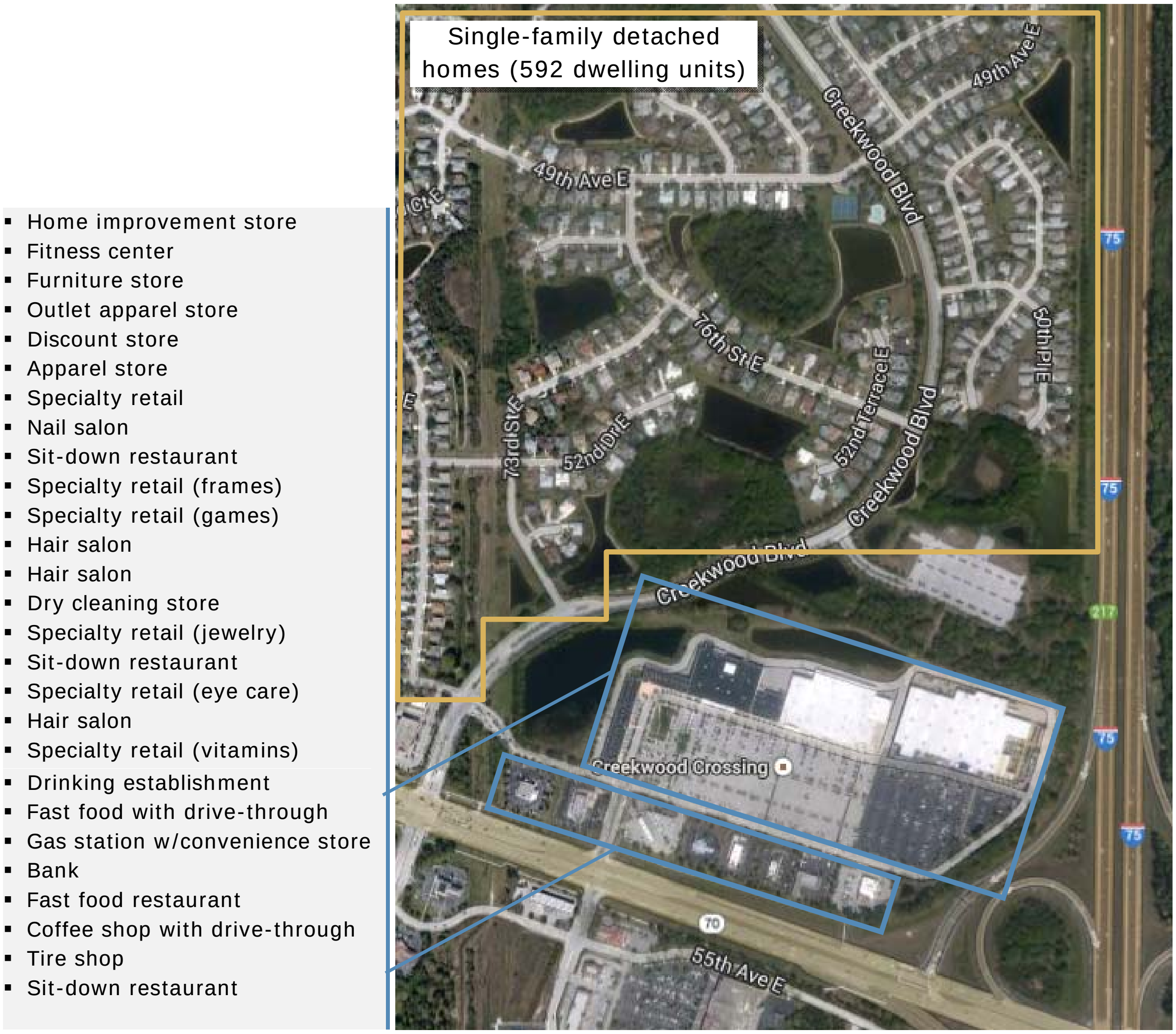


Figure 4-2: Creekwood Land Use Inventory

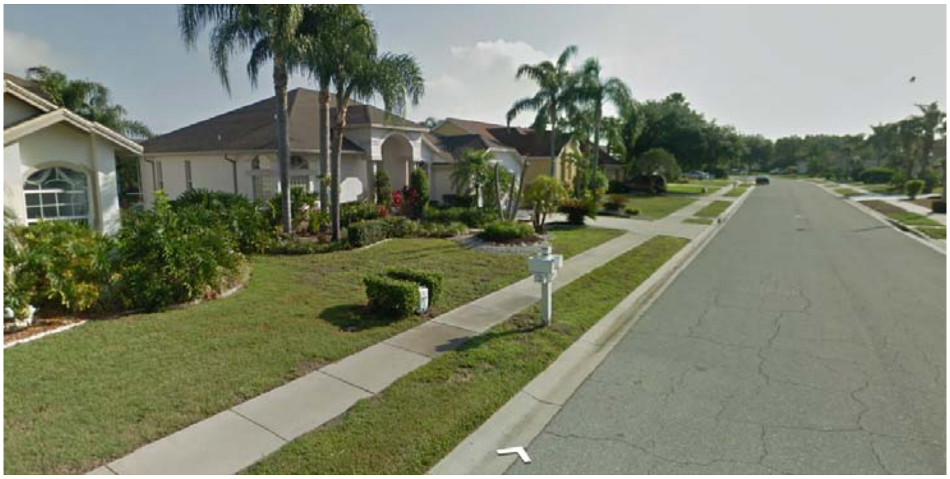
Overall land uses in the development comprised a total of 592 single-family detached homes, 35,405 square feet of restaurants, and 361,792 square feet of retail, as shown in Table 4-1. The commercial area was 95 percent occupied when data were collected, restaurant occupancy was 82 percent, and retail occupancy was 97 percent. Figure 4-3 illustrates the character of Creekwood.

Table 4-1: Land Use Summary for Creekwood

Land Use Type	Size	Units
Residential	592	dwelling units (du)
Restaurants	35,405	sq. ft.
Retail	361,792	sq. ft.

A. Restaurant

B. Retail



C. Residential

Figure 4-3: Restaurant, Retail, and Residential Areas at Creekwood

4.1.2 Cordon Counts and Vehicle Occupancy

Data collection occurred on November 17, 2010, from 3:00-7:00 PM and on November 18, 2010 from 6:00-10:00 AM. The collected data included development cordon counts, establishment door counts, and person interviews.

Cordon counts reflected the total activity of the development and included the interaction between land uses (internal trip capture) and measure the traffic impact of the development on the public roadway system. A summary of the cordon counts and vehicle occupancy by land use and time of day is shown in Table 4-2.

Table 4-2: Summary of Cordon Counts and Vehicle Occupancy by Direction and Time of Day – Creekwood

Type	Direction	Vehicle Counts	Persons-Vehicle	Vehicle Occupancy	Time of Day
Residential	Inbound	128	144	1.13	7:00–9:00 AM
	Outbound	462	583	1.26	
Commercial	Inbound	1,053	1,207	1.15	
	Outbound	866	985	1.14	
MXD	Inbound	1,126	1,289	1.14	
	Outbound	1,309	1,546	1.18	
Residential	Inbound	450	530	1.18	4:00–6:00 PM
	Outbound	263	388	1.48	
Commercial	Inbound	1,091	1,363	1.25	
	Outbound	1,047	1,357	1.30	
MXD	Inbound	1,550	1,901	1.23	
	Outbound	1,377	1,825	1.33	

The distribution of vehicle traffic presented in Table 4-2 for residential and commercial developments is consistent with a typical daily trip pattern for such land uses. For the residential land use, there was a greater vehicle flow in the outbound direction for the AM peak period (128 inbound, 462 outbound). For the PM peak period, a greater vehicle flow was observed in the inbound direction, consisting of returning home-based trips (450 inbound, 263 outbound). For the commercial development, the morning period presented a greater vehicle flow in the inbound direction, most likely due to trips made by area employees (1,053 inbound, 866 outbound). In the PM peak period, both directions had a similar vehicular flow, representing the dynamics of the time of day in a commercial development (1,091 inbound, 1,047 outbound). In terms of vehicle occupancy, the residential land use presented a distinctive behavior in the afternoon, with a maximum vehicle occupancy of 1.48 person per vehicle in the outbound direction.

4.1.3 Trip Generation and Internal Trip Capture PM Peak Period

Trip generation and internal trip capture data were obtained from door counts and interviews by applying the procedure described in Chapter 3. A total of 381 interviews were performed during the PM peak period (3:00–7:00 PM). Data of the interviews for the PM peak hour (4:00–6:00 PM) yielded complete information on 154 trips outbound and 127 trips inbound. Table 4-3 presents the balanced trip distribution for the PM peak period for outbound trips. It can be observed that there were 26 trips outbound from restaurant (as origin) to retail. The interaction between restaurant land uses as trip origins and residential was relatively low, with 8 trips. The maximum interaction was observed for trips exiting retail and going to residential (80 trips) and vice versa.

Table 4-3: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – Creekwood

Outbound From	To					Total
	Residential	Restaurant	Retail	External	Internal	
Residential	-	8	80	177	88	265
Restaurant	8	-	26	247	34	281
Retail	80	53	-	1,062	133	1,195
Total	88	61	106	1,486	255	1,741

Table 4-4 presents observed internal trip capture behavior for Creekwood for the PM peak period in percentages. These percentages are used to generalize the collected data to other developments. For example, for all the trips exiting a restaurant land use in an MXD with similar characteristics to Creekwood, it is expected that 3 percent of those will go to on-site residential, 9 percent to on-site retail, and the remaining 88 percent to external destinations. It can be observed that for outbound trips, the maximum internal trip capture was observed for residential trips (33%), followed by restaurant trips (12%). The overall internal trip capture in the outbound direction was 15 percent.

Table 4-4: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – Creekwood

Outbound From	To				
	Residential	Restaurant	Retail	External	Internal
Residential	-	3%	30%	67%	33%
Restaurant	3%	-	9%	88%	12%
Retail	7%	4%	-	89%	11%
Total Outbound ITC	5%	4%	6%	85%	15%

For inbound trips, the distribution of observed trip generation and internal trip capture is presented in Table 4-5. Inbound trips are interpreted having the destination land use as reference. For instance, in Table 4-5, 8 trips were observed inbound to restaurants from on-site residential. Similarly, 26 trips were inbound to retail from on-site restaurant, with 1,111 coming from external origins. The lowest degree of interaction was observed between restaurant and residential land uses.

Table 4-5: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Inbound Trips – Creekwood

Inbound To	From					Total
	Residential	Restaurant	Retail	External	Internal	
Residential	-	8	80	363	88	451
Restaurant	8	-	53	218	61	279
Retail	80	26	-	1,111	106	1,217
Total	88	34	133	1,692	255	1,947

The inbound trip distribution for the PM peak period in percentages is presented in Table 4-6. For restaurants, 3 percent of the inbound or entering trips were from on-site residential, 19 percent from on-site retail, and 78 percent from external origins. For retail, inbound trips were 7 percent from residential, 2 percent from restaurant, and 91 percent from origins outside the boundaries of Creekwood. The maximum interaction was observed in inbound trips to restaurant from retail, at 19 percent. The overall internal trip capture for inbound trip was 13 percent. The overall internal trip capture for Creekwood (both directions) was 14 percent.

Table 4-6: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – Creekwood

Inbound To	From				
	Residential	Restaurant	Retail	External	Internal
Residential	-	2%	18%	80%	20%
Restaurant	3%	-	19%	78%	22%
Retail	7%	2%	-	91%	9%
Total Inbound ITC	5%	2%	7%	87%	13%

4.1.4 Trip Generation and Internal Trip Capture AM Peak Period

Trip generation data were obtained for the AM peak period. Table 4-7 presents observed trip generation and balanced distribution for vehicle trips. A total of 339 interviews were performed during the AM peak period (6:00–10:00 AM). The interviews during the AM peak hour (7:00–9:00 AM) yielded complete information on 157 trips outbound and 157 trips inbound. For restaurant and retail land uses, the number of external trips was estimated based on door counts and interviews. It was estimated that 678 trips originated at on-site restaurants; of that, 633 were headed outside the boundaries of Creekwood. Similarly, for retail as origin, it was estimated that 495 trips could be attributed to outbound costumers, 417 of which were external trips.

Table 4-7: AM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – Creekwood

Outbound From	To					Total
	Residential	Restaurant	Retail	External	Internal	
Residential	-	22	58	382	80	462
Restaurant	21	-	24	633	45	678
Retail	58	20	-	417	78	495
Total	79	42	82	1,432	203	1,635

Table 4-8 presents the vehicle trip distribution for outbound trips in percentage form for the AM peak period. From the observed behavior for trips exiting from restaurant land uses, 3 percent were headed to on-site residential, 4 percent to on-site retail, and the remaining 93 percent to external destinations. The last column of Table 4-8 indicates the percentage of outbound land use trips captured internally by the MXD. This percentage was 17 for residential, 7 for restaurant, and 16 for retail. The maximum degree of interaction was observed in trips leaving residential land use going to retail land use (13%). The lowest degree of interaction was for trips exiting restaurant going to on-site residential (3%).

Table 4-8: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – Creekwood

Outbound From	To				
	Residential	Restaurant	Retail	External	Internal
Residential	-	5%	13%	83%	17%
Restaurant	3%	-	4%	93%	7%
Retail	12%	4%	-	84%	16%
Total Outbound ITC	5%	3%	5%	88%	12%

For inbound vehicle trips in the AM peak period, the obtained data are presented in Table 4-9. It can be observed that a total of 545 trips were observed entering on-site restaurant, of which 42 came from other on-site establishments (internal trips) and 503 from establishments outside of the boundaries of the MXD. Similar interpretations can be applied for retail and residential land uses.

Table 4-9: AM Peak Period Balanced Vehicle Trip Distribution by Land Use for Inbound Trips – Creekwood

Inbound To	From					Total
	Residential	Restaurant	Retail	External	Internal	
Residential	-	21	58	50	79	129
Restaurant	22	-	20	503	42	545
Retail	58	24	-	594	82	676
Total	80	45	78	1,147	203	1,350

Table 4-10 presents the vehicle trip distribution for inbound trips for the AM peak period in percentages. This representation allows for a more comprehensive interpretation and generalization of the obtained data. For restaurants, 4 percent of the inbound trips came from residential, 4 percent from retail, and the remaining 92 percent from external origins. Having retail as a destination, it was estimated that 9 percent of inbound trips came from on-site residential, 4 percent from restaurants and 88 percent from external destinations. For Creekwood, the AM internal trip capture in the AM peak period was 12 percent in the outbound direction and 15 percent in the inbound direction. The overall internal trip capture was 14 percent.

Table 4-10: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – Creekwood

Inbound To	From				
	Residential	Restaurant	Retail	External	Internal
Residential	-	16%	45%	39%	61%
Restaurant	4%	-	4%	92%	8%
Retail	9%	4%	-	88%	12%
Total Inbound ITC	6%	3%	6%	85%	15%

4.1.5 Transportation Mode and Proximity

In addition to internal trip capture modes, proximity data for internal trips were also collected and analyzed. Figure 4-4 presents the mode distribution for outbound trips during the PM peak period, illustrating that the automobile is the dominant mode. Walking trips accounted for 50 percent of the observed trips leaving retail for on-site restaurants and 33 percent of the trips leaving retail for other on-site retail.

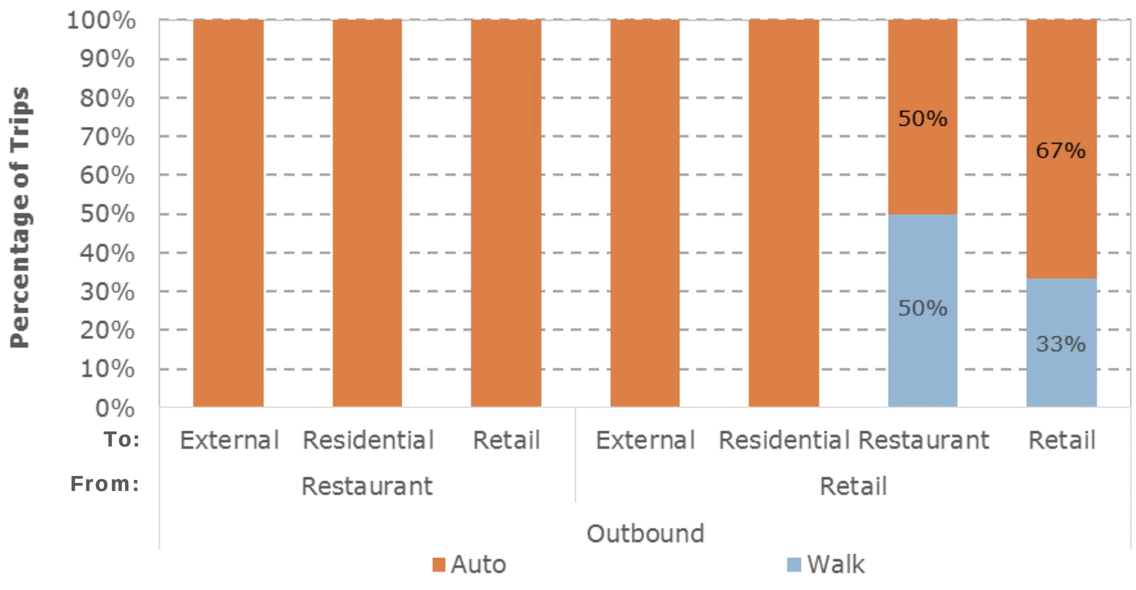


Figure 4-4: Transportation Mode for Outbound Trips in PM Peak Period – Creekwood

The mode distribution for inbound trips for PM peak period is presented in Figure 4-5. For trips inbound to retail from retail, 13 percent were walking trips. All of the remaining trips were automobile-base trips. For the AM peak period, the mode distribution for outbound trips is presented in Figure 4-6. From restaurant to residential, no automobile trips were observed in the morning period; however, half of the observed trips were made via bicycle and the other half via walking. These trips were mainly from the on-site coffee shop.

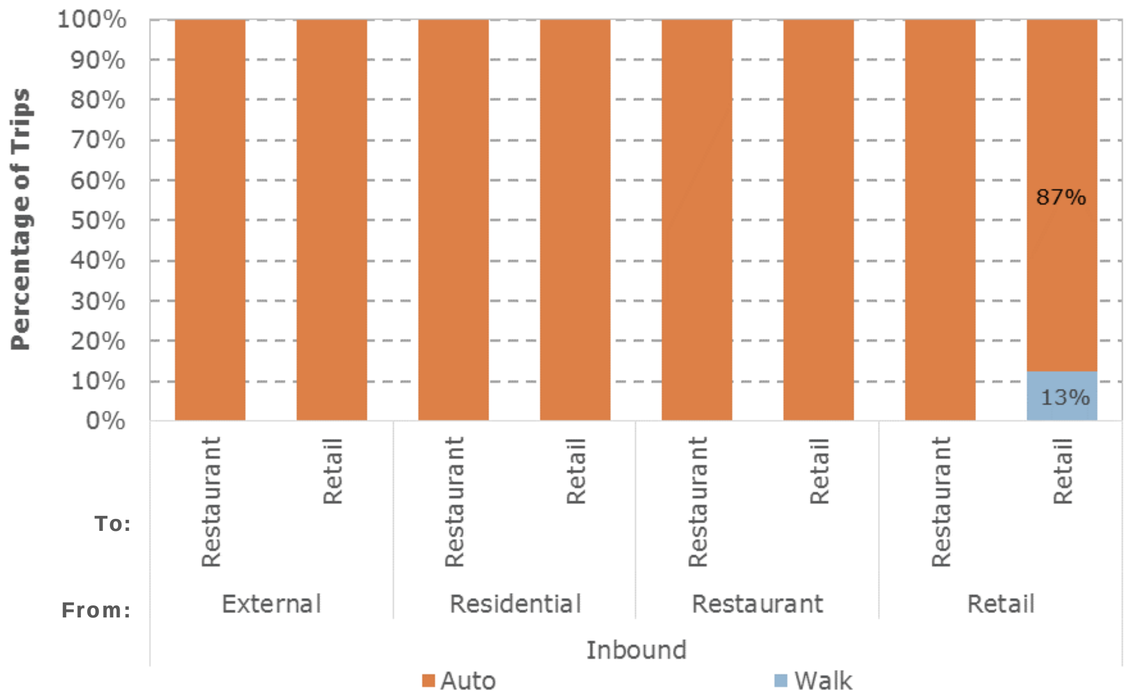


Figure 4-5: Transportation mode for Inbound Trips in PM Peak Period – Creekwood

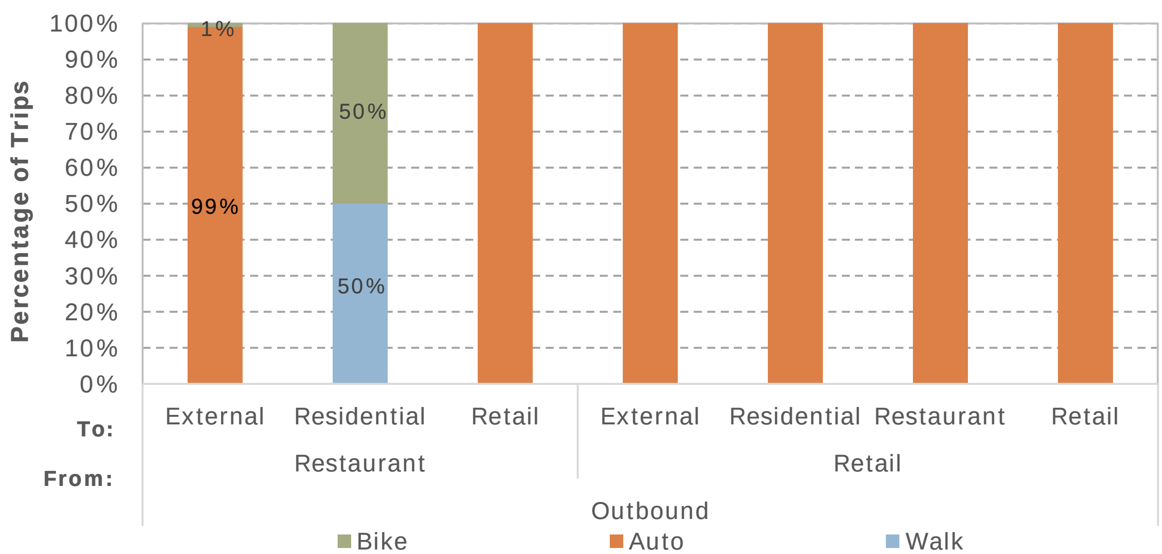


Figure 4-6: Transportation Mode for Outbound Trips in AM Peak Period – Creekwood

For inbound trips in the AM peak period, the mode distribution is presented in Figure 4-7. A total of 17 percent of the trips inbound to restaurants from on-site retail were walking trips, 1 percent of trips inbound from external to restaurant were by bicycle, and the remainder of the inbound trips were via automobile.

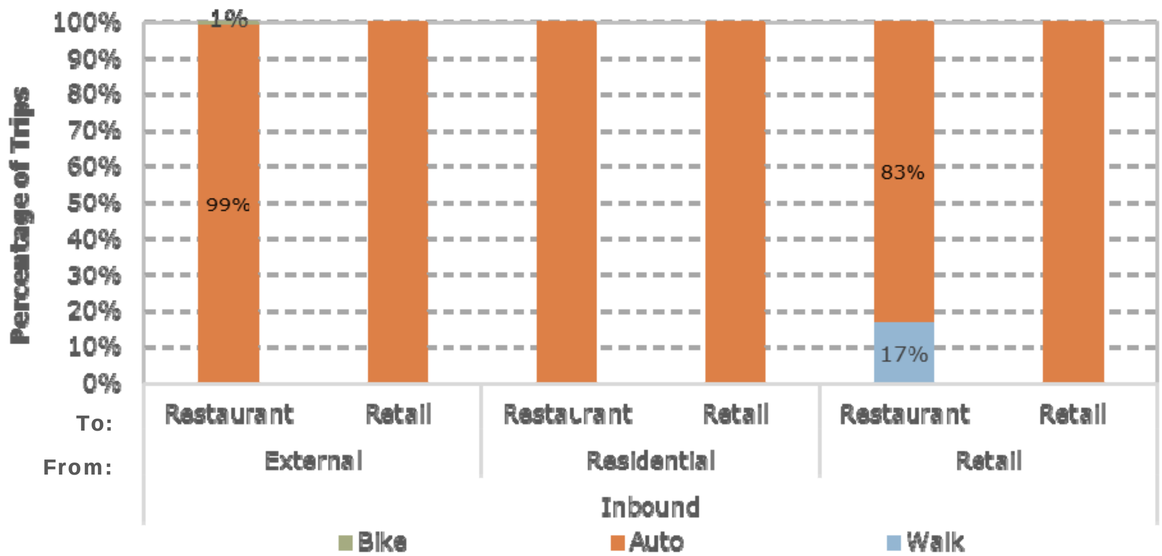


Figure 4-7: Transportation Mode for Inbound Trips in AM Peak Period – Creekwood

The cumulative distribution of internal trips based on distance between internal land uses for both the AM and PM peak periods is presented in Figure 4-8. It can be observed that there is a natural limit on the commercial area trips of 2,000 ft. This is consistent with the maximum trip lengths within the commercial area, as presented in Figure 4-9.

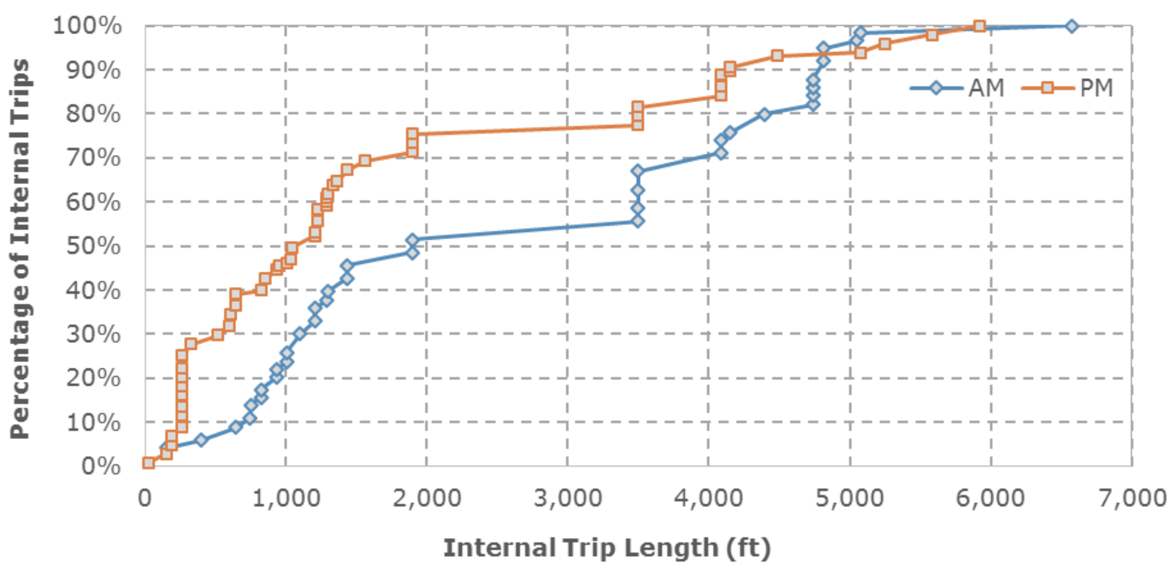
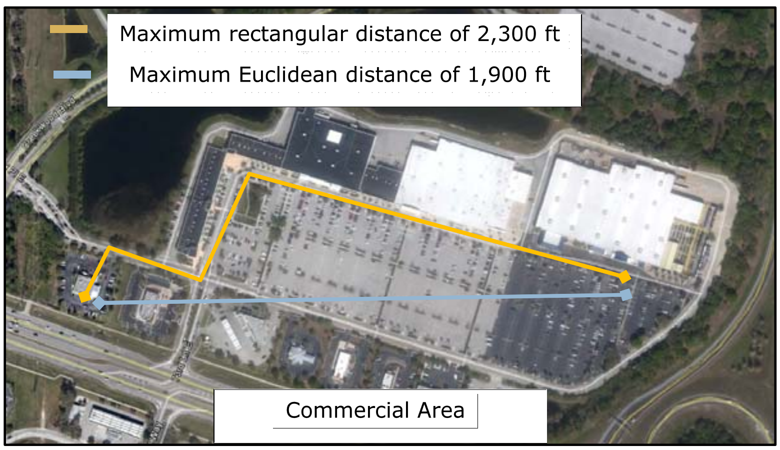


Figure 4-8: Cumulative Distribution for Internal Trips Based on Trip length for AM and PM Peak Periods – Creekwood

During the PM peak period, 80 percent of the internal trips were within 2,000 feet or less, and during the AM peak period, 55 percent of the internal trips were made within the same distance. Trips with lengths greater than 3,000 feet were residential-based trips, as this land use is located at the back end of the MXD. Proximity effects can be observed below the 30th percentile for the PM curve. The upward trend indicates an increased number of trips at short distances. Further investigation of the trend revealed that the trend was mainly retail-retail trips between two big-box apparel stores. The AM trip distributions do not show a particular trend for proximity effects. Additional proximity data by land use pairs are provided in Figure B-1 and Figure B-2, and supplemental data on trip length distribution by land use pair for Creekwood is presented in Appendix B.



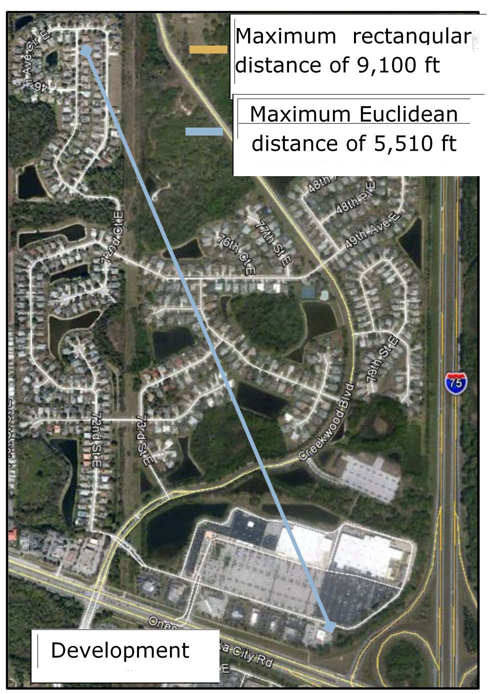


Figure 4-9: Maximum Internal Trip Length – Creekwood

4.2 SODO

The MXD SODO (South of Downtown Orlando) is shown in Figure 4-10. SODO was developed in a decaying urban infill area as an urban revitalization project, as can be seen in Figure 4-11. The 22-acre area originally included a drive-in movie theater, an auto/truck repair garage, and a warehouse. The MXD was completed in 2008, comprising mid-rise residential, retail, and medical office land uses. SODO provides a pedestrian-friendly environment with substantial parking spaces and has four outparcels and a big-box retailer as the anchor establishment.

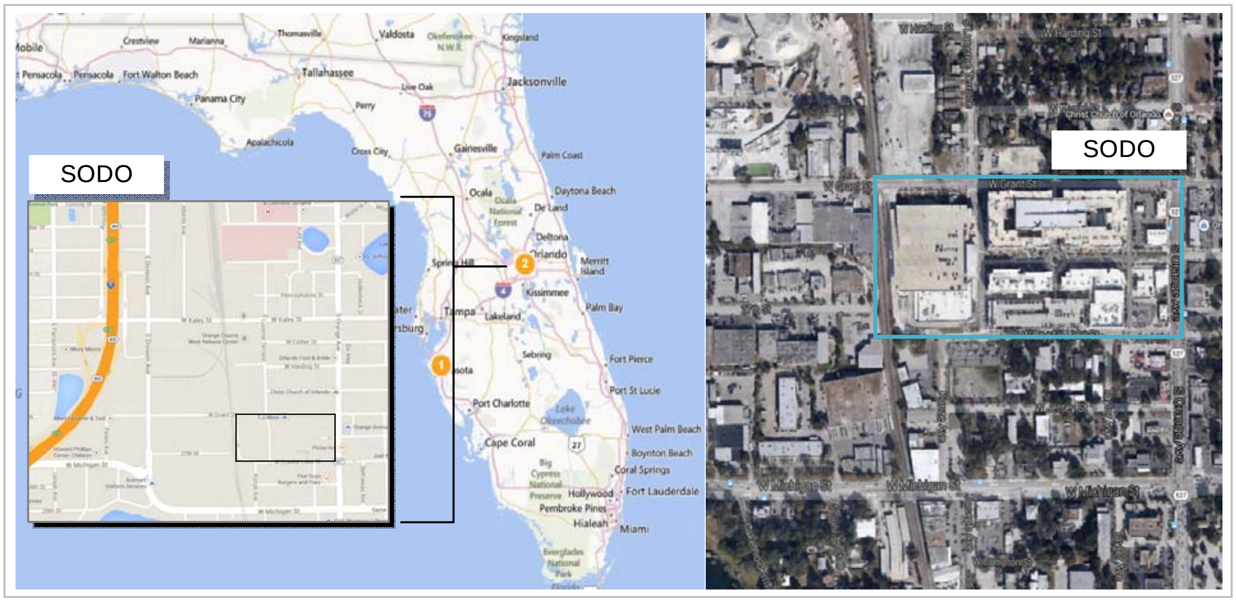


Figure 4-10: Overview of SODO

a) Before SODO, 2003

b) SODO 2013

Figure 4-11: Urban Revitalization of SODO Area

4.2.1 Land Use Inventory

At the time of study, the SODO residential units were fully occupied, and there were two major retailers, a fitness center, two medical offices, several restaurants, and various small retail establishments. The retail space was dominated by a big-box department store with a grocery section and a major apparel retailer (see Figure 4-12). The remaining commercial space corresponds to minor ground-floor retail spaces. The overall commercial space (retail and restaurants) was 85 percent occupied. Nearly 50 percent of the office space was occupied by medical offices. The overall available land use (approved for development) is presented in Table 4-11, and the land usage at the time of this study is shown in Table 4-12. The character of SODO is demonstrated in Figure 4-13.

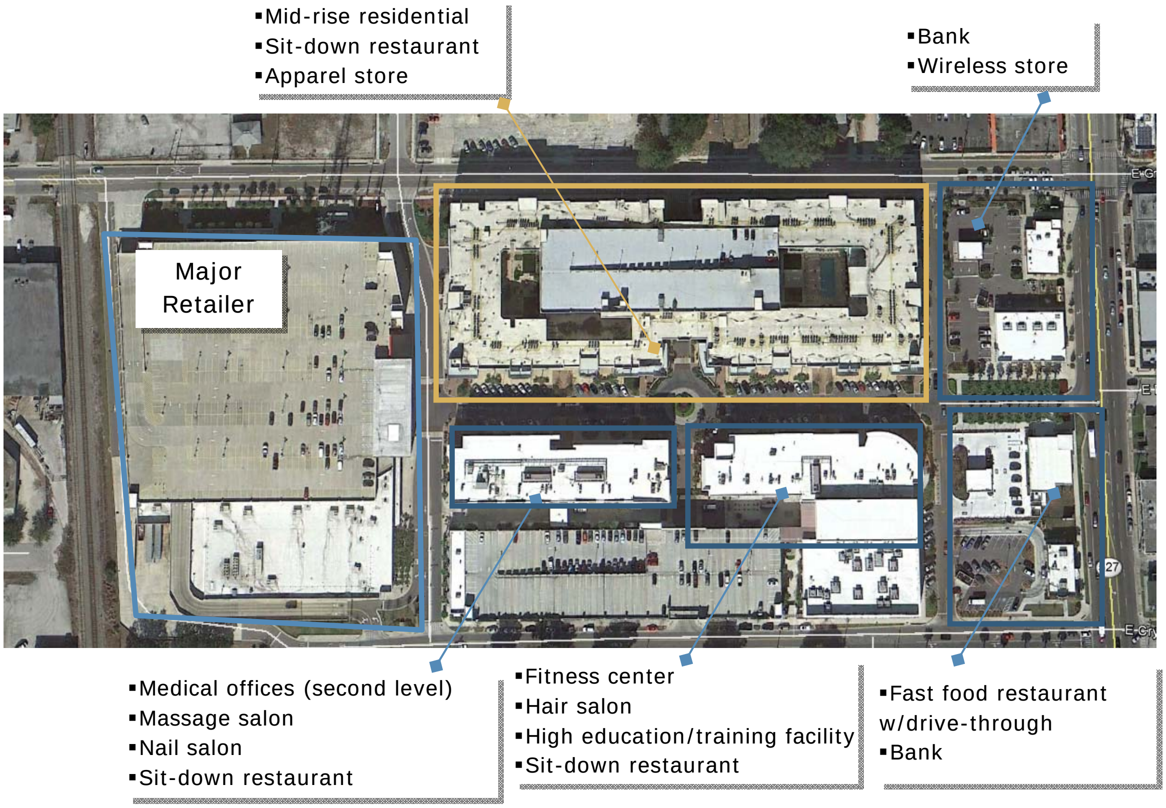


Figure 4-12: SODO Land Use Inventory

Table 4-11: Land Use Availability for SODO

Land Use Type	Size	Units
Residential	300	dwelling units (du)
Commercial	345,000	sq. ft.
Office	100,000	sq. ft.

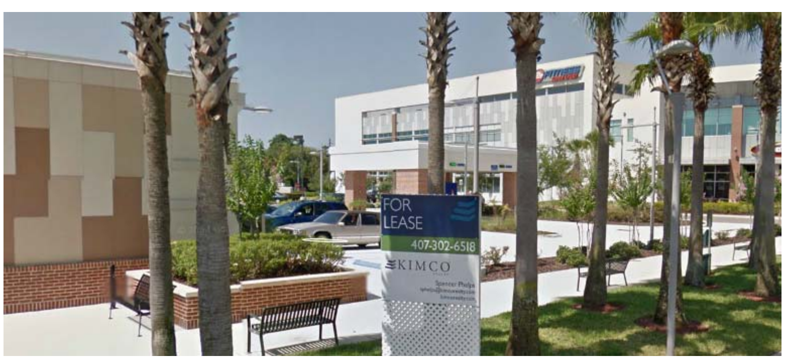
Table 4-12: Land Use Inventory for SODO

Land Use Type	Size	Units
Residential	300	dwelling units (du)
Restaurant	11,309	sq. ft.
Retail	282,862	sq. ft.
Office	46,126	sq. ft.

A. Residential

B. Restaurant

C. Retail



D. Office

Figure 4-13: Residential, Restaurant, Retail, and Office at SODO

4.2.2 Cordon Counts and Vehicle Occupancy

Data collection in SODO was performed on September 27–28, 2011, for the PM and AM periods, respectively. The data collection included cordon counts, door counts, and interviews. Cordon counts measure the traffic impact of the development on the public roadway system. A summary of the cordon counts, vehicle occupancy by land use, and time of day is presented in Table 4-13.

Table 4-13: Summary of Cordon Counts and Vehicle Occupancy by Direction and Time of Day – SODO

Type	Direction	Vehicle Counts	Person Vehicle	Vehicle Occupancy	Period
Residential	Inbound	30	30	1.00	7:00–9:00 PM
	Outbound	167	186	1.11	
MXD	Inbound	541	579	1.07	
	Outbound	458	503	1.10	
Residential	Inbound	119	128	1.08	4:00–6:00 PM
	Outbound	54	63	1.17	
MXD	Inbound	1,055	1,282	1.22	
	Outbound	952	1,107	1.16	

From the vehicle cordon counts for SODO, as shown in Table 4-13, the directional traffic patterns followed the expected behavior. For the AM peak period, there was a heavier volume outbound (167 outbound, 30 inbound) from the residential area, and in the PM peak period, the directional distribution was reversed (119 inbound, 54 outbound). The occupancy factor for this development was relatively low, even during the PM peak period. This is consistent with the type of land uses in the developments that tend to favor the young adult market.

4.2.3 Trip Generation and Internal Trip Capture, PM Peak Period

Trip generation and internal trip capture for the PM peak period are presented in this section. The trip information was obtained from a sample of 305 interviews for the PM data collection (3:00–7:00 PM). For the inbound direction, the number of usable trips during the PM peak period (4:00 PM–6:00 PM) was 71, while for the outbound direction this number was 105. Table 4-14 presents the trip distribution for outbound trips by land use. From residential, 46 outbound trips went to restaurants, 37 to retail, 1 to offices, and 104 to external destinations. A similar interpretation can be applied for the remaining land uses. For example, there were a total of 230 trips exiting the on-site office building, with 221 of these trips going to external destinations and 9 going to internal destinations.

Table 4-14: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – SODO

Outbound From	To						Total
	Residential	Restaurant	Retail	Office	External	Internal	
Residential	-	46	37	1	104	84	188
Restaurant	12	-	2	0	68	14	82
Retail	57	6	-	0	752	63	815
Office	0	4	5	-	221	9	230
Total	69	56	44	1	1,145	170	1,315

The trip distribution for outbound trips in SODO for the PM peak period expressed in percentage form is presented in Table 4-15. It can be observed that there is a strong interaction between restaurant and retail. The percentage of residential outbound trips captured internally is 45 percent and is expected due to the close proximity and convenience of having on-site retail with a grocery store and a fitness center. The distance from residential to the fitness center ranges from 250–500 feet, depending on the exit point from the residential building. The same difference can be applied to the internal trips from all origins.

There is a strong attraction to the on-site restaurants that captured 24, 1, and 2 percent of the residential, retail, and office outbound trips, respectively. For trips exiting retail, 7 percent were headed to residential and 1 percent to restaurants, and 92 percent exiting the site. This number reflects the difference in size and trip generation between retail and residential. Additionally, there was some interaction between the on-site medical office and retail that captured 2 percent of the outbound trips from office land use.

Table 4-15: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – SODO

Outbound From	To					
	Residential	Restaurant	Retail	Office	External	Internal
Residential	-	24%	20%	1%	55%	45%
Restaurant	15%	-	2%	0%	83%	17%
Retail	7%	1%	-	0%	92%	8%
Office	0%	2%	2%	-	96%	4%
Total Outbound ITC	5%	4%	3%	0%	87%	13%

The trip distribution for inbound trips is presented in Table 4-16 for the PM peak period. It can be observed that there were 12 trips entering residential land uses from restaurants and 57 from retail. The number of inbound trips to residential coming from external destinations was 66. Restaurant and retail had incoming trips from office, with 4 and 5 trips, respectively.

Table 4-16: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Inbound Trips – SODO

Inbound To	From						Total
	Residential	Restaurant	Retail	Office	External	Internal	
Residential	-	12	57	0	66	69	135
Restaurant	46	-	6	4	84	56	140
Retail	37	2	-	5	851	44	895
Office	1	0	0	-	31	1	32
Total	84	14	63	9	1,032	170	1,202

Trip distribution for the PM peak period, is presented in Table 4-17. For residential land use, 9 percent of inbound trips originated from an on-site restaurant, 42 percent from on-site retail and 49 percent came from external origins. For restaurants, 33 percent of entering trips came from residential, 4 percent from retail, 3 percent from offices and the remaining 60 percent from external origins. Trips inbound to office from residential were observed as 3 percent. It is important to note that the offices in SODO were medical offices, and some of the observed trips were by medical patients that lived on-site.

Table 4-17: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – SODO

Inbound To	From					
	Residential	Restaurant	Retail	Office	External	Internal
Residential	-	9%	42%	0%	49%	51%
Restaurant	33%	-	4%	3%	60%	40%
Retail	4%	0%	-	1%	95%	5%
Office	3%	0%	0%	-	97%	3%
Total Inbound ITC	7%	1%	5%	1%	86%	14%

In ideal conditions, the number of observed trips from retail to residential with retail as origin should be equal to the number of trips to residential from retail having residential as destination. This concept is known as trip balancing. In reality, these numbers may not coincide for several reasons, such as the random nature of the sampling procedure where interviews are conducted at a variety of locations. In the case of SODO, for this particular land use pair in Table 4-14, the number of trips from retail to residential was 57 (outbound), and, the number of trips entering retail from residential, (inbound) was the same number. The distribution in percentages varies due to the difference in size between the developments. The internal trip capture rate for outbound trips in the PM peak period was 13 percent and for inbound trips was 14 percent. The overall internal trip capture for the development was 14 percent.

4.2.4 Trip Generation and Internal Trip Capture, AM Peak Period

The trip distribution for the AM peak period for outbound trips in SODO is presented in Table 4-18. A total of 199 interviews were conducted during the 7:00–9:00 AM peak period. The collected data yielded complete information on 21 inbound trips and 107 outbound trips. Residential, retail, office were the most active land use pair. Having residential as origin, 34 (16%) of residential trips were headed to on-site retail. From retail, 4 percent of the trips were captured by on-site residential and, for office, 35 percent of the outbound trips were made to residential.

Table 4-18: AM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – SODO

Outbound From	To						Total
	Residential	Restaurant	Retail	Office	External	Internal	
Residential	-	0	34	0	173	34	207
Restaurant	0	-	0	0	0	0	0
Retail	9	0	-	0	223	9	232
Office	9	0	2	-	15	11	26
Total	18	0	36	0	411	54	465

Table 4-19: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – SODO

Outbound From	To					
	Residential	Restaurant	Retail	Office	External	Internal
Residential	-	0%	16%	0%	84%	16%
Restaurant	0%	-	0%	0%	100%	0%
Retail	4%	0%	-	0%	96%	4%
Office	35%	0%	8%	-	58%	42%
Total Outbound ITC	4%	0%	8%	0%	88%	12%

For inbound trips, the trip distribution information is presented in Table 4-20. It can be observed that 34 trips entered from residential to on-site retail, which corresponds to an internal trip capture of 14 percent. For residential, 33 percent of the entering trips were from on-site retail. For office, 100 percent of the inbound trips were from external. This interaction is mostly attributable to the medical nature of the on-site offices. For SODO, the AM internal trip capture in the AM peak period was 12 percent in the outbound direction and 12 percent in the inbound direction. The overall internal trip capture was 12 percent.

Table 4-20: AM Peak Period Balanced Vehicle Trip Distribution by Land Use for Inbound Trips – SODO

Inbound To	From						Total
	Residential	Restaurant	Retail	Office	External	Internal	
Residential	-	0	9	9	9	18	27
Restaurant	0	-	0	0	0	0	0
Retail	34	0	-	2	214	36	250
Office	0	0	0	-	168	0	168
Total	34	0	9	11	391	54	445

Table 4-21: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – SODO

Inbound To	From					
	Residential	Restaurant	Retail	Office	External	Internal
Residential	-	0%	33%	33%	33%	67%
Restaurant	0%	-	0%	0%	100%	0%
Retail	14%	0%	-	1%	86%	14%
Office	0%	0%	0%	-	100%	0%
Total Inbound ITC	8%	0%	2%	2%	88%	12%

4.2.5 Transportation Mode and Proximity

In addition to internal trip capture by mode, proximity data among land uses for internal trips were collected and analyzed. Figure 4-14 presents the mode distribution for outbound trips for the PM peak period for SODO. It can be observed that automobile is the dominant mode for external trips exiting residential. Walking was the dominant mode for internal trips. For outbound trips from retail to restaurant, 100 percent of the observed trips were walking trips. For outbound trips from retail to residential, 11 percent used bicycle. For restaurant, 8 percent of the external outbound trips were made by bus; similarly for retail, this percentage was estimated at 14 percent. For inbound trips, mode distribution is presented in Figure 4-15.

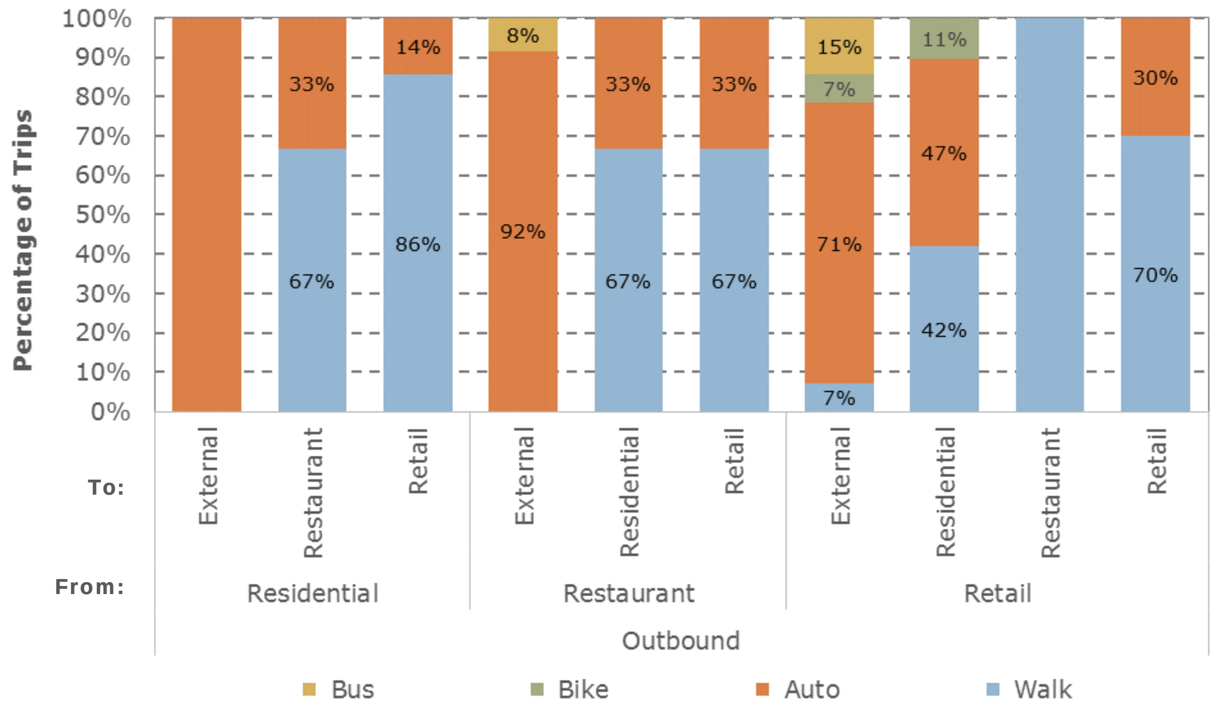


Figure 4-14: Transportation Mode for Outbound Trips in PM Peak Period – SODO

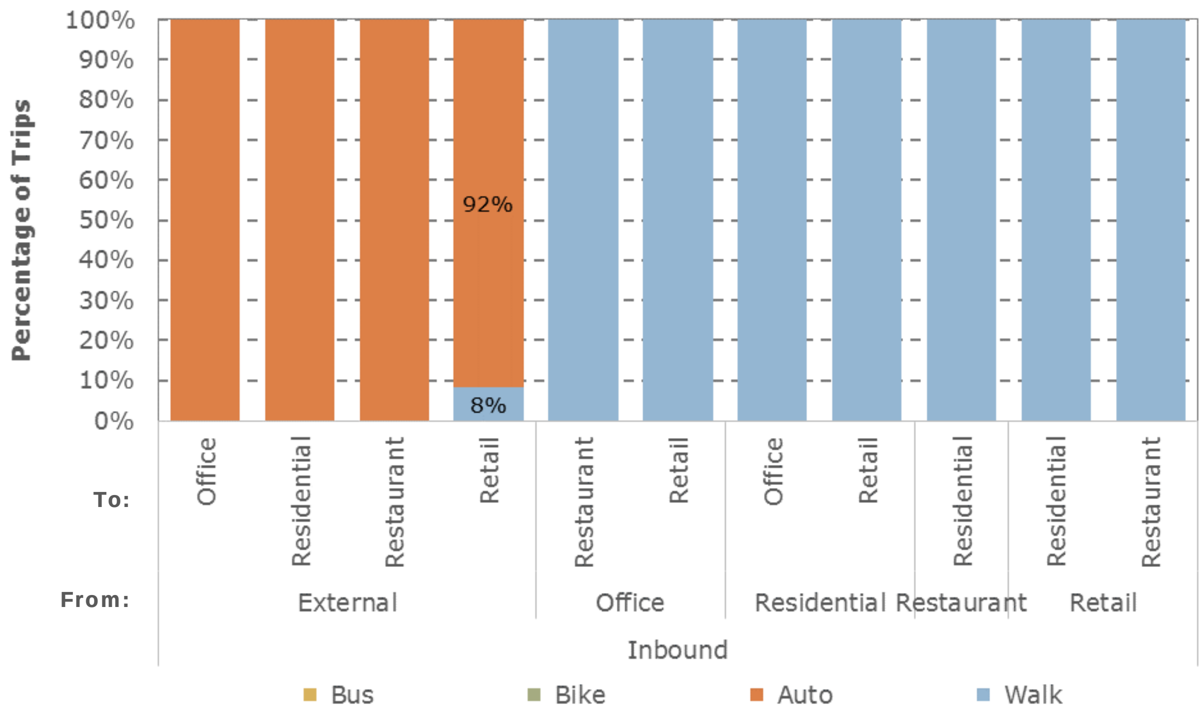


Figure 4-15: Transportation Mode for Inbound Trips in PM Peak Period – SODO

For the AM peak period, the mode distribution for outbound and inbound trips is presented in Figures 4-16 and 4-17. It can be observed that auto trips are the dominant mode for external trips from all land uses. For residential to retail, the majority of the trips were walking trips. For outbound trips from retail, the mode was split consisted of bus (5%), walking (13%), and auto (82%) for external trips.

The modal split for inbound trips to SODO during the AM peak period is presented in Figure 4-17. Walking was the preferred method for internal trips. For external trips, auto was the dominant mode.

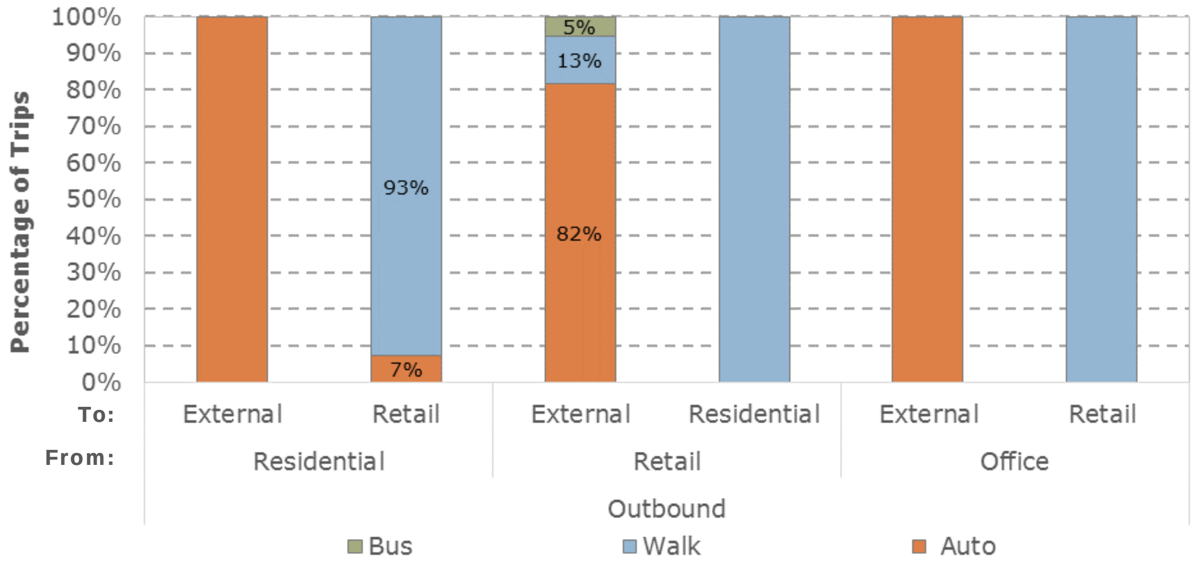


Figure 4-16: Transportation Mode for Outbound Trips in AM Peak Period – SODO

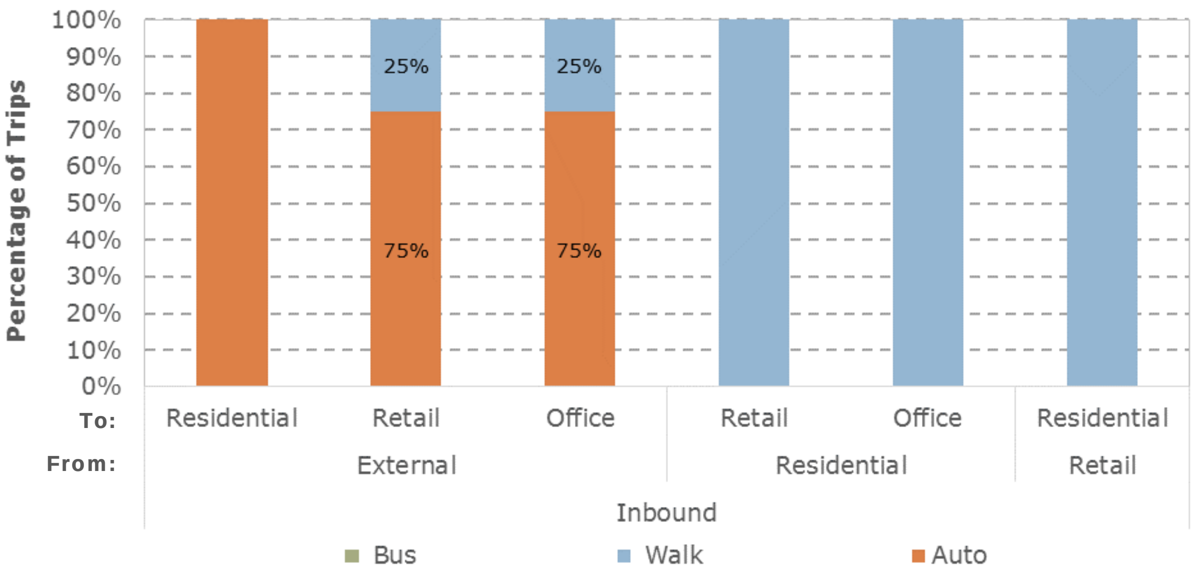


Figure 4-17: Transportation Mode for Inbound Trips in AM Peak Period – SODO

The distribution of trips by distance is presented in Figure 4-18. The segments close to vertical line indicate that there was some clustering of trips occurring at the same proximity. This is due to the strong interaction of residential-retail, with retail being represented by an on-site fitness center and a big-box retailer with grocery shopping. The maximum internal trip length was 1,100 for rectangular distances and 940 feet measured as a straight line (Euclidean distance), as shown in Figure 4-19. The supplemental data on trip length distribution by land use pair for SODO is presented in Appendix C.

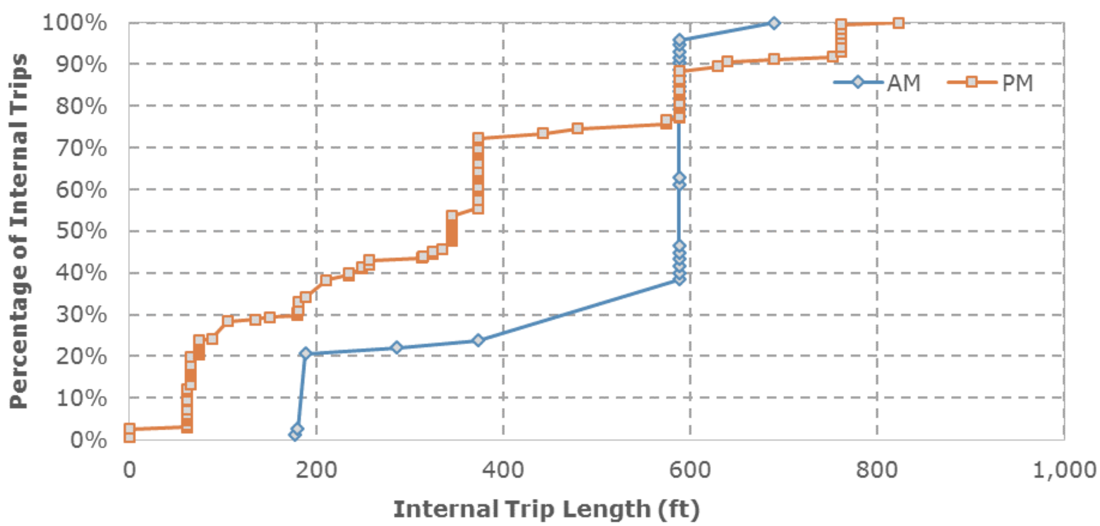


Figure 4-18: Cumulative Distribution for Internal Trips Based on Trip length for AM and PM Peak Periods – SODO

Figure 4-19: Maximum Internal Trip Length – SODO

4.3 Lakeside Village

Lakeside Village is located in southwest Lakeland in the northwest quadrant of the Polk Parkway and Harden Blvd. interchange (see Figure 4-20). Lakeside Village was designed mainly as a lifestyle center or an open-air shopping mall with a movie theater, three on-site hotels, office space, retail, and restaurants. An apartment complex is located at the north and has a direct connection with the shopping center. As a whole, the site comprises six land uses and is an example of a new type of MXD in Florida.

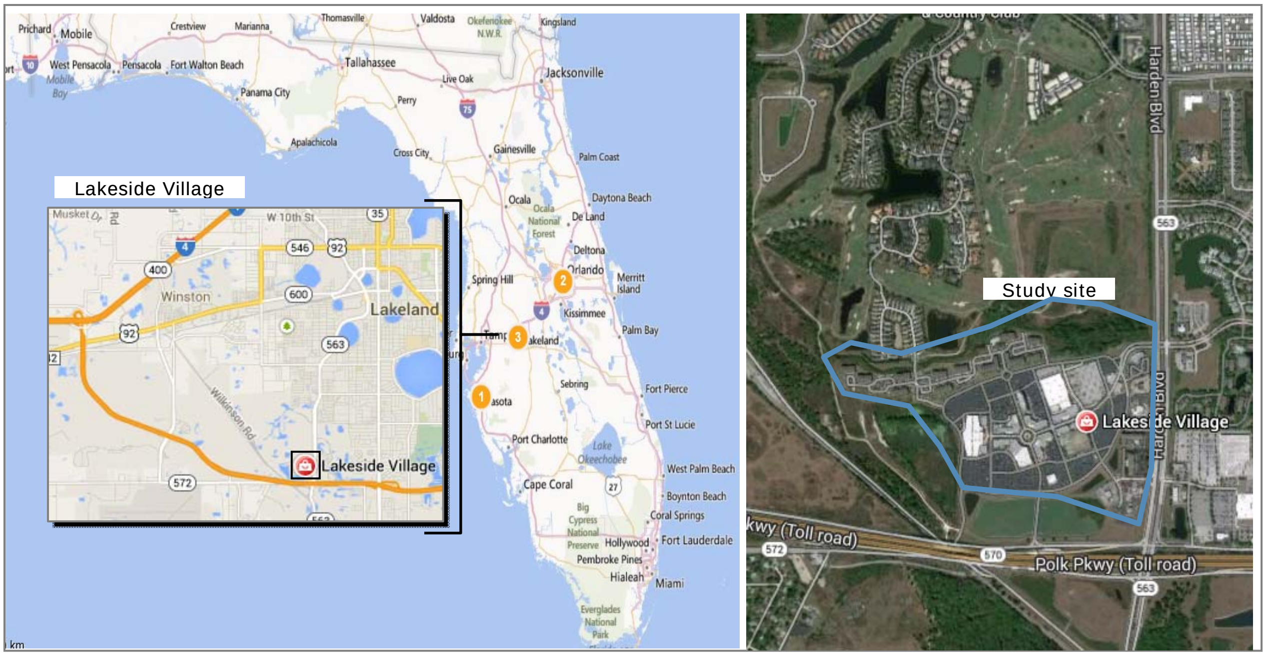


Figure 4-20: Overview of Lakeside Village

4.3.1 Land Use Inventory

The commercial area contains three major anchor stores and a multiplex movie theater. There are three hotels in the MXD, one of which is located in the commercial area; the other two are in located on the outparcels. There are 312 units of high-end multi-family apartments located on the north side of the development. The residential units have direct connectivity with the commercial area with pedestrian and vehicular connections. The shopping center has two big-box apparel retailers and one home improvement store. The shopping center provides a walkable environment. The outparcels have coffee shops, sit-down restaurants, a bank and hotel, and connectivity with the rest of the development through sidewalks. An overview of the land use inventory is presented in Figure 4-21. The available land use is presented in Table 4-22. Figure 4-22 shows the character of Lakeside Village.

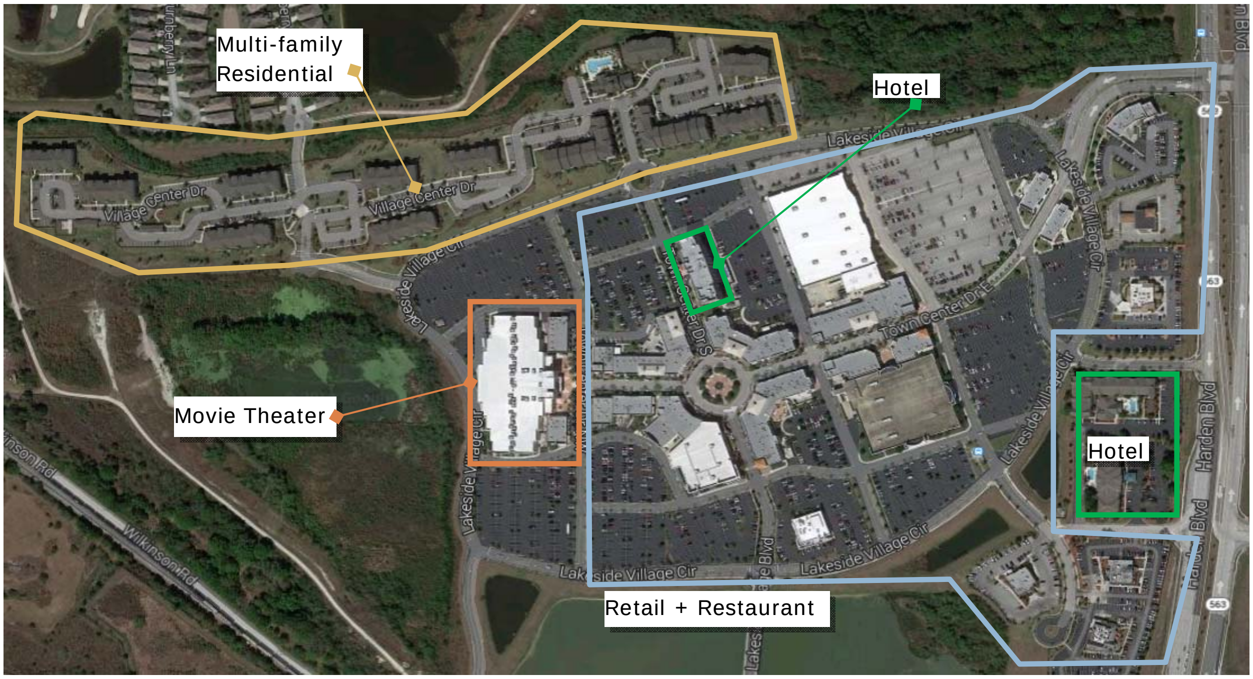


Figure 4-21: Lakeside Village Land Use Inventory

Table 4-22: Land Use Availability for Lakeside Village

Land Use Type	Size	Units
Hotel	900	rooms
Movie	76,902	sq. ft.
Residential	312	dwelling units (du)
Restaurant	79,160	sq. ft.
Retail	387,316	sq. ft.

A. Hotel

B. Movie and Retail

C. Residential

D. Restaurant

Figure 4-22: Hotel, Movie, Retail, Residential, and Restaurant at Lakeside Village

4.3.2 Cordon Counts and Vehicle Occupancy

Cordon counts for vehicles and person were obtained through data collection. Cordon counts reflect the total activity of the development and include the interaction between land uses (internal trip capture) and measure the traffic impact of the development on the public roadway system.

Cordon count and vehicle occupancy values for Lakeside Village are presented in Table 4-23. It can be observed that the morning period presents an expected trip distribution for the residential area, with 92 vehicle trips outbound and 27 inbound. For the MXD as a whole, the total trip generation in the morning was dominated by commercial establishment inbound trips. These trips were employee trips, not customer trips. The occupancy in the morning was similar for both residential and commercial. For the PM peak period, the residential part of the development presented an expected shift in the trip directional distribution, with 144 inbound trips and 76 outbound trips. The residential vehicle trips had low occupancy compared to the overall occupancy of the MXD. Based on general observations from the data collection crew, the residents were predominantly young professionals, typical tenants for high-end apartments.

Table 4-23: Summary of Cordon Counts and Vehicle Occupancy by Land Use, Direction, and Time of Day – Lakeside Village

Type	Direction	Vehicle Counts	Person Vehicle	Vehicle Occupancy	Period
Residential	Inbound	27	31	1.15	7:00–9:00 AM
	Outbound	92	101	1.10	
MXD	Inbound	512	594	1.16	
	Outbound	450	523	1.16	
Residential	Inbound	144	157	1.09	4:00–6:00 PM
	Outbound	76	79	1.04	
MXD	Inbound	1,800	2,309	1.28	
	Outbound	1,654	2,240	1.35	

4.3.3 Trip Generation and Internal Trip Capture, PM Peak Period

Trip generation and internal trip capture data were obtained from door counts and interviews by applying the procedure described in Chapter 3. A sample consisting of 337 interviews was obtained in the PM peak period (3:00–7:00 PM). For the PM peak hour (4:00–6:00 PM), the number of usable trips was 94 for inbound and 165 for outbound. Table 4-24 presents the balanced trip distribution for outbound trips by land use. It can be observed that there were as many as 187 trips going outbound from restaurant (as origin) to retail. Similarly, there were 118 trips going outbound from retail to residential; the interaction between residential land uses as trip origins and retail was relatively low, with 2 trips.

Table 4-24: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – Lakeside

Outbound From	To							Total
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal	
Residential	-	0	2	0	2	75	4	79
Restaurant	47	-	187	0	47	607	281	888
Retail	118	24	-	0	0	1,598	142	1,740
Hotel	0	8	3	-	3	7	14	21
Cinema	0	4	11	4	-	80	19	99
Total	165	36	203	4	52	2,367	460	2,827

Table 4-25 presents observed internal trip capture behavior for Lakeside Village during the PM peak period in percentages. It can be observed that there was a strong interaction between trips generating from hotel to restaurant (38%). The percentage of hotel outbound trips captured internally was 67 percent; this is expected due to the close proximity and convenience of having on-site offices and restaurants. For example, for all trips exiting a residential land use in an MXD with characteristics similar to Lakeside, it was expected that 3 percent of those will go to on-site cinema, 3 percent to on-site retail, and the remaining 95 percent to external destinations.

Table 4-25: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – Lakeside Village

Outbound From	To						
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal
Residential	-	0%	3%	0%	3%	95%	5%
Restaurant	5%	-	21%	0%	5%	68%	32%
Retail	7%	1%	-	0%	0%	92%	8%
Hotel	0%	38%	14%	-	14%	33%	67%
Cinema	0%	4%	11%	4%	-	81%	19%
Total Outbound ITC	6%	1%	7%	0%	2%	84%	16%

For inbound trips, the distribution of observed trip generation and internal trip capture is presented in Table 4-26. Inbound trips are interpreted as having the destination land use as reference. For example, in Table 4-26, 4 trips were observed inbound to hotel from on-site cinema; similarly, 187 trips were inbound to retail from on-site restaurant and 1,579 came from external origins.

Table 4-26: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Inbound Trips – Lakeside Village

Inbound To	From							Total
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal	
Residential	-	47	118	0	0	138	165	303
Restaurant	0	-	24	8	4	711	36	747
Retail	2	187	-	3	11	1,579	203	1,782
Hotel	0	0	0	-	4	22	4	26
Cinema	2	47	0	3	-	78	52	130
Total	4	281	142	14	19	2,528	460	2,988

The trip distribution in inbound direction for the PM peak period as percentages is presented in Table 4-27. For residential land use, 16 percent of inbound trips originated at an on-site restaurant, 39 percent came from retail, and 46 percent came from external origins. For restaurants, 3 percent of entering trips came from retail, 1 percent from cinema, 1 percent from hotel, and the remaining 95 percent from external origins. The internal trip capture rate for outbound trips in the PM peak period was 16 percent and for inbound trips was 15 percent. The overall internal trip capture for the development was 16 percent.

Table 4-27: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – Lakeside Village

Inbound To	From						
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal
Residential	-	16%	39%	0%	0%	46%	54%
Restaurant	0%	-	3%	1%	1%	95%	5%
Retail	0%	10%	-	0%	1%	89%	11%
Hotel	0%	0%	0%	-	15%	85%	15%
Cinema	2%	36%	0%	2%	-	60%	40%
Total Inbound ITC	0%	9%	5%	0%	1%	85%	15%

4.3.4 Trip Generation and Internal Trip Capture, AM Peak Period

The balanced trip distribution for the AM peak period for outbound trips in Lakeside Village is presented in Table 4-28. Residential, restaurant, and hotel were the active establishments at the site during the 7:00–9:00 AM peak period. During the AM data collection (6:00–10:00 AM) a total of 126 interviews were obtained. During the AM peak hour (7:00–9:00 AM) the collected data yielded 37 inbound and 99 outbound usable trips. It was estimated that 173 trips originated at on-site restaurants; of those, 149 were headed outside the boundaries of Lakeside Village. Similarly, for hotel as origin, it was estimated that 155 trips can be attributed to outbound customers, 142 of which are external trips.

Table 4-28: AM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – Lakeside Village

Outbound From	To							Total
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal	
Residential	-	11	0	0	0	90	11	101
Restaurant	11	-	0	13	0	149	24	173
Retail	0	0	-	0	0	0	0	0
Hotel	0	13	0	-	0	142	13	155
Cinema	0	0	0	0	-	0	0	0
Total	11	24	0	13	0	381	48	429

Table 4-29 presents the vehicle trip distribution for outbound trips in percentage form for the AM peak period. Of the observed trips exiting from residential land uses, 11 percent were headed to on-site restaurants and the remaining 89 percent to external destinations. For residential uses, 11 percent of exiting trips were internal to the MXD. The greatest degree of interaction was observed in trips leaving residential land use and going to on site restaurant (11%). The AM internal trip capture in the AM peak period was 11 percent in the outbound direction and 7 percent in the inbound direction. The overall internal trip capture was 9 percent.

Table 4-29: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – Lakeside Village

Outbound From	To						
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal
Residential	-	11%	0%	0%	0%	89%	11%
Restaurant	6%	-	0%	8%	0%	86%	14%
Retail	0%	0%	-	0%	0%	100%	0%
Hotel	0%	8%	0%	0%	0%	92%	8%
Cinema	0%	0%	0%	0%	-	100%	0%
Total Outbound ITC	3%	6%	0%	3%	0%	89%	11%

For inbound vehicle trips in the AM peak period, the obtained data in presented in Table 4-30. It shows a total of 195 trips were observed entering the on-site restaurant, of which 24 trips came from other on-site establishments (internal trips) and 171 from establishments outside the boundaries of the MXD. Similar interpretations can be applied for restaurant and retail land uses.

Table 4-30: AM Peak Balanced Period Vehicle Trip Distribution by Land Use for Inbound Trips – Lakeside Village

Inbound To	From							Total
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal	
Residential	-	11	0	0	0	93	11	104
Restaurant	11	-	0	13	0	171	24	195
Retail	0	0	-	0	0	280	0	280
Hotel	0	13	0	-	0	50	13	63
Cinema	0	0	0	0	-	0	0	0
Total	11	24	0	13	0	594	48	642

Table 4-31 presents the vehicle trip distribution for inbound trip for the AM peak period in percentages. This representation allows for a more comprehensive interpretation and generalization of the obtained data. For restaurant land use as an origin, it was estimated that 6 percent of the inbound trips are coming from on-site residential, 7 percent from hotel, and the remaining 88 percent from external locations.

Table 4-31: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – Lakeside Village

Inbound To	From						
	Residential	Restaurant	Retail	Hotel	Cinema	External	Internal
Residential	-	11%	0%	0%	0%	89%	11%
Restaurant	6%	-	0%	7%	0%	88%	12%
Retail	0%	0%	-	0%	0%	100%	0%
Hotel	0%	21%	0%	-	0%	79%	21%
Cinema	0%	0%	0%	0%	-	100%	0%
Total Inbound ITC	2%	4%	0%	2%	0%	93%	7%

4.3.5 Transportation Mode and Proximity

In addition to internal trip capture mode, land use proximity data for internal trips were collected and analyzed. Figure 4-23 presents the mode distribution for outbound trips for the PM peak period for Lakeside Village. It can be observed that automobile was the dominant mode for external trips exiting residential. Walking was the dominant mode for internal trips. For outbound trips from retail to restaurant, 100 percent of the observed trips were walking trips. A total of 2 percent of the retail external outbound trips were made by bus; for restaurants, 6 percent of the residential external outbound trips were made by bus.

The mode distribution for inbound trips for PM peak period is presented in Figure 4-24. For trips inbound to restaurant from retail, walking and auto trips shared the transportation mode choice equally. A total of 100 percent of trips inbound to restaurant from movie were walking trips, illustrating the close proximity of the movie theater to restaurants on the site. Inbound trips to movie from restaurant were 100 percent auto trips, and trips from restaurant to retail were 100 percent walking trips; all others were automobile-based trips.

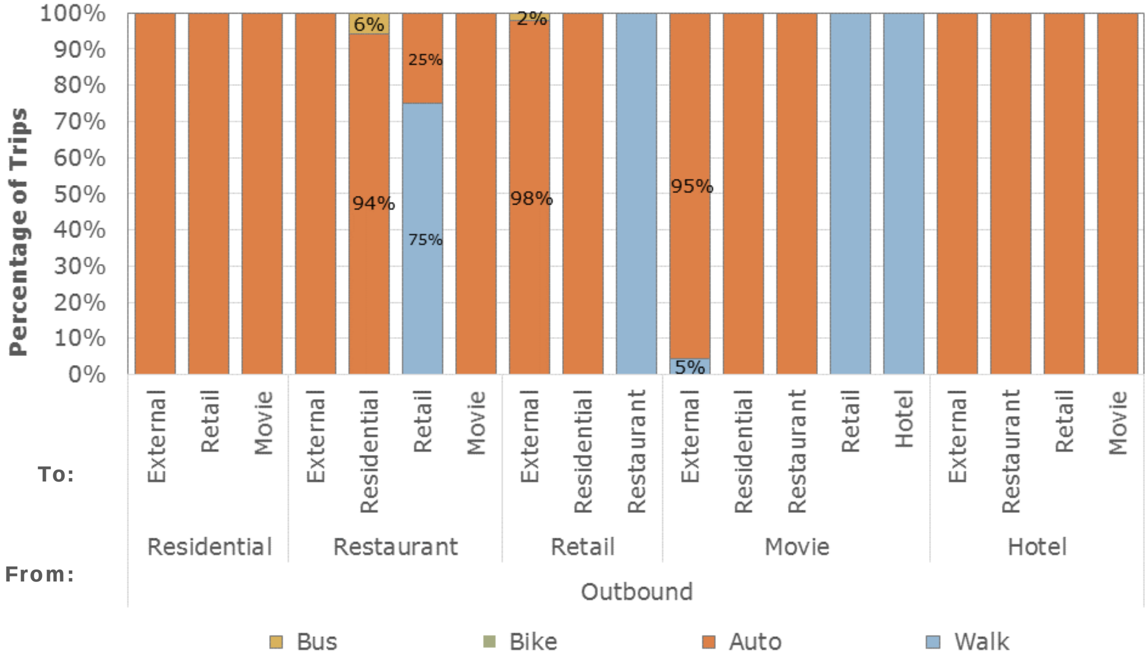


Figure 4-23: Transportation Mode for Outbound Trips in PM Peak Period – Lakeside Village

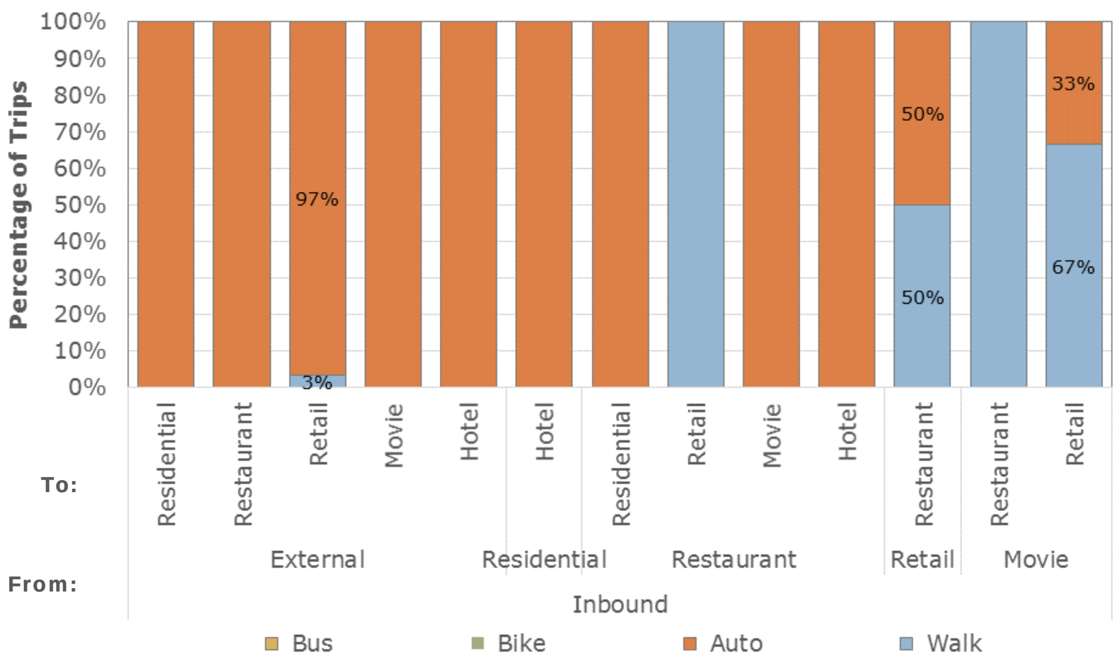


Figure 4-24: Transportation mode for Inbound Trips in PM Peak Period – Lakeside Village

The mode distribution for outbound trips during the AM peak period is presented in Figure 4-25. Automobile trips were the dominant mode for residential trips. For residential to residential, the majority of the trips were walking trips. For outbound trips from restaurant, the mode was split consistently, with walk (33%) and auto (67 %) used for hotel trips.

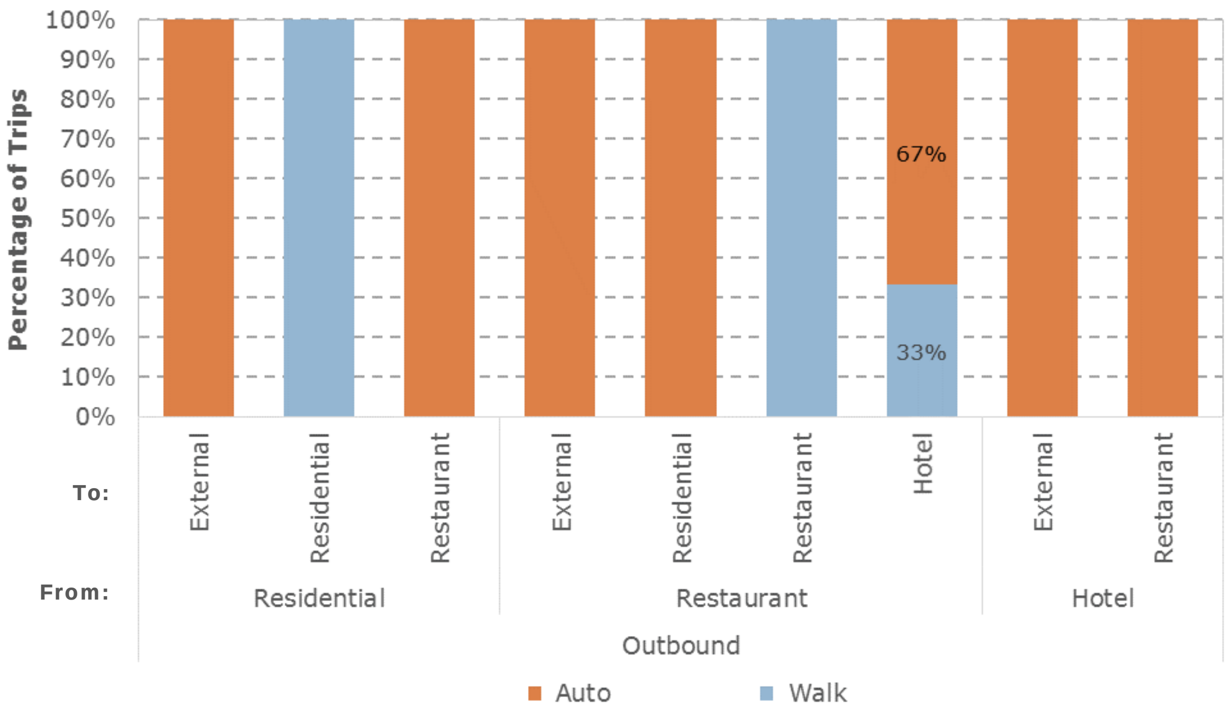


Figure 4-25: Transportation Mode for Outbound Trips in AM Peak Period – Lakeside Village

The modal split for inbound trips for Lakeside Village for the AM peak period is presented in Figure 4-26. It can be observed that walking was the preferred method for internal trips. For external trips, walking was the dominant mode.

The cumulative distribution of trip by distance is presented in Figure 4-27 for both AM and PM peak periods. For the PM peak period, there are two possible trip clusters indicating proximity effects. The first one is between the 0 and 10 and the other between 60 and 75. A total of 80 percent of the trips occurred in less than 1,000 ft. The maximum internal trip length is 3,400 ft. for rectangular distances or 2,500 ft. for Euclidean distances.

The maximum internal trip length for Lakeside Village is shown in Figure 4-28. The supplemental data on trip length distribution by land use pair for Lakeside Village is presented in Appendix D.

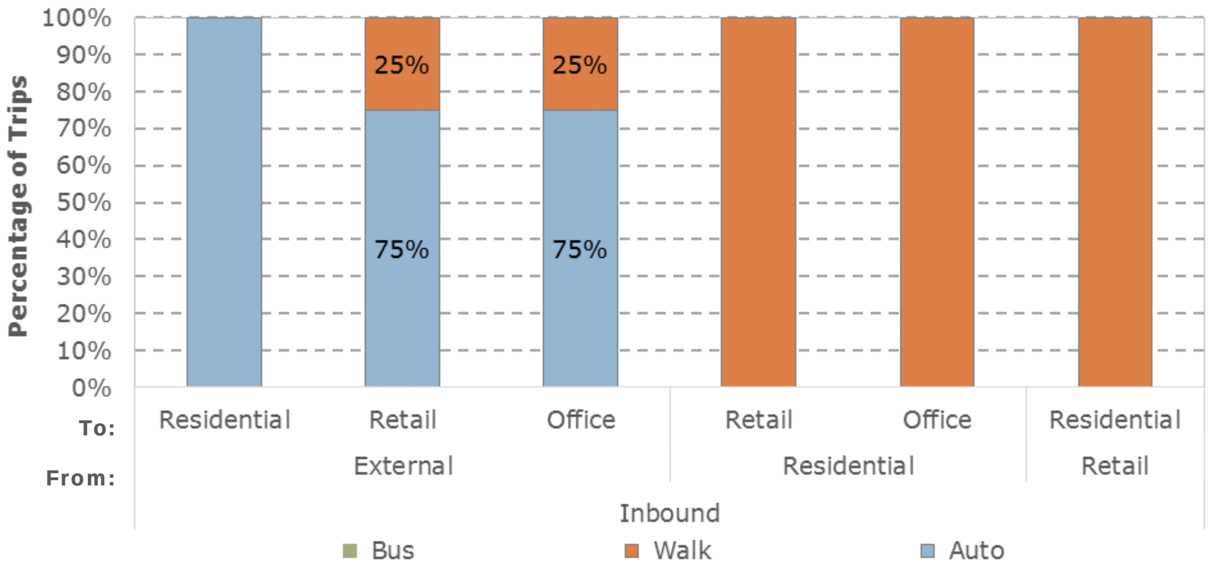


Figure 4-26: Transportation mode for Inbound Trips in the AM Peak Period – Lakeside Village

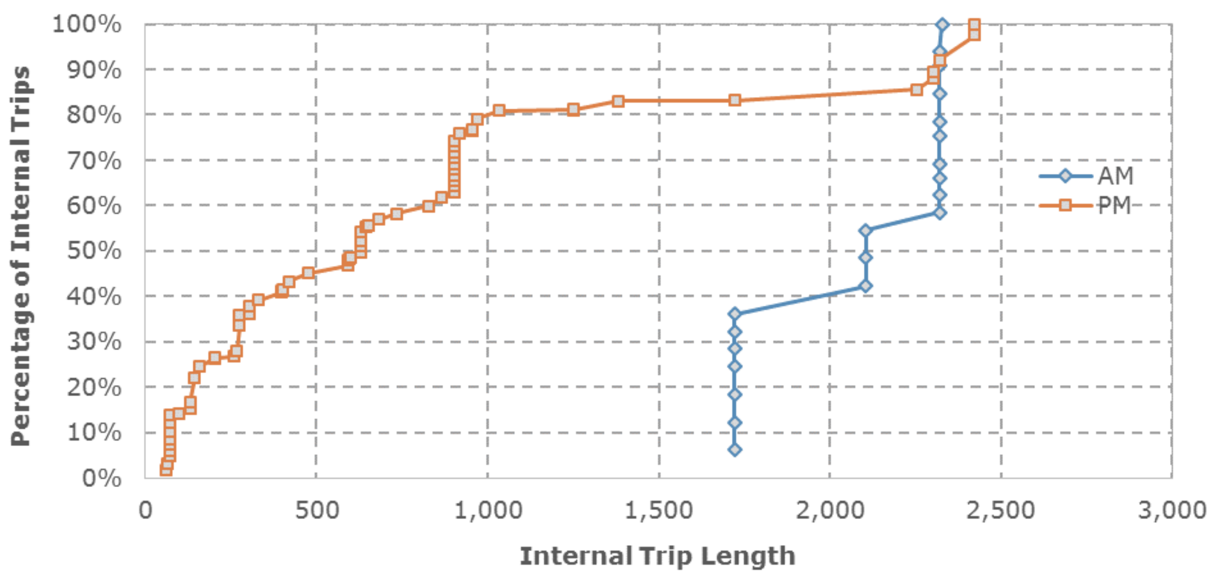


Figure 4-27: Cumulative Distribution for Internal Trips Based on Trip Length for AM and PM Peak Periods – Lakeside Village

Figure 4-28: Maximum Internal Trip Length – Lakeside Village

4.4 Uptown Altamonte

Uptown Altamonte is located on Altamonte Drive in close proximity to the Interstate I-4/ US 92 interchange north of Orlando (see Figure 4-29). Uptown Altamonte is a master planned development resulting from a joint venture of two major Orlando-based development firms, private investors, and the City of Altamonte. The project was scheduled for several phases that included residential, office, retail, and restaurants, some of which were still under construction at the time of this study. Uptown Altamonte was integrated with existing major retail centers such as the Renaissance Centre and the Altamonte Mall. Other isolated land uses also were in place, such as outparcel restaurants, gas stations, multi-family homes, hotel, and mid-rise office buildings.

Uptown Altamonte provides an amenable mix of land uses, including mid-rise apartments, a fitness center, restaurants, and retail in addition to a scenic park that promotes walking and trip internalization. Uptown Altamonte can be traversed via Cranes Roost Boulevard, which allows pass-through traffic in the development. A section of the road is paved with cobblestones effective in slowing traffic, and priority is given to pedestrian infrastructure, as shown in Figure 4-30. Traffic is also diverted through Festival Drive, leaving a more walkable environment towards an on-site waterfront park (Cranes Roost Park).

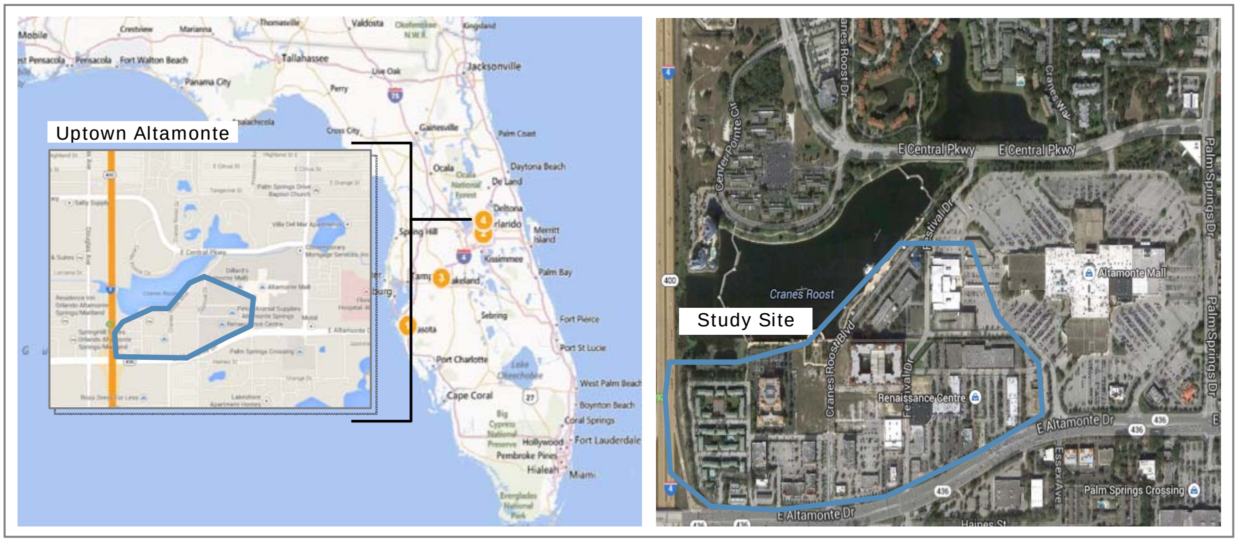


Figure 4-29: Overview of Altamonte

Figure 4-30: View of Cranes Roost Blvd – Uptown Altamonte

4.4.1 Land Use Inventory

To obtain a land use mix, the existing office center, hotel, and existing residential were integrated as part of the study. The Altamonte Mall movie theater was included in the survey, as shown in Figure 4-31; however, since it did not significantly contribute to the cordon counts due to lack of connectivity, it was excluded from the analysis. The Renaissance Centre (shopping center) was included in the analysis since it is highly integrated with Uptown Altamonte. The character of Uptown Altamonte is shown in Figure 4-32 and Figure 4-33.

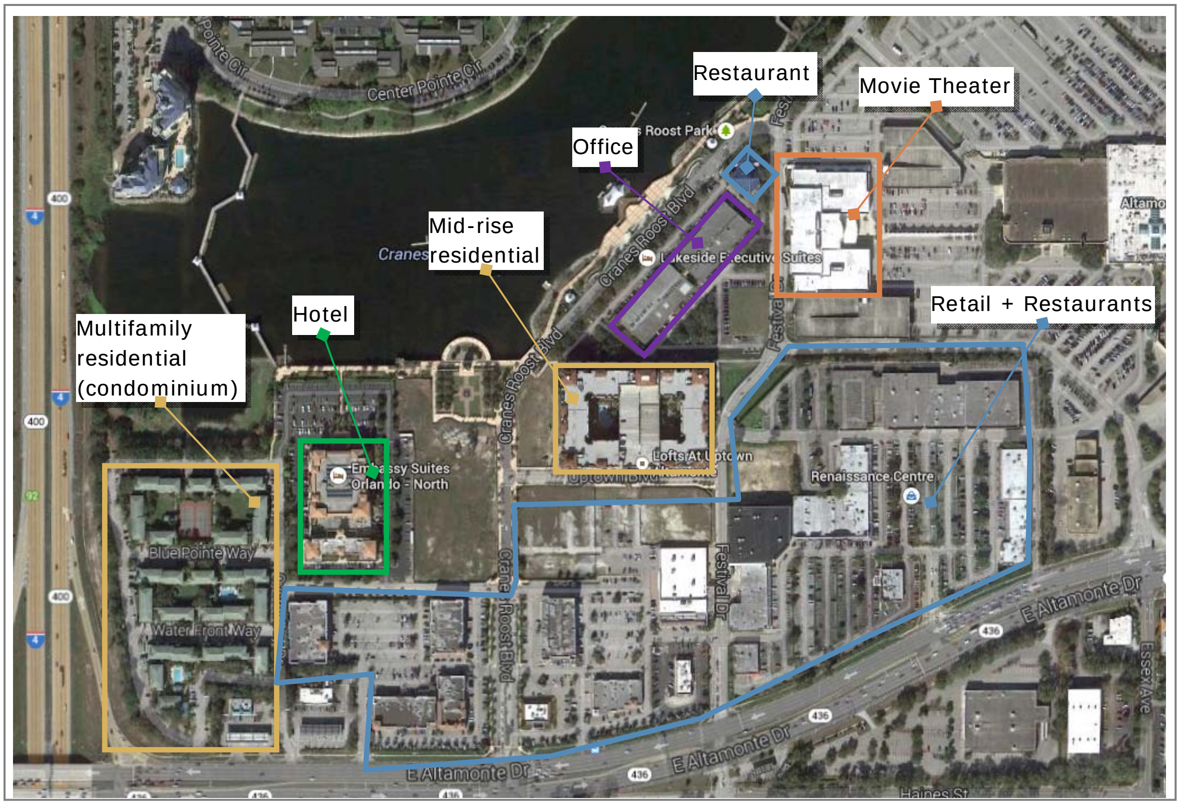
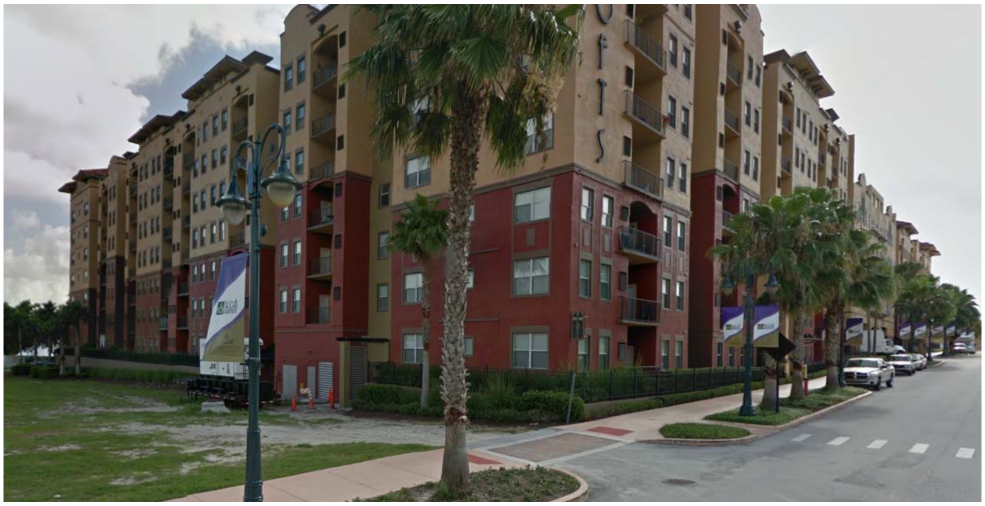


Figure 4-31: Uptown Altamonte Land Use Inventory

Table 4-32: Land Use Availability for Uptown Altamonte

Land Use Type	Size	Units
Residential	880	dwelling units (du)
Restaurant	11,453	sq. ft.
Retail	451,632	sq. ft.
Office	117,175	sq. ft.
Hotel	277	rooms
Cinema*	92,535	sq. ft.

* Cinema land use was not included in the internal trip capture analysis due to a permission issue on data collection.



A. Mid-Rise Residential

B. Restaurant

C. Retail

Figure 4-32: Residential, Restaurant, and Retail at Uptown Altamonte

A. Office

B. Hotel

Figure 4-33: Office and Hotel at Uptown Altamonte

4.4.2 Cordon Counts and Vehicle Occupancy

Data collection in Uptown Altamonte was performed on December 5–6, 2012, for the PM and AM periods, respectively. Cordon counts reflect the total activity of the development and include the interaction between land uses (internal trip capture). The cordon counts in Uptown Altamonte included through traffic and, for this reason, this development was not included in the validation data. The estimated impact of the development traffic to the cordon count is presented for completeness of the analysis. The data collection included cordon counts, door counts, and interviews. Cordon counts measure the traffic impact of the development on the public roadway system.

The vehicle cordon counts for Uptown Altamonte are presented in Table 4-33. The morning period showed an expected trip distribution for the residential area, with 382 vehicle trips outbound and 189 inbound. During the PM peak period, the residential part of the development presented an expected shift in the trip directional distribution, with 144 inbound trips and 76 outbound trips. For the MXD as a whole, the total trip generation in the morning was dominated by the commercial establishment inbound trips. These trips are employee trips, not customer trips.

Table 4-33: Summary of Cordon Counts and Vehicle Occupancy by Land Use, Direction, and Time of Day –Uptown Altamonte

Type	Direction	Vehicle Counts	Person Vehicle	Vehicle Occupancy	Period
Residential	Inbound	189	200	1.06	7:00–9:00 AM
	Outbound	382	435	1.14	
MXD	Inbound	831	904	1.09	
	Outbound	699	749	1.07	
Residential	Inbound	144	157	1.09	4:00–6:00 PM
	Outbound	76	79	1.04	
MXD	Inbound	1,893	2,214	1.17	
	Outbound	1,862	2,169	1.16	

4.4.3 Trip Generation and Internal Trip Capture, PM Peak Period

Trip generation and internal trip capture for the PM peak period are presented in this section. Table 4-34 presents the trip distribution for outbound trips by land use. For the PM data collection (3:00–7:00 PM) a total of 378 interviews were obtained. From the collected data 99 inbound and 37 outbound complete trips were extracted for the PM peak hour (4:00–6:00 PM). Trip distribution for trips exiting residential was 5 trips to restaurant, 43 trips to retail, 0 trips to office and 4 to hotel. The greatest interaction was observed for trips exiting retail and going to restaurant (56 trips) followed by residential to retail (43 trips).

Table 4-34: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – Uptown Altamonte

Outbound From	To							Total
	Residential	Restaurant	Retail	Office	Hotel	External	Internal	
Residential	-	5	43	0	4	48	52	100
Restaurant	12	-	26	3	0	334	41	375
Retail	36	56	-	0	8	782	100	882
Office	16	2	1	-	2	47	21	68
Hotel	2	1	8	0	-	114	11	125
Total	66	64	78	3	14	1,325	225	1,550

The trip distribution for outbound trips in Uptown Altamonte for the PM peak period expressed in percentage form is shown in Table 4-35. The internal trip capture for residential trips was 52 percent, with the majority of them going from residential to retail, to hotel, to office and to restaurants. For restaurants, 89 percent of the outbound trips were headed to an external destination and 11 percent were internal. Some degree of interaction was observed between the office building and a restaurant with a coffee bar located within 300 feet (3%). For retail, the internal trip capture was 11 percent. Office presented an internal trip capture rate of 31 percent, with the highest interaction observed with the on-site residential. The observed internal trip capture for hotel was 9 percent.

Table 4-35: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – Uptown Altamonte

Outbound From	To						
	Residential	Restaurant	Retail	Office	Hotel	External	Internal
Residential	-	5%	43%	0%	4%	48%	52%
Restaurant	3%	-	7%	1%	0%	89%	11%
Retail	4%	6%	-	0%	1%	89%	11%
Office	24%	3%	1%	-	3%	69%	31%
Hotel	2%	1%	6%	0%	-	91%	9%
Total Outbound ITC	4%	4%	5%	0%	1%	85%	15%

The trip distribution for inbound trips during the PM peak period is presented in Table 4-36. Retail had 43 and 26 incoming trips from residential and restaurants, respectively. There were as many as many as 803 external trips to retail, which shows the large variety of retail stores available in the establishment.

Table 4-36: PM Peak Period Balanced Vehicle Trip Distribution by Land Use for Inbound Trips – Uptown Altamonte

Inbound To	From							Total
	Residential	Restaurant	Retail	Office	Hotel	External	Internal	
Residential	-	12	36	16	2	217	66	283
Restaurant	5	-	56	2	1	406	64	470
Retail	43	26	-	1	8	803	78	881
Office	0	3	0	-	0	24	3	27
Hotel	4	0	8	2	-	134	14	148
Total	52	41	100	21	11	1,584	225	1,809

The inbound trip distribution percentages for the PM peak period in Uptown Altamonte are presented in Table 4-37. For residential land uses, it was observed that 23 percent of the inbound trips were coming each from on-site retail, office, hotel, and restaurants. For restaurants, 12 percent of the inbound or entering trips came from on-site retail and 86 percent from external origins. For retail, inbound trips were 5 percent from residential, 3 percent from restaurant, and 91 percent from origins outside the boundaries of Uptown Altamonte. For office, 11 percent of the entering trips came from internal origins, of which 11 percent were from restaurant, and the remaining were from external origins. The maximum interaction was observed in inbound trips to residential from retail, with 13 percent. The internal trip capture rate for outbound trips in the PM peak period was 15 percent and for inbound trips was 12 percent. The overall internal trip capture for the development was 13 percent.

Table 4-37: PM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – Uptown Altamonte

Inbound To	From						
	Residential	Restaurant	Retail	Office	Hotel	External	Internal
Residential	-	4%	13%	6%	1%	77%	23%
Restaurant	1%	-	12%	0%	0%	86%	14%
Retail	5%	3%	-	0%	1%	91%	9%
Office	0%	11%	0%	-	0%	89%	11%
Hotel	3%	0%	5%	1%	-	91%	9%
Total Inbound ITC	3%	2%	6%	1%	1%	88%	12%

4.4.4 Trip Generation and Internal Trip Capture, AM Peak Period

Table 4-38Table 4-38 presents observed trip generation and distribution for outbound vehicle trips in the AM peak period. A total of 232 interviews were obtained during the AM data collection period from 6:00–10:00 AM. The usable AM peak hour trips (7:00–9:00 AM) extracted from the interviews were 44 inbound trips and 75 for outbound trips. For restaurant and retail land uses, the number of external trips was estimated based on door counts and interviews. It was estimated that 77 trips originated at on-site restaurants, all of which were headed outside the boundaries of Uptown Altamonte. Similarly, for hotel as origin, it was estimated that 118 trips could be attributed to outbound costumers, of which 101 were external trips. For residential as origin, 21 trips were headed to the on-site retail, 11 trips to restaurant, and 374 trips were to destinations outside Uptown Altamonte.

Table 4-38: AM Peak Period Balanced Vehicle Trip Distribution by Land Use for Outbound Trips – Uptown Altamonte

Outbound From	To							Total
	Residential	Restaurant	Retail	Office	Hotel	External	Internal	
Residential	-	11	21	0	0	374	32	406
Restaurant	0	-	0	0	0	77	0	77
Retail	6	5	-	0	0	25	11	36
Office	0	0	0	-	0	0	0	0
Hotel	14	3	0	0	-	101	17	118
Total	20	19	21	0	0	577	60	637

Table 4-39 presents the vehicle trip distribution for outbound trips in percentage form for the AM peak period. From hotel, 3 percent of the trips were captured by the on-site restaurant and 12 percent to residential, and for retail 14 percent of the outbound trips were made to a restaurant, 17 percent to residential, and 69 percent to external regions.

Table 4-39: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Outbound Trips – Uptown Altamonte

Outbound From	To						
	Residential	Restaurant	Retail	Office	Hotel	External	Internal
Residential	-	3%	5%	0%	0%	92%	8%
Restaurant	0%	-	0%	0%	0%	100%	0%
Retail	17%	14%	-	0%	0%	69%	31%
Office	0%	0%	0%	-	0%	100%	0%
Hotel	12%	3%	0%	0%	-	86%	14%
Total Outbound ITC	3%	3%	3%	0%	0%	91%	9%

The trip distribution for inbound trips is shown in Table 4-40. A total of 154 trips entered on-site residential, of which 20 were from within the establishments. Similar interpretations can be applied for restaurant and retail land uses. It can be observed that 33 trips were generated from residential, of which 21 and 11 trips were headed to retail and restaurant, respectively. It can be seen that the same trips are represented in percentages in Table 4-41 as 39 percent and 13 percent, respectively. For Altamonte, the AM internal trip capture in the AM peak period was 9 percent in the outbound direction and 17 percent in the inbound direction. The overall internal trip capture was 12 percent.

Table 4-40: AM Peak Period Balanced Vehicle Trip Distribution by Land Use for Inbound Trips – Uptown Altamonte

Inbound To	From							Total
	Residential	Restaurant	Retail	Office	Hotel	External	Internal	
Residential	-	0	6	0	14	134	20	154
Restaurant	11	-	5	0	3	64	19	83
Retail	21	0	-	0	0	33	21	54
Office	0	0	0	-	0	0	0	0
Hotel	0	0	0	0	-	57	0	57
Total	33	0	11	0	17	288	60	348

Table 4-41: AM Peak Period Percent Vehicle Trip Distribution by Land Use for Inbound Trips – Uptown Altamonte

Inbound To	From						
	Residential	Restaurant	Retail	Office	Hotel	External	Internal
Residential	-	0%	4%	0%	9%	87%	13%
Restaurant	13%	-	6%	0%	4%	77%	23%
Retail	39%	0%	-	0%	0%	61%	39%
Office	0%	0%	0%	-	0%	100%	0%
Hotel	0%	0%	0%	0%	-	100%	0%
Total Inbound ITC	9%	0%	3%	0%	5%	83%	17%

4.4.5 Transportation Mode and Proximity

In addition to internal trip capture mode, proximity data for internal trips were also collected and analyzed. Figure 4-34 presents the mode distribution for outbound trips for Uptown Altamonte during the PM peak period. It can be observed that automobile was the dominant mode for external trips, ranging from 85–95 percent for all the land uses. Internal trips presented different scenarios of mode share; for example, trips outbound from retail headed to the on-site restaurant had 38 percent walking and 13 percent biking. Similarly, 50 percent of the outbound trips from retail to residential were walking trips.

The mode distribution for inbound trips for PM peak period is presented in Figure 4-35. For trips, inbound from retail to restaurant, 13 percent were walking trips and the rest were auto trips. Similarly, for trips inbound to residential from retail, 100 percent were walking trips. This shows the close proximity of the shopping center to residential. Inbound trips from residential to retail had 67 percent of walking trips, with the remainder being automobile-base trips.

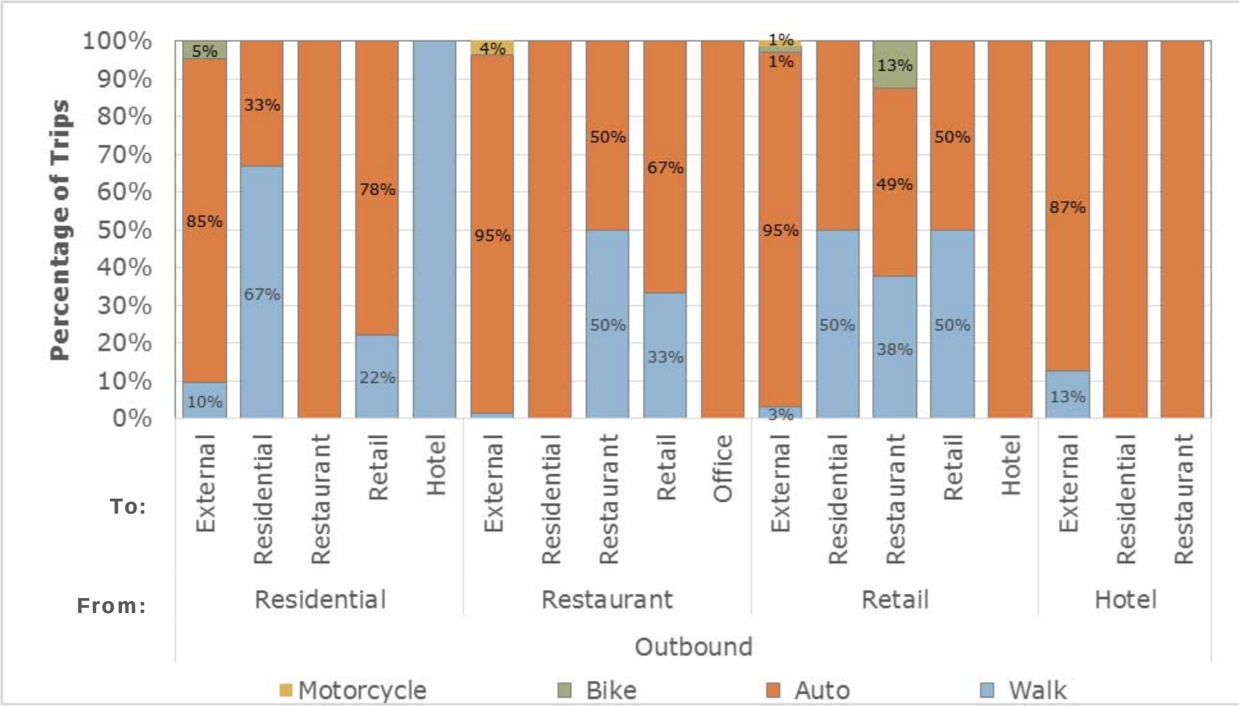


Figure 4-34: Transportation Mode for Outbound Trips in the PM Peak Period – Uptown Altamonte

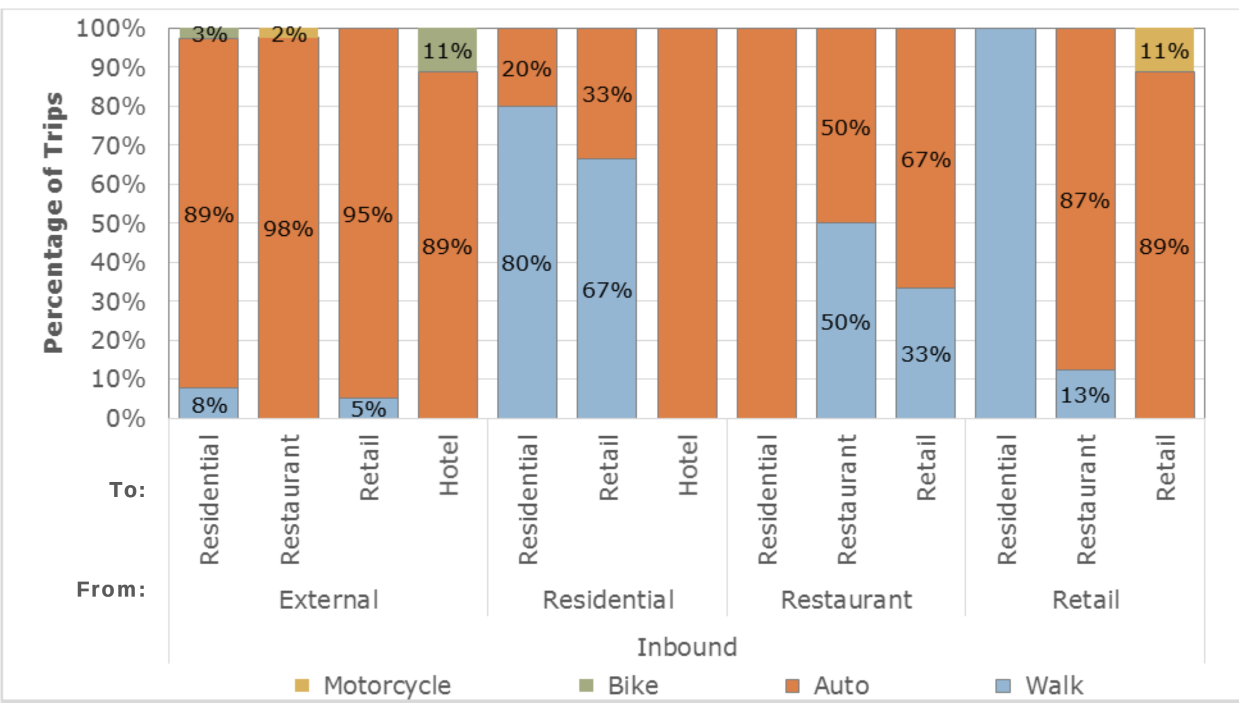


Figure 4-35: Transportation Mode for Inbound Trips in the PM Peak Period – Uptown Altamonte

The distribution for modal split for the AM peak period for Altamonte is presented in Figures 4-36 and 4-37. It can be observed that for residential land uses, 25 percent of the outbound trips to external destinations were made by transit, 69 percent using automobile, and 6 percent using bicycle. For inbound trips in the AM peak period, the dominant mode was automobile, with the exception of inbound trips to retail from residential, for which the mode split is 50 percent automobile and 50 percent walk.

The cumulative distribution of internal trip length is presented in Figure 4-38. The trip lengths do not present any indication of a proximity effect. It is also observed that 90 percent of the trips are within 1,750 feet. The maximum trip length is 3,450 feet in rectangular distance and 2,650 in a straight line distance (Figure 4-39). Supplemental data on trip length distribution by land use pair for Uptown Altamonte are presented in Appendix E.

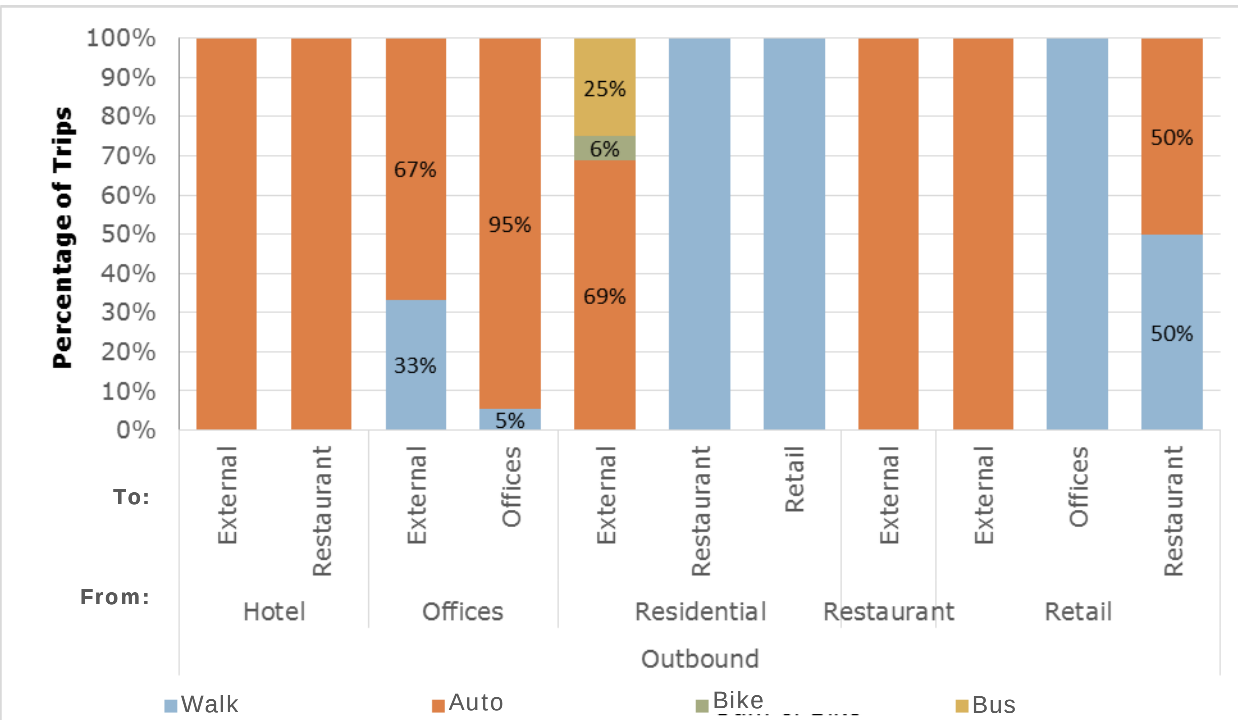


Figure 4-36: Transportation Mode for Outbound Trips in the AM Peak Period – Uptown Altamonte

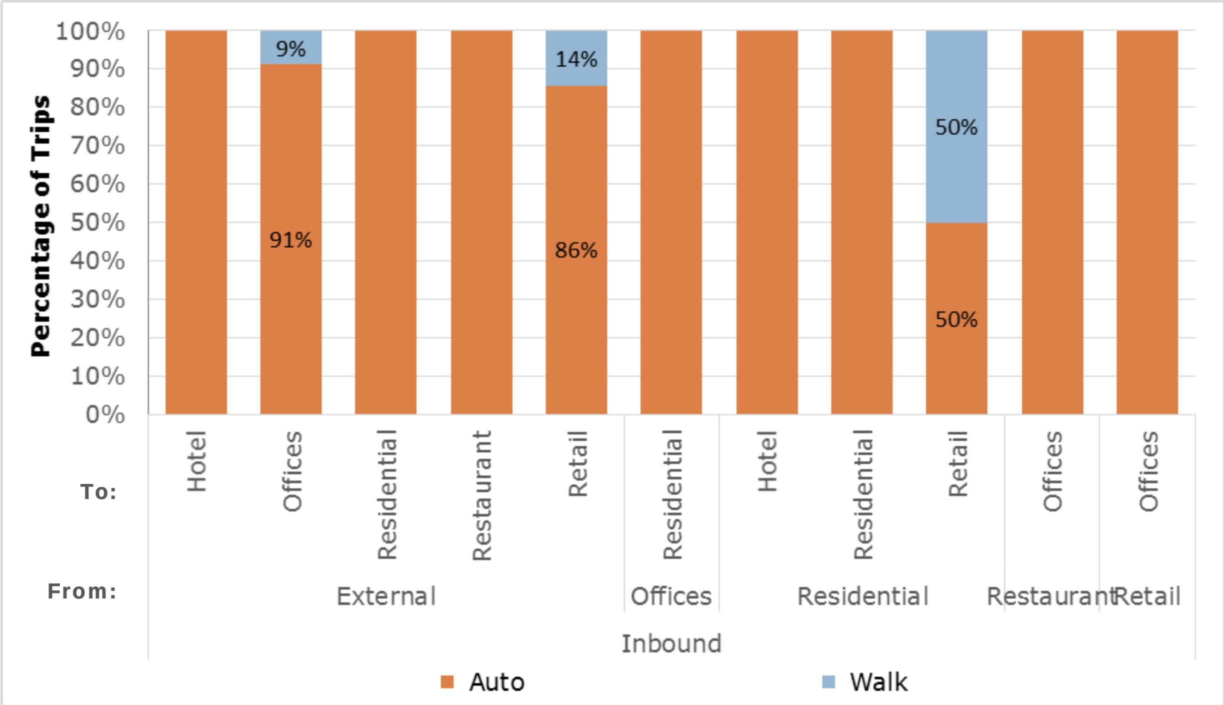


Figure 4-37: Transportation Mode for Inbound Trips in the AM Peak Period – Uptown Altamonte

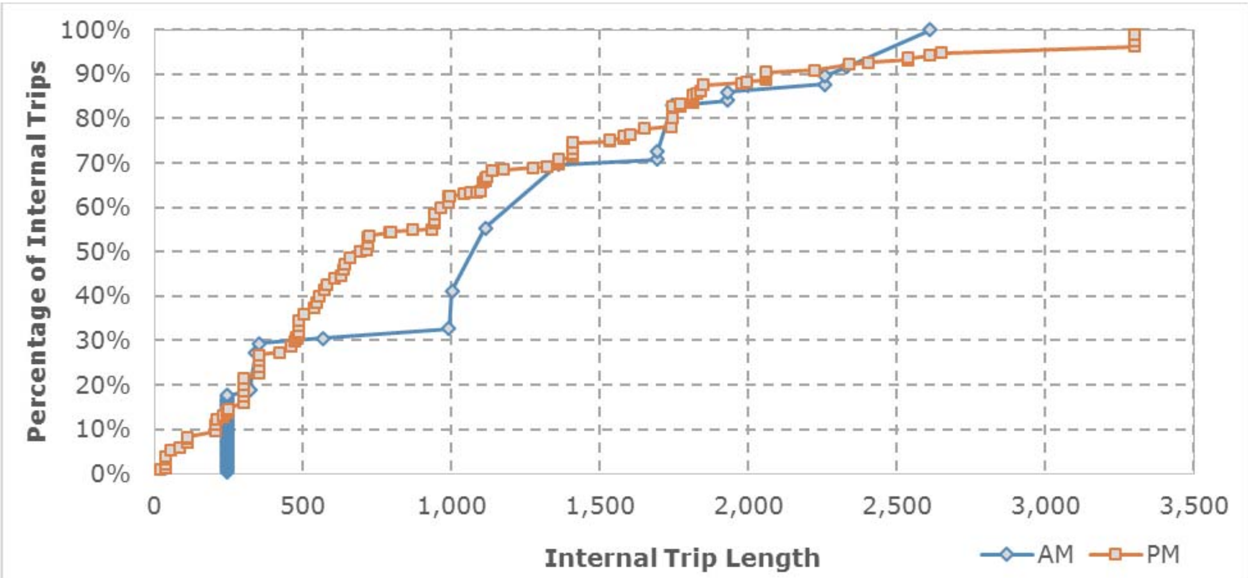


Figure 4-38: Cumulative Distribution for Internal Trips Based on Trip Length for AM and PM peak Periods – Uptown Altamonte

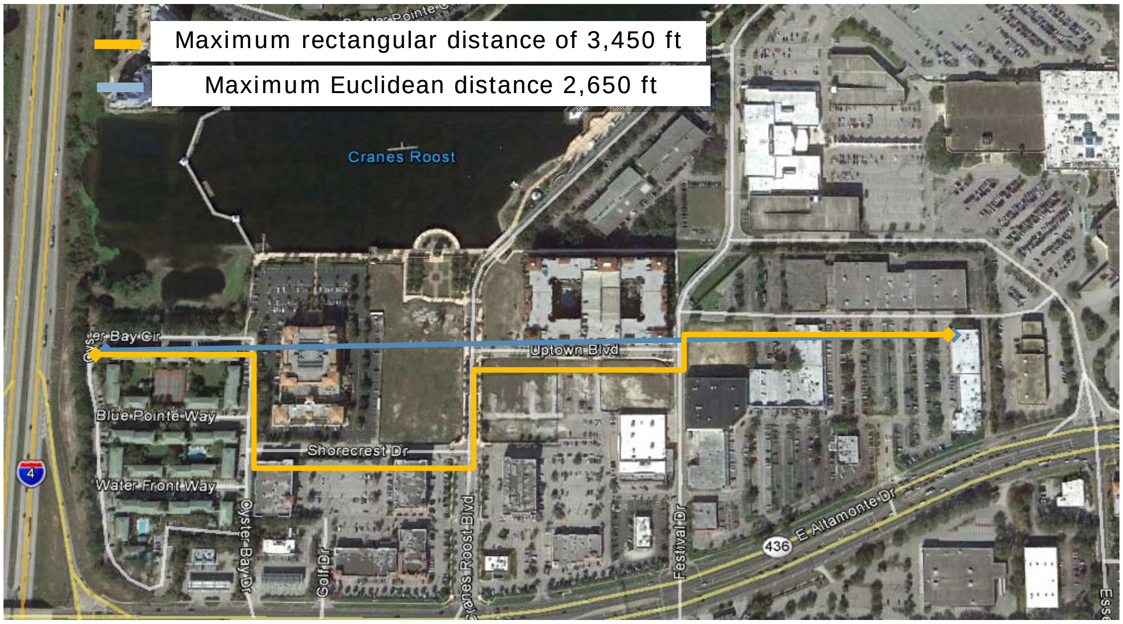


Figure 4-39: Maximum Internal Trip Length – Altamonte

5 Data Analysis and Discussion

This chapter presents the internal trip capture data obtained in this research along with results reported by previous studies. The impact of this research is presented based on the methodology suggested in NCHRP Report 684 [5]. An assessment of the predictive capabilities of the methods and directions for improving prediction capabilities are provided.

5.1 Unconstrained Trip Capture Rates

The unconstrained trip capture rates defined by ITE for all available studies (including this study) for the outbound direction during the PM peak period are presented in Table 5-1. The highest percentages estimated for each land use pair appears in bold font.

Table 5-1: Unconstrained Internal Trip Capture Percentages for Outbound Trips for PM Peak Period

Origin Land Use	MXD Site	Destination Land Use					
		To Office	To Retail	To Restaurant	To Residential	To Cinema	To Hotel
From Office	Creekwood		--	--	--	--	--
	SODO		2	2	0	--	--
	Lakeside Village		--	--	--	--	--
	Uptown Altamonte		1	3	**24**	--	**3**
	Atlantic Station		6	3	0	0	0
	Legacy Town		0	1	2	0	0
	Mockingbird		9	**4**	2	0	--
	Boca Del Mar		0	--	0	--	--
	Country Isles		**20**	--	0	--	--
	Village Commons		6	--	1	--	--
From Retail	Creekwood	--		4	7	--	--
	SODO	0		1	7	--	--
	Lakeside Village	--		1	7	0	0
	Uptown Altamonte	0		6	4	--	1
	Atlantic Station	**2**		19	13	**4**	1
	Legacy Town	1		**29**	**26**	0	**5**
	Mockingbird	1		20	7	**4**	--
	Boca Del Mar	0		--	3	--	--
	Country Isles	1		--	5	--	--
	Village Commons	0		--	7	--	--
From Restaurant	Creekwood	--	9		3	--	--
	SODO	0	2		15	--	--
	Lakeside Village	--	21		5	5	0
	Uptown Altamonte	1	7		3	--	0
	Atlantic Station	1	**41**		3	**8**	**7**
	Legacy Town	2	10		**18**	6	3
	Mockingbird	**3**	38		3	2	--
	Boca Del Mar	--	--		--	--	--
	Country Isles	--	--		--	--	--
	Village Commons	--	--		--	--	--

Note: Highest percentages for each land use pair are indicated in bold.

Table 5-1 (*cont.*): Unconstrained Internal Trip Capture Percentages for Outbound Trips for the PM Peak Period

Origin Land Use	MXD Site	Destination Land Use					
		To Office	To Retail	To Restaurant	To Residential	To Cinema	To Hotel
From Residential	Creekwood	--	30	3		--	--
	SODO	1	20	**24**		--	--
	Lakeside Village	--	3	0		**3**	0
	Uptown Altamonte	0	**43**	5		--	**4**
	Atlantic Station	0	9	3		0	1
	Legacy Town Center	**4**	6	21		0	3
	Mockingbird Station	1	31	11		0	--
	Boca Del Mar	0	42	--		--	--
	Country Isles	0	25	--		--	--
	Village Commons	0	25	--		--	--
From Cinema	Creekwood	--	--	--	--		--
	SODO	--	--	--	--		--
	Lakeside Village	--	11	4	0		**4**
	Uptown Altamonte	--	--	--	--		--
	Atlantic Station	**2**	**21**	11	**8**		0
	Legacy Town Center	0	8	**31**	2		2
	Mockingbird Station	0	17	25	**8**		--
	Boca Del Mar	--	--	--	--		--
	Country Isles	--	--	--	--		--
	Village Commons	--	--	--	--		--
From Hotel	Creekwood	--	--	--	--	--	
	SODO	--	--	--	--	--	
	Lakeside Village	--	14	38	0	**14**	
	Uptown Altamonte	0	6	1	**2**	--	
	Atlantic Station	0	**16**	**68**	2	0	
	Legacy Town Center	0	5	33	0	0	
	Mockingbird Station	--	--	--	--	--	
	Boca Del Mar	--	--	--	--	--	
	Country Isles	--	--	--	--	--	
	Village Commons	--	--	--	--	--	

Note: Highest percentages for each land use pair are indicated in bold.

Each new study on trip internalization can contribute to build a more data-rich internal trip capture rate repository. This research added four additional data points to the existing internal trip capture data. The practice suggested in NCHRP Report 684 [5] consists of selecting the maximum unconstrained interaction to estimate the internal trip capture rate. After the internal trip capture calculation is performed, a trip balancing procedure is applied to the internal trip capture distribution to produce final estimates of internal trip capture. The impact of this or any new study on the unconstrained rates is based on the maximum level of interaction between two land uses. For instance, in Table 5-1, for trips outbound from office to retail, the maximum level of interaction is 20 percent at Country Isles.

This study produced new rates for office to restaurant observed at Uptown Altamonte. The rate of outbound trips from office to restaurant was influenced by the presence of a sit-down restaurant with a coffee bar across from the office building. For the land use pair office to retail, this study confirmed the rates found in the study by Tindale-Oliver & Associates, Inc., in 1993 [8]. Both SODO and Country Isles presented medical office land uses. For retail outbound trips, the dominant developments were Atlantic Station, Mockingbird Station, and Legacy Town Center, all in NCHRP Report 684 [5]. Restaurants in SODO, Uptown Altamonte, and Atlantic Station provided the highest interactions. In SODO, Lakeside Village, Uptown Altamonte, and Legacy Town Center residential presented the highest interactions. Notably, the size of MXDs on residential component was substantially different between the 1993 studies and those considered for this study.

When applying the NCHRP maximum interaction criterion, data for all 10 available sites were used and only those internal trip capture rates reflecting highest internal capture percentages among the same land use pairs were selected, as shown in Table 5-1 highlighted in bold. These maximum interaction rates were used to predict trip generation in the available MXDs for this study. The number of the selected origin-destination land use pairs for the study sites is illustrated in Figure 5-1. Atlantic Station is the MXD that defines 10 out of 30 (33%) highest internal capture percentages for land use pairs in Table 5-1. In case of ties (two studies define maximum rates), both studies were counted for the rate definition. The current FDOT 2014 (four sites) trip internalization data contributes 9 out of 30 (30%) highest internal capture percentages from Altamonte, Lakeside and SODO. A suburban study site, Creekwood, does not define any new maximum internal trip capture rates. Only the Country Isles site in the previous FDOT 1993 (three sites) data defines 1 out 30 (3%) highest internal capture percentages for land use pairs.

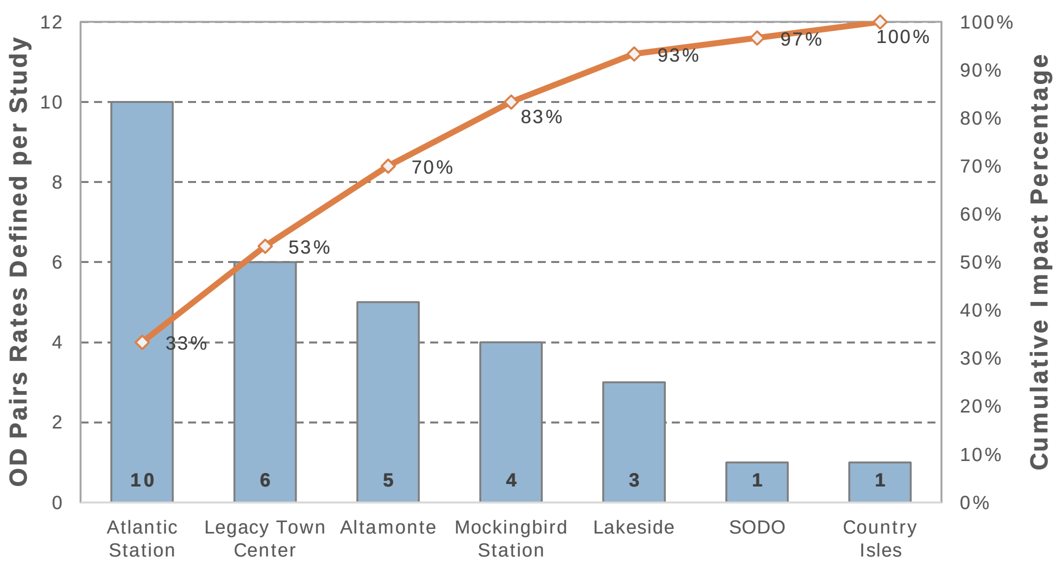


Figure 5-1: Number of OD Rates Defined per Study Using Maximum Interaction Criterion for Outbound Trips in PM Peak Period

A summary of unconstrained internal trip capture rates for inbound trips in the PM peak period for the available studies and the sites surveyed in this project is presented in Table 5-2. For each land use pair, the maximum interaction was selected to estimate the internal trip capture rates. For example, for trips entering retail from restaurants, this rate is 50 percent for Mockingbird Station.

Table 5-2: Unconstrained Internal Trip Capture Percentages for Inbound Trips for PM Peak Period

Destination Land Use	MXD Site	Origin Land Use					
		From Office	From Retail	From Restaurant	From Residential	From Cinema	From Hotel
To Office	Creekwood		--	--	--	--	--
	SODO		0	0	3	--	--
	Lakeside Village		--	--	--	--	--
	Uptown Altamonte		0	11	0	--	0
	Atlantic Station		**31**	8	0	**6**	0
	Legacy Town Center		6	**30**	**57**	0	0
	Mockingbird Station		5	19	2	0	--
	Boca Del Mar		0	--	0	--	--
	Country Isles		2	--	0	--	--
	Village Commons		0	--	0	--	--
To Retail	Creekwood	--		2	7	--	--
	SODO	1		0	4	--	--
	Lakeside Village	--		10	0	1	0
	Uptown Altamonte	0		3	5	--	1
	Atlantic Station	3		28	2	**4**	1
	Legacy Town Center	0		17	**10**	1	**2**
	Mockingbird Station	5		**50**	9	3	--
	Boca Del Mar	0		--	2	--	--
	Country Isles	**8**		--	3	--	--
	Village Commons	3		--	3	--	--
To Restaurant	Creekwood	--	19		3	--	--
	SODO	**3**	4		**33**	--	--
	Lakeside Village	--	3		0	1	1
	Uptown Altamonte	0	12		1	--	0
	Atlantic Station	2	**29**		1	2	**5**
	Legacy Town Center	0	12		14	2	**5**
	Mockingbird Station	1	16		2	**3**	--
	Boca Del Mar	--	--		--	--	--
	Country Isles	--	--		--	--	--
	Village Commons	--	--		--	--	--

Note: Highest percentages for each land use pair are indicated in bold.

Table 5-2 (*cont.*): Unconstrained Internal Trip Capture Percentages for Inbound Trips for PM Peak Period

Destination Land Use	MXD Site	Origin Land Use					
		From Office	From Retail	From Restaurant	From Residential	From Cinema	From Hotel
To Residential	Creekwood	--	18	2		--	--
	SODO	0	42	9		--	--
	Lakeside Village	--	39	**16**		0	0
	Uptown Altamonte	**6**	13	4		--	**1**
	Atlantic Station	1	**46**	6		**4**	0
	Legacy Town Center	1	15	**16**		0	0
	Mockingbird Station	3	19	10		**4**	--
	Boca Del Mar	0	32	--		--	--
	Country Isles	0	23	--		--	--
	Village Commons	4	30	--		--	--
To Cinema	Creekwood	--	--	--	--		--
	SODO	--	--	--	--		--
	Lakeside Village	--	0	**36**	**2**		**2**
	Uptown Altamonte	--	--	--	--		--
	Atlantic Station	**1**	**26**	25	0		0
	Legacy Town Center	0	0	32	0		0
	Mockingbird Station	**1**	14	7	0		--
	Boca Del Mar	--	--	--	--		--
	Country Isles	--	--	--	--		--
	Village Commons	--	--	--	--		--
To Hotel	Creekwood	--	--	--	--	--	
	SODO	--	--	--	--	--	
	Lakeside Village	--	0	0	0	**15**	
	Uptown Altamonte	**1**	5	0	3	--	
	Atlantic Station	0	**17**	**71**	5	0	
	Legacy Town Center	0	13	10	**12**	1	
	Mockingbird Station	--	--	--	--	--	
	Boca Del Mar	--	--	--	--	--	
	Country Isles	--	--	--	--	--	
	Village Commons	--	--	--	--	--	

Note: Highest percentages for each land use pair are indicated in bold.

A similar analysis was performed for the inbound trip rates during the PM peak period. The number of the selected origin-destination land use pairs from the study sites, which define the highest internal capture percentages, is illustrated in Figure 5-2. The current FDOT 2014 (four sites) trip internalization data contributes 11 out of 33 (33%) highest internal capture percentages from Altamonte, Lakeside, and SODO.

A summary of unconstrained internal trip capture rates for both outbound and inbound trips in the AM peak period for the 10 available sites is presented in Appendix F.

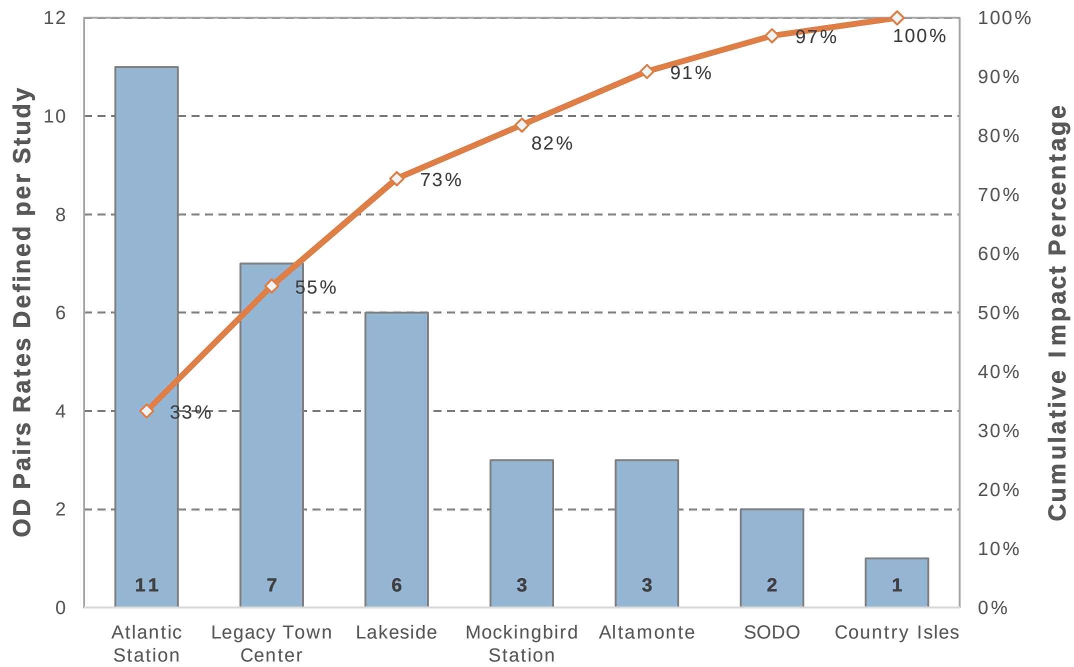


Figure 5-2: Number of OD Rates Defined per Study Using Maximum Interaction Criterion for Inbound Trips in PM Peak period

The proposed revised unconstrained values for percent distribution of internal trip destinations for outbound (exiting) trips and inbound (entering) trips for PM peak period based on this research project are shown in Table 5-3 and Table 5-4, respectively. Table 5-3 and Table 5-4 show the highest values from Table 5-1 and Table 5-2, respectively. These values show how much internal capture was achieved by the best balances between interacting land uses during the PM peak period. These values demonstrated the most unconstrained individual conditions observed at the selected 10 developments.

Table 5-3: Proposed Unconstrained Internal Trip Capture Rates for Outbound Trips for PM Peak Period

Origin Land Use From	Destination Land Use To					
	Office	**Retail**	**Restaurant**	**Residential**	**Cinema**	**Hotel**
Office	N/A	20%	4%	24%	0%	3%
Retail	2%	N/A	29%	26%	4%	5%
Restaurant	3%	41%	N/A	18%	8%	7%
Residential	4%	43%	24%	N/A	3%	4%
Cinema	2%	21%	31%	8%	N/A	4%
Hotel	0%	16%	68%	2%	14%	N/A

Table 5-4: Proposed Unconstrained Internal Trip Capture Rates for Inbound Trips for PM Peak Period

Destination Land Use To	Origin Land Use From					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	31%	30%	57%	6%	0%
Retail	8%	N/A	50%	10%	4%	2%
Restaurant	3%	29%	N/A	33%	3%	5%
Residential	6%	46%	16%	N/A	4%	1%
Cinema	1%	26%	36%	2%	N/A	2%
Hotel	1%	17%	71%	12%	15%	N/A

Similarly, the proposed revised unconstrained values for percent distribution of internal trip destinations for outbound (exiting) trips and inbound (entering) trips for AM peak period based on this research project are shown in Table 5-5 and Table 5-6, respectively. Table 5-5 and Table 5-6 show the highest values from Table F-1 and Table F-2 in Appendix F, respectively.

Table 5-5: Proposed Unconstrained Internal Trip Capture Rates for Outbound Trips for the AM Peak Period

Origin Land Use From	Destination Land Use To					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	28%	63%	35%	N/A	0%
Retail	29%	N/A	14%	17%	N/A	0%
Restaurant	31%	14%	N/A	6%	N/A	8%
Residential	2%	16%	20%	N/A	N/A	0%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	75%	14%	9%	12%	N/A	N/A

Table 5-6: Proposed Unconstrained Internal Trip Capture Rates for Inbound Trips for AM Peak Period

Destination Land Use To	Origin Land Use From					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	4%	14%	3%	N/A	3%
Retail	32%	N/A	8%	39%	N/A	4%
Restaurant	23%	50%	N/A	20%	N/A	7%
Residential	33%	45%	16%	N/A	N/A	9%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	0%	0%	21%	0%	N/A	N/A

A series of tests was necessary to assess the effectiveness of the estimation method using the updated rates and the maximum interaction selection criteria for inbound and outbound trip rates. The analyses focused on the PM peak period since it was used for design purposes. Several combinations of datasets were used to test the following six methodologies:

1. **ITE Single Land Use**: These are the directional trips that are taking place at the establishment level. These trips were generated from vehicle trip generation data from *Trip Generation* [2]. These are the total trips entering and exiting the establishments at particular time. These estimates assume that all the establishments are a free-standing single land use with no internal interactions.

2. **ITE Internal Trip Capture (ITC)**: These are the total trips generation based on the single land use estimation with the correction procedure for internal trip capture proposed in the *Trip Generation Handbook* [1].

3. **NCHRP Report 684 (NCHRP (684))**: This method was proposed in NCHRP Report 684 [5] and contains data from FDOT 1993 and new data collected in the NCHRP 8-51 project. There are 93 percent of the maximum unconstrained internal trip capture rates from the report and about 7 percent from the 1993 FDOT study. The maximum unconstrained internal capture rates are used to estimate the bidirectional vehicle cordon counts of a MXD.

4. **NCHRP with Proximity**: This method is similar to the NCHRP (684) method described previously with the addition of a proximity adjustment factor to improve the prediction capability of the estimator.

5. **NCHRP+FDOT 2014**: This method contains data from the studies in NCHRP Report 684 [5] including the studies by FDOT in 1993 and adds data from the current study. In total, sources of the maximum unconstrained internal capture rates are 64 percent from NCHRP data, 33 percent from FDOT 2014 data, and 3 percent from FDOT 1993 data. The revised maximum unconstrained internal capture rates are used to estimate the bidirectional vehicle cordon counts of a MXD.

6. **NCHRP+FDOT 2014 with Proximity**: This method is similar to the NCHRP+FDOT 2014 method described previously with the addition of proximity adjustment factors from NCHRP Report 684 [5] to improve the prediction capability of the estimator.

Based on field observations, NCHRP Report 684 [5] indicated that as distance increases, the level of interaction (i.e., the internal capture) declines. To quantify this relationship, a set of proximity factors was developed between land use pairs. These generalized NCHRP proximity factors were used in this study as part of testing on the prediction capability of bidirectional cordon counts of a MXD.

The results of these tests on the selected MXDs are presented in Figure 5-3. The estimates for using these six methods to estimate MXD external trips were compared to determine which method(s) provide the most accurate estimates. This test was performed using nine MXDs from which data were collected for the FDOT 1993, NCHRP, and FDOT 2014 studies. The best estimate for each site can be found on Table 5-7.

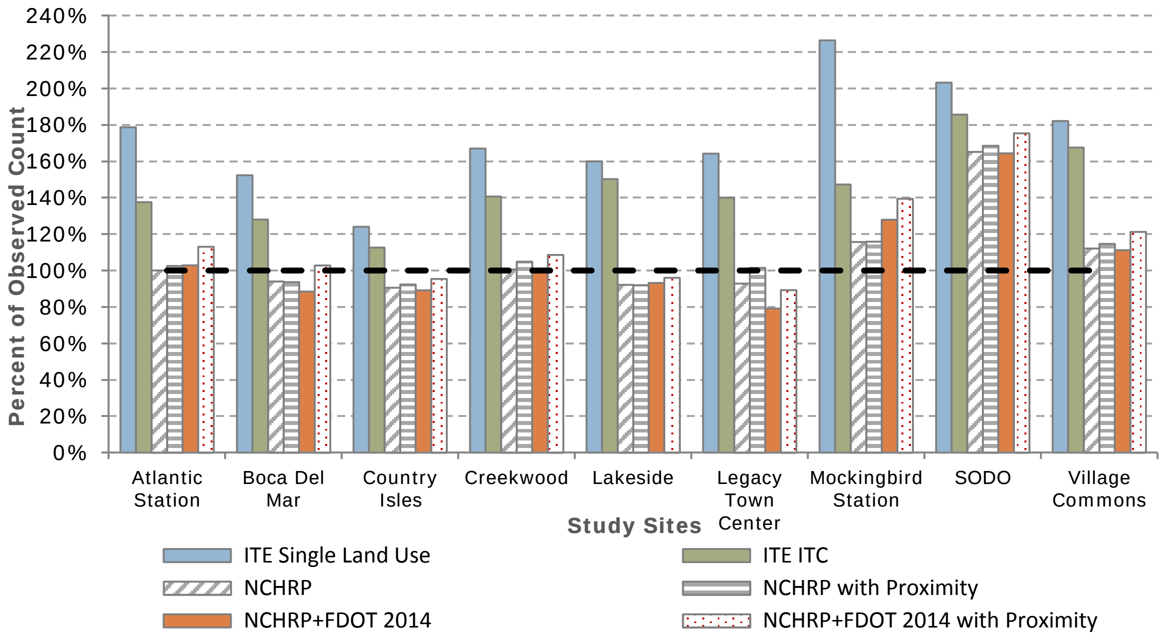


Figure 5-3: Comparison of Cordon Count Estimates (Bidirectional) Using Combinations of Internal Trip Capture Studies

Figure 5-3 presents the results of the analysis to determine the effectiveness of the proposed methods to estimate trip generation of MXDs. The dotted line represents the observed bidirectional cordon counts or 100 percent. The prediction errors are expressed as percentages of the observed cordon counts. Values greater than 100 percent represent overestimation, and values below 100 percent represent underestimation. The expected behavior of a good estimation method is to produce underestimate and overestimate predictions randomly without wandering too far from the 100 percent line.

The ITE single land use estimates were observed to provide a more relaxed estimate by considering trip generation at the establishment level excluding interaction between them. The ITE ITC method is a profession-accepted traditional internal trip capture method based on data from the FDOT 1993 studies. The ITE ITC adjusts the single land use estimate to reflect trip reductions due to internal trips and consistently overestimates the trip generation for MXDs. The method proposed in NCHRP Report 684 [5] provides a more consistent estimate for MXD trip generation estimates.

Table 5-7 presents the summary of bidirectional vehicle cordon counts estimates for study sites. The combined data approach (NCHRP+FDOT 2014) using revised unconstrained internal trip capture rates shows improvement for vehicle cordon counts estimates than the

NCHRP-only data approach, NCHRP (684), which uses the unconstrained internal trip capture percentages based on the NCHRP-only data.

Table 5-7: Results for Best Estimates during PM Peak Period

Development	NCHRP(684)	NCHRP+FDOT 2014	Best Estimate
Atlantic Station	100%	103%	NCHRP
Boca Del Mar	94%	103%	NCHRP+FDOT 2014 with Proximity
Country Isles	92%	96%	NCHRP+FDOT 2014 with Proximity
Creekwood	101%	99%	NCHRP or NCHRP + FDOT 2014 (tie)
Lakeside Village	92%	96%	NCHRP+FDOT 2014 with Proximity
Legacy Town Center	101%	89%	NCHRP with Proximity
Mockingbird Station	116%	128%	NCHRP
SODO	165%	164%	NCHRP+FDOT 2014
Village Commons	112%	111%	NCHRP+FDOT 2014

The estimation error was high for the estimators in the case of SODO. This can be the result of several factors, such as unbalanced land use sizes/trip generation rates or overstated single land use rates. In SODO, there was high trip generation on the retail side for a small development, driven primarily by a big-box retail store with grocery shopping. ITE single land use estimates for this type of land use are very high; therefore, the rate of internal trips from retail as an origin is high. On the other hand, trips coming from retail did not encounter significantly large trip receptors such as restaurant and residential. The trip balancing was driven mainly by the reduced number of inbound trips coming from retail.

Another factor is the overestimation of the single land use generation for that land use when it is in a small MXD. One aspect is that on-site retail does not have direct access to the main arterial road. Moreover, it does not have a typical big-box retail layout with a wide-open parking lot. This may have the potential to affect pass-by trips. Generally, pass-by trips are included in the ITE single land use estimates. In this case, the initial single land use estimate should have been reduced.

5.2 Application of Proximity Factors

Proximity factors were introduced by NCHRP Report 684 [5] to reflect the interaction decay due to increased distance between land use pairs. It is essential to know how the NCHRP proximity factors can be applied to predict the internal capture rate for an MXD. This study examined the results from nine cases with best estimates, as shown in Table 5-8 by comparing the size of an MXD and the use of proximity factors. As expected, a small MXD generally has a better prediction of its observed bidirectional cordon counts without the use of proximity factors. A large MXD has a better prediction of its observed bidirectional cordon counts by using proximity factors. Generally speaking, the estimator without proximity were predicting better when the area of an MXD is within 43 acres. For an MXD with at least 71 acres, estimators with proximity were the best predictors.

Table 5-8: Size of MXDs and Best Estimates

Site	Size (Acres)	Best Estimate
Mockingbird Station	11	NCHRP w/o Proximity
SODO	18	NCHRP+FDOT 2014 w/o Proximity
Creekwood	43	NCHRP or NCHRP+FDOT 2014 w/o Proximity
Country Isles	71	NCHRP+FDOT 2014 with Proximity
Lakeside	74	NCHRP+FDOT 2014 with Proximity
Legacy Town Center	77	NCHRP with Proximity
Village Commons	101	NCHRP+FDOT 2014 w/o Proximity
Atlantic Station	117	NCHRP w/o Proximity
Boca Del Mar	296	NCHRP+FDOT 2014 with Proximity

It is consistent for 7 out of 9 (78%) test sites to use the NCHRP proximity factors based on the size of an MXD. The only two sites with exceptions are Village Commons and Atlantic Station. However, there are only 1 percent and 3 percent differences between the best estimates with and without using the proximate factors for Village Commons and Atlantic Station, respectively. Therefore, based on the acreages of these nine test sites, it is recommended that when the size of an MXD is more than 55 acres, the NCHRP proximity factors should be considered to provide a better estimate of its observed bidirectional cordon counts.

5.3 Recommended Use of Internal Trip Capture Data and Further Enhancements

Based on the detailed data analysis and the results from the nine test cases on predicting cordon counts of MXDs in this research project, it is recommended the local and state transportation planners and developer consultants follow the six basic steps described in the NCHRP Report 684 [5]. They should also use the revised unconstrained internal capture percentages developed from this FDOT research project in Step 4 to estimate the internal trip capture and trip generation from an MXD. The recommended NCHRP estimation method consists of the following six basic steps:

1. Determine whether the methodology is appropriate for the development to be analyzed.
2. Define the pertinent site and development characteristics.
3. Estimate single-use trip generation for each component land use using ITE or other acceptable source; convert to person trips.
4. Use unconstrained internal capture percentages to estimate the number of potential internal trips between each pair of land uses. Include an adjustment for proximity.
5. Balance internal trips generated at both ends of each interacting pair (i.e., internal trips coming from the origin end need to be the same as those coming to the destination end); adapt the existing balancing procedure contained in the ITE *Trip Generation Handbook* [1].
6. Subtract the estimated internal trips from the total trip generation to estimate external trips for the MXD being analyzed; convert to vehicle trips as needed.

For further enhancement of the trip internal capture data, more internal trip capture studies should be performed, keeping track of detailed land uses and distances between them. In this way, more land use categories can be added to an internal trip capture database. For example, fitness centers are a commonly-encountered land use in the surveyed MXDs and can be candidates placed as a separate category for land uses.

The methodology proposed by NCHRP Report 684 [5] and reproduced in this report consisted of collecting MXD data at the establishment level, expanding them to the MXD level, and producing aggregated cordon counts. The final step was to select the maximum interaction by land use pair independently from the rest of the MXD data. Because of the success of this method, the data collection approach can be designed from this result.

Therefore, a way to expand or update the existing tables of unconstrained internal capture percentages could be by surveying OD pairs independently, such that the sample size can be increased in a more economical way and also be less intrusive for an MXD. The OD surveys can be properly documented with development size, land use inventory, and cordon counts for inclusion in the database.

6 Conclusions and Recommendations

This project studied the internal trip capture process for mixed-use developments in Florida to improve the accuracy of trip internalization in the development review process. To achieve this goal, the objective of the research focused on (1) obtaining additional detailed internal trip capture data for multi-use developments in Florida, (2) analyzing the characteristics of the internal trip capture process, and (3) contributing to the available data on internal trip capture. The main findings of the project are presented in this section.

6.1 Findings from Data Collection of Internal Trip Capture

- Obtaining permissions from site managers and individual store managers of a mixed-use development to collect the data are the most time-consuming and the most important aspect of a detailed and successful trip internalization study. Training of supervisory personnel and survey crews also plays an important role of the trip internalization study to ensure data quality.

- The minimum data elements needed to perform an internal trip capture study are door counts and interviews for origin and destination locations. Mode split and other data can be collected for further clarification and analysis but are not necessary.

- Performing door counts at as many establishments as possible allows the capture of activity at the site. This gives more flexibility on data analysis, since the survey data can be expanded to the entire MXD based on activity levels in the trip factoring step.

- The cordon counts of a study mixed-use development should exclude pass-by traffic of a roadway passing through the development to ensure their accuracy.

- Interviewers should be located on sidewalks for exit interviews, where they have the potential to increase the representation of internal trips. Usually, people who are willing to give interviews on sidewalks within a development have more time to spare since they are headed to internal destinations. On the other hand, parking lot interviews can add balance and generalization to exit interviews.

- In this study, the chronology used in the exit interviews was reversed from the NCHRP order such that it matched the chronology of the trip. First, the interviewer asked for previous trip (inbound) information and, then, for information about the next destination. This significantly improved the collection of data regarding the inbound portion of the trip.

6.2 Results of Internal Trip Capture Study

The internal capture rates for MXDs are usually arbitrarily selected for use throughout the jurisdiction. These rates are most typically in the range of 10 percent but were found to range between less than 5 percent and more than 25 percent in most transit-oriented developments. Four MXD sites in central Florida were selected in this research project for data collection and analysis. Table 6-1 summarizes the internal capture rates ranging from

9–14 percent for the AM peak period and from 13–16 percent for the PM peak period for these four study sites.

Table 6-1: Summary of Internal Capture Rates for Four Study Sites on Mixed-Use Developments

Mixed-Use Development Site	AM Peak Period			PM Peak Period		
	Inbound	Outbound	Overall	Inbound	Outbound	Overall
Creekwood (Bradenton) - a suburban development with single-family detached residential units on the back end with front-end commercial.	15%	12%	14%	13%	15%	14%
SODO (Orlando) - a compact development with mid-rise residential, medical offices, a big-box retail grocery store, and a variety of ground-floor retail and restaurants.	12%	12%	12%	14%	13%	14%
Lakeside Village (Lakeland) - a lifestyle center (open shopping mall) with a movie theater, hotels, and a direct connection to an apartment complex.	7%	11%	9%	15%	16%	16%
Uptown Altamonte (Altamonte Springs) - combines existing residential, hotel, and shopping centers with new residential and a retail-themed town center.	17%	9%	12%	12%	15%	13%

The major results of this internal trip capture study are provided below:

- The overall internal trip capture rates of four study MXD sites in Florida for the PM peak period range from 13–16 percent and from 9–14 percent for the AM peak period.

- The internal trip capture rate was higher for the PM peak period in compact developments such as SODO (14%) compared to large developments such as Boca Del Mar (8%). This was observed mainly in the land use pair of residential-retail.

- The overall internal trip capture rates for traditional suburban MXDs during the PM peak period in Florida with front-end commercial and back-end residential in large areas (i.e., Creekwood, 14%) were found to be comparable to those from compacted mixed-use developments (i.e. SODO, 14%).

- This research verified that the NCHRP enhanced internal trip capture method, which included the addition of three primary land uses (restaurant, cinema, hotel) found at

MXDs, proximity of interacting land uses, and the use of maximum unconstrained internal trip capture rates, produced more accurate estimates than the previous ITE methods.

- In the NCHRP enhanced methodology, the maximum unconstrained internal trip capture rates were chosen per OD pair of land uses to represent the maximum interaction between pairs of land uses in MXDs. Before this FDOT research, 93 percent of these rates used for internal trip capture estimation came from NCHRP data and 7 percent from FDOT 1993 data.

- When the internal capture data collected from this FDOT research were added to the existing data collected from NCHRP and FDOT 1993 studies, the updated maximum interaction rates for PM outbound trips comprised 67 percent NCHRP data, 30 percent FDOT 2014 data, and 3 percent FDOT 1993 data. The updated maximum interaction rates for PM inbound trips comprised 70 percent NCHRP data and 30 percent FDOT 2014 data.

- This FDOT research project produced revised maximum unconstrained internal trip capture rates for further improving the estimation of internal trip capture and the trip generation for an MXD.

- The combined data approach (NCHRP+FDOT 2014) using the revised maximum unconstrained internal trip capture rates improved the prediction capability of the existing data-method combination in five out of eight test cases, with one test case tied.

- The important results of this project were the verification of the NCHRP methodology and the generalization capabilities that can be achieved by the addition of the obtained FDOT 2014 data to previous NCHRP data to continue to improve accuracy of internal trip capture and trip generation for MXDs.

- It is important to note that the previous ITE internal trip capture rates produce significantly higher external trip generation rates for MXDs. The enhanced NCHRP method with the use of the revised maximum unconstrained internal trip capture rates based on NCHRP and FDOT 2014 datasets can significantly improve the prediction capability of internal trip capture for MXDs than those predicted from the previous ITE internal trip capture method.

- Proximity adjustments were used for large developments recommended in NCHRP Report 684 [5] to reflect the interaction decay due to increased distance between land use pairs. This FDOT research verified the benefit of using proximity factors for large MXDs and provided a recommendation for when to use the NCHRP proximity factors based on results from the nine test cases in the study. It is recommended that the proximity factors be considered when the area of an MXD is greater than 55 acres.

6.3 Recommendations

- A repository of validation data for MXDs should be developed for use in evaluating the predictive capability of current internal trip capture methods. Data should consist of cordon counts, door counts, multimodal OD interviews (as were collected in this study), land use inventory, and land use occupancy.

- Validation data from mixed-use sites should also be gathered and compiled in the same repositories. The same data should be collected, except for the interview data. These data should be collected to provide test data to evaluate the predictive capability of current internal trip capture methods.

- More internal trip capture studies should be performed, keeping track of detailed land uses and distances between them. In this way, more land use categories can be added to an internal trip capture database.

- The sample for internal trip capture rates at the OD pair level should be expanded to include, for example, collected data on retail–residential land uses. Data collection personnel can be located at both ends. Reporting on these data should include establishment interviews, door counts, MXD cordon counts, land use inventory, and a distance matrix.

- NCHRP Report 684 [5] provided generic proximity factors to account for the reduction of internal trips due to the distance between interacting land uses in a large MXD. With the addition of the FDOT 2014 dataset, more proximity data from 3 sites to 7 sites are available for future research. This provides a good opportunity to improve upon the NCHRP 684 proximity adjustment estimation method or to develop a new one using the new FDOT data plus the NCHRP data. A further understanding on proximity of land uses within an MXD and proximity of competitive land uses outside the MXD potentially could shed some light for further improvement on internal trip capture prediction capabilities of MXDs.

References

[1] Institute of Transportation Engineers, *Trip Generation Handbook, 2nd Edition: An ITE Recommended Practice*. Washington DC: Institute of Transportation Engineers, 2004.

[2] *Trip Generation, 8th Edition: An ITE Informational Report*. Washington DC: Institute of Transportation Engineers, 2008.

[3] Transoft, "Online Traffic Impact Analysis Software, OTISS." Transoft - Institute of Transportation Engineers, March 2012. [Online]. Available: http://otisstraffic.com. [Accessed July 2013].

[4] Urban Land Institute, *Mixed Use Development Handbook*. Washiington DC, 2003, pp. 4-5.

[5] B. Bochner, K. Hooper, B. Sperry and R. Dunphy, "NCHRP Report 684, Enhancing Internal Trip Capture Estimation for Mixed-Use Developments." National Cooperative Highway Research Program, Washington DC, 2011.

[6] A. Christoforidis, "New Alternatives to the Suburb: Neo-Traditional Developments." *Journal of Planning Literature,* 8(4), pp. 429-440, 1993.

[7] R. Cervero, S. Murphy, C. Ferrell, N. Goguts and Y.-H. Tsai, "Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects." Transit Cooperative Reseach Program Report No. 102, Washington DC, 2004.

[8] Tindale Oliver & Associates, Inc., "Trip Characteristics Study of Multi-Use Developments. Report Prepared for the Florida Depatment of Transportation." 1993.

[9] Walter H. Keller, Inc., "Districtwide Trip Generation Study, Task 5, Final Report. Prepared for the Florida Department of Transportation," 1995.

[10] Institute of Transportation Engineers, "Trip Generation, Other Resources Sponsored by the ITE Transportation Planning Council (TPC)." Institute of Transportation Engineers. [Online]. Available: http://www.ite.org/tripgeneration/otherresources.asp. [Accessed July 2013].

[11] Kittelson and Associates, Inc., "A Comparison of Internal Trip Capture Estimation Using ITE and FSUTMS. Report prepared for the Florida Department of Transportation." 2008.

[12] R. Ewing, M. Greenwald, M. Zhang, J. Walters, M. Feldman, R. Cervero, L. Frank and J. Thomas, "Traffic Generated by Mixed-Use Developments- Six-Region Study Using Consistent Built Envirionmental Measures." *Journal of Urban Planning and Development,* 137(3), pp. 248-261, 2011.

[13] Environmental Protection Agency, "Trip Generation Tool for Mixed-Use Developments." [Online]. [Accessed 2013].

[14] URS, "Internal Trip Capture Study District 2. Report prepared for the Florida Department of Transportation." URS, 2010.

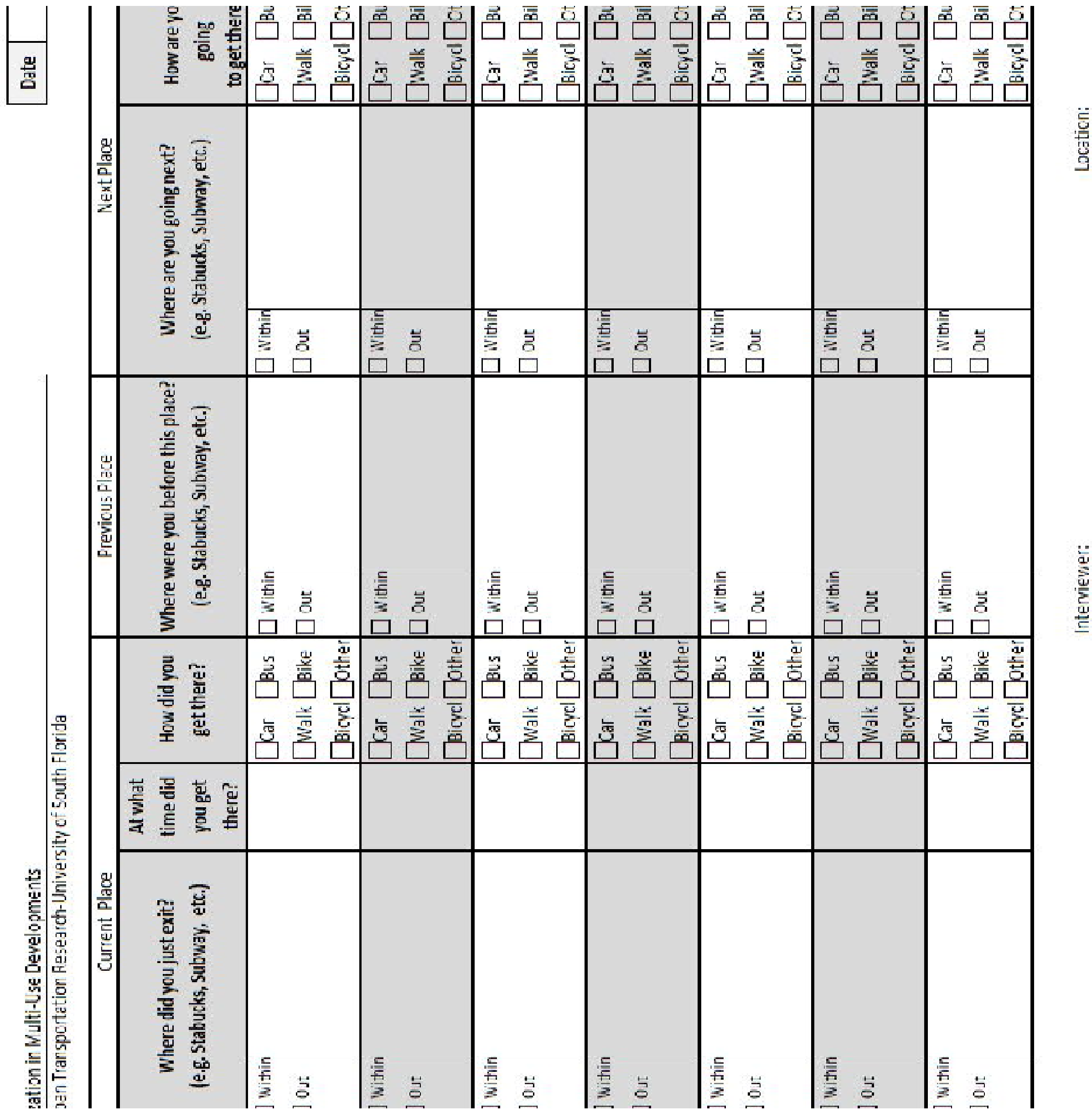
[15] Florida Department of Transportation, "Community Capture Methodology." Systems Planning Office. [Online]. Available: http://www.dot.state.fl.us/planning/systems/programs/sm/siteimp/PDFs/capturemeth.pdf. [Accessed July 2013].

[16] Kimley-Horn and Associates, Inc, "Trip Generation Rates for Urban Infille Land Uses in California. Report prepared for the California Department of Transportation." 2009.

[17] J. M. Saisa, M. Schmitt, P. Reinhofer, K. Hooper, B. Bochner and L. Schwartz, "NCHRP Report 758: Trip Generation Rates for Transportation Impact Analyses of Infill Developments." National Cooperative Highway Research Program, Washington DC, 2013.

Appendix A: Forms

Interview Form



...ation in Multi-Use Developments
...an Transportation Research-University of South Florida

Date

Current Place			Previous Place	Next Place	
Where did you just exit? (e.g. Stabucks, Subway, etc.)	At what time did you get there?	How did you get there?	Where were you before this place? (e.g. Stabucks, Subway, etc.)	Where are you going next? (e.g. Stabucks, Subway, etc.)	How are yo going to get there
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Within Out		Car Bus Walk Bike Bicycl Other	Within Out	Within Out	Car Bu Walk Bi Bicycl Ot
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Interviewer:

Location:

Cordon Count Form

Counter Name: ____________________________ Date:

Time: ______________________

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		1 person														2 people										3 people						4+ people					1			2		1			2+															
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	OUT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
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		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
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		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													

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Counter Name: ____________________________ Date:

Time: ______________________

INTERVALS		CAR																																		MOTORCYCLE					COMMERCIAL TRUCKS						WALK					BIKE							
		1														2										3						4+					1			2		1			2+															
:30 - :45	IN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
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		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
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		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
	OUT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
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		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													
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		1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4+	4+	4+	4+	4+	1	1	1	2	2	1	1	1	2+	2+	2+													

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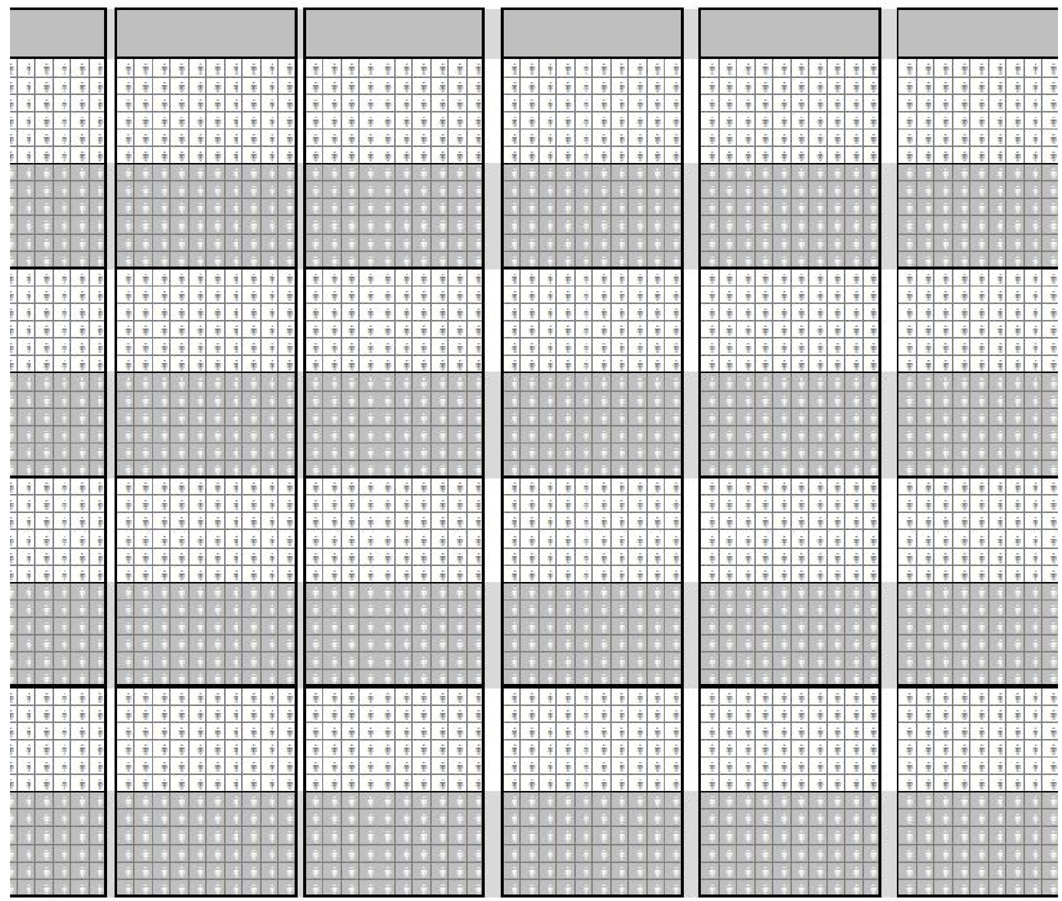
6-Column Door Count Form

Date:



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Trip Internalization for M

Appendix B: Supplemental Data for Creekwood

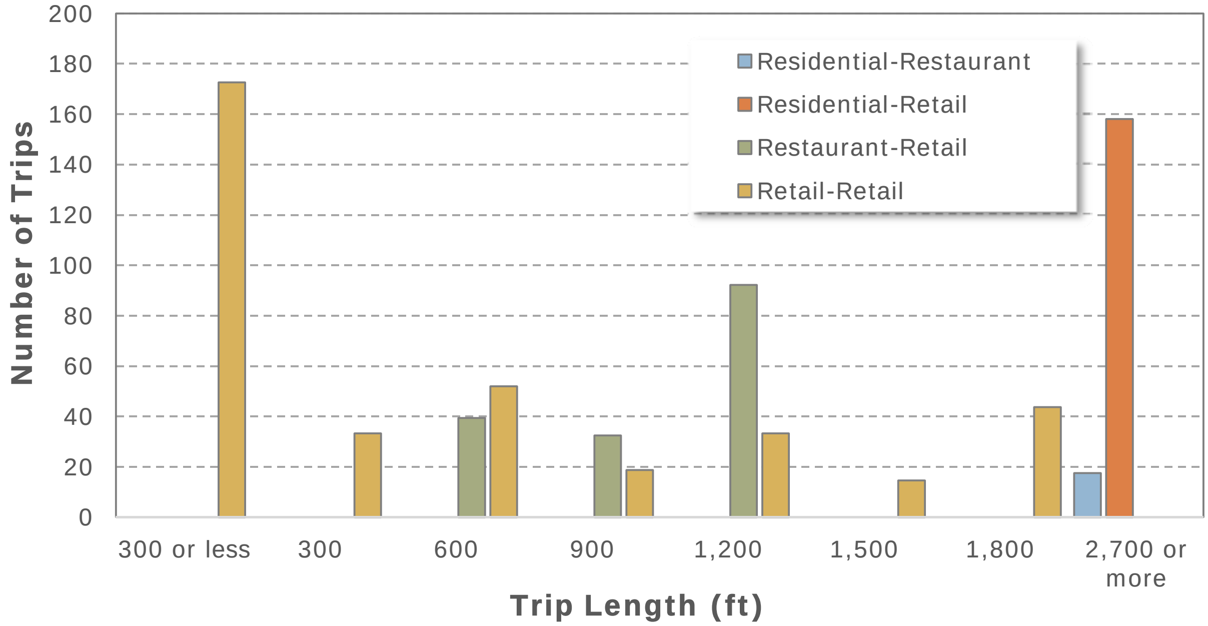

Figure B-1: Trip Length Distribution by Land Use Pair for PM Peak Period – Creekwood

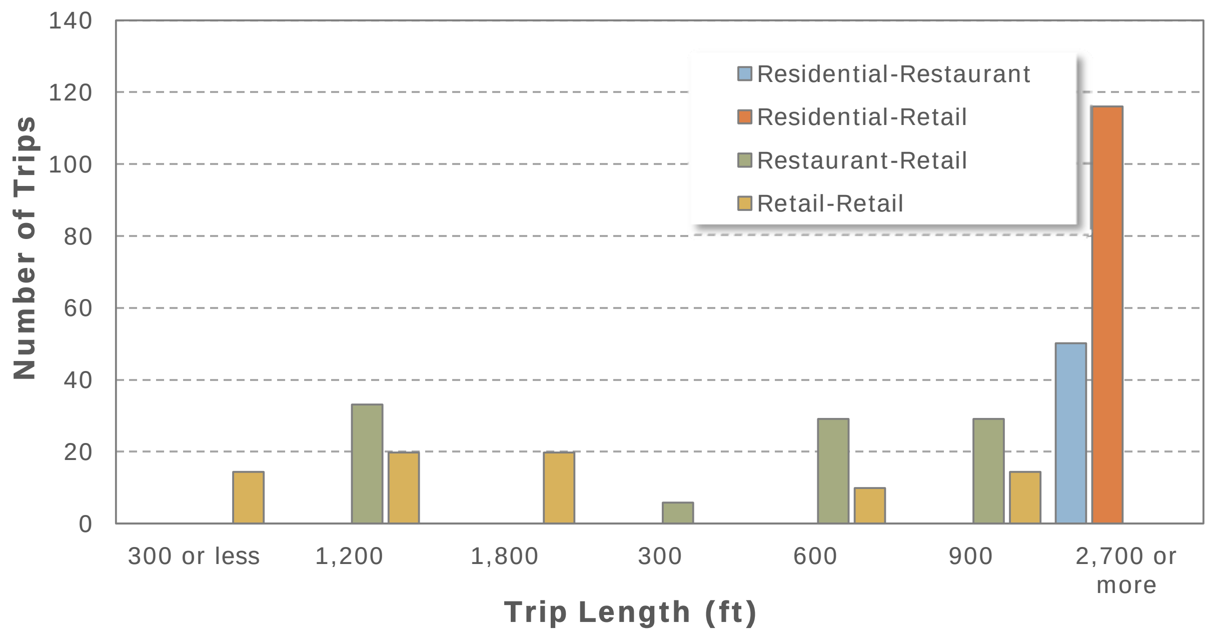

Figure B-2: Trip Length Distribution by Land Use Pair for AM Peak Period – Creekwood

Appendix C: Supplemental Data for SODO

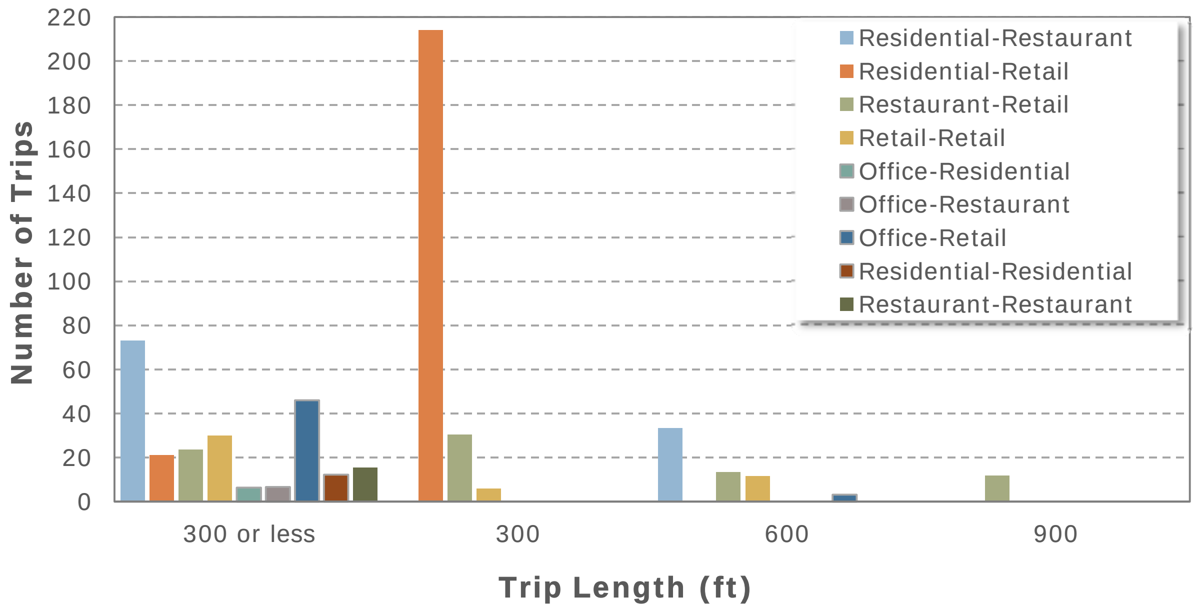

Figure C-1: Trip Length Distribution by Land Use Pair for PM Peak Period – SODO

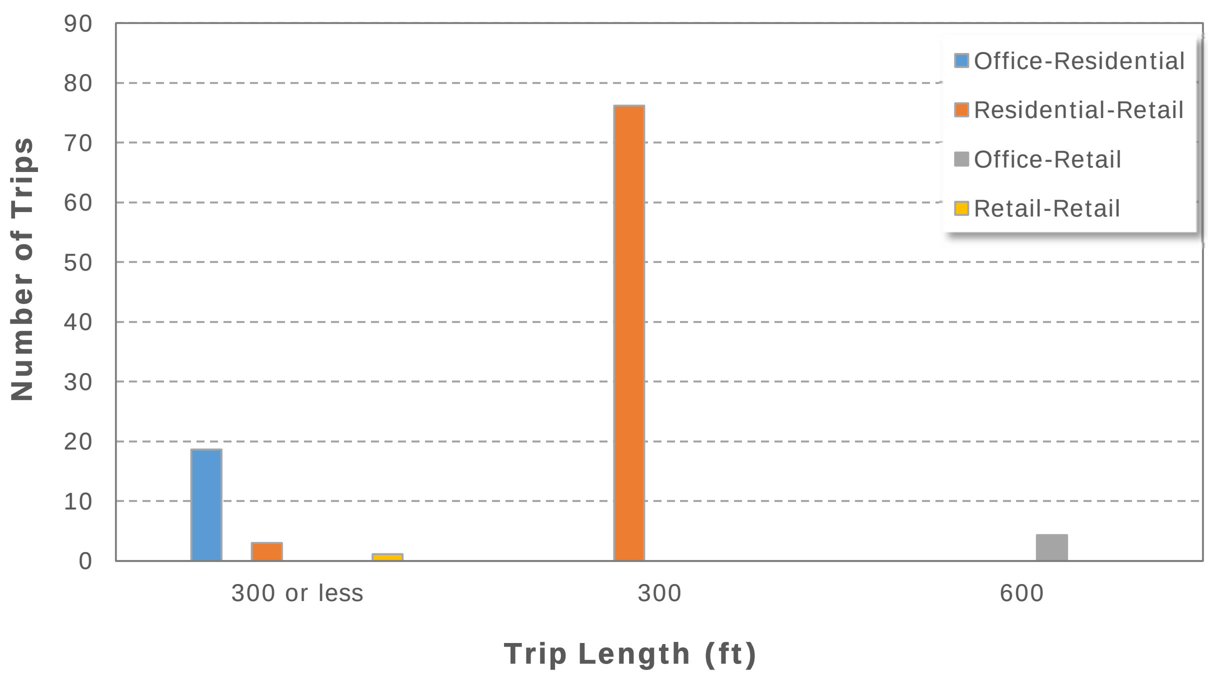

Figure C-2: Trip Length Distribution by Land Use Pair for AM Peak Period – SODO

Appendix D: Supplemental Data for Lakeside Village

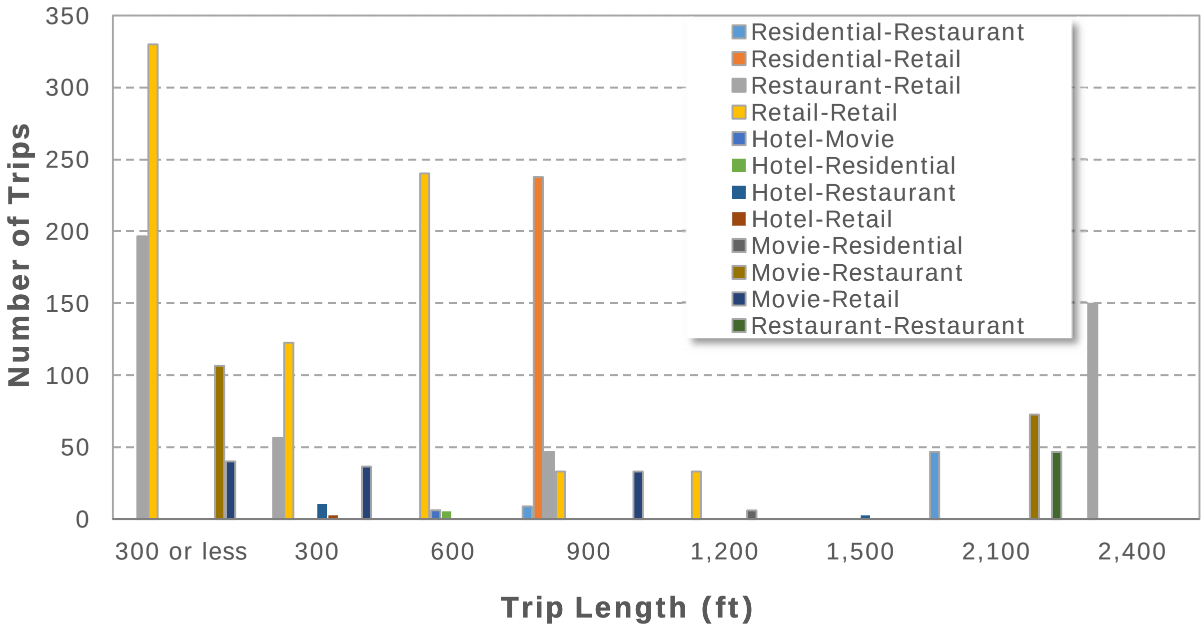

Figure D-1: Trip Length Distribution by Land Use Pair for PM Peak Period – Lakeside Village

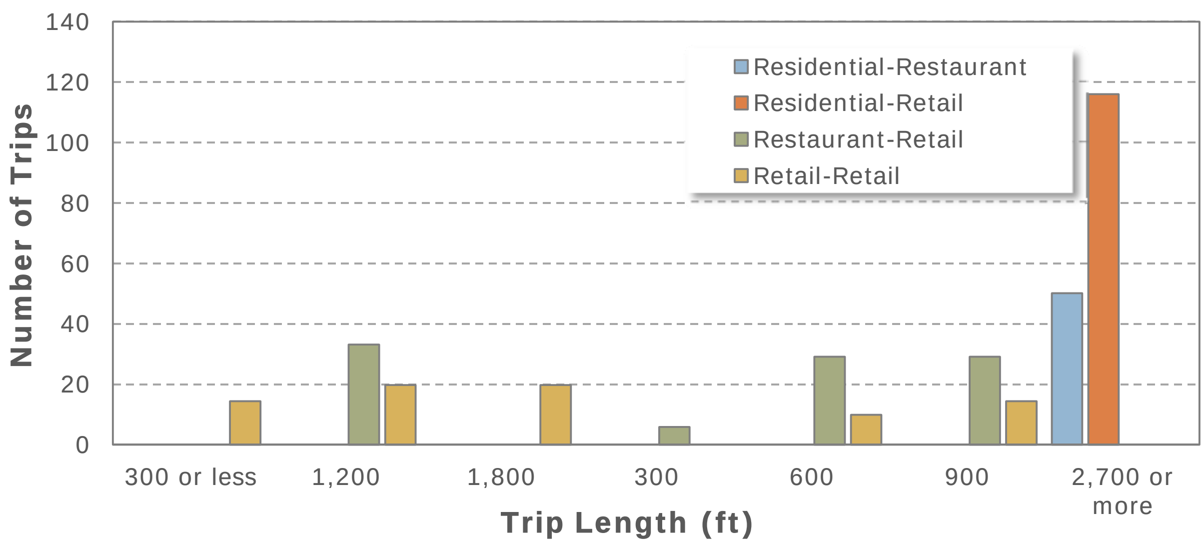

Figure D-2: Trip Length Distribution by Land Use Pair for the AM Peak Period – Lakeside Village

Appendix E: Supplemental Data for Uptown Altamonte

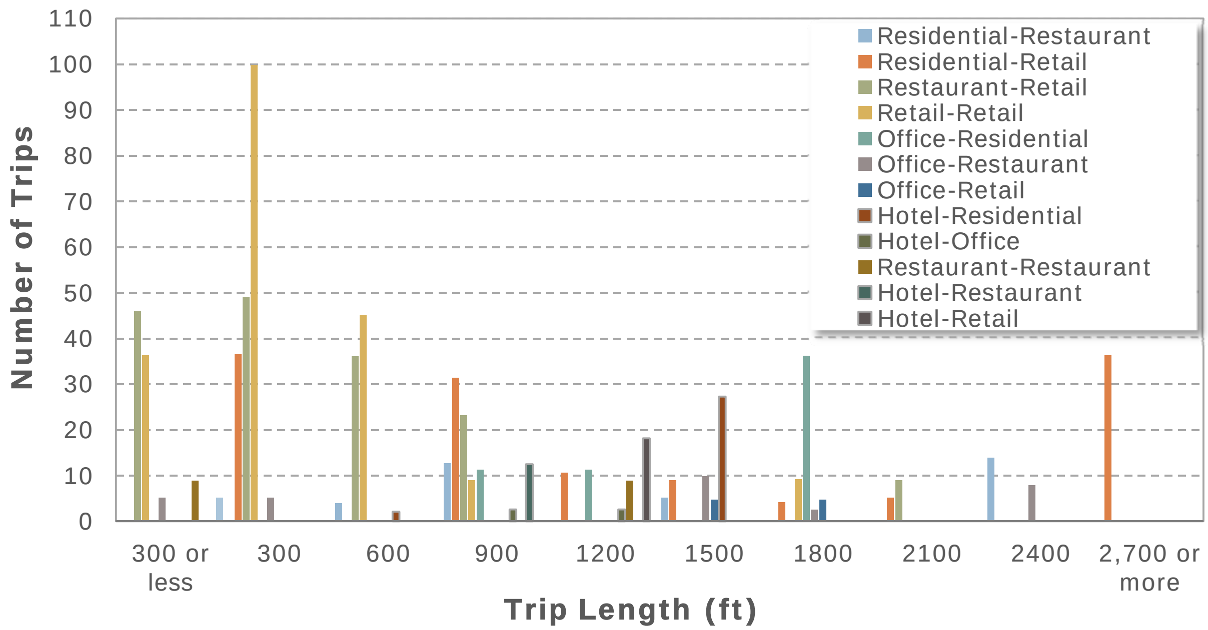

Figure E-1: Trip Length Distribution by Land Use Pair for PM Peak Period – Uptown Altamonte

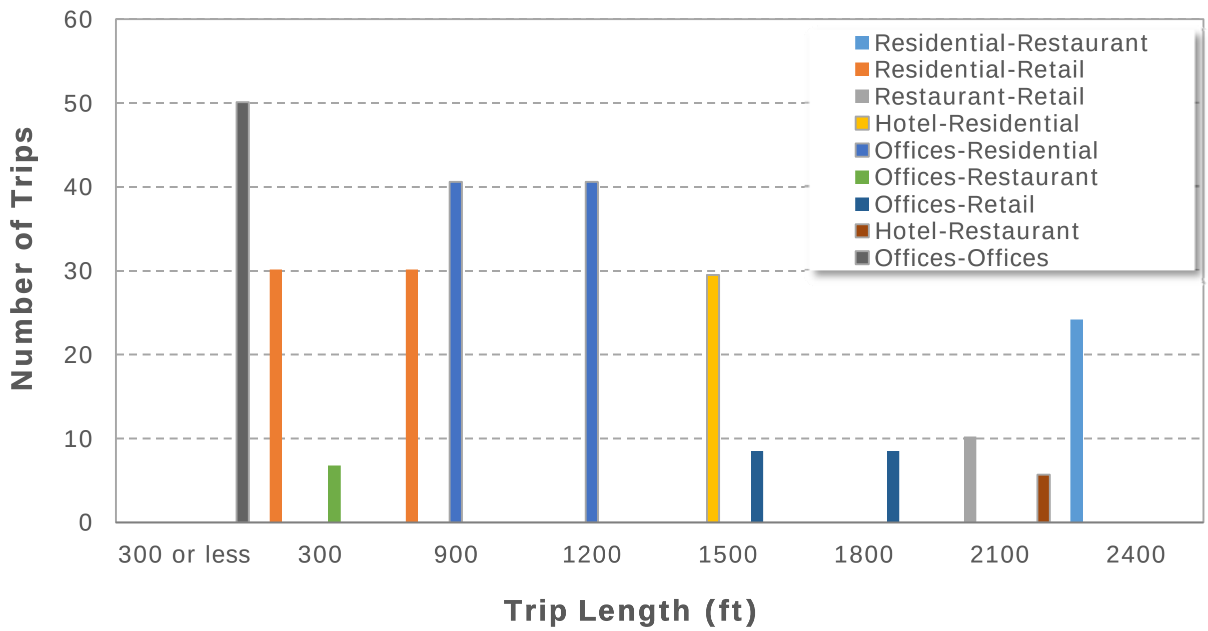

Figure E-2: Trip Length Distribution by Land Use Pair for AM Peak Period – Uptown Altamonte

Appendix F: Internal Trip Capture Rates for AM Peak Period

Table F-1: Unconstrained Internal Trip Capture Percentages for Outbound Trips for AM Peak Period

Origin Land Use	MXD Site	Origin Land Use					
		To Office	To Retail	To Restaurant	To Residential	To Cinema	To Hotel
From Office	Creekwood		--	--	--	--	--
	SODO		8	0	**35**	--	--
	Lakeside		--	--	--	--	--
	Altamonte		0	0	0	--	0
	Atlantic Station		**28**	5	0	--	0
	Legacy Town Center		0	8	0	--	0
	Mockingbird Station		--	**63**	1	--	--
	Boca Del Mar		--	--	--	--	--
	Country Isles		--	--	--	--	--
	Village Commons		--	--	--	--	--
From Retail	Creekwood	--		4	12	--	--
	SODO	0		0	4	--	--
	Lakeside	--		0	0	0	0
	Altamonte	0		**14**	**17**	--	0
	Atlantic Station	**29**		13	0	--	0
	Legacy Town Center	17		6	14	--	0
	Mockingbird Station	--		--	--	--	--
	Boca Del Mar	--		--	--	--	--
	Country Isles	--		--	--	--	--
	Village Commons	--		--	--	--	--
From Restaurant	Creekwood	--	4		3	--	--
	SODO	0	0		0	--	--
	Lakeside	--	0		**6**	0	**8**
	Altamonte	0	0		0	--	0
	Atlantic Station	**31**	**14**		0	--	3
	Legacy Town Center	9	2		4	--	1
	Mockingbird Station	25	--		3	--	--
	Boca Del Mar	--	--		--	--	--
	Country Isles	--	--		--	--	--
	Village Commons	--	--		--	--	--

Note: Highest percentages for each land use pair are indicated in bold.

Table F-1 (*Cont.*): Unconstrained Internal Trip Capture Percentages for Outbound Trips for AM Peak Period

Origin Land Use	MXD Site	Origin Land Use					
		To Office	To Retail	To Restaurant	To Residential	To Cinema	To Hotel
From Residential	Creekwood	--	13	5		--	--
	SODO	0	**16**	0		--	--
	Lakeside	--	0	11		0	0
	Altamonte	0	5	3		--	0
	Atlantic Station	1	1	0		--	0
	Legacy Town Center	1	1	7		--	0
	Mockingbird Station	**2**	--	**20**		--	--
	Boca Del Mar	--	--	--		--	--
	Country Isles	--	--	--		--	--
	Village Commons	--	--	--		--	--
From Cinema	Creekwood	--	--	--	--		--
	SODO	--	--	--	--		--
	Lakeside	--	0	0	0		0
	Altamonte	--	--	--	--		--
	Atlantic Station	--	--	--	--		--
	Legacy Town Center	--	--	--	--		--
	Mockingbird Station	--	--	--	--		--
	Boca Del Mar	--	--	--	--		--
	Country Isles	--	--	--	--		--
	Village Commons	--	--	--	--		--
From Hotel	Creekwood	--	--	--	--	--	
	SODO	--	--	--	--	--	
	Lakeside	--	0	8	0	0	
	Altamonte	0	0	3	**12**	--	
	Atlantic Station	**75**	**14**	6	0	--	
	Legacy Town Center	0	0	**9**	0	--	
	Mockingbird Station	--	--	--	--	--	
	Boca Del Mar	--	--	--	--	--	
	Country Isles	--	--	--	--	--	
	Village Commons	--	--	--	--	--	

Note: Highest percentages for each land use pair are indicated in bold.

Table F-2: Unconstrained Internal Trip Capture Percentages for Inbound Trips for AM Peak Period

Destination Land Use	MXD Site	Origin Land Use					
		From Office	From Retail	From Restaurant	From Residential	From Cinema	From Hotel
To Office	Creekwood		--	--	--	--	--
	SODO		0	0	0	--	--
	Lakeside		--	--	--	--	--
	Altamonte		0	0	0	--	0
	Atlantic Station		**4**	1	0	--	**3**
	Legacy Town Center		3	9	**3**	--	0
	Mockingbird Station		--	**14**	1	--	--
	Boca Del Mar		--	--	--	--	--
	Country Isles		--	--	--	--	--
	Village Commons		--	--	--	--	--
To Retail	Creekwood	--		4	9	--	--
	SODO	1		0	14	--	--
	Lakeside	--		0	0	0	0
	Altamonte	0		0	**39**	--	0
	Atlantic Station	**32**		3	5	--	**4**
	Legacy Town Center	0		**8**	17	--	0
	Mockingbird Station	--		--	--	--	--
	Boca Del Mar	--		--	--	--	--
	Country Isles	--		--	--	--	--
	Village Commons	--		--	--	--	--
To Restaurant	Creekwood	--	4		4	--	--
	SODO	0	0		0	--	--
	Lakeside	--	0		6	0	**7**
	Altamonte	0	6		13	--	4
	Atlantic Station	**23**	**50**		0	--	6
	Legacy Town Center	1	1		18	--	6
	Mockingbird Station	13	--		**20**	--	--
	Boca Del Mar	--	--		--	--	--
	Country Isles	--	--		--	--	--
	Village Commons	--	--		--	--	--

Note: Highest percentages for each land use pair are indicated in bold**.**

Table F-2 (*cont.*): Unconstrained Internal Trip Capture Percentages for Inbound Trips for the AM Peak Period

Destination Land Use	MXD Site	Origin Land Use					
		From Office	From Retail	From Restaurant	From Residential	From Cinema	From Hotel
To Residential	Creekwood	--	**45**	**16**		--	--
	SODO	**33**	33	0		--	--
	Lakeside	--	0	11		0	0
	Altamonte	0	4	0		--	**9**
	Atlantic Station	0	0	0		--	0
	Legacy Town Center	0	2	4		--	0
	Mockingbird Station	0	--	5		--	--
	Boca Del Mar	--	--	--		--	--
	Country Isles	--	--	--		--	--
	Village Commons	--	--	--		--	--
To Cinema	Creekwood	--	--	--	--		--
	SODO	--	--	--	--		--
	Lakeside	--	0	0	0		0
	Altamonte	--	--	--	--		--
	Atlantic Station	--	--	--	--		--
	Legacy Town Center	--	--	--	--		--
	Mockingbird Station	--	--	--	--		--
	Boca Del Mar	--	--	--	--		--
	Country Isles	--	--	--	--		--
	Village Commons	--	--	--	--		--
To Hotel	Creekwood	--	--	--	--	--	
	SODO	--	--	--	--	--	
	Lakeside	--	0	**21**	0	0	
	Altamonte	0	0	0	0	--	
	Atlantic Station	0	0	4	0	--	
	Legacy Town Center	0	0	3	0	--	
	Mockingbird Station	--	--	--	--	--	
	Boca Del Mar	--	--	--	--	--	
	Country Isles	--	--	--	--	--	
	Village Commons	--	--	--	--	--	

Note: Highest percentages for each land use pair are indicated in bold.