NCHRP

REPORT 684

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Enhancing Internal Trip Capture Estimation for Mixed-Use Developments

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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Brian Bochner, P.E., P.T.O.E., and P.T.P., of the Texas Transportation Institute served as project director and principal investigator. Kevin Hooper of Kevin Hooper Associates, Ben Sperry of the Texas Transportation Institute, and Robert Dunphy of the Urban Land Institute also performed major roles in this project. Laura Higgins of the Texas Transportation Institute assisted in the data collection.

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FOREWORD

By Christopher Hedges
Staff Officer
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This report provides an improved methodology to estimate how many internal trips will be generated in mixed-use developments—trips for which both the origin and destination are within the development. The methodology estimates morning and afternoon peak–period trips to and from six specific land use categories: office, retail, restaurant, residential, cinema, and hotel. The research team analyzed existing data from prior surveys and collected new data at three mixed-use development sites. The resulting methodology is incorporated into a spreadsheet model, which can be downloaded from the TRB website at http://www.trb.org/Main/Blurbs/165014.aspx. The report includes recommendations for modification of existing Institute of Transportation Engineers (ITE) procedures in the *Trip Generation Handbook*. This report will be valuable to transportation agency planners and developers who need to provide or fund facilities that meet the transportation demand generated by new developments.

As new development places increasing demands on the transportation system, community leaders, land use planners, developers, and transportation agency administrators need techniques to enable them to reliably estimate the number of net vehicle and person trips that will be generated by new or infill mixed-use development.

For site impact analysis purposes, an internal capture rate that is set too low may unfairly penalize developers by making them pay more than their fair share of costs for transportation mitigation measures. Conversely, an internal capture rate that is set too high may unfairly place this burden on the public. Both cases may result in sub-optimal build-out, particularly in urban areas.

Since the internal capture rate used for a given mixed-use development can be politically contentious, empirical observations are needed to provide professional guidance for better estimating these impacts. By improving the methods for estimating internal capture, the process of determining developers' responsibilities for mitigating transportation impacts of mixed-use development will become more equitable, transparent, and open.

The ITE's *Trip Generation Handbook* has established a procedure for estimating multi-use trip generation; however, the existing framework is based on a limited set of data. ITE advises those estimating transportation impacts of mixed-use developments to "collect additional data if possible." Consequently, when considering potential transportation impacts of proposed mixed-use developments, local and state transportation planners lack a comprehensive, credible data set that can be used to confirm or deny the soundness of proposed internal capture estimates.

Under NCHRP Project 08-51, a research team led by the Texas Transportation Institute developed a methodology to provide an improved estimate of internal trips generated in

mixed-use developments. After an analysis of existing data from previous studies, the research team conducted and analyzed traffic counts and interviews at sites in Dallas, Texas; Atlanta, Georgia; and Plano, Texas. The team developed a classification system for mixed-use developments, an improved methodology for estimating internal trip capture, a data-collection framework and methodology, and a spreadsheet estimation tool to facilitate application of the internal trip capture methodology. Procedures were also provided to enable practitioners to collect and add more data to the database, which has been provided to ITE.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

SUMMARY

Enhancing Internal Trip Capture Estimation for Mixed-Use Developments

The goal of NCHRP Project 8-51 is to improve the methodologies used to estimate the extent to which trips made within mixed-use developments (MXDs) are internalized or satisfied with both origin and destination within the development. Specifically, the project developed

- A classification system of MXDs that identifies site characteristics, features, and context likely to influence trips subject to internal capture;
- A defensible improved methodology for estimating internal trip capture with reasonable accuracy;
- A data-collection framework and methodology to quantify the magnitude of travel associated with MXDs to determine appropriate reductions below single-use trip generation estimates; and
- A spreadsheet estimation tool to facilitate computations (available at http://www.trb.org/Main/Blurbs/165014.aspx).

The improved estimation method was developed from existing survey data from prior studies plus three pilot data collection surveys from this project. The method is based on the existing Institute of Transportation Engineers (ITE) procedure, but expands it to cover both A.M. and P.M. peak periods, six primary land uses found at MXDs, and proximity of interacting land uses. This method was tested and found to reduce estimation error by about one-half compared with the existing ITE method and three-fourths compared with raw trip generation estimates.

Summary of Findings, Conclusions, and Recommendations

Existing Practice

Internal capture for MXDs is of most interest to those who either prepare or review transportation impact analyses (TIAs) for such developments; however, transportation planners and developer consultants are also interested in internal capture and the resulting external trip generation. Some additional uses include planning for transit-oriented developments (TODs) and preparing environmental impact statements or assessments.

ITE provides a recommended practice for estimating internal capture and associated external trip generation for such developments. The ITE method documented in the *Trip Generation Handbook* (*1*) is the most widely used technical method. The other widely used approach is a policy determined flat percentage reduction in external trips. Such percentages are established by local planning, zoning, or transportation engineering officials for use in TIAs prepared

to support applications for zoning, subdivision, site plan approval, or access permits. The percentages are usually arbitrarily selected for use throughout the jurisdiction. These percentages are most typically in the range of 10%, but were found to range between less than 5% and as much as 25%.

The ITE method covers trips between only the three most frequent components of MXDs—office, retail, and residential. Data are available for the weekday P.M. peak hour; midday; and what is called "daily," but which is drawn from data collected between noon and 6:30 P.M. The ITE method has nothing for the A.M. peak hour. The policy percentages mentioned above are applied to each analysis period used.

There is some use of invalid applications for internal capture estimation—the two found most frequently were use of shared parking reduction percentages and metropolitan area travel forecast model intrazonal trip percentages. Shared parking reductions apply only to parking accumulations in a parking facility serving multiple uses; the percentage reduction applies only to parking accumulation, not trip generation. Intrazonal trips apply to complete traffic analysis zones used in regional travel forecast models. Zones may range from a block to a square mile. Intrazonal trips are for the complete zone and are not applicable to portions of a zone. Estimates are also accurate only to a regional level, not a development-site level. Neither method should be used for estimating internal capture for MXDs.

Six land uses are the most frequently used components of MXDs—office, retail, restaurant, residential, cinema, and hotel. Most major MXDs have all of these. Most other MXDs have at least four. Six MXDs analyzed in this project ranged in size between 7 and 300 acres. All were single developments from one master plan developed to fully integrate all uses.

Available Data

There are very limited data available that are capable of supporting internal capture rate estimation methodology that can use information that is *available at the time of zoning*. Three Florida surveys plus three more conducted for this and a parallel project were the only surveys with enough detail to develop internal capture methodology

- For both A.M. and P.M. peak hours,
- For use with information that is available at the time of zoning requests and can be reliably projected,
- That provides the ability to analyze the effect of proximity of land uses to each other, and
- That is sensitive to differences in land use mix.

Some cordon counts have been completed for various periods and could be used for validation testing. More data are needed.

Internal Capture Estimation Methodology

This project expanded the database from three to six developments and after considering options, extended the ITE method to

- Add the weekday A.M. peak hour;
- Added restaurant, cinema, and hotel land uses;
- Created a land use classification structure that would permit disaggregation of the six land uses to more detailed categories should enough data become available;

- Include the effects of proximity (convenient walking distance) between interacting land uses to represent both compactness and design; and
- Provide a method that could easily be put in spreadsheet form.

The method uses the following inputs:

- User-estimated A.M. and P.M. inbound and outbound vehicle trip generation for six land uses: office, retail, restaurant, residential, cinema, and hotel;
- Mode split for MXD trips to/from each land use—percent by automobile, transit, non-motorized;
- Vehicle occupancy by land use; and
- Average walking distance between land use pairs.

The following outputs are produced:

- A.M. and P.M. peak-hour internal person trips by land use in origin-destination form;
- A.M. and P.M. peak-hour percent internal capture (person trips); and
- A.M. and P.M. peak-hour inbound, outbound, and total external trips (trips to and from the development being analyzed) by mode:
  - Person trips;
  - Vehicle trips;
  - Transit trips; and
  - Non-motorized trips.

This method was tested for its ability to estimate external vehicle trip generation. The existing ITE method estimates produce about one-half as much error as do ITE trip generation rates. The method developed in this project cuts the estimation error in half again or roughly to about one-fourth of the raw trip generation rates.

The recommended method is described in Chapter 3. The researchers recommend its use for developments of up to 300 acres. Further testing could validate its use for larger developments, but that has not yet been attempted. Due to the difference in scales and reduced levels of internal connectivity, the researchers do ***not*** recommend use of this method for suburban activity centers or new town types of development: the researchers do not believe it will be applicable.

The recommended estimation method was validated by testing it against actual data from several MXDs. The recommended method was found to be more accurate for estimating external vehicle trips for MXDs than either the existing ITE method or unadjusted ITE trip generation rates and equations. Compared with peak-period cordon counts, the recommended method overestimates external trips by an average of about 1%. More telling is an absolute average of about 13% and a standard deviation of about 15%. Details and comparisons with the other methods are discussed in Appendix F.

Recommended Modifications to Existing ITE Procedures

As mentioned previously, the recommended estimation method builds on the current ITE internal trip capture procedures contained in the second edition of the *Trip Generation Handbook* (*1*). Incorporation of this project's recommendations could be accomplished by the following:

1. Expanding Tables 7.1 and 7.2 of the *Trip Generation Handbook* to include all six land uses covered in this report;

2. Adding the proximity adjustment to be made after the unconstrained internal capture estimates are performed but before the balancing process; and
3. Modifying the data-collection procedures to include those recommended in this project.

Data-Collection Methodology

A methodology and procedural instructions were developed for the selection of data-collection sites and for the data-collection itself. Those procedures were used to conduct surveys at three MXDs. The researchers recommend that additional data be collected. The researchers suggest that MXDs selected meet at least the following criteria:

1. Be representative of typical MXDs being developed or being planned so the data will be of use for future years; the area in which the MXD is located should also be representative;
2. Have at least four land uses;
3. Have owners or managers who will permit the needed surveys to be conducted;
4. Be easy to conduct a large enough sample for an affordable cost (in 2006 dollars, the three surveys each cost about $50,000 to set up, conduct the surveys, and summarize data);
5. Be generally in range of 300 to 500 acres or less; and
6. Be economically successful (by appearance) and mature (fully occupied for at least a year and in an area that is mostly developed).

Organizations that collect additional internal capture data are encouraged to provide a copy of the data and analyses to ITE for further use and future refinement of what was produced in this project.

Application in Practice

This research project developed an improved estimation methodology and data-collection framework for use in estimating internal trip capture in MXDs during weekday A.M. and P.M. peak periods. The estimation methodology is based on weekday A.M. and P.M. peak-period survey data from three MXDs in Texas and Georgia (part of this project) plus similar weekday P.M. peak-period data from three developments in Florida (prior project). The six developments surveyed ranged from about 7 to 300 acres in size and had between four and six primary land uses each.

This report presents a technical advancement beyond the internal capture method published in the 2nd edition of the *Trip Generation Handbook* (*1*). The researchers believe that the limited validations conducted for the proposed estimation method confirm that the results provide accurate approximations of external trip generation for typical MXDs consisting of office, retail, restaurant, residential, cinema, and hotel land uses, consistent with the accuracy of trip generation estimates for single-use developments as portrayed in such references as the 8th edition of *Trip Generation* (*2*).

User Instructions and Cautions

At the time of publication of this report, the approach developed in this research had yet not been advanced through the ITE process for development of recommended practices and, therefore, should not yet be considered an ITE–approved methodology.

This report presents information in Chapter 3 on how to use the proposed estimation procedure; however, the researchers and the overseeing NCHRP project panel felt it is important

to encourage users to adhere to the following instructions and cautions in using the proposed estimation methodology:

- **Identify specific land use components of the MXD and classify them into the six classifications**—office, retail, restaurant, residential, cinema, and hotel—covered by the estimation methodology. Any component land uses that do not fit into those six classifications or are too unique to be considered normal for a classification should be kept separate. No internal capture is estimated in the proposed methodology for trips between uses within each of these categories (e.g., two or more different retail uses).
- **Estimate single-use trip generation individually for each land use within the MXD.** Then, sum the individual estimates into the six aggregated classifications: office, retail, restaurant, residential, cinema, and hotel. Do not combine development units into the six classifications and then use one single-use trip generation rate or equation to estimate trip generation for the aggregated land use.
- **When applying the internal capture estimation methodology, use the percentages suggested in Chapter 3 unless local data are available from developments similar to the development being analyzed.** Users are cautioned that data gathered in a method different than the data-collection methods described in this report may not be applicable and could produce inaccurate internal capture estimates.
- **Do not apply the internal capture percentages for this report to other land uses.** Internal capture estimates were not developed for land uses beyond the six classifications provided herein. The extent of the internal capture for other land use pairs has not been tested as part of this project.

The results presented in this report are based on surveys of six MXDs, and validation was limited to seven such developments. As a result, some members of the project's advisory panel strongly recommend that additional research, data collection, and validation testing be conducted before the method is adopted for use in TIAs.

Furthermore, caution should be exercised in the application of this methodology. For example, it cannot be concluded that the methodology will be appropriate for MXDs that differ significantly from those surveyed in this project in terms of

- Regional context, including competing opportunities outside the development;
- Access and parking;
- Scale of the development;
- Complementary land uses, including specific pairs of business types;
- Specific residence types,
- Other component characteristics within each land use category;
- Proximity and connectivity between each pair of land uses, especially the layout of the land uses relative to each other;
- Other characteristics such as proximity to transit and pedestrian access within and around the site; and
- Colder locations that might limit or constrain pedestrian traffic.

Suggested Future Research

Clearly, this project has made progress in estimation of internal capture; however, the database is still sparse and much that is thought to be logical about MXD travel characteristics is

still unproven and even largely untested. Two of the research efforts recommended by the research team include the following:

1. Collect more data at MXDs—the researchers think data are needed from at least six more sites that have five to six land uses.
2. Independent of the additional data collection, test the applicability of the existing methodology for MXDs of different sizes, character, and land use components. Use validation tests similar to those used in this project. The only data needed are a complete directional cordon count for the A.M. and P.M. peak-hours plus development data and a good site plan from which to estimate proximities.

Request for Additional Data

Users are encouraged to collect and contribute additional data using the data-collection procedures described in this report. Those data could be used to further enhance the accuracy of the proposed methodology and/or expand the number of land use classifications covered by the methodology. New data should be forwarded to the Institute of Transportation Engineers at 1627 I Street, Suite 610, Washington, D.C., 20006-4007, or by email to ite_staff@ite.org.

Report Contents

NCHRP Report 684 is composed of the following sections:

- **Chapter 1: Introduction** is a summary of findings from a review of the state of the practice.
- **Chapter 2: Research Approach** describes the objectives, approach, and work performed.
- **Chapter 3: Findings and Applications** describes the work performed and the results, findings, and recommended estimation methodology.
- **Chapter 4: Conclusions, Recommendations, and Suggested Research** includes those items plus lessons learned. Detailed procedures for computations are also included.
- **References** lists the works cited in this report.
- **Appendix A: Trends in Mixed-Use Development** is a description of past and expected trends and characteristics of MXD.
- **Appendix B: Land Use Classification System** presents a framework for classifying land uses for analysis of internal capture.
- **Appendix C: Procedures for Internal Capture Surveys** is a detailed description of how to prepare for and conduct surveys to obtain data for use in analyzing internal capture for MXDs. Sample forms are included.
- **Appendix D: Pilot Survey Experiences and Lessons Learned** contains useful information for those who may be planning to conduct internal capture surveys.
- **Appendix E: Florida Survey Questionnaires** presents the samples of questionnaires used for three Florida internal capture surveys that produced some data used in this project.
- **Appendix F: Validation of Estimation Procedure** documents a test of seven MXDs for which recommended estimation methodology was tested for its ability to reproduce cordon external vehicle trip volumes.

Additionally, a spreadsheet estimation tool to facilitate computations is available at http://www.trb.org/Main/Blurbs/165014.aspx

CHAPTER 1

Introduction

Background

Problem Statement

NCHRP Project 8-51, "Enhancing Internal Trip Capture Estimation for Mixed-Use Developments," was undertaken to improve the methodology(s) used to estimate the extent to which trips made within mixed-use developments are internalized or satisfied with both origin and destination within the development. Such estimates are important in determining the quantities of external trips generated by mixed-use developments.

To fully understand the project, it is first necessary to understand some of the terms used in describing the project. Terms are defined as follows:

- **Mixed-Use Development:** A mixed-use development, according to the Urban Land Institute (ULI), is a single physically and functionally integrated development of three or more revenue-producing uses developed in conformance with a coherent plan (*3*, pp. 4–5). The Institute of Transportation Engineers (ITE) suggests two interacting land uses compose a mixed-use development (MXD) (*2*). MXDs have internal pedestrian connectivity and share parking among some or most uses. An example of a true MXD would be a galleria consisting of retail, hotel, office, restaurant, and entertainment uses, possibly in separate buildings, but interconnected and sharing parking facilities. For the purposes of this project, it has been deemed appropriate and necessary to expand this definition to include multi-use developments. A multi-use development is a real estate project of separate uses of differing and complementary, interacting land uses that do not necessarily share parking and may not be internally interconnected except by public street and/or other public transportation facilities. A multi-use development example would be an activity center such as Tysons Corner in northern Virginia, also with a variety of interactive land uses, but relying on the public road system and separate parking facilities for most of the interaction.
- **Activity Centers:** An activity center is a well-defined, focused concentration of development with high density and a high mix of land uses. An activity center usually meets the above expanded definition of an MXD. An activity center is generally very large compared with other MXDs in its urban area and usually occupies at least several blocks. Perimeter Center in Atlanta is a good example of an activity center. This is not to be confused with shopping centers (for which ITE has specific trip generation rates) (*4*, pp. 561–562); however, for the purposes of this project, activity centers are not a focus of this research, but the estimation methodology may be adaptable for use in activity centers.
- **Neighborhoods and Subareas:** ITE notes that any area that has a specific identity and generates large amounts of traffic could be considered an area or subarea with unique transportation issues (*4*, p. 561). For the purposes of this project, neighborhoods can be classified within this concept when they exhibit a mix of interactive uses. Neighborhoods and subareas are not specifically within the focus of this research; however, as with activity centers, the methodology developed by this research may be adaptable for use in neighborhoods and subareas.
- **Transit-Oriented Development:** According to the American Public Transportation Association (APTA), a transit-oriented development (TOD) is a compact, MXD near new or existing public transportation infrastructure that serves housing, transportation, and neighborhood goals. Its proximity to transit services and pedestrian-oriented design encourages residents and workers to drive their cars less and ride mass transit more (*5*). For the purposes of this project, the research team stipulates that the development must be not only near transit, but the transit service must also be convenient to reach, the service must link the development

with other complementary locations, and the development must include land uses that generate activity that can be readily used by transit patrons.

- **Internal Trip:** An internal trip, as defined by ITE, is one that is made without utilizing the major road system (*2*, p. 85). For the purposes of this project, the definition is expanded to include travel within a highly interactive area containing complementary land uses and convenient internal on- or off-street connections that may use short segments of major streets. An example might be a one-block development consisting of residential, office, and retail buildings with convenient sidewalk connections between them and a single parking facility serving all three land uses.
- **External Trip:** An external trip is a trip made between land uses within the MXD and locations outside the boundaries of the development. This excludes internal trips.
- **Internal Trip Capture (Site) Rate:** Internal trip capture for a development site is the percentage of total trips (normally, but not always, vehicle trips when used for typical traffic impact studies) that are made internally to the development without using roads that are external to the site being analyzed. The internal trip capture is most frequently expressed in terms of a percentage or rate, but can be described in other forms such as equations. For example, if retail uses within an MXD generate 10 trips, 3 of which go to other land uses within the development and 7 of which go to external locations, the 3 internal trips are considered internally captured. The internal capture is 3 out of 10 trips, or 30%. MXDs addressed in this project may be a part of a major activity center. The level of internal connectivity and internalization of trips may be different for MXDs and activity centers. Only MXDs of less than 300 acres in size were examined in this project.
- **Internal Trip Capture (Area):** This area can be defined to include all trips made internally to a defined area such that the trips do not use transportation facilities external to the area. For the purposes of estimating impact of such developments and their internal trip capture on the transportation, care must be taken when considering the impact of the internal trips on the (major) public road system passing through the area.
- **Trip Generation:** Trips to or from a specific land use or a group of land uses constitute trip generation. Trips are inbound, outbound, or total.
- **Transportation or Traffic Impact Analyses (TIAs) or Studies (TISs):** TIAs are analyses of the impact of projected travel associated with existing or proposed land development and determination of needed access and transportation system improvements to successfully accommodate the development without undue deterioration of travel conditions.

Scope of Study

Specifically, the project had three objectives: to develop

1. A classification system of MXDs that identifies site characteristics, features, and context likely to influence trips subject to internal capture;
2. A defensible improved methodology for estimating internal trip capture with reasonable accuracy; and
3. A data-collection framework to quantify the magnitude of travel associated with MXDs to determine appropriate reductions below single-use trip generation estimates.

To accomplish these objectives, several tasks were completed:

- Compilation of a state-of-the-practice summary of methods in use to estimate internal trip capture for use in TIS;
- Development of a prototypes methodology to guide the subsequent work;
- Analysis of internal capture relationships;
- Determination of data needs;
- Conduct of a pilot survey to test the data-collection methodology and provide additional data;
- Identification of data gaps and suggest data to be collected; and
- Documentation of the findings, conclusions, and recommendations.

Following a review of available methods, it was determined that there were few methods and little data available that could credibly be used to estimate internal capture for TIAs. As a result, emphasis shifted from analyzing existing data to expanding the database through an additional pilot study. Subsequently, a third pilot study was made possible through funding of a separate project by a different sponsor (Texas DOT). As a result, two additional tasks were added after the three pilot surveys:

1. Analysis and compilation of data in combination with data available from other sources, and
2. Refinement of the estimation methodology and factors and conduct a verification test.

Past Research and Practice

This portion of the chapter summarizes the state of the art as it was at the time the background work was completed.

Land Use Synergy

Interaction of land uses has probably existed since the first settlements had people who performed different types of work. Older towns and cities had all different types of uses within

walking distances since walking was the principal mode of transportation. When suburbanization started to occur in the late 1800s, there began to be separations of different land use types. By the mid 20th century, zoning and single-use areas had become the normal way to develop.

However, a new type of development began to be seen: the major shopping center, followed by regional malls with restaurants, theaters, and other uses. Next came the MXDs, which had combinations of uses. Developers found the mixed- or multi-use developments appealing because such developments offered a way to capture several types of development in one project that was larger than any single project they might create in the same place. Moreover, the interaction and sharing of facilities had the potential to reduce long-term development costs and increase profitability. Trends in MXDs have progressed through many phases—from early urban villages to downtown complexes, early mixed-use towers, atrium developments, and open centers and, most recently, to town centers and urban villages (*3*, pp. 9–22).

What made MXDs work then and now is the interaction and shared-use features. The key to success is synergy between the land uses. Table 1 shows what ULI considers to be major land use combinations that have the most synergy.

Several other factors that affect internal trip capture have been suggested by Steele (*6*)—mixing uses in proximity, clustering, and siting buildings to promote interaction, connectivity between buildings and parcels, and proper time-phasing. To those Cervero added density, diversity, and other factors in design such as accessibility and high-quality pedestrian convenience and provisions (*7*). The Sacramento Transportation and Air Quality Collaborative lists land use balance as one of the most crucial factors in reducing off-site trips (*8*). Filion et al. found that the synergy works best if it is pedestrian-based to reduce the dependence on personal vehicle travel and internalize the trips (*9*, p. 427).

In their evaluation of multimodal areas, Guttenplan et al. discuss the importance of the infrastructure for walking and biking when assessing the performance of the transportation system (*10*). When evaluating internal trip capture for an area, site, or activity center, the presence of safe facilities for pedestrians and bicyclists can be a factor in the ability for a project to attract and internalize higher percentages of trips.

The importance of pedestrian-based design is emphasized in many studies promoting connections between land uses, but adding the transit component completes the overall picture. TODs combine the MXD with good pedestrian connections and direct access to transit. Portland's Land Use, Transportation, and Air Quality (LUTRAQ) approach to land use and transportation planning worked to reduce vehicle-miles of travel (VMT), increase transit usage, increase walking and biking, and reduce trips overall. Internal trip capture was assumed to explain a portion of the VMT reduction based on the design, proximity of uses, and overall accessibility (*11*). In a later study by the Oregon DOT, Reiff and Kim identified several similar characteristics that may influence internal trip capture including density; land use dissimilarity; urban form; proximity to complementary uses (specifically retail-residential); building coverage ratio (i.e., compactness); and local street connectivity (*12*).

Ewing and Cervero identified a number of potential independent variables that might be used to establish travel characteristics of MXD: land use mix, availability of convenience services, accessibility of services, perception of safety, and pleasing aesthetics (*13*). Much of their quantitative findings were derived from regional transportation models and may not be directly adaptable for individual sites and developments.

Kittelson & Associates listed key characteristics to be analyzed for MXDs when determining internal capture rate, which were as follows (*14*, p.7-1):

- Site Characteristics
  - Development size;
  - Land uses and quantity of development for each use;
  - Parking spaces provided for each use;
  - Density of development for each use; and

Table 1. On-site support and synergy in mixed-use projects.

Land Use	Degree of Support/Synergy			
	Residential	Hotel[1]	Retail/ Entertainment[2]	Culture/Civic/ Recreation
Office	●●	●●●●●	●●●●	●●●
Residential	●●●	●●●	●●●●	●●●●●
Hotel	●●●●●	●●●	●●●●	●●●●
Retail/Entertainment	●●●●●	●●●●●	●●●●●	●●●●
Cultural/Civic/Recreation	●●●●	●●●●●	●●●●●	●●●

Bullets: ●=very weak, ●●=weak, ●●●=moderate, ●●●●= strong, ●●●●●= very strong.
[1] Synergy is strongest between high-end hotels and condominiums, less so for mid-priced hotels and residences.
[2] Restaurants and food services are the main source of benefit for offices.
Source: (*3*, p. 85.)

  - Proximity of residential and non-residential developments within the development.
- Transit Characteristics
  - Bus or rail routes serving the development;
  - Proximity of transit stops to the development;
  - Transit assistance provided to workers by employers; and
  - On-site connectivity to transit stops.
- Non-Motorized Transportation Characteristics
  - Internal connectivity among land uses (for pedestrians, bicyclists, and motorists);
  - Parking spaces designated for carpools or vanpools;
  - Fee charged for employee parking spaces; and
  - Availability of on-site bicycle amenities.

Gordon and Peers noted that the jobs-to-housing balance was a crucial component to internal capture of trips. People living near where they work were more likely to stay within the development area for daily activities (*15*, p. 144). The Florida DOT (FDOT) cites the following factors to consider when evaluating internal trip capture: remoteness from other developments and areas, development phasing, income compatibility between residents and patrons, competing opportunities, and internal circulation (*16*).

Other factors that have been discussed by the ITE Trip Generation Committee during development of ITE's Trip Generation Handbook as affecting MXD synergy include competing opportunities and proximity, size of both the development and the individual land uses, maturity and viability of the development and its components, and compatibility of patron/employee income levels with the development's uses.

Trip Capture—Sites

The research team reviewed websites and contacted representatives of a cross section of organizations and agencies that prepare or review traffic impact studies (TISs) to determine what surveys or other data may have been completed in recent years. Table 2 summarizes the responses. It had been expected that a significant amount of survey data would be available based on responses to a 2004 ITE member survey; however, it was determined that respondents misinterpreted a question regarding data in hand. Of the 77 persons interviewed, 12 were able to provide data either directly or indirectly related to internal trip capture. Some data had already been acquired by the research team. No additional new survey data was found. Some information related to regional travel modeling was discovered as was some general or limited findings that may be usable as supporting information.

The interviews confirmed that the most frequently used resource for estimating internal trip capture is the ITE *Trip Generation Handbook* (*2*, p. V-39). It contains summaries of studies of internal trip capture for individual sites and developments as available through 1998. With caveats, Chapter 7 of the report provides suggested capture rates and a recommended procedure for use in TIS for proposed developments. The recommended procedure permits estimates for several different land uses and includes a procedure for balancing internalization of trips based on the size of the component land uses. The handbook also contains unconstrained internal capture rates (that assume sufficient quantity of complementary land use to accept internal trips) for office, retail, and residential land uses. These rates are based on surveys that had been made available to ITE by 1998.Capture rates for origins within a multi-use development range between 0% and 53%; for destinations, they range between 0% and 37%. Tables 3 and 4 provide the unconstrained internal capture rates used in the ITE internal trip capture procedure.

The handbook also recommends procedures for data-collection including interview questions. The handbook includes several summaries of key quantitative and qualitative findings from previous studies of trip generation characteristics at mixed-use sites. For each study, available data are presented on the mix and sizes of land uses within the site, the level of internalization of trips within the site, overall trip generation characteristics for the site, and the level of pass-by trips for the site. In most cases, the analyses use traditional

Table 2. Summary of interview responses.

Sources			Have Completed Surveys or Other Information	Suggested One or More Others
Type	Called	Interviewed[1]		
Agency Rep.	35	34	3	9
TIA Preparer	44	35	8	5
Researcher	7	3	0	1
Other	5	5	1	2
Total	**91**	**77**	**12**	**17**

[1] Sources not interviewed were called at least twice and either declined interview or did not return calls.

Table 3. Unconstrained internal trip capture rates for trip origins within an MXD.

From	To	Weekday Percent Trips Captured Internally[1]		
		Midday Peak Hour	P.M. Peak Hour of Adjacent Street Traffic	Daily
Office	Office	2%	1%	2%
	Retail	20%	23%	22%
	Residential	0%	2%	2%
Retail	Office	3%	3%	3%
	Retail	29%	20%	30%
	Residential	7%	12%	11%
Residential	Office	NA	NA	NA
	Retail	34%	53%	38%
	Residential	NA	NA	NA

[1] Based on limited data; NA = not available.
Source: (*2*, p. 93)

Table 4. Unconstrained internal trip capture rates for trip destinations within an MXD.

From	To	Weekday Percent Trips Captured Internally[1]		
		Midday Peak Hour	P.M. Peak Hour of Adjacent Street Traffic	Daily
Office	Office	6%	6%	2%
	Retail	38%	31%	15%
	Residential	0%	0%	NA
Retail	Office	4%	2%	4%
	Retail	31%	20%	28%
	Residential	5%	9%	9%
Residential	Office	0%	2%	3%
	Retail	37%	31%	33%
	Residential	NA	NA	NA

[1] Based on limited data; NA = not available.
Source: (*2*, p. 94)

ITE independent variables. In several cases, new variables are introduced.

Districtwide Trip Generation Study, FDOT, District IV, March 1995. This study sponsored by FDOT was to develop databases of internal capture rates for MXD sites and for pass-by capture rates. Table 5 presents a summary of the characteristics of six surveyed mixed-use sites (*17*). The sites range in area from 26 to 253 acres (with four of the sites being 72 acres or less). The office/commercial square footage ranges between 250,000 and 1.3 million sq. ft. (with three of the sites having less than 300,000 sq ft).

Internal Trips. Table 6 lists the proportion of daily trips generated within the surveyed mixed-use sites, which were internal to the sites. The internal capture rates ranged between 28% and 41% (average 36%).

Three of the mixed-use sites were further evaluated to determine the internal capture rates for different types of tripmakers. As listed in Table 7, the internal capture rates for trips

Table 5. Characteristics of mixed-use sites surveyed by FDOT.

Mixed-Use Site	Site Size (acres)	Office (sq ft)	Commercial (sq ft)	Hotel (rooms)	Residential (units)
Crocker Center	26	209,000	87,000	256	0
Mizner Park	30	88,000	163,000	0	136
Galleria Area	165	137,000	1,150,000	229	722
Country Isles	61	59,000	193,000	0	368
Village Commons	72	293,000	231,000	0	317
Boca Del Mar	253	303,000	198,000	0	1,144

Table 6. Daily internal capture rates at FDOT sites.

Mixed-Use Development Site	Internal Capture Rate
Crocker Center	41%
Mizner Park	40%
Galleria Area	38%
Country Isles	33%
Village Commons	28%
Boca Del Mar	33%
Average	**36%**

made by site workers is typically higher than rates found for visitors to the site (i.e., users of the mixed-use-site services). The rates by trip-maker are consistent across all three sites. On average, 37% of user trips are internal and 47% of worker trips are internal to the mixed-use site.

Finally, three of the mixed-use sites were further evaluated to determine the internal capture rates of individual land uses. Table 8 lists the reported internal capture rates by land use/trip purpose. In general, the higher internal capture rates were reported for trips to/from banks and sit-down restaurants.

Pass-By Trips. Table 9 lists the pass-by trip proportions as determined through intercept surveys for the six study sites. Pass-by trips are made as intermediate stops on the way along a street on the way from an origin to a primary trip destination (*2*, p. 29). Four of the six sites have pass-by rates between 26% and 29%. These rates appear to be high given the size and composition of the developments. Future surveys should attempt to verify these rates.

FDOT Trip Characteristics Study of MXDs, FDOT District IV, December 1993. This study was the predecessor of the March 1995 FDOT trip generation study (*18*). Much of the data that were collected and many of the relationships derived in this first study are included in the 1995 study results described previously. The 1995 study did not report on two relationships presented in the 1993 report: a procedure for estimating internal trips and internal trip capture by time of day.

Internal Trip Estimation Method. Relationships were developed for estimating internal trips as a function of the

Table 7. Internal trip capture rates by type of trip-maker at FDOT sites.

Trip-Maker	Crocker Center	Mizner Park	Galleria Area	Average
Users	37%	38%	36%	37%
Workers	46%	49%	46%	47%
Total	**41%**	**40%**	**38%**	**40%**

Table 8. Internal trip capture rates by land use type at FDOT sites.

Land Use/Trip Purpose	Crocker Center	Mizner Park	Galleria Area
Office (General)	11%	11%	7%
Office (Medical)	–	15%	12%
Retail	36%	30%	42%
Restaurant (Sit–Down)	54%	52%	–
Restaurant (Fast)	26%	–	56%
Hotel	30%	–	29%
Bank	–	48%	62%
Cinema	–	23%	–
Multi–Family Housing	–	11%	50%
Retail Mall	–	–	39%

Table 9. Daily pass-by rates at FDOT sites.

MXD Site	Daily Pass-By Rate
Crocker Center	26%
Mizner Park	29%
Galleria Area	40%
Country Isles	28%
Village Commons	14%
Boca Del Mar	29%
Overall Average	**28%**

combination of two interacting land use types in terms of development units (e.g., residential dwelling units and office/retail square footage). Good relationships were developed for two internal trip type categories: residential-retail and retail-retail. The office-retail relationship was less definitive.

The study presented a working hypothesis that the number of internal trips from one land use type (A) to another land use (B) within a mixed-use site is directly proportional to the size of Land Use A and also proportional to the size of Land Use B. This suggests a functional relationship of the form

$$\textit{Person Trips between A and B} = \textit{Constant} \times \textit{Land Use A} \times \textit{Land Use B}$$

where:

Land Use A = total site land use of Type A in residential units or 1,000 sq ft;
Land Use B = total site land use of Type B in residential units or 1,000 sq ft; and
Constant = a value that is solely a function of the two land use types.

In the equation shown above, the constant can be derived from information collected on person trips between different land use types and on the sizes of these different land uses. Table 10 shows the derived constants.

Application of these coefficients was tested for the three MXDs. Table 11 shows the results (not included in ITE *Trip Generation Handbook* [*1*]) (*16*, p. V-39). Two of the three estimates were within 15% of actual; the third differed from actual by about 25%.

Table 11. Comparison of internal trip capture: estimation model vs. actual.

MXD	Trip Capture	
	Model Estimate	Actual
Country Isles	24.5%	33.0%
Village Commons	31.9%	27.5%
Boca Del Mar	35.0%	32.7%

Source: (*18*, p. V-39)

This study also collected information on internal capture rates by time of day. Table 12 shows the total internal capture rates for the three surveyed mixed-use sites. The estimated daily, midday, and evening peak period internal capture rates are quite similar. The mean values for the entire survey period shown in the table have a high degree of statistical validity; the maximum two-tailed errors calculated using the binomial distribution, with 90% confidence-level methodology, are all less than 5%.

This report also identified the percentage of employees who are also residents and vice versa (*18*, p. V-27). Table 13 shows the findings for each of the three developments (not included in ITE report [*1*]). The 16% to 19% of employees being locally employed are possibly a major factor in the reported internal trip capture rates.

Trip Generation for MXDs, Technical Committee Report, Colorado-Wyoming Section, ITE, January 1986. This study included interviews to determine whether persons entering and leaving mixed-use sites came there for multiple purposes (*19*). Table 14 lists the size and mix of land uses at the eight sites with interviews to ascertain internal trip-making.

Internal Trips. A key piece of information collected was the number of trip purposes that a respondent accomplished on the particular trip to the mixed-use site. Overall, a majority (77%) of the interviewees indicated that their trip involved only a single stop within the mixed-use site, but this still left a significant proportion (23%) who indicated they were making

Table 10. Internal trip coefficients for paired land use types.

Paired Land Uses	Midday Peak Period (12 noon–2 P.M.)	Evening Peak Period (4 P.M.–6 P.M.)	Daily
Residential/Retail	0.00082	0.00103	0.00557
Retail/Retail	0.01219	0.00995	0.07407
Office/Retail	0.00087	0.00024	0.00232

Table 12. Internal person trip ends by time of day.

Time Period	Average Recorded at Three Sites	Range Recorded at Three Sites
Daily	31%	28–33%
Midday Peak Period (12 noon–2 P.M.)	32%	30–35%
Evening Peak Period (4 P.M.–6 P.M.)	30%	28–32%

Table 13. Percent locally employed residents and locally residing employees.

	MXD		
	Country Isles	Village Commons	Boca Del Mar
Residents employed within development	3.9%	NA	0.9%
Employees residing within development	16.1%	16.8%	18.9%

two or more stops within the mixed-use site. Based on these interview results, the study authors estimated that 25% of an otherwise total number of trips generated by individual trips were eliminated with the linking of internal trips within the eight surveyed mixed-use sites.

Table 15 presents the number of trip purposes/stops reported by survey respondents. The responses are arrayed according to the primary destination. Office buildings and a post office generated the greatest number of multi-stop trips. Theaters, restaurants, and banks tended to generate lower-than-average numbers of multi-stop trips within the mixed-use site.

The Brandermill Planned Unit Developments Traffic Generation Study, Technical Report, JHK & Associates, Alexandria, Virginia, June 1984. Brandermill is a large, planned MXD (and, in many respects, is a small town/village) located approximately 10 miles southwest of Richmond, Virginia. At the time of the study (*20*), there were approximately 2,300 occupied dwelling units, with 180 townhouse-style condominiums and 2,120 single-family detached units. Commercial development consisted of an 82,600–sq ft shopping center; a 63,000–sq ft business park; a 14,000–sq ft medical center; and a 4,400–sq ft restaurant. There were also recreational facilities including a golf course, tennis courts, swimming facilities, and several lakeside recreation facilities. Finally, there was a day-care center, a church, an elementary school, and a middle school. The study had the overall goal of determining the onsite (internal) and off-site (external) traffic generation at Brandermill.

Internal Trips. Based on the various data collected, the split between internal and external trips was estimated. As Table 16 shows, 51% of the daily trips, 55% of the P.M. peak-hour trips, and 45% of the A.M. peak-hour trips were internal to (or captured within) the mixed-use site. Additionally, 46% of the persons employed in Brandermill also reside in Brandermill.

Table 14. Characteristics of mixed-use sites with interviews.

Site	Size (sq ft)	Land Uses
1	240,917	Retail, General Office, Government Office, Restaurants, Health Club, Bank
2	731,846	Retail, Office, Restaurants, Hotel
3	500,000	Retail, Office, Restaurants, Motel, Theaters
4	115,000	Retail, Restaurants, Hardware Store, Supermarket
5	1,000,000	Regional Mall, Retail, Restaurants, Banks, Office, Theaters
6	110,000	Retail, Theaters, Restaurants, Banks
7	95,104	Retail, Restaurants, Supermarket, Medical Office, Savings and Loan
8	300,000	Retail, Hardware, Restaurants, Supermarkets, Post Office

Table 15. Percentages of persons within multi-sites by number of purposes (stops) and by primary destination.

Primary Destination	Number of Purposes/Stops Stated by Interviewee		
	1 Purpose	2 Purposes	3+ Purposes
Bank/Savings and Loan	83%	8%	9%
Hardware Store	76%	22%	2%
Supermarket	77%	17%	6%
Theater	93%	7%	0%
Office/Work Site	68%	31%	1%
Small Retail Shop	73%	14%	13%
Restaurant	85%	12%	3%
Health Club	71%	29%	0%
Post Office	63%	24%	13%
Total (Average)	**77%**	**16%**	**7%**

Travel questionnaires were distributed to residences and used to measure the level of internal trip ends for home-based trips. As Table 17 shows, approximately 35% of the daily home-based trips from Brandermill residences are linked with trip ends within Brandermill. Over 39% of the daily trip ends ***to*** Brandermill residences began within Brandermill. For the shopping center trips within Brandermill, approximately two-thirds of the trips originate within Brandermill during the midday and evening peak hours. These internal percentages are higher than the Florida examples.

Other Surveys. As previously mentioned, a study by the Colorado/Wyoming Section Technical Committee of ITE included surveys of eight MXDs ranging in size between about 95,000 and 1 million sq ft with varying combinations of component land uses (*19*). That study recommended that peak-hour trip generation rates be reduced by only 2.5% even though the surveys showed 25% internal trips. The reason is that driveway counts showed a lower reduction below estimates based on ITE rates. While one of the most ambitious of the early studies of internal trip capture, this study illustrates a key point: survey responses depend on how a question is worded, and asking how many trip purposes are being satisfied on one trip to a development may not yield the same responses as asking how many stops or how many different businesses were visited within the development or how many driving trips would have been needed otherwise. It also demonstrates that the effect of a successful (financially) development's additional trips may overshadow internal trip capture (this is also one reason why trip generation data are so highly dispersed). For this project, the research team sought out developments that appeared to be active and had low vacancy rates.

ITE recently conducted a member survey asking about availability of additional studies on internal trip capture (*21*). The survey identified methods currently being used to estimate internal trip capture. Unfortunately, a question that inquired about trip capture data was misunderstood, and responses indicating 48 sources for additional information were incorrect. Other findings are described later in this section.

In *Transportation Research Record 1617,* Steiner studied six shopping districts that were integrated within residential areas and found that in these districts walking was more prevalent, ranging from 24% to 41% of users studied (*22,* p. 29). Steiner

Table 16. Split between internal and external trip ends at Brandermill.

Trips	A.M. Peak Hour	P.M. Peak Hour	Daily
Total Generated	2,570	2,935	33,540
External Trips	1,420	1,325	16,280
Internal Trips	1,150 (45%)	1,610 (55%)	17,260 (51%)

Table 17. Internal trip ends linked with Brandermill residences and retail centers.

Hours	Home-based trips with destinations within Brandermill	Home-based trips with origins within Brandermill
7 A.M. to 9 A.M.	18%	51%
9 A.M. to 4 P.M.	44%	50%
4 P.M. to 6 P.M.	55%	34%
6 P.M. to 7 A.M.	41%	34%
Daily	35%	39%
Hours	**Shopping center trips with destinations within Brandermill**	**Shopping center trips with origins within Brandermill**
11 A.M. to 1 P.M.	66%	65%
4 P.M. to 6 P.M.	66%	52%

used the ITE rates for shopping centers, rather than for mixed use. Steiner compares trip rates from both ITE and *NCHRP Report 187* (*23*) with the local daily trips that occurred in the six shopping districts studied and found situations where the ITE and NCHRP methods overestimate and underestimate trips when compared with the local data (*22*, p. 35). Kittelson & Associates conducted surveys for three mixed-use sites in Florida: the Crocker Center, Mizner Park, and the Galleria area. They found that the rate of internalization of trips ranged between 38% and 41% (*14*, pp. 5–7).

Mehra and Keller reported relationships between the percentage of internal trips and the ratio of office space to residential units and the ratio of commercial space to residential units (*24*). Based on a Richmond Regional Planning District Commission Planned Unit Developments study they had reviewed, they reported finding that A.M. peak-period home-based work trips were internalized at rates between 0% and about 15% and that midday home-based other trip internal percentages ranged up to more than 40%. Both percentages increased as the ratio of office or other commercial space per dwelling unit increased in ranges of more than 80 sq ft/dwelling unit.

JHK & Associates conducted a shared parking study for San Diego that included user surveys. Table 18 shows the results of surveys of office worker trips to internal destinations in two MXDs (*25*). For both developments, 6% of the midday trips made by office workers are to onsite locations.

Table 19 shows the percentage of internal trips to restaurants and retail for five San Diego MXDs. Also shown are percentages of trips made by walking.

Trip Capture—Activity Centers

In a comprehensive study of suburban activity centers, Hooper conducted interviews of employees, patrons, and visitors to office, retail, residential, and hotels within some of the largest U.S. suburban activity centers (SACs) (*26*). That research developed a comprehensive procedure for determining travel patterns, including trips internal to the activity centers. Data were collected at the six SACs listed in Table 20. In the following discussion, larger centers refer to the three centers having at least 15 million sq ft of office/retail space in each; smaller centers refer to the remaining three, which have less than 8 million sq ft.

For activity center residents, Hooper found that 13% to 50% of employed residents work within the activity centers, with the average being 27% to 33% based on activity center size and whether they lived in owned or rented dwellings. An average of 50% of office employees was found to make midday trips outside their buildings; 20% to 33% of those trips were internal to the activity centers. Work-related, eating, and shopping trips were the most common midday trips for office employees. The study also examined stops to and from work during peak periods and found that such stops within the activity centers were made on an average of 13% to 15% of the trips.

Table 18. Internal trips by office workers to onsite destinations.

Internal Trip Purpose	Internal Trips	
Office work location to	Marriott Mission Valley	La Jolla Village Professional Center
Business	6%	–
Shopping	14%	13%
Eat Meal	29%	–
Health Club	–	–
Other	–	–
Total	**6%**	**6%**

Table 19. Percentage of internal trips to restaurants and retail.

MXD	Origin Percent Internal	Percent Walking	Origin Percent Internal	Percent Walking	Component Land Uses						
	To Restaurants		To Retail		Retail	Restaurant	Gen'l Office	Medical Office	Cinema	Hotel	Residential
La Jolla Village	23%	14%	–	–		•	•	•			
University Square	15%	14%	2%	10%	•	•			•		
Hazard Center	21%	6%	20%	18%	•	•	•		•	•	
La Mesa Village	25%	21%	13%	17%		•	•				•
Point Loma Place	4%	25	–	–	•	•				•	

Hooper found that internal trips involving retail centers within activity centers were higher in larger activity centers. P.M. peak-hour internal trips averaged 24% (7% to 57% range) while midday trips averaged 37% (7% to 68% range). In the A.M. peak periods, hotel trips internal within the large and largest activity centers averaged 19% and 37%, respectively, and 27% and 36% in the P.M. peak period, respectively, with the internal percentage increasing with the amount of activity center office space.

Table 21 presents a summary of some relevant relationships reported by Hooper in *NCHRP Report 323*. Many of the internal trip percentages resemble the 30% order of magnitude reported in some of the studies previously mentioned. From the information provided, it appears that the larger SACs have higher percentages of internal capture. This is logical since larger activity centers (1) offer more opportunities to meet traveler needs and (2) similarly offer more choices to meet a given need.

Zietsman and Joubert conducted extensive studies at three MXDs in South Africa (*27, 28*). They distinguished between internal trips made out of pure convenience and planned internal trips that would have saved a trip on the external road network. Internal capture rates ranging from 5% to 33% were observed depending on factors such as center size, types of secondary land uses, and weekends versus weekdays.

Cervero found that the existence of a retail component in office buildings in major activity centers was associated with an 8% reduction in vehicle trip rates per employee (*29*). Filion et al. found that over 40% of office building employees make restaurant trips outside their buildings, but internal to the activity center, averaging 2.2 such trips per week (*9*, pp. 420, 428–434). About one-third make similar trips for shopping, averaging about 1.6 trips per week. Four times as many retail customers said they shopped within the activity center due to location rather than because of specific retailers located there. About 55% of the internal trips are made on foot (compared with 26% driving and 19% by transit), with preference being given to "easy and pleasant" (pedestrian environment, no traffic conflicts) walking experiences. The researchers noted that more internalization of trips resulted from better balance, proximity, and pedestrian connectivity of interacting uses.

Trip Capture—Neighborhoods, Small Communities, and Subareas

Several studies have been conducted in neighborhoods and subareas to assess the amount of trip internalization as well as the differences in vehicle trip generation. Some have used regional travel modeling to compare characteristics of neighborhoods or areas with different design characteristics. The

Table 20. Characteristics of *NCHRP Report 323* study sites.

Suburban Activity Center	Office Space		Retail Space		Hotel	Residential
	Gross Floor Area	Employees	Gross Leasable Area	Employees	Rooms	Dwelling Units
Bellevue (WA)	4.7 million	12,880	3 million	6,150	1,000	N/A
South Coast Metro (Orange Co., CA)	3.5 million	10,465	4 million	6,865	1,800	2,300
Tysons Corner (Fairfax Co., VA)	17.0 million	35,020	7 million	13,355	3,100	15,000
Parkway Center (Dallas, TX)	13.0 million	39,000	2 million	3,430	1,800	206
Perimeter Center (Atlanta, GA)	13.0 million	32,500	3 million	5,150	910	2,000
Southdale (Minneapolis, MN)	4.0 million	13,700	3 million	6,155	2,200	3,000

Source: (*2*)

Table 21. Internal trip-making characteristics at *NCHRP Report 323* study sites.

	Average	Range
OFFICE EMPLOYEES		
Percent who make an intermediate stop within SAC		
• on the way to work	10%	7% to 15%
• on the way home from work	11%	6% to 16%
Percent who make midday trips internal to the activity center		
• SACs with high level of professional employment[1]	-----	29% to 33%
• SACs with low level of professional employment	—	20% to 23%
OFFICE VISITORS—Percent from within activity center		
• A.M. peak period		
o all SACs	—	15% to 59%
o small SACs	30%	-----
o large SACs	54%	-----
• P.M. peak period		
o all SACs	—	15% to 68%
o small SACs	33%	-----
o large SACs	58%	-----
REGIONAL MALLS—Percent trips which are internal to SACs		
• Midday		
o all SACs	37%	7% to 68%
o small SACs	23%	-----
o large SACs	47%	-----
• P.M. peak period		
o all SACs	24%	7% to 57%
o small SACs	14%	-----
o large SACs	31%	—
EMPLOYED RESIDENTS—Percent who work within SACs		
• all	-----	13% to 50%
• small SACs	27%	—
• large SACs	33%	—
HOTEL TRIPS—Percent internal to SACs		
• A.M. peak period		
o all SACs	—	13% to53%
o small SACs	19%	-----
o large SACs	37%	-----
• P.M. peak period		
o all SACs	—	15% to 46%
o small SACs	27%	-----
o large SACs	36%	—

[1] Sites with at least 60% of the work force in professional, technical, managerial, or administrative positions.
Source: *2, 26*.

research team chose not to include those here since the level of detail is insufficient for use for development sites and the need is for primary data.

In comparative surveys of Austin, Texas, neighborhoods, Handy found that walkable neighborhoods with neighborhood shopping could generate 6.3 walking trips per (adult) resident per month to internal neighborhood retail establishments and that 77% of those apparently substituted for driving trips (*30*). This might correspond to a reduction in the residential vehicle trip rate of 3% to 5%.

Steiner added that higher density puts destinations closer together, making it possible to walk for some trips, thereby reducing vehicle trip generation rates (*31*). She cautioned that other factors such as income, household size, and other factors affect transportation choices and highlighted the importance of separating the effects of those factors.

Ewing et al. used regional travel surveys to identify internal travel within suburban communities in Florida that ranged in size between about 600 to more than 15,000 acres (*32*). Although this is not the development scale sought for this research, it is interesting to note that within complete suburban communities, internal trips averaged about 25% but ranged between 0% and 57%. Ewing et al. attributed the variation to two factors: (1) larger population communities had higher

internal capture rates, and (2) lower *regional* accessibility resulted in higher internal trip capture. This finding is relevant when considering the relative attraction of an internal complimentary use destination given access to similar offsite opportunities of a similar type. According to this study, easy access to regional areas decreases the attraction of fulfilling several trip purposes without increasing trips on non-internal roadways.

Rutherford et al. found that in multi-use neighborhoods, the total number of trips were about the same as for suburban single-use neighborhoods but walk trips accounted for about 8% more of the total trips (*33*). Vehicle availability did not seem to be a factor, but higher household income was associated with fewer walking trips. Over 70% of the walking trips were ½ mile or less, and about 40% were less than ¼ mile. Less than 10% were over a mile. This confirms the importance of proximity and walkability in internalizing trips.

Gordon and Peers note in their research on pedestrian design for a mixed-use community in Sacramento County (Laguna West) that based on the correlation that the National Resources Defense Council has established between urban density and automobile usage, this development may have a reduction in VMT on the order of 20% to 25% (*15*, p. 144). Furthermore, they noted that the job capture rate in this area averaged between 15% to 20% of local residents holding jobs internal to the area, thus reducing trips and increasing the potential for walking (*15*, pp. 144–145).

A 2003 cordon count of Celebration, Florida—a 10-year-old, self-contained MXD of 3,500 developable acres—compared a three-weekday cordon traffic count to estimated trip generation for development existing at that time based on ITE trip generation rates. The comparison indicated that actual daily external trips were 27.7% less than ITE–based estimates. P.M. peak-hour counts were 31.8% less than ITE–based estimates (*34*).

When analyzing the impact of smart growth site design using a travel modeling process for a project in Atlanta, Walters, Ewing, and Schroeer suggested that good site design using TOD and MXD principles conservatively resulted in a 14% to 52% reduction in travel. This evaluation utilized INDEX software in the modeling process, which is discussed later in this chapter (*35*).

A study was conducted to compare trip-making characteristics between a traditional neighborhood development (TND) in Chapel Hill, North Carolina (Southern Village) and a conventional residential neighborhood in Carrboro, North Carolina (*36*). The TND was comprised of 920 occupied dwelling units (611 single-family, 197 apartments, and 112 condominiums); 30,000 sq ft of retail (including a 5,800–sq ft grocery store and a four-screen movie theater); 95,000 sq ft of office; a 90,000–sq ft elementary school (with 606 students); a 6,000–sq ft daycare center; and a 27,000–sq ft church.

A survey of TND residents found that TND households made about the same number of total trips, but made fewer automobile trips and fewer trips external to the site when compared with households in the conventional neighborhood. A survey of the TND businesses found that 5.2% of the employees live within the TND, 39.2% of the business customers/visitors live in the TND, and 18.1% of trips to TND businesses are by walking.

Based on the survey results and vehicle counts taken at the neighborhood access points, the study estimated 20.2% internal capture of all trips made to or from businesses and households within the TND. The comparable surveys and counts at the conventional neighborhood measured 5.5% internal capture. The study postulated that the difference in internal capture (14.7%) is the product of the TND mixing of uses and spatial characteristics.

Other Related Findings

One of the trip characteristics that may be needed to estimate internal trip capture is trip purpose. The International Council of Shopping Centers conducted surveys in 2003 to obtain detailed information on typical office worker lunchtime activities and shopping habits during and after the workday (*37*). Based on about 500 completed interviews in both suburban and downtown locations, retail density is not a crucial factor: employee mode of transportation was more important, with driving employees spending nearly 30% more per week on each category (shopping, food, and convenience items). On average, office workers bought lunch outside their offices three out of five days a week (more often downtown than in suburbs). Some 62% shopped before, during, or after work at least once a week (slightly more in suburban office locations), with an average of 2.6 shopping trips per week. Office workers were reported to make about twice as many shopping trips close to home than close to work. Of their shopping expenditures, almost 60% were on dry goods and about 40% on convenience items. In addition, 32% of respondents socialize after work at least once per week with most stopping one or two times during the week. Those stopping after work for food and drinks were about twice more likely to stop closer to home than closer to work.

TCRP Report 95, Chapter 15: Land Use and Site Design, Traveler Response to Transportation System Changes contains information related to analyzing transit ridership and other travel relationships to land use and site design features (*38*). This report is a compilation of a large number of sources, some of which are related to internal trip capture.

This report concluded that transit mode choice and ridership are highly related to development density if it is coupled with a higher level of transit service. Density alone is not enough (*38*, p. 15-10). Similarly, non-motorized travel (primarily walking and biking) increases with density, but in conjunction with

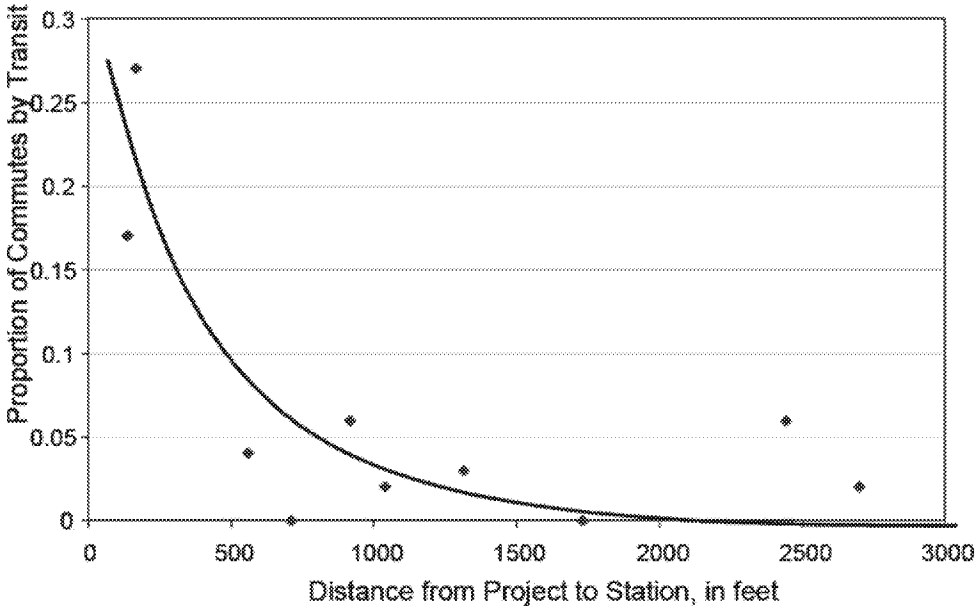
more land use mixing, compactness involving interacting uses, and pedestrian connections. This report concluded that density was not found to be significant by itself in some cases. This report also reports more walking in traditional neighborhoods (mixed use) than in late 20th-century planned unit developments. This report also contains a finding that transit ridership declines with distance of housing to transit, falling 1% to 2% per 100-ft increase in walking distance (*38*, p. 15-31).

A California DOT (Caltrans) funded study confirmed that residential density is insignificant (correlation –0.025) in affecting transit ridership within a 1-mile radius of a transit station (*36*). Street connectivity was found to have the highest correlation (+0.373). Walking distance to the transit station was found to have a significant affect, as Figure 1 shows. The number of walking conflicts is more influential (–0.11 correlation) as is presence of sidewalks on one or both sides of the street (+0.171 and +0.150, respectively). That research concluded that sidewalk width, landscaping, and number of intersections have insignificant influence on transit ridership.

TCRP Report 95, Chapter 15 also reports that vehicle trip generation is 1% to 3% less when improved pedestrian access is provided at regional shopping centers and 6% to 8% less for office employee vehicle trips at the edge city office buildings containing retail (*38*, p. 15-12). This source also reported that Steiner found decreased vehicle use in higher-density residential areas because of closeness, safety in numbers, and attraction of supportive lifestyles that support walking (*38*, p. 15-18). The report contains elasticities of –0.10 for total VMT related to density and –0.05 for vehicle trips related to density, but (1) those elasticities reflect other urban area conditions and (2) the elasticities are derived from regional travel forecasting zonal databases and may not be directly transferable for this internal trip capture research (*38*, p. 15-23). The same report shows that good pedestrian environment and transit versus bad results in about 21% less trips per household and 46% less household VMT (*38*, p. 15-28).

TCRP Report 95, Chapter 15 also examined the relationship between jobs/housing balance and trip making. Most findings showed significantly better balance results in shorter trips, but not fewer trips (*38*, p. 15-41). The quantified results reported in this report varied widely, but one finding was that the "best new communities in the United States" are estimated to achieve 31% to 37% internal commutes (*38*, p. 15-41). Job balance was also reported to result in employees taking jobs closer to home, although the quantification relates to inside or outside city of residence rather than distance per se (*38*, pp. 15-44 through 15-45). The same report indicates that land use balance/mix has an elasticity of –0.10 related to household VMT and that land use balance/mix has an elasticity of +0.23 related to walk/bike trip elasticity (*38*, pp. 15-47 through 15-51). Another source quoted in this report indicates that local land use balance/diversity has an elasticity of –0.03 related to vehicle trips (*38*, p. 15-48).

The same report contains information on residence and shopping land use mix in traditional neighborhoods—those with shopping in or adjacent to and well connected with housing areas. Table 22 shows the relationship between the percentage of survey respondents living within ½ mile of shopping and the number who reported walking to shop (*38*, pp. 15-52



Source: *39*, p. 101.

Figure 1. Percentage of transit commutes by walking distance from station.

Table 22. Comparison of shoppers who walk to shopping with percentage of residents within one-half mile of shopping.

Traditional Shopping Area	Residents Living within 1/2 Mile of Shopping Area	Percent Walking Trips	
		Weekday	Saturday
Rockridge—Market Hall (full array, restaurants)	24%	26%	28%
Rockridge—Alcatraz (grocery, specialty)	40%	38%	41%
Elmwood (convenience, specialty)	33%	28%	36%
El Cerrito Plaza (full array)	12%	10%	10%
Hopkins Specialty (food)	32%	23%	29%
Kensington (convenience, services)	58%	20%	27%
All Areas	**32%**	**24%**	**28%**

through 15-53). This table shows a very close relationship between residential location and the percentage of residents who walk.

Hooper showed in activity center surveys that an integrated development—the Dallas Galleria—had a midday walking trip share of 17% while other suburban activity centers with nearby, but mostly auto-accessible, complementary uses had walk shares of only 2% to 7% (*38*, p. 15-61).

TCRP Report 95, Chapter 15 reports that land use mix in activity centers reduce midday vehicle shares, at least to major retail, and that land use mix influences choice of vehicle or walk access, with greater mix associated with less vehicle use and more walk access (but not transit access) (*38*, p. 15-55). Another researcher found that vehicle trip generation rates at office buildings in suburban activity centers were 6% to 8% lower than normal and transit trips were about 3% higher than normal. The same source reported vehicle occupancy rates for 1 million–sq ft office buildings averaged 0.8 more passengers per work trip than for buildings half that size (*38*, p. 15-62). For activity centers with major office concentrations, for every 10% addition of retail or commercial uses, there was a 3% increase in non-single occupant vehicle commuting (+0.30 elasticity) (*38*, p. 15-64). Similarly, it was reported for Seattle that walking is about twice as prevalent in mixed-use neighborhoods than for suburban-type neighborhoods, although walk percentages varied by location in the region (*38*, p. 15-72).

The same report shows that household income has more effect on mode choice and on total trips per household than does whether the development is a traditional or conventional suburban neighborhood (*38*, p. 15-78). Table 23 shows results of a survey in Orange County, California. Similar walk

Table 23. Trip rates and mode share in different neighborhood types, Orange County, California.

Travel Parameter	Income	Neighborhood Type		
		Traditional neighborhood development	Planned unit development	All types
Mean daily trips per household	Low	6.4	7.2	6.5
	Medium	8.8	10.7	9.9
	High	10.8	12.3	12.5
	All	8.2	10.9	9.6
Mean daily vehicle trips per household	Low	5.1	6.6	5.6
	Medium	8.0	9.7	8.8
	High	10.2	11.3	11.6
	All	7.0	9.8	8.5
Percent by vehicle	Low	80%	91%	86%
	Medium	91%	91%	90%
	High	94%	92%	92%
	All	86%	91%	89%
Percent by transit	Low	6%	3%	3%
	Medium	2%	2%	2%
	High	1%	1%	15
	All	4%	3%	3%
Percent by walk	Low	15%	11%	11%
	Medium	7%	7%	7%
	High	5%	7%	7%
	All	9%	8%	8%

Table 24. Transit share at work sites with alternative land use characteristics.

Conditions	Principal Land Use Characteristic[1]	Percent Trips By Transit	
		With Land Use Characteristic	Without Land Use Characteristic
Offices, residential, retail, personal services, parks within $\frac{1}{4}$ mile of site	Substantial land use mix	6.4%	2.9%
Four or more services, service frequency, sidewalks, transit, transit stops	Accessibility to services	6.3%	3.4%
Restaurant, bank, child care, dry cleaner, drug store, post office	Availability of convenience services	7.1%	3.4%
Sidewalks, street lighting, pedestrian activity, no vacant lots	Perception of safety	5.4%	3.6%
Trees, shrubs in sidewalk zone, wide sidewalks, small building setbacks, no graffiti	Aesthetic setting	8.3%	4.2%

[1] Sites also have TDM programs.

mode results were reported for a pair of neighborhoods in northern California (*38*, p. 15-79).

Transit mode shares at work sites vary based on different land use characteristics. As Table 24 shows, transit ridership is higher—approximately double—with substantial land use and services mixes than without (*38*, p. 15-86). Providing safety and aesthetics also produce greater willingness to use transit.

Table 25 shows some bottom line elasticities contained in *TCRP Report 95, Chapter 15* (*38*, p. 15-117). Local density, diversity, and design all have modest impacts on both vehicle trips and VMT. A Portland, Oregon, METRO report found a source that concluded that residents of mixed-use, gridded neighborhoods in the San Francisco area made 15% fewer automobile trips and 22% more walking trips than did residents of typical suburban neighborhoods (*40*). It is not clear if other factors were kept constant.

Current Practice

When using TIS became more widespread during the 1970s and 1980s and developers took more interest in mixed- and multi-use development during the same period, traffic study preparers and reviewers began to focus on internal trip capture. In a 1993 survey of 15 Texas cities that required TIS, 11 permitted reductions for MXDs (*41*). One had a set reduction percentage and a minimum development size; the others required justification, and what constituted acceptable justification varied. A national survey in 1994 indicated that 17% of responding agencies that required TISs permitted reductions for mixed use (*42*). Permitted reductions reported averaged 10%.

Procedures vary significantly—for example, Destin, Florida, states that any claim for internal capture rate must be justified by the applicant based on empirical data for similar land uses located in similar urban environments. Data are to be from a source generally acceptable to the transportation planning profession. Any internal capture rate exceeding 25% must be justified and approved by the city (*43*). The City of Tempe, Arizona, simply requires that capture rates and sources of information be documented and limits internal capture to no more than 15% (*44*). The City of San Diego uses a simple method. It stipulates internal capture reductions to be used, providing a table of reductions by land use type (i.e., residential, industrial, office, or retail) by time of day (i.e., daily, A.M. peak, and P.M. peak) (*45*). Table 26 is a reproduction of San Diego's table. Retail reductions are permitted only if the retail is neighborhood oriented and more than 100,000 sq ft. All three approaches are used in a variety of cities. San Jose, California, limits internal capture to a maximum of 10%, but provides a bonus if there is a commitment to travel demand management programs and if nearby transit is available in addition to the site being mixed use (*46*). In California, Caltrans indicates that internal trip capture rates may exceed a 5% reduction, but requires approval and review with transportation staff (*47*). Table 27 was compiled by the research team

Table 25. Typical travel elasticities related to land use density, diversity, and design.

Characteristic	Description	Elasticity	
		Vehicle Trips	VMT
Local density	(residents + employees)/ land area	−0.05	−0.05
Local diversity (land use mix)	Jobs/population balance	−0.03	−0.05
Local design	Sidewalk completeness, route directness, street network density	−0.05	−0.03

Table 26. Permitted internal trip capture reductions, City of San Diego.

Land use within MXD	Percent weekday internal trip reductions for MXDs that include predominantly neighborhood-oriented commercial retail		
	A.M. Peak Hour	P.M. Peak Hour	Daily
Residential	8%	10%	10%
Industrial	5%	5%	4%
Commercial Office	5%	4%	3%
Commercial Retail	*	*	*

* Commercial retail reduction equals the sum of the total mixed-use reduction in residential, industrial, and commercial office.
Source: (*45*)

and lists a total of 21 agencies and their requirements for accounting for internal capture for MXDs.

For the U.S. Environmental Protection Agency, Criterion Partners developed geographic information systems (GIS) based software, INDEX. The INDEX software assists in determining the impact of a variety of community design characteristics on vehicle trip generation and VMT (*48*). As inputs to vehicle trips and VMT, the procedure uses population and employment density; population and employment balance (as an indicator of mixed land uses); street network and sidewalk densities; distance to transit; and travel times. The methodology is calibrated and applied at the traffic-analysis-zone level. It uses zone-level regional travel model trip generation as a base and applies elasticities associated with the factors listed above. It does not directly use specific land use trip generation rates or equations of the type typically used in TISs.

ITE's *Trip Generation Handbook* includes a detailed method for estimating internal trip capture (*1*, Ch. 7). It is based on

Table 27. Internal trip capture rates for selected agencies.

State	Agency	Internal Trip Capture Procedure						
		Max or flat %	Justify/ agency approval for higher rate	Agency approval	ITE *Trip Generation Handbook* procedure	Verify with survey	Formula or table	Other
AZ	Phoenix	● (10–15%)						
	Tempe	● (15%)						
	Tucson				●			
CA	Caltrans	● (5%)	●					
	L.A. County			●		●		
	Newport Beach	● (10%)						
	Pasadena		●		●			
	San Diego						●	
	San Jose	● (10%)						TDM bonus
CO	Boulder			●				
FL	Destin	● (25%)	●					
	FDOT				●			Additional considerations
	Gainesville				●			
	Orlando				●			
GA	GRTA				● (modified)			
IN	Indianapolis				●			
NM	NMDOT				●			Prescribed by city
TX	Austin				●			Other approved sources
	Plano				●			Or citywide study
WA	Seattle				●			
D.C.	Washington				●			Documented alternative

Source: Texas Transportation Institute.

complementary land use by number of development units, trip generation rates, and trip capture percentages for any given pair of land use classifications for which data are available and provides a balancing computation to ensure the origin and destination land uses can send and receive the same number of internal trips. It assumes convenient internal connectivity. It depends on empirical data supplied from surveys; data in the handbook are from studies transmitted to ITE.

The Georgia Regional Transportation Authority (GRTA) requirements represent a more specific approach now more commonly used (*49*): it requires use of the ITE–recommended practice as documented in ITE's *Trip Generation Handbook* (*1*). However, GRTA modifies the procedure in accordance with a table that reduces the adjustments according to a combination of distance between complementary uses and whether bicycle/pedestrian facilities are provided (see Table 28). Any other claims for internal trip reductions must be approved by GRTA in advance.

A survey conducted in 2004 by ITE indicated that 64% of the respondents use the method provided in the *Trip Generation Handbook* (*50*). The responses were from a combination of preparers and reviewers, so the percentages should not be interpreted as representing the portion of agencies that require a given method. Multiple responses were permitted, so the total does not add to 100%. A total of 12% reported they use locally established methods; 34% reported they use rule of thumb (usually specific percentage) methods; and 19% reported they use other detailed methods. The locally established and other methods include engineering judgment, specific considerations, state DOTs or other guidance, distance-based method, ULI shared parking rates, results from surveys, and travel forecast model. Land uses for which internal capture estimates are desired were most frequently reported to include retail, residential, office, hotel, health club, theater, and conference center, but several other uses were also mentioned. Those that collected new data usually have done so mainly through interview surveys, although several other methods were reported including traffic and turning movement counts, parking durations/turnover, and field observations.

Additionally, Kittelson & Associates note that it is not advisable to apply internal capture rate reductions in very-high-density MXDs that generate activity that exceeds suburban development because the rates developed by ITE were based on suburban vehicle-oriented travel patterns and may be lower than the same land uses in high-density MXDs (*14*, p. 7-3).

URBEMIS2002, a national model for calculating air-quality impacts of projects, contains adjustments to reflect the effects of several land use and design factors discussed earlier in this chapter. Internal trip capture-related factors specifically included in formulas that compose the adjustment factors are as follows (*51*, *52*):

- Net residential density (households per net acre; excludes land consumed by arterial right-of-way);
- Mix of land uses (based on number of study area [0.5 mile radius] households and employment—a jobs/housing balance—with a 2% bonus for inclusion of retail within the study area);
- Transit service index (function of buses stopping within ¼ mile of site, number of rail or bus rapid stops within ½ mile of site, number of dedicated daily shuttle trips);
- Pedestrian/bike score (function of intersection density, and sidewalk and bike lane completeness); and
- Parking supply (function of parking provided/ITE parking generation rate).

Formulas are provided for each of the reductions, but the documentation does not provide complete explanations of how the formulas were derived, and it appears that at least one formula (reflecting residential density) is based on assumptions that are not supported. Nevertheless, URBEMIS2002 provides for air-quality emissions estimation trip reductions of up to the amounts shown in Table 29. The numerical information was developed using a variety of sources including some referenced above. Further review of additional supporting documentation would be needed before the formulas should be considered for use in this project's improved estimation method. The reports' text states that redundancy has been removed by using reduction factors within the equations. Ewing slightly deviated from the standard classification of trips in the modeling process when studying communities in Palm Beach County. Ewing treated trips as part of tours rather than home-based or non-home-based (*53*). Assessing trips as part of a multistop and multipurpose tour or activity-based traffic

Table 28. Adjustments to ITE *Trip Generation Handbook* mixed-use internal trip capture rates.

Bicycle/pedestrian facilities provided	Percent of full reductions allowed by distance between complementary uses			
	¼ mile or less	¼ – ½ mile	½ – ¾ mile	> ¾ mile
Yes	100%	67%	33%	None
No	67%	33%	None	None

Source: (*49*)

Table 29. URBEMIS2002 trip reduction credits related to internal trip capture factors.

Physical Measures	Land Use Type	
	Residential	Non-Residential
Net residential density	Up to 55%	Not applicable
Mix of uses	Up to 9%	Up to 9%
Local-serving retail	2%	2%
Transit service	Up to 15%	Up to 15%
Pedestrian/bicycle friendliness	Up to 9%	Up to 9%
Total	**Up to 90%**	**Up to 90%**

Source: (*51*, p. 3)

modeling is an enhancement to standard modeling that may address internal capture rates more effectively.

Some have tried to adapt the ULI shared parking method for use in estimating trip generations for MXDs. While the ULI shared parking method is applicable to MXDs, it is valid only for estimating parking accumulation and not for trip generation estimation (*54*); however, it is apparent that some preparers are using it to estimate internal trip capture.

Trip Capture Variables

Travel is affected by a myriad of factors ranging from travelers' own demographic characteristics to characteristics of the trip destination. Extensive research has been conducted related to travel behavior. For example, it is widely accepted that income levels and vehicle ownership affect the magnitude of a person's and household's travel. Travel time, travel distance, available travel modes, residential development density, and other factors have all been shown to influence travel characteristics. Table 30 lists a wide range of variables that could influence internal trip capture. Also listed are considerations that are applicable in selecting a smaller set of variables for consideration in developing an improved estimation procedure.

Table 30 also lists (in the first column) the final candidate variables selected by the research team for consideration in developing an improved estimation method. These variables were selected based on causal relationship to internal trip capture, ease of quantification in the field and from preliminary site plans, potential data availability, data collection complexity, and likelihood of acceptance by the user community. Chapter 3 addresses these variables more fully.

Trends in MXD and classification of land uses found in MXDs are covered in Appendixes A and B.

Summary

These findings revealed several estimation techniques and a lot of related data and research findings, but detailed surveys of only seven MXDs (six in two Florida studies and one in Virginia). Hard-copy survey data were acquired for the six Florida sites. All were completed by the mid-1990s, prior to the time that ITE published the first edition of its *Trip Generation Handbook* in 1999 (*55*), which as an ITE–recommended

Table 30. Candidate independent variables.

Use	Variable	Anticipated Sensitivity	Comments
No	Density/compactness	High	Combine as a single independent variable (proximity)
√	Proximity	High	
No	Connectivity	High	
No	Parking	Moderate	Reflect instead in mode of access that may be considered similar in effect. Parking-supply constraints reduce total trip generation but may not significantly change internal trip capture *percentage*. Normally only a factor in central business districts (CBDs), TODs; such sites may require special study anyway. Add parking garage "access time" to impedance used for "competing external opportunity" model component.
√	Land use synergy	High	Use as "yes/no" variable to match users among site land uses
√	Balance of land use quantities	High	Use as control check
No	Principal trip purpose to site	High	Covered largely by land uses and time of day
√	Mode of access	Moderate	Driver trips can be associated with mode of access to site for primary trip. Primary trip purpose strongly influences mode of access. Will be a significant factor where good transit service exists.
√	Time-of-day	Moderate	Provide one trip capture table for each time period of interest (e.g., weekday A.M. peak hour, P.M. peak hour, midday; Saturday peak hour)
	Day of week, season	Moderate	
No	Competing external opportunities	High	Attempt to quantify if data can be found. Data expensive to collect.

practice (approved by its International Board of Direction) contained the first endorsed internal trip capture estimation technique for use in TISs for MXDs.

Most public agencies and preparers of TISs use the ITE method (or a locally developed variation of the ITE method). The two other approaches that are also commonly used are (1) a local agency accepted or established internal trip capture reduction percentage to apply to estimated site vehicle trip generation and (2) negotiations between the study preparer and agency reviewer.

Developers, through payment for TIS, have typically funded most previous site trip generation research; however, since the appearance of the ITE *Trip Generation Handbook* that endorsed an estimation method and provided some data on capture rates for the most frequent mixed uses, a combination of high cost of internal trip capture data collection and an existing accepted method have resulted in no new comprehensive data.

Since the late 1980s, there have been numerous studies of various census and regional travel survey databases, limited site data collection, and studies and surveys of related travel and development characteristics that could contribute useful material for developing an improved estimation technique. Many studies were related to mode of access and finding ways to promote transit usage, including through use of land use and development tools such as TODs. Internal trip capture rates found in the research vary widely depending on conditions and land uses, but for developments with major commercial components, capture rates (percentage of trips made from internal points to internal destinations) typically ranged up to more than 30%. For mixed-use neighborhoods and small communities, internal capture reached 50% and even higher. Interaction between individual pairs of land uses, in the proper balance, also was found in similar ranges; however, it appears from the available data that few developments (all uses combined) completed by about 2000 can typically be expected to have internal capture rates much above 30%, and that percentage requires the right mixes and balances of land use mix.

Besides land use mix, other factors were found to affect internal trip capture. These include connectivity and proximity between interacting land uses and location within an urban area (thought to reflect both competing opportunities and modal options). Conflicting information was found on the effects of development density. Modal impacts found were attributed to proximity to transit (with good service). Trip generation rates and mode split were found to be affected by such traveler characteristics as income and vehicle availability. However, no site-internal travel data have been collected that included those characteristics, and they would be hard or impossible to accurately project for a proposed development at the zoning stage.

Conclusions

Based on this review of past work and the personal experience of the research team, the following were selected as being a reasonable starting place for NCHRP Project 8-51 to develop an improved internal trip capture estimation method:

- To be of value, the project should address both mixed-use and multi-use developments (hereafter referred to in combination as MXDs).
- Activity synergy between the different uses within an MXD is what captures trips internally. Other factors contribute to making this synergy and interaction both possible and more or less attractive compared with other opportunities.
- Land uses that are most frequently identified as having synergy of the type that affects trip making *and* that are commonly included in MXDs include residential; retail (especially convenience); office; hotel; restaurant; and entertainment (theater). However, within each general land use classification, there will be a need for subclassifications if a method is to be easily and accurately applied. Chapter 3 addresses land use categories.
- The research team identified other characteristics most likely to influence internal trip capture and be most readily developed in actual practice. Table 30 lists these characteristics.
- Trip capture has been studied at essentially three development levels: single-site project, larger multi-site development and activity centers, and neighborhoods and subareas. The issues and challenges are similar, but some implications of internal trip capture are different and the extent and complexity of data collection will be different. Findings at each level may not be directly transferable, at least quantitatively.
- Specifically, there are more different scales of mixed development that may act somewhat differently or have to be treated or have data collected in different ways:
  - Single developments;
  - Blocks of separate interactive developments;
  - Small areas of blocks containing interactive uses;
  - Neighborhoods and districts with multiple interactive uses;
  - Mixed- and multi-use subdivisions;
  - Multi-use activity centers; and
  - Small communities.
- The sites for which travel data were used to develop the recommendations in this study are all single master-planned developments. Mockingbird Station is a single block. Atlantic Station and Legacy Town Center are multiple block districts containing fully integrated and adjacent complementary uses. Boca del Mar, Country Isles, and Village Commons all contain pod-type mixtures of single-use development within a single development to provide the mixed-use interaction.

- Trip capture percentages vary greatly among land uses and development types. They also vary by time of day and probably to some extent by the day of week and by season. Various studies have found internal trips make up as little as 0 and as much as more than 60% of total trips generated. Several studies included multiple developments or areas and were able to compute averages.
- The extent to which trips are captured internally may also be influenced by other factors, such as
  - Availability of personal vehicle during the stay at the primary destination (accounted for by mode of access);
  - Match between traveler characteristics and characteristics of potential destinations (e.g., market position versus income levels);
  - Availability of competing onsite and off-site opportunities; and
  - Internal and external accessibility (including such factors as proximity, connectivity, cost, comfort, attractiveness, convenience, parking availability, etc.) to desired activities.
- Local data or more diverse and representative data points regarding internal trips associated with the different MXDs and multi-use-development types is needed to improve the accuracy of predicting trips for MXDs.
- Despite the availability of the method provided in the *Trip Generation Handbook*, several other methods are being used. Some are arbitrary (e.g., set or maximum percentages), and a few are incorrect for application to transportation or TIA or studies (e.g., ULI shared parking percentages). It appears that only the ITE method balances internal trips based on the amount of each interacting land use.
- Two methods are most currently used for estimating internal trip capture: The ITE method contained in the *Trip Generation Handbook*, 2nd edition (*1*), and percentages that local agencies establish as acceptable. In many cases, these methods are specified in local agency TIS requirements or even ordinances. Both approaches are easy to use and require minimal data.
- Since the advent of the first edition of the *Trip Generation Handbook* in 1999 (*55*), there has been wide acceptance of internal trip capture percentages contained in the handbook or lower values accepted by review agencies. The cost of internal trip data collection is high compared with other TIS components, which has resulted in little incentive for developers to fund collection of new data. Obtaining developer commitments to fund additional data collection may be a challenge unless there is expectation of major increases in internal trip capture credit.
- Little detail was found in the literature on data collection methods. The research team's familiarity with data collection for internal trips has revealed a relatively high cost necessitated by interviews, a low return rate on intercept mail-back surveys, and, most crucially, significant variability in questions and the way they were asked—which affects data stability and accuracy. A standard, low-cost method for collecting data is needed.
- Travel forecast models have been used to provide the basis for internal trip estimation and even directly to estimate internal trips. Given the absence of intrazonal trips on the model network and limits to traffic analysis zones, these travel models are not usable for estimating internal trips for TIS or traffic impact fee use.

In conclusion, the estimation and data-collection methods developed by NCHRP Project 8-51 should be easily used, explained, and understood so that they can be used in zoning cases and other TIS applications as well as for other more sophisticated uses. They should also be as economical as possible while supplying enough data to be reasonably reliable.

CHAPTER 2

Research Approach

The approach used to develop an improved estimation procedure and data-collection methodology consisted of the following 12 sequential steps:

1. **Compile and review existing data, practices, research, technical papers and articles,** and other information from published, Internet, and informal sources. One source was a survey conducted by ITE that asked respondents whether they had data from studies of MXD.
2. **Call sources of data or authors of documents** containing information of interest to obtain more details about data, procedures, applications, and lessons learned.
3. **Develop a summary of practice and available data.**
4. **Determine what gaps exist in the data quantifying internal capture** as well as estimation procedures and data-collection methods; this also included assessing the strengths and weaknesses of the data and methods being employed.
5. **Change emphasis to collecting new data.** The intent was to analyze and synthesize a potentially improved estimation procedure from the available data. The researchers found that the reported data available from respondents to the ITE survey were almost all estimates of internal capture used in TISs or related types of studies: there were little actual survey data available. As a result, the researchers, in conjunction with the NCHRP Project 8-51 Panel, decided to shift the emphasis from analyzing existing data to collecting new data to add to the usable existing data.
6. **Develop a proposed land use classification system** that could be used both in the long term with an expanded database and in the short term with an initial smaller database. The land use classification system should be reflective of current and anticipated development trends for MXDs.
7. **Develop an improved estimation methodology for calculating internal capture for MXDs** in a manner that would be usable for at least TIS, using the land use classification system for structure. A key feature was that the input variables need to be known at the stage of development during which rezoning occurs. In some cases, preliminary TIAs may even precede zoning (e.g., platting or subdivision). The procedures needed to be readily usable by analysts in consulting firms or public agencies and need to rely upon information that would be almost certainly available or very easily obtainable in all instances.
8. **Develop a methodology for collecting internal capture data in a manner that could be accomplished at a wide variety of MXDs** using proven data-collection methods and tools for a reasonable cost.
9. **Conduct a pilot study to test and then refine the data collection tools and procedures.** With the shift in priority mentioned in Step 5, a second pilot study was added. Subsequently, a separate sponsor agreed to fund a related study that provided a third pilot study site and the resulting data.
10. **Add the pilot study data to the existing base** of usable data and develop the computational factors needed to populate the estimation method and tools.
11. **Conduct a validation test** to determine how well the estimation procedure reproduced the external trips obtained in the surveys at pilot and other sites.
12. **Recommend methodologies** for both estimation of internal capture and collection of internal capture data.

The desire was to create an improved method that would produce the following outputs:

1. A.M. and P.M. peak-hour internal person trips by land use in origin-destination form;
2. A.M. and P.M. peak-hour percent internal capture (person trips); and
3. A.M. and P.M. peak-hour inbound, outbound, and total external trips (trips to and from the development being analyzed) by mode
   - Person trips,
   - Vehicle trips,
   - Transit trips, and
   - Non-motorized trips.

A key decision made early in the process was to use an estimation method usable with base trip generation estimates from other sources (such as the ITE *Trip Generation Handbook* [*1*, Ch. 7] or local data). This decision was reached for the following reasons:

1. Relieve the method to be developed in this project from largely having to duplicate what has been accomplished over several decades to assemble the ITE and other local trip generation rate databases,
2. Make available a procedure that could be applied to MXD person trip generation that has been developed from any source,
3. Enable users more flexibility in how they conduct the remainder of their analyses, and
4. Focus resources on examining internal capture relationships and developing an improved estimation method.

A second important decision was to develop a method that could grow with the size of the internal trip capture database. The background review found that there were little data available at the necessary level of detail. The researchers recognized the need to be able to work with a small database to develop the methodology, but also saw potential advantage to being able to make the method and tools more sophisticated as the database becomes larger. For example, land use classifications could initially be basic (e.g., residential), but later be split into separate classifications (e.g., single unit detached, townhouse, and multiple family).

The project panel reviewed results and provided suggestions at several junctures, beginning with the initial work scope. There was interest in both studying and surveying different types of MXDs. In the end, current and projected development trends and the limited data narrowed what could be included. The results documented in this report are for what are essentially single developments (i.e., one master developer developing under a single master plan on contiguous sites). Most are on multiple urban blocks. Site sizes range from less than 10 to more than 300 acres. Some could be considered "pod" developments—that is, developments with multiple uses that are adjacent to each other, but not truly mixed together. Others are more fully integrated with closer proximity of interacting uses. However, all of the developments meet the definitions and characteristics identified in this project for MXDs (see Chapter 1 and Appendixes A and B).

CHAPTER 3

Findings and Applications

Chapter 1 provides background about MXDs and current practice in estimating internal trip capture for MXDs. It also describes what was available from existing data found from other sources. Chapter 3 describes the findings from the pilot studies and the compilation of usable data into the estimation procedure. Appendix B provides details about the land use classification system. Appendix C describes the data-collection methodology. Appendix D summarizes the experiences and lessons learned when conducting the surveys.

Pilot Study Surveys

The following are the results for the pilot study surveys conducted.

Mockingbird Station

Development Characteristics

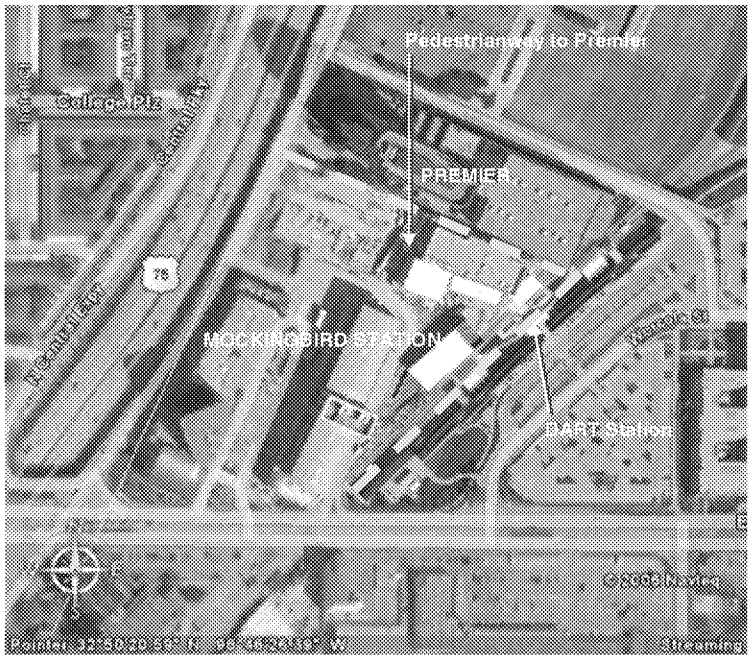
Mockingbird Station is a midtown mixed-use TOD in Dallas, Texas, consisting of five primary land use types: residential, retail, office, restaurant, and cinema. Figure 2 shows an aerial photograph of Mockingbird Station. Figure 3 shows the site plan for Mockingbird Station. The site plan is of the second-floor level, but the notes describe what is on each of the levels of each building. Not shown is a parking garage beneath the surface parking area between the two north-south buildings; this garage serves the loft apartments. The parking shown at the north end of the site also extends below the two buildings on the north end of the site. That parking is available to all users. Lower portions of the garage in the west building are also open to any user; upper spaces are reserved for the office building. However, almost no one other than office building occupants or visitors was observed by the survey crew to have used this garage during survey periods.

Mockingbird Station is bordered on the east by a Dallas Area Rapid Transit (DART) station and transit center on a light-rail line that splits just north of the station. Mockingbird Station has direct access to the station as well as to the transit center that is served by six bus routes. Five routs are year round; the sixth provides shuttle service to nearby Southern Methodist University (SMU) when school is in session. Bus service headways range from 6 to 20 minutes during weekday peak periods, from 20 to 45 minutes during daytime off-peak periods, and 45 to 60 minutes during the late evening hours. Bus service on most of the routes begins before 5 A.M. and continues until about 12:30 A.M. Two routes run slightly shorter schedules. The two light-rail lines have peak-period service ranging between 6 and 10 minutes, with daytime off-peak service ranging between 20 and 30 minutes and evening weekday service at about 30-minute headways.

Mockingbird Station is bounded by Mockingbird Lane, a six-lane arterial on the south and US 75, the North Central Expressway, an eight-lane freeway on the west. To the north, Mockingbird Station is bounded by another development containing an office building and a health club. There is no vehicular access between the two developments, but there is a connecting pedestrianway about midway along the boundary between the two developments.

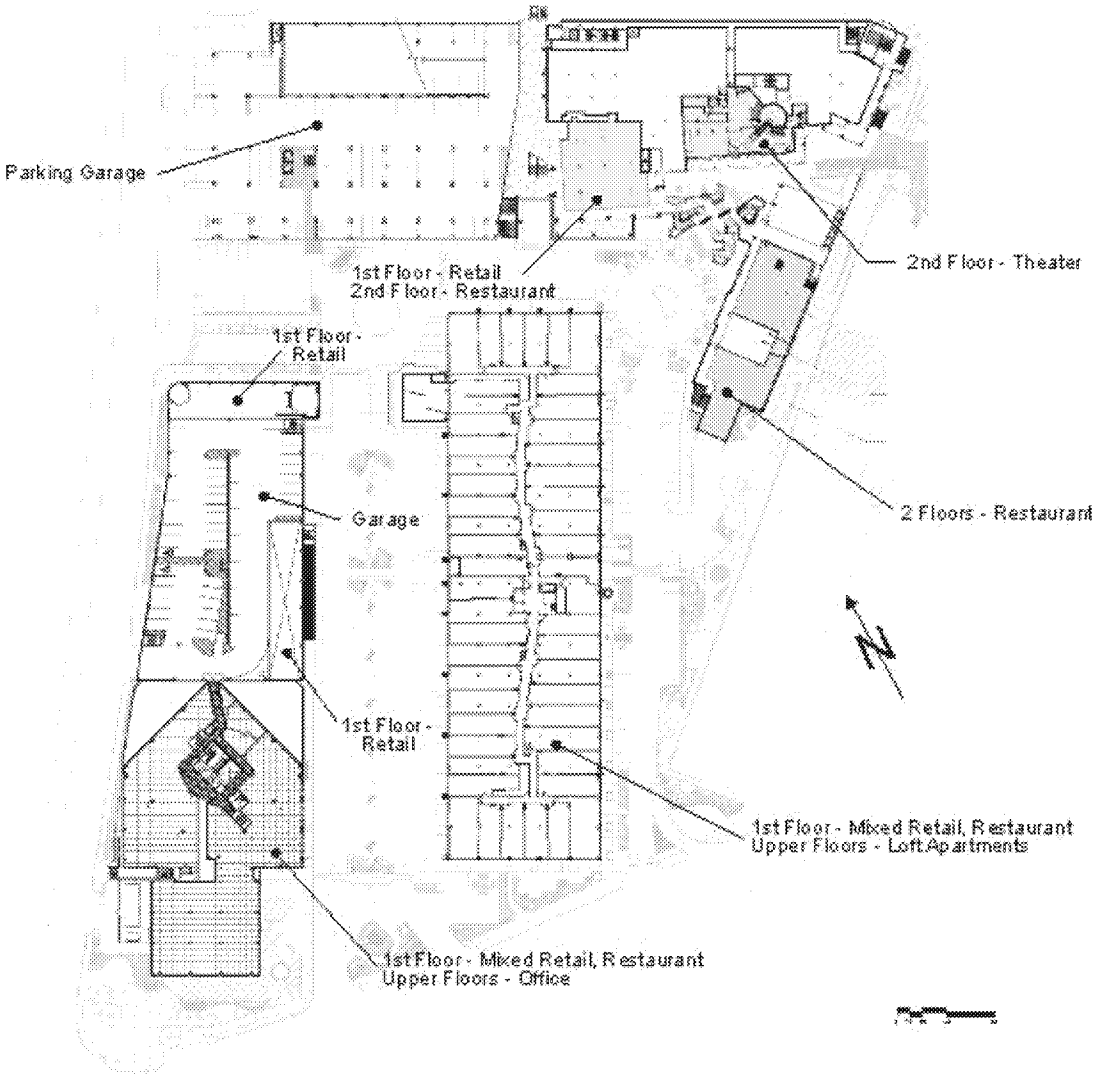
Beginning about a block west of US 75 is the SMU campus, which has a total enrollment of approximately 11,000 students. SMU students occupy several apartments in the area, although no percentage was available and rental rates were reported to be the highest in the area and beyond budgets of most students. Mockingbird Station has vehicular access along only Mockingbird Lane (two driveways) and the northbound frontage road of US 75 (one direct garage access and two additional driveways).

Walk access is available from the east and north via conventional sidewalks adjacent to the street curbs. From the south and west, walk access requires crossing the very busy Mockingbird Lane intersection with the US 75 frontage roads. Walk access to the east is also available through the DART light-rail station and requires traversing stairs (of an elevation of about one building level) between the west side of the station and Mockingbird



Source: Google Earth.

Figure 2. Mockingbird Station.



Source: Selzer Associates.

Figure 3. Mockingbird Station upper-level leasing plan and land uses, 2006.

Station's ground level. There is no elevation change on the east side of the station. As noted previously, walk access is available to the middle of the development to the north via a walkway, which is also about one level above ground and is reachable by a stairway. An elevator is also available to reach these last two pedestrian connections; it is near the stairway to the DART station.

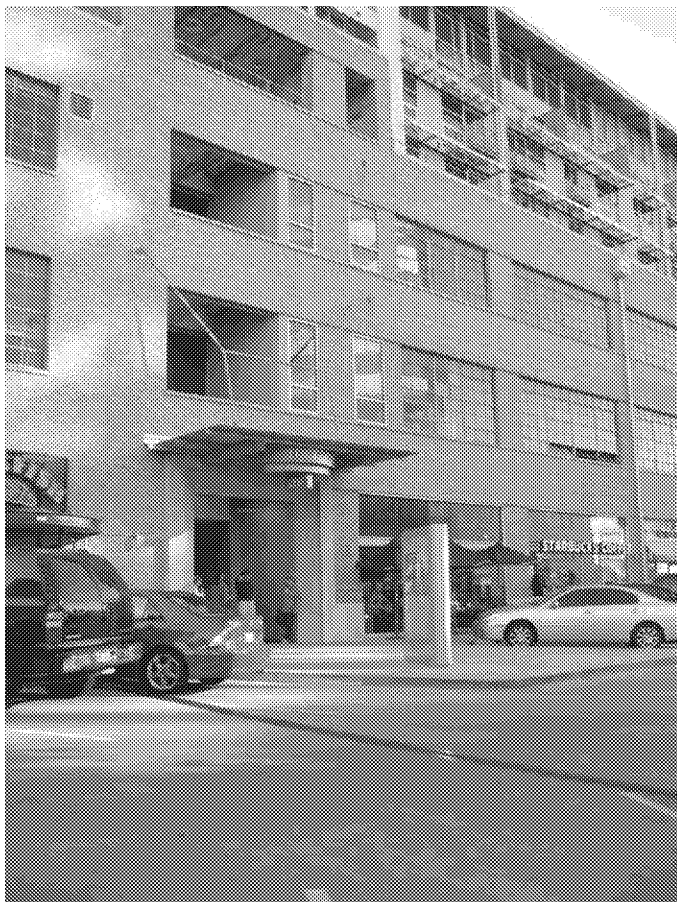
Parking is provided in three garages and surface lots. One garage is reserved for office building use although its visitor spaces can also be used for reaching other Mockingbird Station destinations. A second garage serves the apartments. The third garage is for general use. The second and third garages are actually a single garage that has been partitioned into two facilities by a fence.

During peak onsite activity periods, surface parking is usually fully occupied and drivers circulate hoping to find a space close to the desired destination, but convenient garage parking was observed to be always available. There was no noticeable traffic congestion at any access point during the field surveys. The only congestion occurred occasionally in the parking lots due to excess circulation by drivers seeking a parking space.

Access between the DART station and Mockingbird Station is very convenient. Walking distance between the station and the most distant building entrance is about 700 ft. Only the stairway is judged to present any challenge.

Walking within Mockingbird Station is very easy and convenient. Although few sidewalks are much more than 10-ft wide, there are no obstacles except where three restaurants have set up outdoor tables and left fairly narrow walking widths. However, those constraints did not present deterring bottlenecks. No special provisions have been made for bicycle access. Figure 4 shows an example of sidewalk provisions at the entrance to the apartment building.

Table 31 shows the occupied development in Mockingbird Station. The combined retail and restaurant space and the apartments are more than 90% occupied, and the office space is about 80% occupied. The development appears to be mature and has been in operation long enough to be experiencing initial turnover of tenants that are not correctly positioned in the local market.



Source: Texas Transportation Institute

Figure 4. Entrance to Mockingbird Station lofts.

About one-third of Mockingbird Station's occupied floor space is residential, and another third is retail. More than 20% is office with the remainder split between the restaurants and the cinema. The residential is high-end rental. Mockingbird Station has no major retailers. All have 15,000 sq ft or less. The retail is primarily specialty women's apparel. The restaurants represent a range of middle- to upper-priced sit-down and convenience offerings, including an ice cream shop and a specialty coffee shop.

Table 31. Mockingbird Station development.

Land Use	Occupied Development Units	Largest
Residential	191 DU, 192,940 sq ft	84% one-bedroom
Retail	156,100 sq ft	Two specialty apparel stores of 15,000 sq ft only stores over 10,000 sq ft
Office	114,600 sq ft	All in one building
Restaurant	28,900 sq ft	Largest about 8,800 sq ft
Cinema	31,500 sq ft, 8 screens	
Parking	1,528 spaces	

Travel Survey

The survey of travel characteristics focusing on internal trip capture was conducted on Tuesday afternoon through Thursday morning, May 9–11, 2006. The primary objective was to quantify the percentage of internal trip capture during weekday peak periods in a manner that would support the proposed methodology to estimate internal capture using component land use quantities and reflect mode of original access and the degree of internal connectivity.

The survey was designed to be adaptable to a variety of mixed-use areas. Mockingbird Station was the first site surveyed, and a second site was proposed with somewhat different characteristics. At the time, permission for a second site had not been secured, so specific survey requirements for that site were not known; however, it was known that while there was a standard survey method to be used, some customizing might be needed to fit other sites. The essential requirement was to produce comparable data for each survey site.

For Mockingbird Station, the following travel data were collected for peak periods between 6:30 A.M. and 10 A.M. and between 4 P.M. and 7 P.M.:

- Multimodal cordon count covering all access points;
- Counts of people entering and exiting doors of each building or business being surveyed during a particular period;
- Exit interviews of people as they departed selected doors; and
- Interviews of people leaving the DART rail station and transit center (customer survey to respond to local conditions).

The exit interviews were the primary information source. The counts were used to factor interview results. The DART station interviews were used to provide a more complete indication of who was using transit. All interviews were conducted recognizing that the results would be a sample of all people exiting during a time period. Over the complete duration of the survey, interviews were conducted at all entrances that were open during the survey periods (a few secondary entrances were kept locked by businesses). Survey supervisors selected the entrances to be surveyed during each period, and interviews were conducted at those entrances for complete periods. In some cases, the business activity was low so interviewers were assigned to cover multiple entrances and to intercept and interview any exiting patron they could.

During the A.M. peak period, the only businesses open during the full period were the office building and a Starbucks coffee shop. One other business opened at 9 A.M. while the remainder opened at 10 A.M. (restaurants at 11 A.M.). During the P.M. peak period, all businesses were open for the complete survey period. As a result, all entrances could be fully covered during the A.M. peak, but P.M. interviews covered some entrances one day and the remainder the second day, although interviews were conducted at some locations both days.

Interviewers and counters were trained for several hours prior to the first afternoon's surveys. Each was observed during the first hour in the field (i.e., an hour before the actual data were going to be used) and adjustments were made as needed. Supervision continued throughout the survey period. In a few cases, interviewers were moved to locations that were more active or better suited the interviewer's particular skills (e.g., more mobile to cover several entrances). In another few cases, interviewers were reassigned to perform counts to optimize results. Interview forms were reviewed during each shift and then checked more completely at the end of each shift. Any errors or missing data were checked with the interviewer either by phone and/or prior to starting the next shift. Incomplete and erroneous interviews were not used. The same process was used for the counts although those checks were much more straightforward. Survey personnel who did not perform adequately were released and not used again. The survey crew was initially overstaffed with the expectation that some would be released, so there was no need to add new personnel and repeat the training.

Survey Results

Most of the findings are based on 761 completed exit interviews conducted during two morning and two afternoon peak periods. Of these approximately 30% were obtained during the A.M. peak and 70% during the P.M. peak. The completed and usable interviews covered an average of 33% of people exiting buildings during the A.M. peak period and about 11% during the P.M. peak period. Table 32 shows the numbers of interviews completed and usable for each peak period and land use category. Most interviews yielded one usable trip made during one of the peak periods; some interviews yielded two trips. The A.M. interview percentage was higher than the P.M. percentage because A.M. activity was lower and a similar number of interviewers were available near each interview location. The A.M. population also included more regulars and fewer occasional visitors, which resulted in interviewees who were more comfortable with being interviewed in the morning.

The interview forms included questions not only about the exit trip, but also about the trip made to the location just being departed (see Appendix C for forms closely resembling the forms used in this pilot survey). If the inbound trip to the survey location occurred during the survey period, it could be used as part of the survey database if the information was sufficiently complete. Most inbound trips preceding exiting trips occurred before the survey period or lacked complete information.

Table 33 shows the number of usable trips that were derived from the usable interviews (a usable interview was defined as

Table 32. Peak-period interviews, exit movements, and percent interviewed—Mockingbird Station.

Land Use	A.M. Peak Period			P.M. Peak Period		
	Interviews[1]	Exit Movements	Percent Interviewed	Interviews[1]	Exit Movements	Percent Interviewed
Office	49	130	38%	78	275	28%
Retail[1]	—	—	—	285	2,311	12%
Restaurant	146	395	37%	104	1,560	7%
Residential	43	188	23%	34	218	16%
Cinema[2]	—	—	—	22	220	10%
Hotel[3]	—	—	—	—	—	—
Total	**238**	**713**	**33%**	**523**	**4,584**	**11%**

[1]Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.
[2]Retail and cinema not open during morning peak period.
[3]No onsite hotel at Mockingbird Station.

one that contained at least one fully reported trip). For the A.M. peak, total usable surveyed trips accounted for about 36% of all counted exit movements. For the P.M. peak period, about 13% of the counted trips are represented with usable interview information.

Table 33 information provides the basis for factoring the survey data to represent all peak-period trips made. That expansion is needed to permit an estimate of the number of internal trips. The results reported herein are based on factoring to reflect sampling at each building entrance; factoring was performed by land use for each peak period. The survey results were summarized for the A.M. and P.M. peak periods.

Table 34 shows a different summary of completed interviews, exiting people, and usable trips derived from the interviews. Respondents were asked about not only the trips that they were in the midst of making as they exited from an establishment, but also the trip they had previously made to that same place. The total of the reported trips, if made during one of the two peak periods, are shown as usable trips in Table 34. Some of the reported inbound trips occurred outside the peak periods, but for many of those trips, the respondent was unable or unwilling to provide enough complete information to make the inbound trip usable. Finally, some otherwise complete interviews were not usable because the inbound trip reported was not actually the immediately previous trip—for example, some respondents thought they were being asked for the first trip of the day onsite or to the site and not the immediately previous trip to the establishment they were just leaving. Many of those trips were made outside the peak periods. First trips of the day from the onsite apartments did not have a previous trip that day.

The interviews reported in Table 34 differ slightly from interviews reported in prior tables because the interviews reported in Table 34 are associated with the land use for which an exit trip is reported. Hence, if an interview that was reported in Table 32 has a valid entering trip but not a valid exiting trip

Table 33. Peak-period usable trips, exit movements, and percent usable—Mockingbird Station.

Land Use	A.M. Peak Period			P.M. Peak Period		
	Usable Trips[1]	Exit Movements	Percent Usable	Usable Trips[1]	Exit Movements	Percent Usable
Office	59	130	45%	85	275	31%
Retail[2]	—	—	—	307	2,311	13%
Restaurant	147	395	37%	108	1,560	7%
Residential	51	188	27%	49	218	23%
Cinema[2]	—	—	—	24	220	11%
Hotel[3]	—	—	—	—	—	—
Total	**257**	**713**	**36%**	**573**	**4,584**	**13%**

[1]Must include specific origin location, location of destination, and land use of destination if internal; this total includes reported exiting and entering trips made this period.
[2]Retail and cinema not open during morning peak period.
[3]No onsite hotel at Mockingbird Station.

Table 34. Peak-Period interviews, exit movements, percent interviewed, and usable trips—Mockingbird Station.

Land Use	Morning Peak Period				Afternoon Peak Period			
	Interviews[4]	Exit Movements	Percent Interviewed	Usable Trips[5]	Interviews[4]	Exit Movements	Percent Interviewed	Usable Trips[5]
Office	44	130	34%	50	68	275	25%	70
Retail[1]	8	18	50%	11	292	2,311	13%	368
Restaurant	146	395	37%	165	85	1,560	5%	105
Residential	33	188	18%	33	28	218	13%	30
Cinema[2]	—	—	—	—	22	220	10%	22
Hotel[3]	—	—	—	—	—	—	—	—
Total[1]	**231**	**731**	**32%**	**259[a]**	**495**	**4,584**	**11%**	**595[b]**

[1] Retail trips subsequently removed from further analysis since all stores closed during this period.
[2] No interviews attempted at cinema during the morning peak period since cinema was closed.
[3] No onsite hotel at Mockingbird Station.
[4] Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.
[5] Must include specific origin location, location of destination, and land use of destination if internal; this total includes reported exiting and entering trips made this period.
[a] Includes 2 movements counted at establishments where too few interviews were completed for valid sample.
[b] Excludes 22 movements counted at establishments where too few interviews were completed for valid sample.

(e.g., incomplete information), that interview is reported in Table 32 for the land use where the interview occurred, but reported for the trip origin land use in Table 34.

Table 34 points out one final lesson learned from the survey procedures used in the pilot studies. To obtain accurate inbound trip information while conducting exit surveys, it is necessary to increase the amount of interview practice for each interviewer (i.e., mock interviews with trainers). Interviewers recorded too many incomplete interviews and incorrect previous trips. Some interviewers also failed to ask or record responses for all of the questions about the inbound trip, resulting in more incomplete inbound trip information. However, since only trips that occurred during the two peak periods were of interest and since some of the respondents' inbound trips occurred outside the two peak periods, it was expected that inbound trips would be fewer than outbound trips that are directly surveyed. The only way to obtain similar samples of inbound trips is to interview people as they enter an establishment—something management declined to approve at all three pilot study sites.

Table 34 shows that a few A.M. interviews were completed at retail outlets. These were primarily employees and deliveries. However, the project panel agreed that the number of interviews was too small to provide a representative sample and that the results would not be representative of retail stores that might be open during the A.M. peak period (generally convenience retail or grocery or drug stores), so those data are not reported in other tables.

Table 35 shows for the A.M. peak period the total number of people exiting from each land use. People could exit in one of two ways: (1) from a door of the establishment to the sidewalk in front of the establishment or (2) from the establishment directly to a parking garage via an internal access way and then drive out of the garage and off the site without an opportunity to be interviewed. A sample of the first group was interviewed. None of the second group was interviewed because they immediately became external trips and could be directly categorized in that manner. Table 35 also has a column labeled un-surveyed locations. That column does not apply for Mockingbird Station, but does apply to two other pilot survey sites. Numbers in that column represent the numbers of people counted exiting establishments where no interviews were taken.

Table 35 shows that a number of people exiting the office building and loft apartments did so by going internally to their garage parking space and then driving out of Mockingbird Station. As mentioned above, all of these trips were classified as external trips; drivers and passengers did not need to be interviewed to get the needed information since one garage exits only outside the development's boundary, and the driving distance from the other garage to internal locations is longer than walking. The right column shows the percentage of all exiting trips represented by survey information—either a completed interview or a count of vehicles and occupants exiting the site from garages with internal access. The interviewed and direct garage trips accounted for about half of all exiting trips.

Table 36 shows similar information but for the P.M. peak period. The direct exits from the site establishments through the garages accounted for a much smaller percentage of the total trips. The resulting surveyed percentage of total trips is about 22% in total, but ranges between 7 and 73% by land use.

The survey samples for Mockingbird Station and all other surveyed developments were factored in the same manner. Interviews were expanded to represent the door counts by

Table 35. Morning peak-period surveyed trips, exit movements, and percent surveyed—Mockingbird Station.

Land Use	Surveyed Trips[3]	Exit Movements				Percent Surveyed[6]
		Doors	Unsurveyed Locations[4]	Garage Direct[5]	Total	
Office	59	130	—	34	164	57%
Retail[1]	—	—	—	—	—	—
Restaurant	147	395	—	—	395	37%
Residential	51	188	—	216	404	66%
Cinema[1]	—	—	—	—	—	—
Hotel[2]	—	—	—	—	—	—
Total	**257**	**713**	**—**	**250**	**963**	**53%**

[1]Retail and cinema did not actively generate trips during the morning peak period.
[2]No onsite hotel at Mockingbird Station.
[3]Number of usable trip origins at each land use recorded from traveler interviews.
[4]Includes locations where no interviews were attempted (prorated by sq ft) and locations where door counts were made, but no usable trip origins were recorded on interviews.
[5]Person-trips observed exiting onsite parking garages, assumed to be traveling directly to an external location.
[6]Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

land use. Where door counts were not available for all establishments within a land use classification, development units were used as a basis for expanding door counts to cover all floor space of a classification. Direct movements to and from inside buildings to external locations were handled through direct counts. The complete discussion is contained in Appendix G.

Table 37 shows data for entering trips that resembles the contents of Tables 35 and 36. A sample of persons entering from the DART rail station and transit center was interviewed; numbers of those persons are shown by the destination land use. The first three columns under each time period accounted for people who entered through either the establishments' outside doors (and are represented by expanded interviews at those doors or at the DART station) or an internal access from a parking garage. The last column shows the remaining people who were counted upon entry but are not represented in the first three columns of the table. All these were considered to be from external origins since they did not have an internal trip origin represented in an interview. These

Table 36. Afternoon peak-period surveyed trips, exit movements, and percent surveyed—Mockingbird Station.

Land Use	Surveyed Trips[3]	Exit Movements				Percent Surveyed[6]
		Doors	Unsurveyed Locations[4]	Garage Direct[5]	Total	
Office	85	275	—	416	691	73%
Retail[1]	307	2,311	—	—	2,311	13%
Restaurant	108	1,560	—	—	1,560	7%
Residential	49	218	—	144	362	53%
Cinema[1]	24	220	—	—	220	11%
Hotel[2]	—	—	—	—	—	—
Total	**573**	**4,584**	**—**	**560**	**5,144**	**22%**

[1]Retail and cinema did not actively generate trips during the morning peak period.
[2]No onsite hotel at Mockingbird Station.
[3]Number of usable trip origins at each land use recorded from traveler interviews.
[4]Includes locations where no interviews were attempted (prorated by sq ft) and locations where door counts were made, but no usable trip origins were recorded on interviews.
[5]Person-trips observed exiting onsite parking garages, assumed to be traveling directly to an external location.
[6]Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

Table 37. Peak-period person-trips entering land uses—Mockingbird Station.

Land Use	Morning Peak Period					Afternoon Peak Period				
	Survey[3]	Garage Direct[4]	Transit Direct[5]	Balance[6]	Total	Survey[3]	Garage Direct[4]	Transit Direct[5]	Balance[6]	Total
Office	101	382	91	110	684	69	126	12	56	263
Retail[1]	—	—	—	—	—	787	—	129	256	1,172
Restaurant	167	—	29	196	392	380	—	170	1,051	1,601
Residential	12	48	5	138	203	161	236	18	34	449
Cinema[1]	—	—	—	—	—	79	—	106	171	356
Hotel[2]	—	—	—	—	—	—	—	—	—	—
Total	**280**	**430**	**125**	**444**	**1,279**	**1,476**	**362**	**435**	**1,568**	**3,841**

[1] Retail and cinema did not actively generate trips during the morning peak period.
[2] No onsite hotel at Mockingbird Station.
[3] Trip destinations recorded from exit interviews, expanded as described.
[4] Person-trips observed entering onsite parking garages, assumed to be traveling directly from an external location.
[5] Trips entering onsite land uses from external locations recorded on transit interviews.
[6] Balance of person-trips entering onsite land uses; assumed to originate externally.

trips account for approximately one-third of the A.M. peak-period entering trips and about 40% of the P.M. peak-period entering trips.

Table 38 shows the mode split of person trips to Mockingbird Station during the A.M. peak period. Personal vehicles (drivers and passengers) account for about three-quarters of the person trips to and about 70% from Mockingbird Station during the A.M. peak period. The A.M. peak-hour exiting percentages by personal vehicle are about 5% lower than during the A.M. peak period. Table 39 shows similar information for the P.M. peak period.

Transit is a major mode of access for Mockingbird Station. About 15% of inbound and 11% of outbound A.M. peak-period trips use DART rail or bus transit. The peak hour percentages are slightly higher. During the P.M. peak period, transit accounts for about 13% of inbound and 19% of outbound trips. Peak hour percentages are approximately similar. The larger outbound percentage reflects employees who came by transit in the morning in addition to the evening visitors who come and leave by transit. Transit accounts for a significant amount of the trips during both peak periods, attributable at least in part to the proximity of the DART light-rail station and bus transfer center adjacent to Mockingbird Station.

Walk trips also account for more than might be expected in a midtown area, with 5 to 15% walking to or from Mockingbird Station. Although Mockingbird Station is close to SMU, bicycle trips were negligible as were trips by motorcycle. There are limited street crossings of US 75. All are heavily used by traffic and there are no bike lanes. SMU students tend to be more affluent. All these factors may explain the low bicycle share of peak period trips to and from Mockingbird Station.

Table 38. A.M. peak-period and peak-hour cordon person-trip count and mode split—Mockingbird Station.

Travel Mode	Peak Period (7:00 A.M.–10:00 A.M.)				Peak Hour (7:45 A.M.–8:45 A.M.)			
	Trips		Percent[3]		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle[1]	670	361	76%	70%	280	129	77%	65%
Motorcycle	0	0	0%	0%	0	0	0%	0%
Delivery Vehicle	39	17	4%	3%	12	3	3%	2%
Transit[2]	128	57	15%	11%	58	28	16%	14%
Walk	42	79	5%	15%	15	38	4%	19%
Bicycle	0	0	0%	0%	0	0	0%	0%
Total All Modes	**879**	**514**	**100%**	**100%**	**365**	**198**	**100%**	**100%**

[1] Personal vehicle occupancies (entering/exiting): peak period 1.08/1.11; peak hour 1.09/1.11.
[2] Transit trips include light rail and bus.
[3] Percentage totals may not sum to 100 due to rounding.

Table 39. P.M. peak-period and peak-hour cordon person-trip count—Mockingbird Station.

Travel Mode	Peak Period (4:00 P.M.–7:00 P.M.)				Peak Hour (5:00 P.M.–6:00 P.M.)			
	Trips		Percent		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle[1]	1,292	1,208	76%	74%	456	443	77%	73%
Motorcycle	12	5	1%	<1%	2	1	<1%	<1%
Delivery Vehicle	24	21	1%	1%	8	4	1%	1%
Transit[2]	225	301	13%	19%	71	131	12%	21%
Walk	153	83	9%	5%	55	32	9%	5%
Bicycle	4	6	<1%	<1%	0	0	0%	0%
Total All Modes	**1,710**	**1,624**	**100%**	**100%**	**592**	**611**	**100%**	**100%**

[1] Personal vehicle occupancies (entering/exiting): peak period 1.25/1.22; peak hour 1.26/1.21.
[2] Transit trips include light rail and bus.

Vehicle occupancies were higher during the P.M. peak (more than 1.2) than for the A.M. peak (about 1.1). This is attributable to people going shopping or to restaurants or the cinema. Table 40 shows (1) the number and percent of internal person trips each peak period and (2) the total person trips generated by each land use type and those that are internal to Mockingbird Station. For example, during the A.M. peak period, 64% of trips leaving the office building are destined for internal destinations. Similarly, 15% of the A.M. inbound trips come from origins within Mockingbird Station.

Note that the only uses active during the A.M. peak were the apartments, the office building, a coffee shop, and a mobile phone store that opened at 9 A.M. All other businesses opened at 10 A.M., although a few employees and delivery people entered before that time. Hence, most of Mockingbird Station was inactive during the A.M. peak period.

Table 40 shows that for the A.M. peak, about 22% of the inbound and 31% of the outbound trips were internal, excluding trips between similar uses (e.g., from retail to retail). Internal trips between similar uses have been excluded (from both internal and total trips) because they are not included in trip generation estimates used for TIS, which are based on trips entering and leaving a site. The office building has about 64% of its trips destined for internal destinations. Nearly all of those were to a coffee shop located less than 300 ft from the office building. The office building did not contain a snack shop, so a strong linkage developed with the coffee shop. This may not always be the case with other types of restaurants. Note that most office building trips during the A.M. peak are inbound; only about 17% of the trips are outbound, so the high percentage of internal trips does not reflect a high number of internal trips in this case.

Table 40. Peak period person-trips and percent internal trip capture by land use—Mockingbird Station.

Land Use	A.M. Peak Period				P.M. Peak Period			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Office	684	15%	142	64%	263	26%	669	15%
Retail[1]	----	----	----	----	1,172	67%	1,284	32%
Restaurant	392	43%	371	28%	1,601	22%	1,519	46%
Residential	203	5%	388	22%	449	36%	361	43%
Cinema[1]	—	—	—	—	356	22%	220	50%
Hotel[2]	—	—	—	—	—	—	—	—
Total All Trips	**1,279**	**22%**	**901**	**31%**	**3,841**	**38%**	**4,053**	**36%**

[1] Retail and cinema not open during morning peak period.
[2] No onsite hotel at Mockingbird Station.

Table 41. Percent distribution of internal trip destinations for trips exiting Mockingbird Station buildings—A.M. peak period.

Origin Land Use	Internal Destination Land Use						Destination Summary			
	Office	Retail[2]	Restaurant	Residential	Cinema[2]	Hotel[3]	Internal	External	Total	Total Trips
Office	—[1]	—	63%[a]	1%	—	—	64%	36%	100%	142
Retail[2]	—	—[1]	—	—	—	—	—	—	—	—
Restaurant	25%	—	—[1]	3	—	—	28	72	100	371
Residential	2	—	20	—[1]	—	—	22	78	100	388
Cinema[2]	—	—	—	—	—[1]	—	—	—	—	—
Hotel[3]	—	—	—	—	—	—[1]	—	—	—	—
All Origins	**11%**	**—**	**19%**	**1%**	**—**	**—**	**31%**	**69%**	**100%**	**901**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] Retail and cinema not open during morning peak period.
[3] No onsite hotel at Mockingbird Station.
[a] Chain specialty coffee shop close to office building.

The P.M. peak period internal trip capture percentages are somewhat higher, with about 38% of the inbound and 36% of the outbound trips being internal. Table 41 shows the A.M. peak period internal trip capture for outbound trips by land use. Since Mockingbird Station is fully and conveniently walkable, there are virtually no driving trips (although a few people were observed driving a few hundred feet from one end of a parking area to the other). Since no internal transit is provided, there are no internal trips by transit.

Table 42 shows the same information for the P.M. peak period. For both A.M. and P.M. peak periods, it *appears* that there are a few stronger linkages between land use pairs and several modest linkages. However, note that the internal trip capture percentages are a result of inherent interaction between given land use pairs as well as the quantities and proximities of each. This is discussed elsewhere in this report.

Table 43 shows the distribution of internal origins resulting from inbound trips. For example, of trips inbound to the office building, 1% come from the onsite residential units. This shows that while the coffee shop has a strong interaction with the office building, it also has a stronger interaction with the residential apartments that result in several trips to the coffee shop. However, this table shows that the residents then proceed from the coffee shop to off-site destinations; few return home.

Table 44 shows similar data for the P.M. peak period. As with the interactions shown in Table 42, there are a few strong relationships and a number of minor relationships. The cases and relationships are discussed in a subsequent chapter.

Table 45 shows the percent of trips made into and out of Mockingbird Station buildings that are internal for each mode of travel. Only a small percentage of vehicle driver trips are internal. Not surprisingly, a very high percentage of walk trips are internal.

Table 42. Percent distribution of internal trip destinations for trips exiting Mockingbird Station buildings—P.M. peak period.

Origin Land Use	Internal Destination Land Use						Destination Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel[2]	Internal	External	Total	Total Trips
Office	—[1]	9%	4%	2%	0	—	15%	85%	100%	669
Retail	1%	—[1]	20	7	4%	—	32	68	100	1,284
Restaurant	3	38	—[1]	3	2	—	46	54	100	1,519
Residential	1	31	11	—[1]	0	—	43	57	100	361
Cinema	0	17	25	8	—[1]	—	50	50	100	220
Hotel[2]	—	—	—	—	—	—[1]	—	—	—	—
All Origins	**2%**	**19%**	**9%**	**4%**	**2%**	**—**	**36%**	**64%**	**100%**	**4,053**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] No onsite hotel at Mockingbird Station.

Table 43. Percent distribution of internal trip origins for trips entering Mockingbird Station buildings—A.M. peak period.

Destination Land Use	Internal Origin Land Use						Origin Summary			
	Office	Retail[2]	Restaurant	Residential	Cinema[2]	Hotel[3]	Internal	External	Total	Total Trips
Office	—[1]	—	14%	1%	—	—	15%	85%	100%	684
Retail[2]	—	—[1]	—	—	—	—	—	—	—	—
Restaurant	23%	—	—[1]	20	—	—	43	57	100	392
Residential	0	—	5	—[1]	—	—	5	95	100	203
Cinema[2]	—	—	—	—	—[1]	—	—	—	—	—
Hotel[3]	—	—	—	—	—	—[1]	—	—	—	—
All Destinations	**7%**	**—**	**8%**	**7%**	**—**	**—**	**22%**	**78%**	**100%**	**1,279**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] Retail and cinema not open during morning peak period.
[3] No onsite hotel at Mockingbird Station.

Table 44. Percent distribution of internal trip origins for trips entering Mockingbird Station buildings—P.M. peak period.

Destination Land Use	Internal Origin Land Use						Origin Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel[2]	Internal	External	Total	Total Trips
Office	—[1]	5%	19%	2%	0	—	26%	74%	100%	263
Retail	5%	—[1]	50	9	3%	—	67	33	100%	1,172
Restaurant	1	16	—[1]	2	3	—	22	78	100%	1,601
Residential	3	19	10	—[1]	4	—	36	64	100%	449
Cinema	1	14	7	0	—[1]	—	22	78	100%	356
Hotel[2]	—	—	—	—	—	—[1]	—	—	—	—
All Destinations	**2%**	**11%**	**18%**	**4%**	**3%**	**—**	**38%**	**62%**	**100%**	**3,841**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] No onsite hotel at Mockingbird Station.

Table 45. Peak-period person-trips and percent internal trip capture by mode of travel—Mockingbird Station.

Mode of Travel	A.M. Peak Period				P.M. Peak Period[1]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Automobile Driver	857	2	526	3	1,941	4	1,815	5
Automobile Passenger	32	0	35	0	72	0	212	0
Taxi/Car Service	0	0	0	0	0	0	0	0
Transit (Bus)	0	0	12	0	0	0	88	0
Transit (Light Rail)	125	0	22	0	435	0	413	0
Walk/Bicycle	266	100	307	87	1,367	100	1,500	91

[1] Travel mode not reported for 26 entering and 25 exiting trips.

Table 46. Peak-period person-trips and percent internal trip capture by mode of access—Mockingbird Station.

Mode of Access	A.M. Peak Period[1]				P.M. Peak Period[2]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Vehicle Driver	1,058	20%	697	31%	2,847	35%	2,694	37%
Vehicle Passenger	32	0%	34	0%	130	45%	354	23%
Taxi/Car Service	0	0%	0	0%	0	0%	0	0%
Transit (Bus)	7	100%	7	100%	60	100%	118	51%
Transit (Light Rail)	131	5%	23	26%	586	26%	654	23%
Walk/Bicycle	10	100%	13	77%	71	100%	157	45%

[1] Access mode not reported for 41 entering trips and 177 exiting trips.
[2] Access mode not reported for 79 entering trips and 244 exiting trips.

Table 46 shows different information. The table shows internal trips by the original mode of access to Mockingbird Station—for example, the first row of the table shows that for the A.M. peak period, of the exiting people who came to Mockingbird Station as vehicle drivers, 31% of them went to internal destinations. The purpose of this table is to determine whether people arriving by different modes have different internal trip-making tendencies. The cells that have larger numbers of trips provide the most useful comparisons. The cells that contain more than 300 trips have consistent internal trip percentages ranging from 20% to 37% internal trips, but even though most numbers of total trips are small, those who arrive by bus or walking/bicycling are much more prone to making more internal trips, perhaps due to fewer options. The apparent tendency of rail transit riders to make fewer internal trips—at least during peak periods—may reflect that many of them use transit to commute to work and are less likely to make internal peak-period trips during peak periods (e.g., some of those trips may be made during midday). The small numbers of people who walk, bike, or ride buses to Mockingbird Station make further analysis speculative. The other two MXDs surveyed for this project had fewer transit riders, so they do not provide significant insight into this question.

Table 47 attempts to explore whether having a personal vehicle available for trips affected internal travel tendencies. One might assume that a person with no vehicle available would have fewer options to make off-site (external) trips, so they would make more internal trips. Accounting for effects of the sample sizes shown, the table does not support that assumption: internal trip capture does not exceed that for people with access to drive personal vehicles.

Findings from surveys of two other MXDs—Atlantic Station and Legacy Town Center—follow. Analyses of relationships between the findings and causal factors are described in subsequent chapters.

Atlantic Station

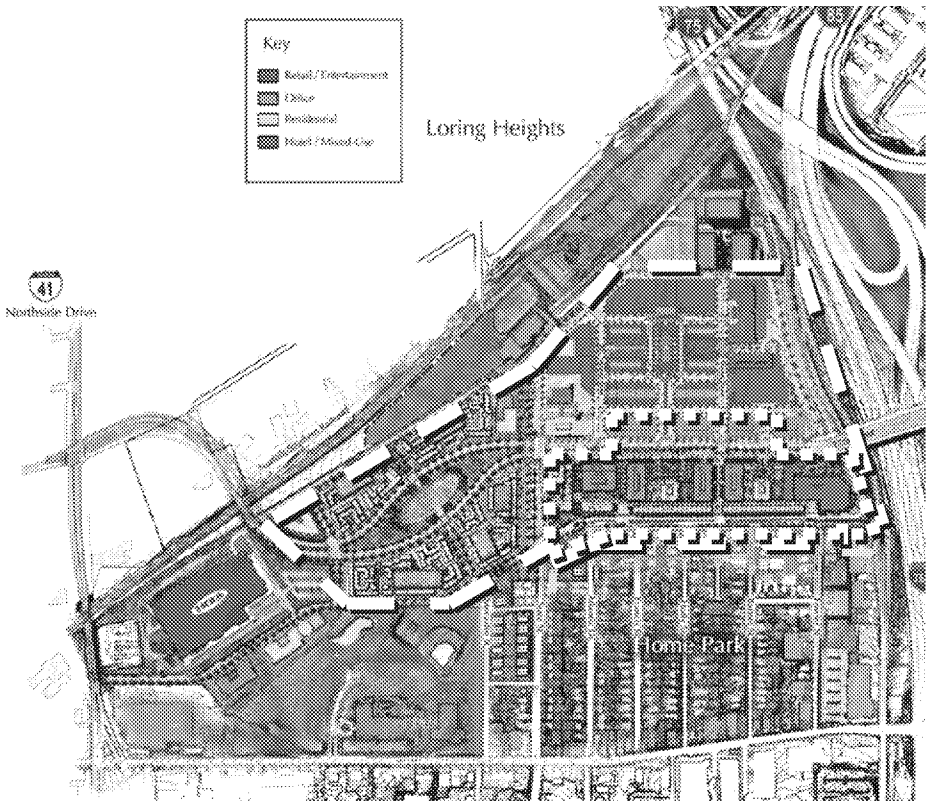
Development Characteristics

As with Mockingbird Station, Atlantic Station is a midtown redevelopment/infill project, but it is substantially larger and is spread over several blocks rather than being on a single block. Figure 5 shows an illustrative site plan of Atlantic Station when it is fully complete. A dashed outer boundary line shows the outer limits of the portions that had been completed and

Table 47. Peak-period person-trips and percent internal trip capture by vehicle access—Mockingbird Station.

Vehicle Access	A.M. Peak Period[1]				P.M. Peak Period[2]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Yes (Vehicle Driver)	1,098	20%	720	30%	265	29%	462	51%
Yes (Non-Vehicle Driver)	118	14%	31	52%	318	33%	571	59%
No Vehicle Access	18	28%	16	31%	3,094	35%	2,795	32%

[1] Automobile access not reported for 45 entering trips and 134 exiting trips.
[2] Automobile access not reported for 164 entering trips and 225 exiting trips.



Source: www.atlanticstation.com/images/SitePlan_large.jpg. Image is used by permission: ©2010 Atlantic Station, LLC. All rights reserved.

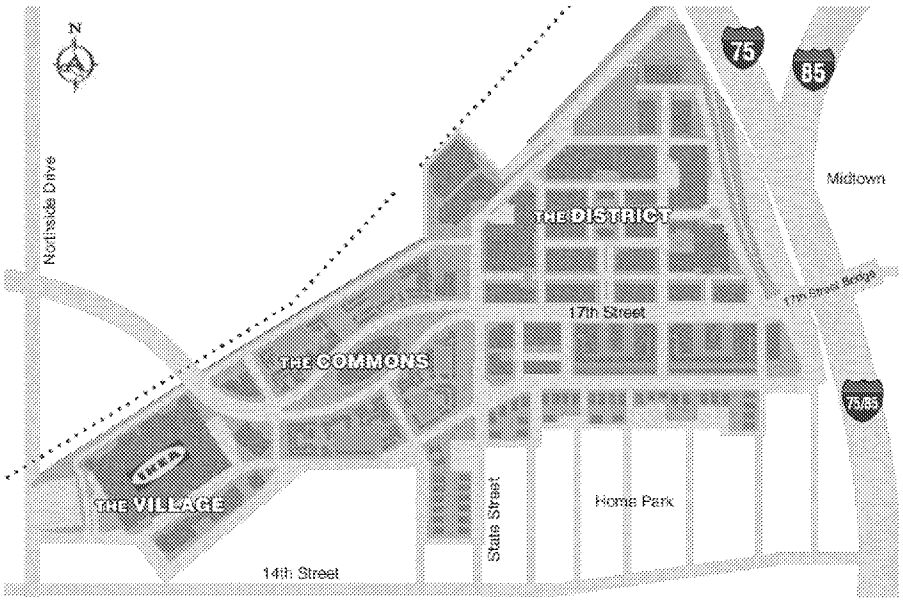
Figure 5. 2006 Atlantic Station site plan at buildout.

occupied at the time surveys for this project were completed. The area inside the inner dashed boundary line has not been developed although some of the parking to serve that development has been completed. Although complete, the survey conducted for this project did not include the IKEA store on the far west end because it was viewed as a non-integrated, free-standing component of Atlantic Station oriented away from the remainder of the development. Figure 6 shows the street names and sectors of Atlantic Station. Atlantic Station consists of three adjacent sectors: the District, the Commons, and the Village.

The District. The District is clearly the heart and most active part of Atlantic Station. It is the densest and has six interactive land uses. The mostly commercial District is on a grid of blocks extending from the south side of 14th Street to 20th Street and from Fowler Street on the east to State Street on the west. Virtually the entire area north of 17th Street has three levels of parking below ground. All parking is contiguous although parking for a few buildings has been partitioned. The garages are designed so the streets on the surface are duplicated underground for ease of navigation and comprehension. There is also short-term metered curb parking on most blocks of the surface level. All spaces are pay parking although businesses have the option of validating parking for specific durations. Visitor parking is free for the first 2 hours, $2 up to 3 hours, $3 up to 4 hours, $5 up to 5 hours, then increasing $3 per hour to the daily maximum of $14 for more than 7 hours. Employees park free on the lowest garage level during their work hours. At the time of the survey, garage parking supply far exceeded demand. Surface curb parking was generally fully occupied during normal business hours.

Land uses in the District consist of residential, retail, office, restaurant, hotel, and cinema. Table 48 shows the number of development units of each type. The largest retailers are Dillard's (department store), Publix (grocery store), and a shoe store. The retailers provide a range of products similar to what can be found in a regional mall. Restaurants range from specialty coffee shops to high-end shops. Residential units open at the time of the survey are in one high-rise building at the corner of 17th and State Streets and along both sides of 16th Street (townhouses). The office space is all in one high-rise building at 17th and Market Streets, while the restaurants and retail are distributed across most of the District.

The entire area north of 17th Street is conveniently walkable due to general compactness; short block lengths (about 150 to 300 ft in most cases); and an attractive walking environ-



Source: www.atlanticstation.com/site_parking.php. Image is used by permission: ©2010 Atlantic Station, LLC. All rights reserved.

Figure 6. Schematic map of Atlantic Station, 2006.

ment. There is a grade between 16th and 17th Streets that may discourage some from walking, but walking is viable for most people.

The Commons. This area includes two multistory apartment complexes along the north (Park District) and south (Art Foundry) sides of 17th Street, which has a wide median in the middle of the area. Resident parking is beneath the residential units, with visitor parking along 17th Street. The walking environment is typical for urban areas. Typical sidewalks are provided along 17th Street. There are no special provisions other than banners that integrate The Commons with The District. Other than banners and a few signs, the two areas could easily pass for being totally disassociated.

The Village. This western sector contains only one building: an IKEA furniture store. The IKEA building faces away from 17th Street and the remainder of Atlantic Station. It has its own parking and, as with the Commons, no strong connection to the District. Although walking between IKEA and the Commons is convenient by conventional sidewalk, little pedestrian activity was observed.

Access

Vehicular access to Atlantic Station and the District is concentrated on 17th Street from both east and west. I-75 and I-85 merge just to the north of 17th Street so Atlantic Station has good regional access by motor vehicle. An interchange

Table 48. Atlantic Station Development (all units within the District except as noted).

Land Use	Occupied Development Units	Largest
Residential	798 DU	• District: 190 apartments at 17th and State; 55 townhomes south of 16th Street • Commons: 553 apartments
Retail	434,500 sq ft	• Department store 227,000 sq ft • Grocery store 30,300 sq ft • Shoe store 27,000 sq ft • Only stores over 12,000 sq ft
Office	550,600 sq ft	• Almost all in one building
Restaurant	64,600 sq ft	• Sports bar/restaurant 19,100 sq ft • Only restaurant over 10,000 sq ft
Hotel	101 rooms	• One hotel
Cinema	87,000 sq ft, 16 screens, 6,000 seats	• One cinema

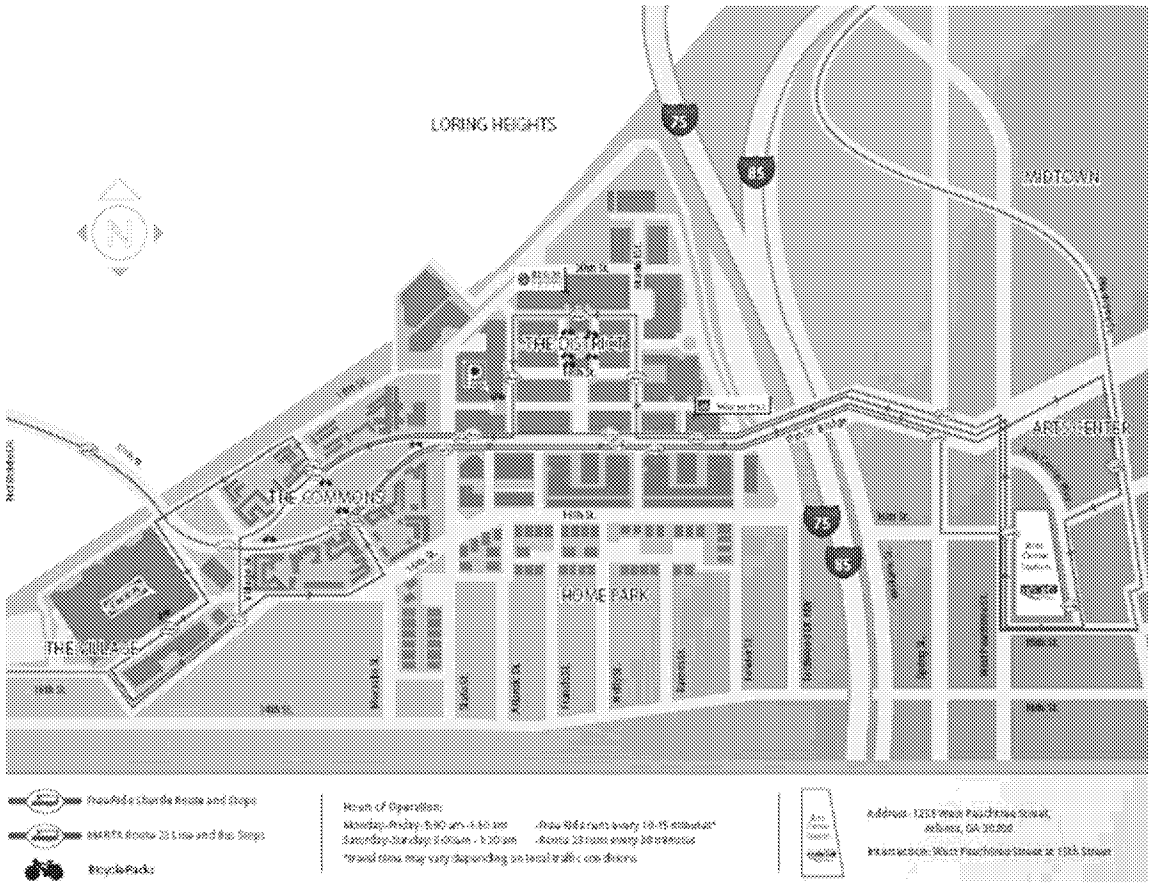
exists serving 14th and 17th Streets. Access to regional arterial streets is via 17th Street. There is some additional access to and from the south via local streets between Fowler and State. Access to underground parking of The District is from Fowler on the east, 16th Street on the south, State Street on the west, and 20th Street on the north. There are no ramps between the three levels; all access is to a single level. Some of the largest buildings are garage-accessible only from one or two of the three levels; however, there are stairs, elevators, and an escalator providing access between all garage levels and the street level. Stairs are spaced closely so that stairway access is quite convenient. Vehicular access to The Commons and IKEA is primarily via 17th Street although 16th Street also provides access.

Atlantic Station has two types of transit access as Figure 7 shows. Atlantic Station provides a dedicated free shuttle between the District and the Metropolitan Atlanta Regional Transit Authority (MARTA) Art Center rail station that is about ½ mile to the east of the District. The shuttle uses 17th Street but loops through the District. The shuttle operates on 5- to 10-minute headways, between 5 A.M. and 1 A.M., covering MARTA's rail system hours of 5 A.M. to 1 A.M.

MARTA also provides conventional bus service along 17th Street and along 14th Street. The 17th Street service (Route 23) also connects with the Art Center Station on the east. Going west and south from Atlantic Station, this route extends past Georgia Institute of Technology (Georgia Tech) and to downtown. It runs on 30- to 40-minute headways during the day, operating between about 5:30 A.M. and midnight. The 14th Street service runs between the Arts Center Station and the MARTA rail west end station, providing service to the Georgia Tech campus and an additional rail station. This route (Route 98) operates on 14th Street east of State Street and has approximately 40-minute headways all day. Two additional local routes run north–south on Northside Drive just west of the IKEA store. Those routes operate on 60-minute headways between about 6 A.M. and 10 P.M.

Travel Survey

The travel survey was conducted in the same manner as for Mockingbird Station. Surveys were conducted on Tuesday afternoon July 11, 2006, through Thursday morning July 13, 2006. The surveys conducted were



Source: www.atlanticstation.com/site_parking.php. Image is used by permission: ©2010 Atlantic Station, LLC. All rights reserved.

Figure 7. Atlantic Station transit access, 2006.

- Multimodal cordon count covering all access points of the District and the Bezar townhome area plus the parking garages for the Art Foundry and Park District apartment complexes;
- Counts of people entering and exiting doors of each building or business being surveyed during a particular period;
- Exit interviews of people as they departed selected doors;
- Pedestrian intercept interviews at one sidewalk location between the District and the Commons to catch those not included in the interviews in the Commons apartment complexes (custom survey to respond to local conditions); and
- Interviews of people using the Atlantic Station shuttle (custom survey to respond to local conditions).

MARTA bus patrons were not interviewed specifically because there were very few observed. The Atlantic Station shuttle seemed to be functioning as an almost complete substitute for conventional transit access.

Interviews were conducted in a manner similar to that used for Mockingbird Station, with one exception: the large number of businesses and entrances precluded all being covered. All large businesses were covered as was a sample of smaller ones. Those not surveyed (including a small number that declined permission) were accounted for by including expansion factors using applicable development units (e.g., sq ft). The research team was told by onsite management that occupants of the two residential developments in the Commons were similar and provided permissions for only one complex. Dwelling units were used to apply survey results to cover those units.

Survey Results

Most of the findings are based on 822 usable interviews conducted near doorways to Atlantic Station establishments during two morning and two afternoon peak periods. Of these approximately 27% were obtained during the A.M. peak and 73% during the P.M. peak. Approximately 45% of exiting people were interviewed in the A.M. peak period while about 15% were interviewed in the much more active P.M. peak. The results described in this report are based on expansion factors applied to usable interviews based on sampling rates for each land use and time period as well as the businesses surveyed. The expansion factor process is explained elsewhere in this report.

Table 49 shows the numbers of completed and usable interviews by peak period and land use category. Interviews were completed for about 30% of people exiting at street level (and the grocery store garage) during the A.M. peak and 15% during the P.M. peak. Interviews were not attempted at building entrances within the garage because it was felt that nearly all people using those few entrances would be either leaving Atlantic Station or returning to street level through the same buildings. In the first case, the trips would be external and easily categorized as such. In the second case, the people would be candidates for interviews as they departed from the building at street level. In addition, a few retail buildings were not covered with interviews due to the available survey crew and similarity of tenants to those being surveyed. Survey results were expanded to cover unsurveyed buildings in accordance with development units. Finally, not all residential buildings were surveyed. Local management staff indicated that profiles of the residents were similar to those in buildings being surveyed. Cordon counts were used to factor the residential survey results.

As with the Mockingbird Station interviews, some Atlantic Station interviews yielded more than one trip. All exiting trips were obtained. Some people interviewed also provided complete and usable information about their inbound trips to the interview location. Table 50 shows the total numbers of

Table 49. Peak-period interviews, counted building exit movements, and percent interviewed—Atlantic Station.

Land Use	A.M. Peak Period			P.M. Peak Period		
	Interviews[1]	Building Exit Movements	Percent Interviewed	Interviews[1]	Building Exit Movements	Percent Interviewed
Office	15	93	16%	15	84	18%
Retail	29	153	19%	266	2,138	12%
Restaurant	24	29	83%	184	918	20%
Residential	157	523	30%	66	305	22%
Cinema[2]	—	—	—	31	282	11%
Hotel	21	36	58%	14	95	15%
Total	**246**	**834**	**30%**	**576**	**3,822**	**15%**

[1] Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.
[2] Cinema not open during morning peak period.

Table 50. Peak-period usable trips, counted building exit movements, and percent usable—Atlantic Station.

Land Use	A.M. Peak Period			P.M. Peak Period		
	Usable Trips[1]	Building Exit Movements	Percent Usable	Usable Trips[1]	Counted Exit Movements	Percent Usable
Office	13	93	14%	26	84	31%
Retail	29	153	19%	313	2,138	15%
Restaurant	26	29	90%	189	918	21%
Residential	141	523	27%	56	305	18%
Cinema[2]	—	—	—	38	282	14%
Hotel	37	36	103%[a]	43	95	45%
Total	**246**	**834**	**30%**	**665**	**3,822**	**17%**

[1] Must include specific origin location, location of destination, and land use of destination if internal; this total includes reported exiting and entering trips made this period.
[2] Cinema not open during morning peak period.
[a] More trips reported from both exit and entering trip responses than movements counted.

usable interviews available based on their points of origin. Interviews during the P.M. peak period yielded some second usable trips; none were derived from the A.M. interviews.

The results reported herein are based on factoring to reflect sampling at each building entrance; factoring was performed separately for each peak period. That process is described elsewhere in this report. The survey results were summarized for the A.M. and P.M. peak periods.

Table 51 shows a summary of completed interviews, exiting people, and usable trips derived from the interviews. The total of the reported trips, if made during one of the two peak periods, is shown as usable trips in Table 50. Some of the reported inbound trips occurred outside the peak periods; however, for many of those trips, the respondent was unable or unwilling to provide enough complete information to make the inbound trip usable. Finally, some otherwise complete interviews were not usable because the inbound trip reported was not actually the immediately previous trip. Many of those trips were made outside the peak periods. First trips of the day from the onsite apartments did not have a previous trip that day.

The interviews reported in Table 51 differ slightly from interviews reported in prior tables. This is because the interviews reported in Table 50 are associated with the land use for which an exit trip is reported whereas previous tables reported by where the interview occurred.

Table 51 points out the same lesson learned from the survey procedures as did the Mockingbird Station surveys: to

Table 51. Peak-period interviews, exit movements, percent interviewed, and usable trips—Atlantic Station.

Land Use	Morning Peak Period				Afternoon Peak Period			
	Interviews[2]	Exit Movements	Percent Interviewed	Usable Trips[3]	Interviews[2]	Exit Movements	Percent Interviewed	Usable Trips[3]
Office	13	93	14%	13	15	84	18%	15
Retail	29	153	19%	30	243	2,138	11%	311
Restaurant	26	29	90%	28	167	918	18%	212
Residential	141	229[a]	62%	141	79	115[b]	69%	79
Cinema[1]	----	----	----	----	32	282	11%	32
Hotel	34	36	94%	34	16	95	17%	16
Total	**243**	**540**	**45%**	**246[c]**	**552**	**3,632**	**15%**	**665**

[1] No interviews attempted at cinema during the morning peak period since cinema closed during this period.
[2] Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.
[3] Must include specific origin location, location of destination, and land use of destination if internal; this total includes reported exiting and entering trips made this period.
[a] Excludes 294 movements counted at two residential developments where no interviews were completed.
[b] Excludes 190 movements counted at two residential developments where no interviews were completed.
[c] Includes 3 movements counted at establishments where no or too few interviews were completed for valid sample.

obtain accurate inbound trip information while conducting exit surveys, it is necessary to increase the amount of interview practice for each interviewer (mock interviews with trainers). Interviewers recorded too many incomplete interviews and incorrect previous trips. Most interviewers also failed to ask or record responses for all of the questions about the inbound trip, resulting in more incomplete inbound trip information. Table 51 shows that, unlike Mockingbird Station, A.M. interviews were completed at retail outlets. These were almost all at the onsite grocery store.

Table 52 shows, for the morning peak period, surveyed trips (usable from interviews) by origin land use as well as the number of people exiting doors for each land use. The third column represents exit movements from establishments where no completed interviews occurred. These trips were estimated based on square footage for the specific land use. The fourth column contains the number of drivers plus passengers who exited Atlantic Station from parking garages after reaching the garages via direct internal access from establishments above. Trips in this fourth column were assumed to all be external since they involved trips downstairs into the below ground garages and a drive along the perimeter or beyond to another location. In almost all cases, a walk trip would take less time except between the District and the apartment complexes to the west or townhouses to the south. About 46% of all trips made from survey locations were represented by an interview or direct external trips.

Table 53 displays similar information for the P.M. peak period. For this period, about 31% of the total trips are represented by interviews or direct external trips. Unsurveyed locations, which were judged by the research team to have characteristics similar to other establishments of the same land uses, represent less than 15% of the exiting trips made. The direct garage trips to the external street system accounted for about 20% of the total trips, a little less than for the A.M. peak period.

Table 54 contains somewhat similar information for the entering trips for both peak periods. As with the similar table for Mockingbird Station, this table shows the several sources for information on trips made. Trips represented by exit surveys are shown in the first column of numbers. Trips made direct from internally accessed parking garages to external locations are shown in the second column. Trips made using the free Atlantic Station shuttle and represented by interviews conducted on the shuttle are shown in the third column of numbers. The balance column represents the difference between the total number of counted (or prorated by sq ft) persons entering the establishments (through public doorway or from external points to the garage sections with private internal access) and the trips represented in the prior three columns. All trips in the fourth column of numbers were assumed to be external since they had no reported internal source for trips.

Table 55 shows the mode split of person trips to and from Atlantic Station during the A.M. peak period and peak hour. Personal vehicles account for about 80% of the inbound trips and slightly more than 70% of the outbound trips during both periods, indicating little difference between the periods. Similarly, peak-period and peak-hour mode shares differed little for other modes. Transit, including the free Atlantic Station shuttle, accounted for 8% of the inbound A.M. peak period trips and 9% of the inbound A.M. peak-hour trips. Outbound percentages were smaller. Virtually all transit trips used the free shuttle; MARTA bus service attracted almost no

Table 52. Morning peak-period surveyed trips, exit movements, and percent surveyed—Atlantic Station.

Land Use	Surveyed Trips[2]	Exit Movements				Percent Surveyed[5]
		Doors	Unsurveyed Locations[3]	Garage Direct[4]	Total	
Office	13	93	—	66	159	50%
Retail	29	153	8	136	297	56%
Restaurant	26	29	—	—	29	90%
Residential	141	523	—	68	591	35%
Cinema[1]	—	—	—	—	—	—
Hotel	37	36	—	—	36	100%
Total	**246**	**834**	**8**	**270**	**1,112**	**46%**

[1] Cinema did not actively generate trips during the morning peak period.
[2] Number of usable trip origins at each land use recorded from traveler interviews.
[3] Includes locations where no interviews were attempted (prorated by sq ft) and locations where door counts were made but no usable trip origins were recorded on interviews.
[4] Person-trips observed exiting onsite parking garages, assumed to be traveling directly to an external location.
[5] Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

Table 53. Afternoon peak-period surveyed trips, exit movements, and percent surveyed—Atlantic Station.

Land Use	Surveyed Trips[2]	Exit Movements				Percent Surveyed[5]
		Doors	Unsurveyed Locations[3]	Garage Direct[4]	Total	
Office	26	84	—	585	669	91%
Retail	313	2,138	532	418	3,088	24%
Restaurant	189	918	115	—	1,033	18%
Residential	56	305	—	50	355	30%
Cinema[1]	38	282	—	—	282	13%
Hotel	43	95	—	—	95	45%
Total	**665**	**3,822**	**647**	**1,053**	**5,522**	**31%**

[1] Cinema did not actively generate trips during the morning peak period.
[2] Number of usable trip origins at each land use recorded from traveler interviews.
[3] Includes locations where no interviews were attempted (prorated by sq ft) and locations where door counts were made but no usable trip origins were recorded on interviews.
[4] Person-trips observed exiting onsite parking garages, assumed to be traveling directly to an external location.
[5] Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

Table 54. Peak-period person-trips entering land uses—Atlantic Station.

Land Use	Morning Peak Period					Afternoon Peak Period				
	Survey[2]	Garage Direct[3]	Transit Direct[4]	Balance[5]	Total	Survey[2]	Garage Direct[3]	Transit Direct[4]	Balance[5]	Total
Office	86	829	41	41	997	55	69	17	(17)[a]	124
Retail	114	35	24	17	190	1,769	411	66	406	2,652
Restaurant	26	—	31	(23)[a]	34	542	—	48	694	1,284
Residential	0	8	6	186	200	313	90	14	131	548
Cinema[1]	—	—	—	—	—	165	—	39	111	315
Hotel	1	—	7	17	25	88	—	7	0	95
Total	**227**	**872**	**109**	**238**	**1,446**	**2,932**	**570**	**191**	**1,325**	**5,018**

[1] Cinema did not actively generate trips during the morning peak period.
[2] Trip destinations recorded from exit interviews, expanded as described.
[3] Person-trips observed entering onsite parking garages, assumed to be traveling directly from an external location.
[4] Trips entering onsite land uses from external locations recorded on transit interviews.
[5] Balance of person-trips entering onsite land uses; assumed to originate externally.
[a] See Appendix C for more information.

Table 55. A.M. peak-period and peak-hour person-trip cordon count—Atlantic Station.

Travel Mode	Peak Period (7:00 A.M.–10:00 A.M.)				Peak Hour (8:00 A.M.–9:00 A.M.)			
	Trips		Percent		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle[1]	2,378	1,165	79%	71%	972	447	81%	72%
Motorcycle	0	0	0%	0%	0	0	0%	0%
Delivery Vehicle	172	216	6%	13%	46	70	4%	11%
Transit[2]	244	56	8%	3%	104	34	9%	5%
Walk	226	195	7%	12%	78	68	6%	11%
Bicycle	6	4	<1%	<1%	2	1	<1%	<1%
Total All Modes	**3,026**	**1,636**	**100%**	**100%**	**1,202**	**620**	**100%**	**100%**

[1] Personal vehicle occupancies (entering/exiting): peak period 1.08/1.13; peak hour 1.05/1.12.
[2] Transit trips include circulating shuttle and bus.

Table 56. P.M. peak-period and peak-hour person-trip cordon count—Atlantic Station.

Travel Mode	Peak Period (4:00 P.M.–7:00 P.M.)				Peak Hour (5:00 P.M.–6:00 P.M.)			
	Trips		Percent		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle[1]	3,727	3,423	87%	88%	1,382	1,242	89%	86%
Motorcycle	0	0	0%	0%	0	0	0%	0%
Delivery Vehicle	50	43	1%	1%	14	18	1%	1%
Transit[2]	195	243	5%	6%	72	103	5%	7%
Walk	300	184	7%	5%	86	72	6%	5%
Bicycle	15	4	<1%	<1%	4	2	<1%	<1%
Total All Modes	**4,287**	**3,897**	**100%**	**100%**	**1,558**	**1,437**	**100%**	**100%**

[1] Personal vehicle occupancies (entering/exiting): peak period 1.40/1.27; peak hour 1.37/1.22.
[2] Transit trips include circulating shuttle and bus.

Atlantic Station trips, possibly due to the fare difference, more frequent shuttle service, and the shuttle loop throughout the District, which the MARTA service does not provide.

Table 56 shows similar summaries for the P.M. peak period and peak hour. Personal vehicles account for more of the travel during the P.M. peaks, accounting for 87–88% of all peak period trips and 86–89% of peak-hour trips. As for the A.M. peaks, there is little difference in mode splits between the peak period and peak hour. Deliveries account for far fewer trips during the P.M.. The transit mode splits are similar in total but more balanced between inbound and outbound trips. Inbound walk trips are similar for both A.M. and P.M. peaks, but outbound walk trips make up a larger percentage of A.M. peak trips than for the P.M.. Note, however, that the A.M. inbound and outbound walk volumes are fairly similar.

From these two tables it is apparent that motor vehicles are the primary mode of travel for Atlantic Station, but transit and walking also play a role. As was found for Mockingbird Station, the P.M. peak-period vehicle occupancies are significantly higher than those for the A.M. peak; this is attributable to people going shopping or to restaurants or the cinema in groups of two or more during the P.M. peak. Almost none of those businesses are open during the A.M. peak.

Table 57 shows the total A.M. and P.M. peak-period entering and exiting trips by land use category plus the percentage of those that were internal. Overall A.M. peak-period internal trip capture was about 12% for inbound and 17% outbound. For the P.M. peak period, the inbound and outbound internal capture percentages total about 44 and 38 percent, respectively. As the table shows, internal capture varies significantly by land use as it did for Mockingbird Station. The A.M. retail percentage reflects activity at the full-service grocery store, which serves both residential and office patrons during that period. The open restaurant was a coffee shop, similar to Mockingbird

Table 57. Peak-period person-trips and percent internal trip capture by land use—Atlantic Station.

Land Use	A.M. Peak Period				P.M. Peak Period			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Office	990	8%	152	33%	124	45%	668	9%
Retail[1]	135	44%	136	42%	1,431	38%	1,867	39%
Restaurant	34	77%	29	48%	1,218	39%	967	60%
Residential	200	0%	591	2%	543	57%	350	13%
Cinema[2]	—	—	—	—	315	52%	281	42%
Hotel	25	4%	36	95%	95	92%	94	86%
Total All Trips	**1,384**	**12%**	**944**	**17%**	**3,726**	**44%**	**4,227**	**38%**

[1] Retail open during A.M. peak period was primarily grocery store.
[2] Cinema not open to customers during morning peak period.

Table 58. Percent distribution of internal trip destinations for exiting trips—Atlantic Station, A.M. peak period.

Origin Land Use	Destination Land Use						Summary			
	Office	Retail[2]	Restaurant	Residential	Cinema[3]	Hotel	Internal	External	Total	Total Trips
Office	—[1]	28	5	0	—	0	33	67	100	152
Retail[2]	29	—[1]	13	0	—	0	42	58	100	136
Restaurant	31	14	—[1]	0	—	3	48	52	100	29
Residential	1	1	0	—[1]	—	0	2	98	100	591
Cinema[3]	.....	.....	.....	.....	....[1]	.....	.....	.....	.....	.....
Hotel	75	14	6	0	—	—[1]	95	5	100	36
All Origins	**8**	**6**	**3**	**0**	**—**	**0**	**17**	**83**	**100**	**944**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] Retail open during A.M. peak period was primarily grocery store.
[3] Cinema not open to customer during morning peak period.

Station. The hotel appeared to be heavily oriented to serving the onsite office building, which was the only nearby office building although others exist about ½ mile away. For the P.M. peak period, the internal percentage of entering trips was consistent across most uses, other than the hotel, which again appeared to be very internally oriented. There was more variation in trips exiting Atlantic Station buildings during the P.M. peak period, ranging between 9 and 86%. The office low percentage is reflective of commuters going home, or at least off-site, after work. The low residential percentage is a little surprising, but the longer distance to other uses may be influential.

Table 58 shows the percent distribution of trips from each origin land use to other land uses within Atlantic Station as well as to external destinations. As was explained for Mockingbird Station, trips between similar land uses are not included because they would not be counted as external trips for single-use developments. Some land use pairs have little interchange; others have extensive interaction, as described in the preceding paragraph.

Table 59 shows similar information for the P.M. peak period. A few land use pairs account for most of the internal trips, similar to Mockingbird Station; however, the specific pairs are not the same. This is a result of the residential units being farther removed from the non-residential uses and different balances of land uses. During the P.M. peak, the heaviest percentages of interaction are retail-restaurant (both directions) and from retail to restaurant and residential, cinema to retail, and from hotel to retail and restaurant.

Table 60 shows the A.M. peak period percentage distribution of inbound trips to each destination land use from each origin land use. The highest inbound internal capture percentages are retail from office and restaurant from office and retail. Many of those trips may result from trips for morning coffee or picking up a lunch on the way to work.

Table 61 shows similar information for the P.M. peak period. The largest internal capture percentages are to office, restaurant, cinema, and hotel from retail and to restaurant from retail, cinema, and hotel. These two tables demonstrate that there is a

Table 59. Percent distribution of internal trip destinations for exiting trips—Atlantic Station, P.M. peak period.

Origin Land Use	Destination Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Internal	External	Total	Total Trips
Office	—[1]	6	3	0	0	0	9	91	100	668
Retail	2	—[1]	19	13	4	1	39	61	100	1,867
Restaurant	1	41	—[1]	3	8	7	60	40	100	967
Residential	0	9	3	—[1]	0	1	13	87	100	350
Cinema	2	21	11	8	—[1]	0	42	58	100	281
Hotel	0	16	68	2	0	—[1]	86	14	100	94
All Origins	**1**	**13**	**11**	**7**	**4**	**2**	**38**	**62**	**100**	**4,227**

[1] Internal trips within a land use are not included in internal trip capture methodology.

Table 60. Percent distribution of internal trip origins for entering trips—Atlantic Station, A.M. peak period.

Destination Land Use	Origin Land Use						Summary			
	Office	Retail[2]	Restaurant	Residential	Cinema[3]	Hotel	Internal	External	Total	Total Trips
Office	—[1]	4	1	0	—	3	8	92	100	990
Retail[2]	32	—[1]	3	5	—	4	44	56	100	135
Restaurant	21	50	—[1]	0	—	6	77	23	100	34
Residential	0	0	0	—[1]	—	0	0	100	100	200
Cinema[3]	—	—	—	—	—[1]	—	—	—	—	—
Hotel	0	0	4	0	—	—[1]	4	96	100	25
All Destinations	**4**	**4**	**1**	**1**	**—**	**2**	**12**	**88**	**100**	**1,384**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] Retail open during A.M. peak period was primarily grocery store.
[3] Cinema not open to customer during morning peak period.

different internal capture rate by direction, similar to that for Mockingbird Station. This should be no surprise as some of the peak period activities are very directional (e.g., commuting to work in A.M., from work in P.M.).

Table 62 shows the internal person trips and percentages for both peak periods by mode of travel for the reported trip. During the A.M. peak, there are a few internal vehicle driver and vehicle passenger trips. All walk and bicycle trips are internal. However, no taxi or transit trips are internal. Unlike Mockingbird Station, Atlantic Station is larger and encourages use of personal vehicles for some trips; the maximum internal trip length is about 0.6 miles.

In the P.M. peak period, the internal capture percentages are significant for trips by all modes. Some combination of after-work shopping, dinner, or cinema may be the cause of higher vehicle use for internal trips. Visitors who are less familiar with specific locations or distances may view the Atlantic Station shuttle as more convenient for internal trips.

Table 63 shows similar information for Atlantic Station, but by original mode of access. The mode shown is that used for the first trip to Atlantic Station, not for the trip being reported; therefore, if a person arrived early in the morning driving a vehicle but is interviewed during a walk trip, the mode of access is vehicle driver. Hence, for those who originally entered Atlantic Station by driving a personal vehicle, during the A.M. peak period 6% of the inbound trips were from internal origins and 26% of the outbound trips from Atlantic Station buildings were to internal destinations. During the A.M. peak period, there were few enough non-vehicle driver trips that the differences in internal trip percentages may be nearly meaningless. However, during the P.M. peak period, those with a personal vehicle as their access mode have a lower percentage of internal trips than most other modes. People who originally arrived by walk/bike and circulator modes tend to have higher internal trip percentages.

Table 64 reports internal capture percentages by whether or not the trip-maker had access to a vehicle for the trip. The

Table 61. Percent distribution of internal trip origins for entering trips—Atlantic Station, P.M. peak period.

Destination Land Use	Origin Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Internal	External	Total	Total Trips
Office	—[1]	31	8	0	6	0	45	55	100	124
Retail	3	—[1]	28	2	4	1	38	62	100	1,431
Restaurant	2	29	—[1]	1	2	5	39	61	100	1,218
Residential	1	46	6	—[1]	4	0	57	43	100	543
Cinema	1	26	25	0	—[1]	0	52	48	100	315
Hotel	0	17	71	5	0	—[1]	92	8	100	95
All Destinations	**2**	**20**	**16**	**1**	**3**	**2**	**44**	**56**	**100**	**3,726**

[1] Internal trips within a land use are not included in internal trip capture methodology.

Table 62. Peak period person-trips and percent internal trip capture by mode of travel—Atlantic Station.

Mode of Travel	A.M. Peak Period[1]				P.M. Peak Period[2]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Vehicle Driver	1,110	4%	761	6%	2,125	18%	2,336	17%
Vehicle Passenger	72	10%	26	27%	215	27%	358	16%
Taxi/Car Service	0	0%	0	0%	18[a]	100%	43	42%
Transit (Bus)	0	0%	17	0%	15[a]	100%	101	15%
Transit (Circulating Shuttle)	86	0%	9	0%	325	41%	406	62%
Walk/Bicycle	116	100%	129	90%	1,026	100%	1,158	89%

[1] Travel mode not reported for 2 exiting trips.
[2] Travel mode not reported for 2 entering trips and 25 exiting trips.
[a] Limited sample; possible erroneous response.

Table 63. Peak-period person-trips and percent internal trip capture by mode of access—Atlantic Station.

Mode of Access	A.M. Peak Period[1]				P.M. Peak Period[2]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Vehicle Driver	1,141	6%	283	26%	2,552	32%	2,645	31%
Vehicle Passenger	70	7%	31	16%	277	43%	409	29%
Taxi/Car Service	1	100%	1	100%	22	100%	22	100%
Transit (Bus)	36	100%	56	64%	40	100%	152	26%
Transit (Circulating Shuttle)	89	3%	4	75%	468	59%	331	84%
Walk/Bicycle	11	100%	18	61%	86	100%	129	68%

[1] Access mode not reported for 36 entering trips and 551 exiting trips.
[2] Access mode not reported for 281 entering trips and 539 exiting trips.

Table 64. Peak period person-trips and percent internal trip capture by vehicle access—Atlantic Station.

Automobile Access	A.M. Peak Period[1]				P.M. Peak Period[2]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Yes (Vehicle Driver)	1,206	6%	302	24%	2,710	30%	2,857	29%
Yes (Non-Vehicle Driver)	58	24%	14	100%	71	49%	78	45%
No Vehicle Access	54	13%	20	35%	169	21%	107	34%

[1] Automobile access not reported for 66 entering trips and 608 exiting trips.
[2] Automobile access not reported for 776 entering trips and 1,185 exiting trips.

limited response seems to indicate that vehicle availability does not consistently influence the amount of internal trip making at Atlantic Station. Since most is conveniently walkable, the personal vehicles are not crucial to move around within Atlantic Station.

Legacy Town Center

Development Characteristics

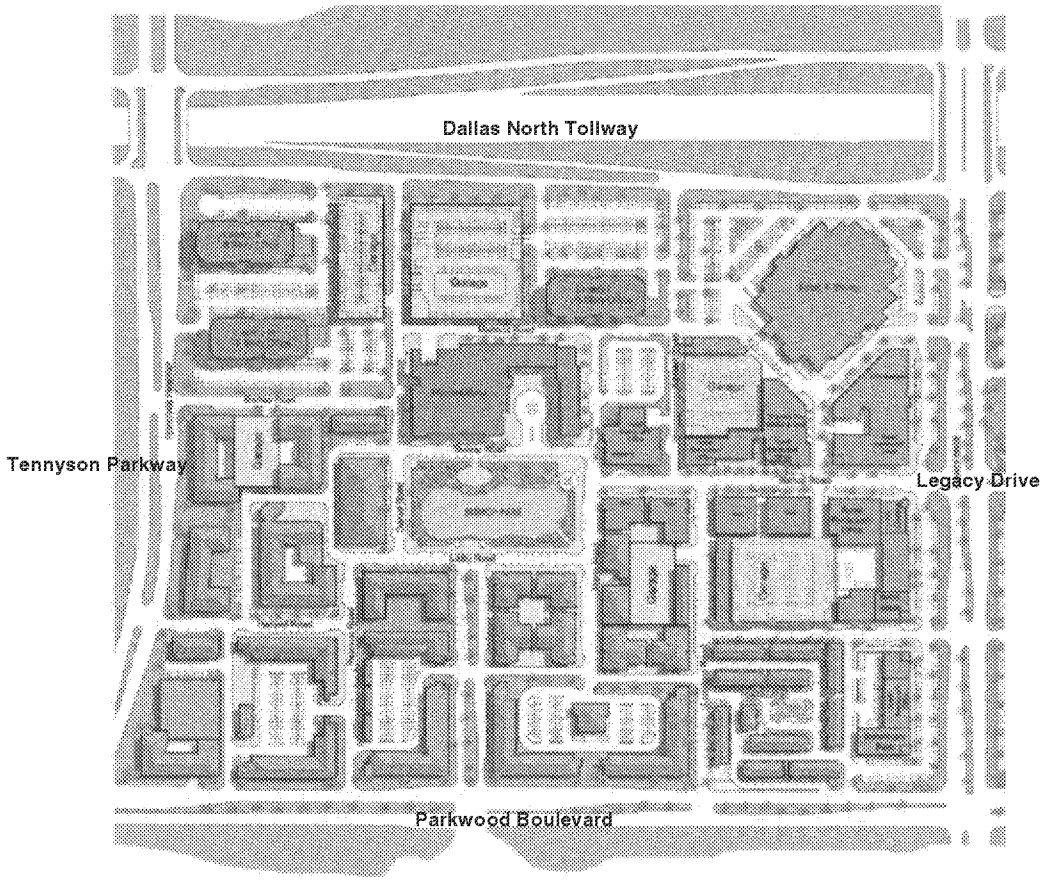
The third MXD surveyed was Legacy Town Center in Plano, Texas, which is a northern suburb in the Dallas–Ft. Worth area. Plano is located about 20 miles north of downtown Dallas. Development is almost solid to the south and east. Much of the area north and west of Plano is in active development.

Phase 1 of Legacy Town Center is completely developed. It is a multiple-block, single-development site bounded on all four sides by major roadways. The site is just over 70 acres. It consists of office, retail, restaurant, cinema, hotel, and residential land uses. Most retail and restaurant buildings are single story. Tenants tend to be specialty retail and restaurants ranging from better fast food to very exclusive. Most office space is in six-to-eight story buildings although a small amount is in second and third stories of two mixed-use buildings (which contain retail, restaurant, office, and/or residential space). Residential development consists of owner-occupied townhomes and rental apartments. There is one major full-service hotel and one five-screen cinema that shows mainly artistic movies. Table 65 contains the development program. Additional phases of Legacy Town Center are being developed to the north of Legacy Drive.

Table 65. Legacy Town Center development components.

Land Use	Occupied Development Units
Residential	1,300 apartments; 60 townhomes
Retail	196,264 sq ft
Office	310,764 sq ft
Restaurant	69,318 sq ft
Cinema	27,125 sq ft; 5 screens; 1,019 seats
Parking	6,070 parking spaces

Figure 8 illustrates the site plan of Legacy Town Center. The site is about 1,600 ft by 2,000 ft. The site is well connected by streets, with block lengths ranging between 300 and 600 ft. Each land use tends to be concentrated in a section of Legacy Town Center—for example, the apartments are in the southeastern



Source: The Shops at Legacy L.P.

Figure 8. Legacy Town Center illustrative site plan.

Source: Texas Transportation Institute

Figure 9. Legacy Town Center retail, restaurant, and cinema buildings along main retail street.

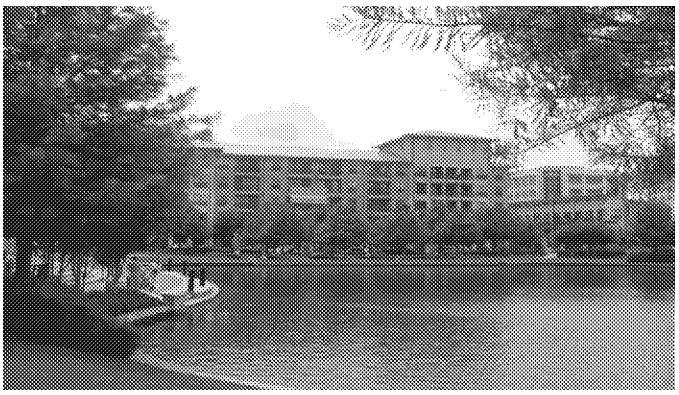
section, retail and restaurants are mixed but in the north portion, and townhomes are in a small portion of the east side. However, the connectivity provides a high degree of linkages between all blocks and land uses. Almost all blocks have landscaped walkways making them attractive to walk along and often are shaded. Figures 9 through 11 illustrate the character of Legacy Town Center.

Legacy Town Center is actually part of a large business park development, which could evolve upon buildout into a major suburban activity center. Much of the area is occupied by free-standing corporate headquarters buildings, but there are many other types of commercial and residential development close by including hotels, regional shopping centers, and residential complexes.

Observed activity demonstrated that Legacy Town Center has become a center of activity in the area, especially after work and in the evenings. Several restaurants were very busy, even during the week. The developer reported that most Legacy Town Center residents work within 5 miles of Legacy Town Center although a few work in Legacy Town Center. Most Legacy Town Center employees also live in the north Dallas region although, again, few are thought by management to live within Legacy Town Center.

Source: Texas Transportation Institute

Figure 10. Pedestrian-friendly environment in main retail and restaurant area.



Source: Texas Transportation Institute

Figure 11. Apartment building on south side of central park with office building in background.

Access to Legacy Town Center is provided by the Dallas North Tollway (which extends to downtown Dallas) and State Highway 121 (which extends across the region from northeast to central Ft. Worth), which is less than 1 mile north of Legacy Town Center. Legacy Drive is a regional east–west arterial. Tennyson Parkway and Parkwood Boulevard are minor arterials about 5 miles long.

Transit service to Legacy Town Center is limited: there is one DART bus route (452) that serves Legacy Town Center in a directional loop along both its north and south boundaries. Service operates between 6 A.M. and 11:30 P.M. Headways are 30 minutes during peak periods and 60 minutes during off-peak periods. There are multiple stops on both Legacy Drive and Tennyson Parkway. No use of this route by travelers to and from Legacy Town Center was observed either during survey periods or occasional additional observations. The Marriott Hotel offers its patrons free shuttle service to and from destinations in the area. Small shuttle vehicles provide this service. Hotel patrons do use this service.

Travel Survey

Travel surveys virtually identical to those conducted at Mockingbird Station and Atlantic Station were conducted at Legacy Town Center. Surveys were conducted Tuesday afternoon through Thursday morning, May 22–24, 2007. Due to rainy weather, surveys were also conducted on the following Thursday afternoon and Tuesday morning. One addition was employed for this survey: inbound office building interviews were conducted during the morning peak period.

Survey Results

Table 66 shows the number of exit movements and interviews during the 6:30–10 A.M. morning and 3:00–7:00 P.M.

Table 66. Peak-period interviews, exit movements, and percent interviewed—Legacy Town Center.

Land Use	Morning Peak Period			Afternoon Peak Period		
	Interviews[1]	Exit Movements	Percent Interviewed	Interviews[1]	Exit Movements	Percent Interviewed
Office	9	77	12%	80	362	22%
Retail	24	91	26%	59	595	12%
Restaurant	99	453	22%	74	913	11%
Residential	146	628	23%	80	592	19%
Cinema[2]	----	----	----	48	108	49%
Hotel	49	181	27%	50	299	17%
Total	**327**	**1,430**	**23%**	**391**	**2,869**	**16%**

[1] Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.
[2] Cinema not open during morning peak period.

afternoon peak periods. Due to the size of Legacy Town Center and number of buildings and businesses, interviews could not be conducted at all buildings and businesses. Samples of each land use were selected based on discussions with the developer and property managers—for example, two of the three office buildings were surveyed and six of the eight major block faces of retail were surveyed. One furniture store declined to be included in the survey.

Overall, 23% of people exiting surveyed buildings were interviewed during the A.M. peak and 16% for the P.M. peak. No land use interview rate was less than 10%. The cinema was closed during the A.M. peak as were almost all non-convenience retail businesses and most restaurants. The only restaurants open were a specialty coffee shop and a bakery/coffee/light breakfast restaurant.

Table 67 shows the number of usable trips derived from the interviews. These are compared with the counted exit movements during the interview periods (including some buildings for which no interviews were conducted). In all, usable trips constituted 18% of the morning people exiting surveyed buildings and 14% in the afternoon. The minimum sample rate for the morning was 12% and afternoon was 8%.

Table 68 shows a summary of completed interviews, exiting people, and usable trips derived from the interviews. Table 67 shows the total of the reported trips as usable trips, if they were made during one of the two peak periods. Unusable trips included inbound trips that occurred outside the peak periods or trips for which the respondent was unable or unwilling to provide enough complete information to make the inbound trip usable. Finally, some otherwise complete interviews were not usable because the inbound trip reported was not actually the immediately previous trip; many of those trips were made outside the peak periods. First trips of the day from the onsite apartments did not have a previous trip that day.

The interviews reported in Table 68 differ slightly from interviews reported in prior tables because the interviews

Table 67. Peak-period usable trips, exit movements, and percent usable—Legacy Town Center.

Land Use	Morning Peak Period			Afternoon Peak Period		
	Usable Trips[1]	Exit Movements	Percent Usable	Usable Trips[1]	Exit Movements	Percent Usable
Office	9	73	12%	74	362	20%
Retail	25	108	23%	62	595	10%
Restaurant	100	551	18%	77	913	8%
Residential	148	710	21%	96	592	16%
Cinema[2]	----	----	----	49	108	45%
Hotel	54	400	14%	50	299	17%
Total	**336**	**1,842**	**18%**	**408**	**2,869**	**14%**

[1] Must include specific origin location, location of destination, and land use of destination if internal; the total includes total reported outbound and inbound trips made this period.
[2] Cinema not open during morning peak period.

Table 68. Peak-period interviews, exit movements, percent interviewed, and usable trips—Legacy Town Center.

Land Use	Morning Peak Period				Afternoon Peak Period			
	Interviews[2]	Exit Movements	Percent Interviewed	Usable Trips[3]	Interviews[2]	Exit Movements	Percent Interviewed	Usable Trips[3]
Office	9	73[a]	12%	9	80	312[b]	26%	74
Retail	24	108	22%	25	59	536[c]	11%	62
Restaurant	99	551	18%	100	74	913	8%	77
Residential	146	710	21%	148	80	592	14%	96
Cinema[1]	—	—	—	—	48	108	44%	49
Hotel	49	400	12%	54	50	299	17%	50
Total	**327**	**1,842**	**18%**	**336**	**391**	**2,760**	**14%**	**408**

[1] No interviews attempted at cinema during the morning peak period since cinema was closed.
[2] Number of interviews conducted with travelers exiting doors of a particular land use that contained at least one usable trip.
[3] Must include specific origin location, location of destination, and land use of destination if internal; the total includes total reported outbound and inbound trips made this period.
[a] Excludes 4 movements counted at establishments where no or too few interviews were completed for valid sample.
[b] Excludes 50 movements counted at establishments where no or too few interviews were completed for valid sample.
[c] Excludes 59 movements counted at establishments where no or too few interviews were completed for valid sample.

reported in Table 66 are associated with the land use for which an exit trip is reported, whereas previous tables reported where the interview occurred. A.M. interviews were completed at the open retail outlets—in this case, a convenience retail store and a dry cleaner—throughout the morning peak period. A United Parcel Service (UPS) store opened at 9 A.M.

Table 69 shows the number of trips exiting Legacy Town Center establishments that had exit trips described in interviews. This table also shows the number of persons counted exiting at locations where interviews were conducted plus the prorated number estimated to have exited at locations where counts and interviews were not conducted. These locations were judged by the researchers to be represented by similar establishments that were surveyed except one case in which the proprietor declined to permit any interviewing. That location was included in the proration by square footage. Legacy Town Center had no direct internal access to parking garages where the interviewers could not intercept exiting people. Hence, unlike Mockingbird Station and Atlantic Station, Legacy Town Center trip characteristics are based entirely on the exit interviews. Legacy Town Center also has far more separate establishments than either of the other two developments surveyed

Table 69. Morning peak-period surveyed trips, exit movements, and percent surveyed—Legacy Town Center.

Land Use	Surveyed Trips[2]	Exit Movements				Percent Surveyed[5]
		Doors	Unsurveyed Locations[3]	Garage Direct[4]	Total	
Office	9	77	21	—	98	9%
Retail	25	108	—	—	108	21%
Restaurant	100	551	—	—	551	18%
Residential	148	710	953	—	1,663	9%
Cinema[1]	—	—	—	—	—	—
Hotel	54	400	—	—	400	14%
Total	**336**	**1,846**	**974**	**—**	**2,820**	**12%**

[1] Cinema did not actively generate trips during the morning peak period.
[2] Number of usable trip origins at each land use recorded from traveler interviews.
[3] Includes locations where no interviews were attempted (prorated by sq ft) and locations where door counts were made but no usable trip origins were recorded on interviews.
[4] Person-trips observed exiting onsite parking garages, assumed to be traveling directly to an external location.
[5] Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

Table 70. Afternoon peak-period surveyed trips, exit movements, and percent surveyed—Legacy Town Center.

Land Use	Surveyed Trips[2]	Exit Movements				Percent Surveyed[5]
		Doors	Unsurveyed Locations[3]	Garage Direct[4]	Total	
Office	74	362	155	—	517	14%
Retail	62	595	266	—	861	7%
Restaurant	77	913	491	—	1,404	5%
Residential	96	592	794	—	1,386	7%
Cinema[1]	49	108	—	—	108	45%
Hotel	50	299	—	—	299	17%
Total	**408**	**2,869**	**1,706**	**—**	**4,575**	**9%**

[1] Cinema did not actively generate trips during the morning peak period.
[2] Number of usable trip origins at each land use recorded from traveler interviews.
[3] Includes locations where no interviews were attempted (prorated by sq ft) and locations where door counts were made but no usable trip origins were recorded on interviews.
[4] Person-trips observed exiting onsite parking garages, assumed to be traveling directly to an external location.
[5] Includes those trips described in usable interviews or direct exits from a parking garage to the external street system.

in the pilot surveys, so a smaller portion of the establishments could be surveyed with the available resources. Approximately ⅔ of all trips were covered by direct interview sampling; the other ⅓ was included by proration. For the morning peak period, approximately 12% of all exiting trips are represented by surveyed trips.

Table 70 displays similar information for the P.M. peak period. There were about 60% more exiting trips in the P.M. peak period than during the A.M. peak period. The interviewed trips represent a sample of approximately 9% of all exiting trips.

Table 71 shows for each peak period the sources of entering trip information for trips entering Legacy Town Center establishments. For the morning peak period, interviews represent about 18% of the trips and the balance was assumed to all be external. For the evening peak period, about 38% of the entering trips are represented by interviews and the remaining 62% considered all external.

Table 72 shows results from the morning cordon count. As might be expected for a suburban development with limited transit service, almost all trips to and from Legacy Town Center were by motor vehicle. Transit, shuttle, walking, and bicycling combined accounted for about 4 to 6% of the A.M. and P.M. peak person trips. Almost none were by bicycle or public transit although some were by hotel shuttle van. Personal vehicle occupancy rates were about 1.07 inbound and 1.12 outbound for the A.M. peak period.

Table 71. Peak-period person-trips entering land uses—Legacy Town Center.

Land Use	Morning Peak Period					Afternoon Peak Period				
	Survey[2]	Garage Direct[3]	Transit Direct[4]	Balance[5]	Total	Survey[2]	Garage Direct[3]	Transit Direct[4]	Balance[5]	Total
Office	121	—	—	476	597	89	—	—	7	96
Retail	30	—	—	89	119	316	—	—	507	823
Restaurant	156	—	—	437	593	787	—	—	1,217	2,004
Residential	79	—	—	593	672	592	—	—	924	1,516
Cinema[1]	—	—	—	—	—	71	—	—	150	221
Hotel	6	—	—	181	187	115	—	—	200	315
Total	**392**	—	—	**1,776**	**2,168**	**1,970**	—	—	**3,005**	**4,975**

[1] Cinema did not actively generate trips during the morning peak period.
[2] Trip destinations recorded from exit interviews, expanded as described.
[3] Person-trips observed entering onsite parking garages, assumed to be traveling directly from an external location.
[4] Trips entering onsite land uses from external locations recorded on transit interviews.
[5] Balance of person-trips entering onsite land uses; assumed to originate externally.

Table 72. Morning peak-period and peak-hour person-trip cordon count—Legacy Town Center.

Travel Mode	Peak Period (7:00 A.M.–10:00 A.M.)				Peak Hour (7:30 A.M.–8:30 A.M.)			
	Trips		Percent		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle[1]	1,767	1,745	93%	91%	770	725	94%	93%
Motorcycle	0	1	0%	<1%	0	0	0%	0%
Delivery Vehicle	77	66	4%	3%	17	12	2%	2%
Transit[2]	15	76	1%	4%	11	29	1%	4%
Walk	49	31	3%	2%	21	13	3%	2%
Bicycle	0	0	0%	0%	0	0	0%	0%
Total All Modes	**1,908**	**1,919**	**100%**	**100%**	**819**	**779**	**100%**	**100%**

[1] Personal vehicle occupancies (entering/exiting): 1.07/1.12.
[2] Transit trips include bus and hotel shuttle.

Table 73 shows similar data for the P.M. peak period. As with the A.M. peak period, the P.M. shows that nearly all trips to and from Legacy Town Center are by personal vehicle. Transit, bicycle, and walk modes in total compose a slightly lower percentage of trips in the P.M. than the A.M.. Vehicle occupancies were significantly higher during the P.M. peak period, possibly due to the increased percentages of trips to and from retail, restaurants, and entertainment businesses that are open during the P.M. peak period but not during the A.M. peak period.

Table 74 shows the A.M. and P.M. peak-period internal trip capture percentages as reported in the interviews. The A.M. peak-period internal capture was about 15% for entering trips and 11% for exiting trips. During the P.M. peak period, the internal capture percentages were higher at 33% for entering trips and 37% for exiting trips. These summaries include only trips between different land uses; trips between the same land use are not included to remain consistent with the trip generation methodology used by the ITE.

As might be expected, the highest A.M. internal capture rates are for retail (largely convenience). Office, residential, and hotel generated the lowest percentages of internal trips. Residential trips to internal destinations were primarily to convenience retail or the coffee shop. During the P.M. peak period, interaction between retail, restaurant, cinema, and hotel was demonstrated. Many onsite residents also traveled to these destinations. P.M. internal trip capture percentages were consistent for most land uses with between 30% and 43%. Although there were few trips destined for the office buildings, a high percentage were from internal origins; however, very few of those leaving office space at Legacy Town Center made trips to other onsite destinations. Trips leaving retail also had a high percentage of internal capture, with

Table 73. Afternoon peak-period and peak-hour person-trip cordon count—Legacy Town Center.

Travel Mode	Peak Period (4:00 P.M.–7:00 P.M.)				Peak Hour (5:00 P.M.–6:00 P.M.)			
	Trips		Percent		Trips		Percent	
	Entering	Exiting	Entering	Exiting	Entering	Exiting	Entering	Exiting
Personal Vehicle[1]	3,192	2,832	94%	95%	1,107	1,066	93%	95%
Motorcycle	5	5	<1%	<1%	3	1	<1%	<1%
Delivery Vehicle	61	57	2%	2%	20	22	2%	2%
Transit[2]	39	13	1%	<1%	22	6	2%	1%
Walk	100	60	3%	2%	35	27	3%	2%
Bicycle	0	0	0%	0%	0	0	0%	0%
Total All Modes	**3,397**	**2,967**	**100%**	**100%**	**1,187**	**1,122**	**100%**	**100%**

[1] Personal vehicle occupancies (entering/exiting): peak period 1.23/1.16.
[2] Transit trips include bus and hotel shuttle.

Table 74. Peak-period person-trips and percent internal trip capture by land use—Legacy Town Center.

Land Use	Morning Peak Period				Afternoon Peak Period			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Office	560	15%	61	8%	90	93%	511	3%
Retail	119	25%	109	37%	728	30%	766	61%
Restaurant	593	26%	550	16%	1,833	33%	1,233	39%
Residential	631	6%	1,622	9%	1,352	32%	1,222	34%
Cinema[1]	—	—	—	—	221	32%	108	43%
Hotel	187	3%	400	9%	315	36%	299	38%
Total All Trips	**2,090**	**15%**	**2,742**	**11%**	**4,539**	**33%**	**4,139**	**37%**

[1] Cinema not open during morning peak period.

leisure shoppers remaining for dinner or a movie or going home to their residence onsite.

Table 75 shows the percentages of internal capture by land use for exiting A.M. peak period trips—that is, trips leaving those land uses. These percentages are based on the interviews. This table shows the degree of interaction between the various land uses. The greatest synergies during the A.M. peak period are from retail (i.e., convenience retail) to office and residential. As with Mockingbird Station and Atlantic Station, there is some interchange from restaurant (i.e., the coffee shop) to office, although at Legacy Town Center the specialty coffee shop is most of the way across the development from the major office buildings.

Table 76 shows similar data for the P.M. peak period. Exiting trips destined to other internal destinations are most frequent from retail to restaurant and residential; from restaurant to residential; and from residential, cinema, and hotel to restaurant. This reflects what is expected for an area that has significant amounts of synergy between complementary land uses.

Table 77 shows the internal trip capture percentages for entering trips by interchange between land uses. These percentages are shown as the percentage of total entering trips from individual land uses in Legacy Town Center. This table is for trips entering the various Legacy Town Center land uses. Internal capture percentages are highest entering retail (i.e., convenience retail) and restaurant from onsite residential.

Table 78 shows P.M. peak-period trip capture percentages for entering trips by interchange between land uses. With a higher total internal capture, the P.M. peak period also exhibits higher percentages of internal trips on individual interchanges with other land uses. The highest percentage of internal trip capture for entering trips was observed for trips entering office buildings from onsite residential and restaurant; however, inbound trips to office are very small in total numbers.

Table 75. Percent distribution of internal trip destinations for exiting trips—Legacy Town Center, morning peak period.

Origin Land Use	Destination Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema[2]	Hotel	Internal	External	Total	Total Trips
Office	—[1]	0	8	0	—	0	8	92	100	61
Retail	17	—[1]	6	14	—	0	37	63	100	109
Restaurant	9	2	—[1]	4	—	1	16	84	100	550
Residential	1	1	7	—[1]	—	0	9	91	100	1,622
Cinema[2]	—	—	—	—	—[1]	—	—	—	—	—
Hotel	0	0	9	0	—	—[1]	9	91	100	400
All Origins	**3**	**1**	**6**	**1**	**—**	**0**	**11**	**89**	**100**	**2,742**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] Cinema not open during morning peak period.

Table 76. Percent distribution of internal trip destinations for exiting trips—Legacy Town Center, afternoon peak period.

Origin Land Use	Destination Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Internal	External	Total	Total Trips
Office	—[1]	0	1	2	0	0	3	97	100	511
Retail	1	—[1]	29	26	0	5	61	39	100	766
Restaurant	2	10	—[1]	18	6	3	39	61	100	1,233
Residential	4	6	21	—[1]	0	3	34	66	100	1,222
Cinema	0	8	31	2	—[1]	2	43	57	100	108
Hotel	0	5	33	0	0	—[1]	38	62	100	299
All Origins	**2**	**5**	**15**	**10**	**2**	**3**	**37**	**63**	**100**	**4,139**

[1] Internal trips within a land use are not included in internal trip capture methodology.

Table 77. Percent distribution of internal trip origins for entering trips—Legacy Town Center, morning peak period.

Destination Land Use	Origin Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema[2]	Hotel	Internal	External	Total	Total Trips
Office	—[1]	3	9	3	—	0	15	85	100	560
Retail	0	—[1]	8	17	—	0	25	74	100	119
Restaurant	1	1	—[1]	18	—	6	26	74	100	593
Residential	0	2	4	—[1]	—	0	6	94	100	631
Cinema[2]	—	—	—	—	—[1]	—	—	—	—	—
Hotel	0	0	3	0	—	—[1]	3	97	100	187
All Destinations	**0**	**2**	**4**	**7**	**—**	**2**	**15**	**85**	**100**	**2,090**

[1] Internal trips within a land use are not included in internal trip capture methodology.
[2] Cinema not open during morning peak period.

Table 78. Percent distribution of internal trip origins for entering trips—Legacy Town Center, afternoon peak period.

Destination Land Use	Origin Land Use						Summary			
	Office	Retail	Restaurant	Residential	Cinema	Hotel	Internal	External	Total	Total Trips
Office	—[1]	6	30	57	0	0	93	7	100	90
Retail	0	—[1]	17	10	1	2	30	70	100	728
Restaurant	0	12	—[1]	14	2	5	33	67	100	1,833
Residential	1	15	16	—[1]	0	0	32	68	100	1,352
Cinema	0	0	32	0	—[1]	0	32	68	100	221
Hotel	0	13	10	12	1	—[1]	36	64	100	315
All Destinations	**0**	**10**	**10**	**9**	**1**	**3**	**33**	**67**	**100**	**4,539**

[1] Internal trips within a land use are not included in internal trip capture methodology.

Table 79. Peak-period person trips and percent internal trip capture by mode of travel—Legacy Town Center.

Mode of Travel	Morning Peak Period				Afternoon Peak Period[1]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Vehicle Driver	1,968	10%	2,337	8%	3,569	16%	2,875	20%
Vehicle Passenger	6	100%	102	6%	20	100%	177	11%
Taxi/Car Service	0	0%	15	0%	0	0%	16	0%
Transit (Bus)	0	0%	16	0%	0	0%	0	0%
Transit (Hotel Shuttle)	0	0%	140	0%	5	100%	5	100%
Walk/Bicycle	118	100%	136	87%	943	100%	1,069	89%

[1] Travel mode not reported for 2 entering trips and 7 exiting trips.

More significant were trips entering the cinema and retail from restaurants; trips entering restaurants from residential and retail; trips entering residential from retail and restaurants; and trips entering the hotel from retail, restaurants, and residential. Inbound trips to restaurant and residential make up the great majority of the total inbound trips to Legacy Town Center land uses.

Table 79 shows the percentages of internal trip capture by mode of travel for each entering and exiting trip. This table shows data for trips for which mode of travel was reported. Unlike Mockingbird Station where there were almost no internal driving trips, Legacy Town Center has 8% to 10% of personal driving trips that are internal in the A.M. peak period and 16% to 20% in the P.M. peak period. By contrast, all inbound and nearly all outbound walk and bike trips remained internal to Legacy Town Center.

Table 80 shows similar data, but these are for trips made by people based on their original mode of access to Legacy Town Center. These results are limited to those who correctly reported mode of access; a few travelers reported mode of access to the area rather than to Legacy Town Center. During the A.M. peak period, nearly all trips were made by people who arrived at Legacy Town Center as a personal vehicle driver. During the P.M. peak period, there are more trips made by people who used modes of access other than driving. Of those nondrivers (who presumably did not have a vehicle available to drive the next trip unless they were onsite residents), virtually all of the trips entering Legacy Town Center land uses were internal trips. However, for trips exiting the Legacy Town Center land uses, about 25% of the original vehicle passengers were going to other internal land uses and about 50% of the taxi/car service passengers were destined internally; this compares with 31% for people who originally arrived onsite by driving a personal vehicle.

Given the size of the samples and internal trip capture percentages, no conclusion can be drawn from these data as to whether mode of access affects internal capture rates. Table 81 shows similar data, but this is based on availability

Table 80. Peak-period person-trips and percent internal trip capture by mode of access—Legacy Town Center.

Mode of Access	Morning Peak Period[1]				Afternoon Peak Period[2]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Vehicle Driver	1,892	6%	670	17%	3,862	22%	2,772	31%
Vehicle Passenger	0	0%	11	0%	40	100%	159	25%
Taxi/Car Service	0	0%	0	0%	23	100%	45	51%
Transit (Bus)	6	100%	6	100%	0	0%	0	0%
Transit (Hotel Shuttle)	0	0%	0	0%	5	100%	5	100%
Walk/Bicycle	9	100%	9	100%	0	0%	0	0%

[1] Access mode not reported for 189 entering trips and 2,052 exiting trips.
[2] Access mode not reported for 609 entering trips and 1,158 exiting trips.

Table 81. Peak-period person-trips and percent internal trip capture by automobile access—Legacy Town Center.

Vehicle Access	Morning Peak Period[1]				Afternoon Peak Period[2]			
	Entering		Exiting		Entering		Exiting	
	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal	Trips	Percent Internal
Yes (Vehicle Driver)	1,892	6%	670	17%	3,862	22%	2,772	31%
Yes (Non-Vehicle Driver)	0	0%	11	0%	13	100%	121	11%
No Vehicle Access	9	100%	9	100%	52	100%	90	58%

[1] Automobile access not reported for 189 entering trips and 2,052 exiting trips.
[2] Automobile access not reported for 612 entering trips and 1,156 exiting trips.

of a personal vehicle for travel. It appears that the internal capture rate for those who did not have a personal vehicle available is higher than for those who could have driven. This is logical since once one travels to a destination, it makes sense to combine trips at the destination area.

Florida Survey Data

FDOT sponsored two studies of MXDs during the early 1990s. The two studies each covered three developments. While the objectives were similar to those for this project, procedural details were quite different for one of the studies. For the Florida study, the resulting internal capture data do not have as much specificity about internal trip-making.

The two studies used different questionnaires and, therefore, collected different data. One questionnaire provided data by individual trip, and the resulting data were usable for the current project. The other aggregated internal trips, so the data were not usable. For the usable study, data were collected for midday and P.M. peak periods. No data were collected for the A.M. peak period. Three MXDs were included. All three are located in Broward and Palm Beach counties (i.e., the east coast of Florida in the Fort Lauderdale–Palm Beach area).

Data for the usable study were not available in original form, so the relevant portion was re-keyed from copies of formatted printouts of the original data so that they could be analyzed. Some survey trip records were not totally clear and a few ran off the available pages, so there could be minor inaccuracies in a few records; however, this was not judged to compromise the overall value of the data for the purposes of this project.

Data for the three Florida developments were collected from mid-morning until 6:15 P.M. Only data matching the data collection periods for the NCHRP Project 8-51 pilot studies were used. Hence, the Florida data used covered the P.M. peak period (3:30 P.M. to 6:15 P.M. compared with 3:30 P.M. to 7:00 P.M. for the NCHRP Project 8-51 pilot studies).

One other characteristic of the data was different from the pilot study data. Interviews for the pilot studies were primarily exit interviews conducted as people departed from specific businesses or other uses and were expanded based on counts of people exiting the same doors. The Florida interviews were conducted at locations within the developments, some of which were in front of entrances and some of which were along busy walkways. The three developments surveyed were

- Country Isles,
- Village Commons, and
- Boca del Mar.

Three sites were surveyed in 1993 as part of a study that produced a report titled *FDOT Trip Characteristics Study of Multi-Use Developments* (*18*). Each site not only had multiple uses, but also had different parts of the development separated from each other in distance, connectivity, or both. Whereas Mockingbird Station, Atlantic Station, and Legacy Town Center are essentially fully integrated and well connected, the Florida sites were more conventionally arranged in pods. Interaction between the pods requires crossing parking lots and some separations that are beyond reasonable walking distances.

Origin-destination interviews were conducted at each of the study sites. The interviews were structured to collect three different types of information about each site: macro trip-making characteristics, micro trip-making characteristics, and trip length. The characteristics for each type of information are as follows:

1. **Macro trip-making** characteristics pertain to the characteristics of a trip to and from the site. These characteristics were used in the FDOT research project to categorize trips as captured, primary, diverted, or secondary.
2. **Micro trip-making** characteristics pertain only to the part of the trip *within* the site. This information was used in the FDOT research project to determine the number of internally captured trips, the number of the trip stops within the site, and the interaction between land uses. Through examination of individual survey records, researchers for

NCHRP Project 8-51 were able to identify next-stop locations and to categorize them as internal or external, and, if internal, the specific land use or site tenant.

3. **The length of the trip** made to and from the site was used in the FDOT research project to calculate the percentages of trips originating or ending at various distances from the site. This was collected in the Florida study for use in impact fee analyses.

Pedestrian count data were collected at most locations where origin-destination surveys were conducted. The purpose of the pedestrian data was to develop survey sample rates. The number of pedestrians entering and exiting each business was recorded. The areas of each site were sectioned off to establish areas of responsibility for each pedestrian counter so that the counts represented a complete, and not overlapping, count of persons entering or leaving the site.

Three different origin-destination survey forms were used. The office and retail/services forms were very similar, each containing 14 questions. The residential survey forms were divided into two different categories: one for incoming surveys and one for outgoing surveys. Appendix E includes copies of the forms.

Country Isles

The Country Isles mixed-use site is located in an area of west Broward County known as Weston. Figure 12 illustrates the general location of the site. Its commercial area is bounded by I-75, SW 14th Street, Weston Road, and Dykes Road. The residential component is directly across Weston Road from the Country Isles Shopping Center. The Country Isles mixed-use site covers approximately 61 acres, of which 46 are commercial and 15 are residential.

The Country Isles site was surveyed on June 30, 1993. Origin-destination surveys were conducted at 18 different locations within the site. Based on site observations, there appeared to be ample parking. There was no charge for parking anywhere within the site. There was no fixed-route transit service to the site.

Site Composition

Country Isles consists of three major development areas:

- Fairlake at Weston, a multi-family residential area;
- Country Isles Shopping Center; and
- Indian Trace Shopping Center.

Figure 13 shows the layout of Country Isles. Total commercial building square footage was 252,681, with about 70% retail (175,697 gross sq ft); 25% office (64,234 gross sq ft); and 5% daycare. The total number of dwelling units was 368. Figure 13 shows the tenant types and locations.

Proximity of Commercial Competition

At the time of data collection, the Country Isles development was the primary shopping center site serving the Weston and Bonaventure areas. The closest competing shopping center was Westgate Square, located approximately 2 miles away. Both sites had a supermarket, drug store, restaurants, banks, and small retail land uses; however, the Country Isles development was larger and more centrally located within the Weston community. It also offered a wider variety of land uses including medical and professional offices, a movie theater, daycare, and a convenience store. Finally, in the opinion of the original FDOT report authors, the general appearance of the Country Isles site (e.g., landscaping, site entrance) was more appealing than that of Westgate Square.

Site Components

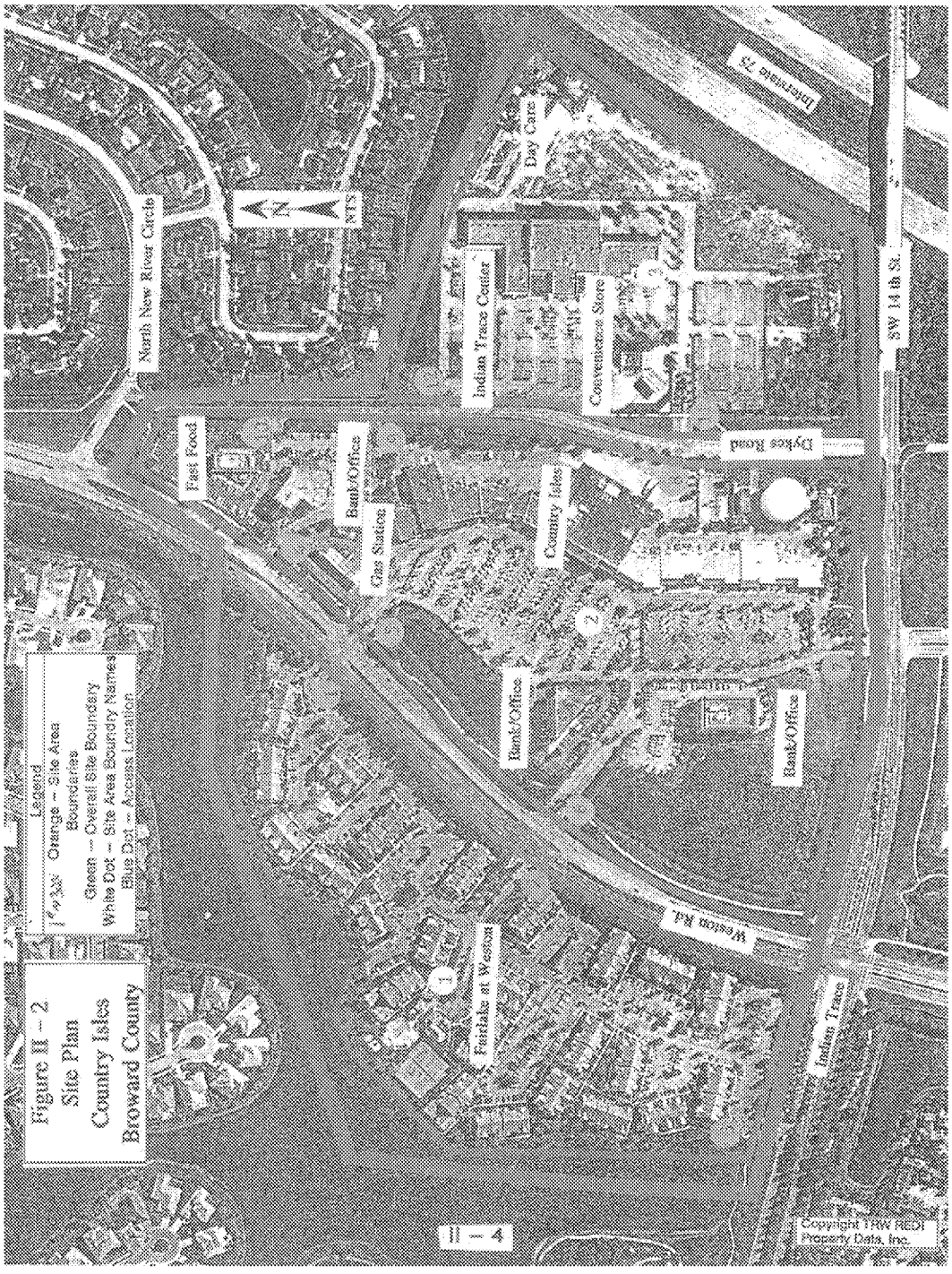
The descriptions that follow are grouped according to how land uses are aggregated for the data collection and data analysis.

Country Isles Shopping Center. The Country Isles Shopping Center was the primary retail center of this mixed-use site. Its 33 businesses included

- A supermarket and drug store;
- Five restaurants, including pizza, bagel, Italian, and Chinese;
- Numerous retail stores, including ice cream, party goods, video rental, shoes, liquor, children's clothing, framing, bicycles, florist, hardware, cards; and
- Several services such as medical offices, insurance agents, banks, shoe repair, a hair salon, a dry cleaner, a weight clinic, real estate agencies, an eye center, and a travel agency.

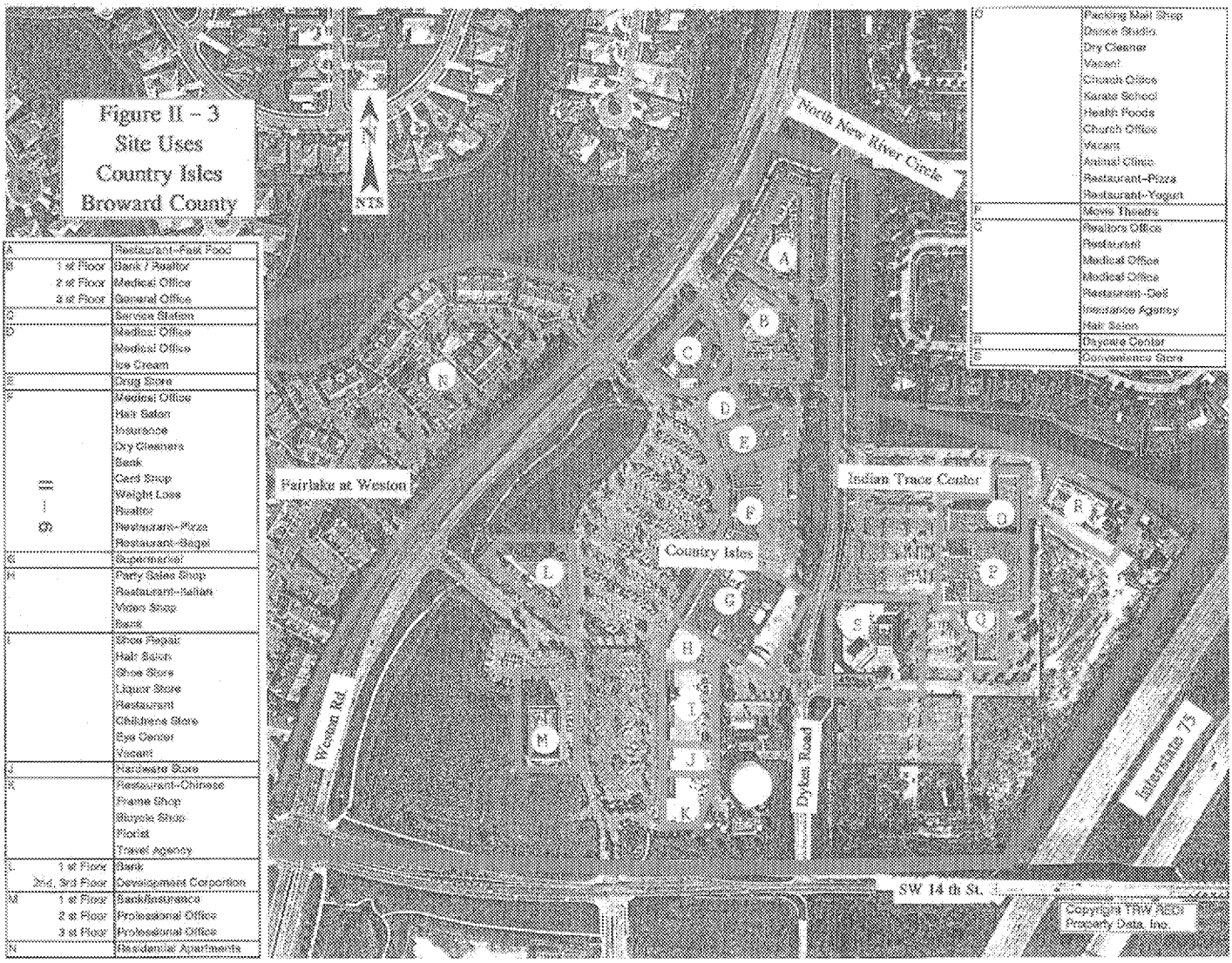
The Country Isles Shopping Center was 99,651 gross sq ft in size. Its largest tenant was a supermarket composing about 40% of the space. Restaurant use was 11%, bank space was 5%, and miscellaneous office space was 6%. The convenience retail, service units, and the supermarket composed about 78% of the shopping center space. The shopping center was approximately 90% occupied at the time of data collection. The shopping center had approximately 459 parking spaces, all in a surface lot.

Indian Trace Shopping Center. The Indian Trace Shopping Center included various restaurant, retail service, small office, and movie theater land uses. Because Indian Trace faces the back of the Country Isles Shopping Center, the most direct



Source: *FDOT Trip Characteristics Study of Multi-Use Developments*, Tindale-Oliver & Associates, final report, December 1993, p. II-4

Figure 12. Country Isles as depicted in the FDOT report (18).



Source: *FDOT Trip Characteristics Study of Multi-Use Developments*, Tindale-Oliver & Associates, final report, December 1993, p. II-6

Figure 13. Country Isles land use details as depicted in the FDOT report (18).

path between their primary parking areas was approximately 1,400 ft. Indian Trace tenants included

- Four restaurants, ranging from pizza to yogurt to deli;
- Several services including mail shipping, a dance studio, a dry cleaner, a karate school, health foods, an animal clinic, insurance, real estate, and a hair salon;
- Several small offices including a church office and medical offices; and
- A movie theater.

The Indian Trace Shopping Center was 68,400 gross sq ft in size. Its largest tenant was a movie theater composing about 38% of the space. Restaurant use was 8% and miscellaneous office space was 7%.

Convenience Stores. The Country Isles site also had two convenience stores, both with gasoline pumps. The first was located near the Country Isles shopping center and was 924 gross sq ft in size. It had 12 vehicle-fueling positions. The second was located near the Indian Trace shopping center and was 2,946 gross sq ft, with 8 vehicle-fueling positions. Together, the two convenience stores were 3,870 sq ft (less than 2% of the total commercial square footage at Country Isles). Of the three sites surveyed as part of the FDOT internal capture research project and the three sites surveyed as part of NCHRP Project 8-51, Country Isles was the only mixed-use site with onsite convenience stores with gasoline pumps.

Fast-Food Restaurant. There was a stand-alone, fast-food restaurant located in the northern most corner of the

site. Its building was 3,776 gross sq ft (less than 2% of the total commercial square footage at Country Isles). During the P.M. peak period for the NCHRP Project 8-51 analysis window, only two useable interviews were conducted. Therefore, no trips *from* fast-food restaurant were assumed to be internal to the site, but trips to the fast-food restaurant from other Country Isles uses were recorded and reported in the following sections.

Office Buildings. The Country Isles site had three stand-alone office buildings, totaling 64,234 gross sq ft. There was a three-story office building complex located just to the south of the fast-food restaurant. The complex had 26,000 sq ft and included a bank with drive-through facilities, a real estate agency, some medical office space, and some general office space. About one-third of the space was the bank. The building had approximately 118 parking spaces. Persons leaving this office building were not interviewed.

In the west central part of the site, there was a three-story office building complex. The building was 10,000 sq ft and included professional offices and a bank with drive-through facilities. About one-third of the space was occupied by the bank. The building had approximately 46 parking spaces and was located approximately 300 ft from the center of the Country Isles Shopping Center.

In the southern part of the site, there was a three-story office building complex. The building was 28,234 sq ft and included a bank with drive-through facilities, an insurance agency, and professional office space. About 15% of the building space was occupied by the bank. The building had approximately 113 parking spaces and was located approximately 300 ft from the center of the Country Isles Shopping Center.

Fairlake at Weston. Fairlake at Weston is a residential, multi-family apartment development with 368 units. Its occupancy level at the time of this study was estimated at 90%. The approximate center of Fairlake was located 1,200 ft from the supermarket at the Country Isles Shopping Center.

Daycare Center. The Country Isles site had a daycare center located near the northern edge of the Indian Trace Shopping Center, approximately 1,700 ft from the supermarket at the Country Isles Shopping Center and 2,600 ft from the center of the Fairlake residential development. The daycare center was 12,750 gross sq ft. Of the three sites surveyed as part of the FDOT internal capture research project and the three sites surveyed as part of NCHRP Project 8-51, Country Isles was the only one with a daycare center.

Data Collection

Origin-destination interviews were conducted at 18 stations throughout Country Isles. Different expansion factors were developed for each site (i.e., residential, office, and commercial land use categories) based on pedestrian counts, vehicle counts, and vehicle-occupancy counts. Table 82 lists the numbers of useable surveys collected at each land use. Also interviewed were 13 (or 5%) of the 269 inbound motorists at the Fairlake at Weston residential site.

Analysis of Internal Capture

Table 83 summarizes the overall internal capture found at the individual Country Isles land uses. The data shown in the second column represent the percentage of trips from the origin land use that are internally captured within the study site. Data in the right column show the same for trips to the destination land use. To more fully understand these overall internal capture rates for each land use, it was necessary to investigate internal capture rates for pairs of land uses. The following presents these data.

Table 84 presents the distribution of trip destinations for trips exiting each of the surveyed Country Isles land uses. Separate sets of values are listed for the Country Isles Shopping Center, for the Indian Trace Shopping Center, and for the combined trips exiting both shopping centers. The distribution is as follows:

- Of trips leaving the onsite office buildings, 25% had an internal retail destination—20% at the shopping centers and 5% at either of the two gasoline/convenience stores.

Table 82. P.M. peak-period useable surveys and sample rate—Country Isles.

Land Use	Exit Movements	Usable Interviews	Percent Interviewed
Office	573	45	8%
Retail	1,644	123	7%
Gasoline/Convenience	466	65	14%
Residential	173	44	25%
Daycare	396	73	18%
Total	**3,252**	**350**	**11%**

Table 83. P.M. peak-period percent internal capture by land use—Country Isles.

Land Use	Percent Internal Capture as Origin Land Use	Percent Internal Capture as Destination Land Use
Office	25%	2%
Shopping Center	20% for Country Isles 44% for Indian Trace 26% overall	20% for Country Isles 57% for Indian Trace 28% overall
Gasoline/Convenience	4%	36%
Fast-Food Restaurant	Not available	30%
Residential	36%	25%
Daycare	18%	0%
Total	**22%**	**24%**

- Of the trips leaving the Country Isles Shopping Center, 12% were destined to a non-shopping center internal use; 29% of the trips leaving the Indian Trace Shopping Center were destined for the same.
- When combined, the two shopping centers sent 1% of their outbound trips to onsite office buildings; 7% to the onsite gasoline/convenience stores; 2% to the onsite, free-standing fast-food restaurant; and 4% to the onsite residential area.
- Of the trips leaving the onsite gas/convenience stores, 4% were destined to onsite retail; the remainder travel to external destinations.
- Of trips leaving onsite residential, 36% were traveling to onsite destinations—25% to the shopping centers, 9% to the gasoline/convenience stores, and 2% to the fast-food restaurant.
- Of trips leaving the onsite daycare center, 17% were traveling to onsite destinations—15% to the shopping centers and 1% each to the gasoline/convenience stores and to residential.

Table 85 shows the distribution of trip origins for trips entering each of the surveyed Country Isles land uses. Separate sets of values are listed for the Country Isles Shopping Center, for the Indian Trace Shopping Center, and for the combined trips entering both shopping centers. The distribution is as follows:

- Of trips entering the onsite office buildings, 2% had an internal origin, all from the shopping centers (as opposed to 25% of the exiting trips that are internal as shown in Table 84).
- Of the trips entering the Country Isles Shopping Center, 13% arrived from internal use (same as for exiting); also arriving from an internal use were 34% of the trips entering the Indian Trace Shopping Center (greater than the percentage exiting). When combined, the two shopping centers received 7% of their inbound trips from onsite office buildings, 1% from the onsite gasoline/convenience stores, 3% from the onsite residential area, and 4% from the onsite daycare center.

Table 84. P.M. peak-period percent distribution of internal trip destinations for exiting trips—Country Isles.

Origin Land Use	Percent Internal Trips by Destination Land Use[1]							Percent External	Total
	Office	Shopping Center	Gas/ Conv	FF Rest	Residential	Day Care	Total Internal		
Office	—	20	5	0	0	0	25	75%	100
Country Isles Shopping Center	0	—	9	3	0	0	12	88%	100
Indian Trace Shopping Center	2	—	5	3	19	0	29	71%	100
Both Shopping Centers	1	—	8	2	5	0	16	84%	100
Gasoline/Convenience	0	4	—	0	0	0	4	96%	100
Residential	0	25	9	2	—	0	36	64%	100
Daycare	0	15	1	0	1	—	17	83%	100

[1] Calculated to exclude trips within the same land use.

Table 85. P.M. peak-period percent distribution of internal trip origins for entering trips—Country Isles.

Origin Land Use	Percent Internal Trips by Destination Land Use[1]							
	Office	Shopping Centers			Gas/ Conv	FF Rest	Residential	Daycare
		Country Isles	Indian Trace	Subtotal				
Office	—	6	17	8	6	0	0	0
Shopping Center	2	—	—	—	25	27	23	0
Gas/Convenience	0	1	5	1	—	0	0	0
Residential	0	3	3	3	3	3	—	0
Daycare	0	3	9	4	1	0	2	—
Total Internal	2	13	34	17	36	30	25	0
External	98	87	66	83	64	70	75	100
Total	100	100	100	100	100	100	100	100

[1] Calculated to exclude trips within the same land use; totals shown may not equal sums due to rounding.

- Of the trips entering the onsite gasoline/convenience stores, 36% came from onsite uses—6% from the office, 25% from the shopping centers, 3% from residential, and 1% from the daycare center.
- Of the trips that traveled to the onsite, free-standing, fast-food restaurant, 30% came from onsite uses—27% from the shopping centers and 3% from residential.
- Of the trips entering onsite residential, 25% traveled from an onsite origin—23% from the shopping centers and 2% from the daycare.
- Of the trips entering the onsite daycare center, 100% traveled from outside Country Isles.

Village Commons

The Village Commons site is located within the southwestern limits of the City of West Palm Beach in Palm Beach County. The overall mixed-use site straddles Village Boulevard, immediately northwest of Palm Beach Lakes Boulevard. The Village Commons mixed-use site encompasses approximately 72 acres, of which 54 are commercial and 18 are residential. Figure 14 shows the general layout of Village Commons. Figure 15 shows the types and locations of tenant land uses.

Village Commons was surveyed on July 14, 1993. Origin-destination surveys were conducted at 14 different locations within the site. There was no charge for parking anywhere within the site. Additionally, based on field observations, there was an adequate parking supply to service all land uses, with the possible exception of the health spa. There was no formal fixed-route transit service provided to the Village Commons site.

Site Composition

The Village Commons site has four major development areas: the Village Commons Shopping Center, the Brandywine Center, various office buildings located throughout the site, and the Pointe multi-family residential community. Total commercial square footage in Village Commons was 524,350 with 34% retail (179,840 sq ft), 57% office (297,581 sq ft), and 9% health spa. The total number of dwelling units was 317.

Proximity of Commercial Competition

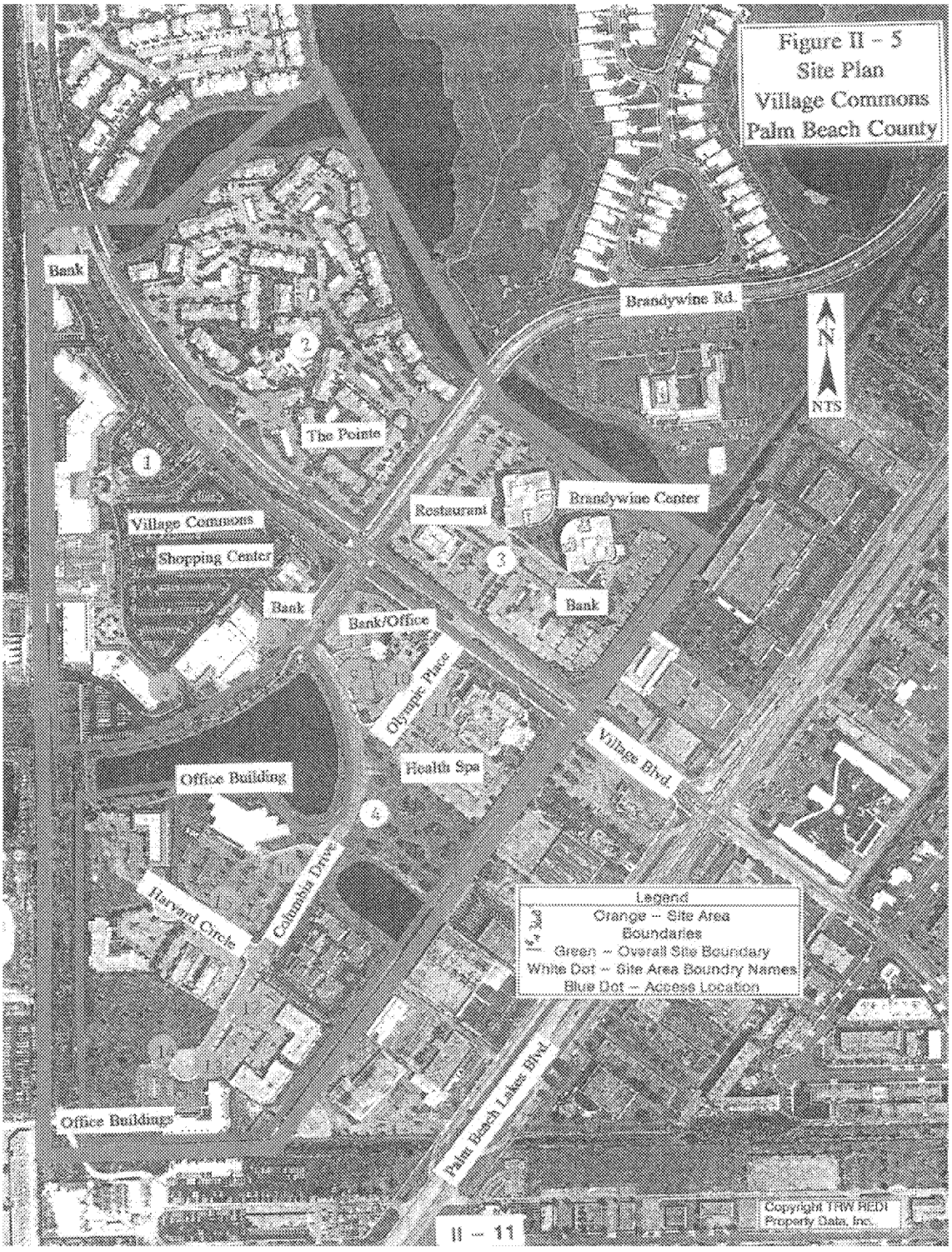
There were numerous office, restaurant, hotel, and retail land uses (including a regional mall) that were proximate to the Village Commons site.

Site Components

The descriptions that follow are grouped according to how land uses are aggregated for the data collection and data analysis.

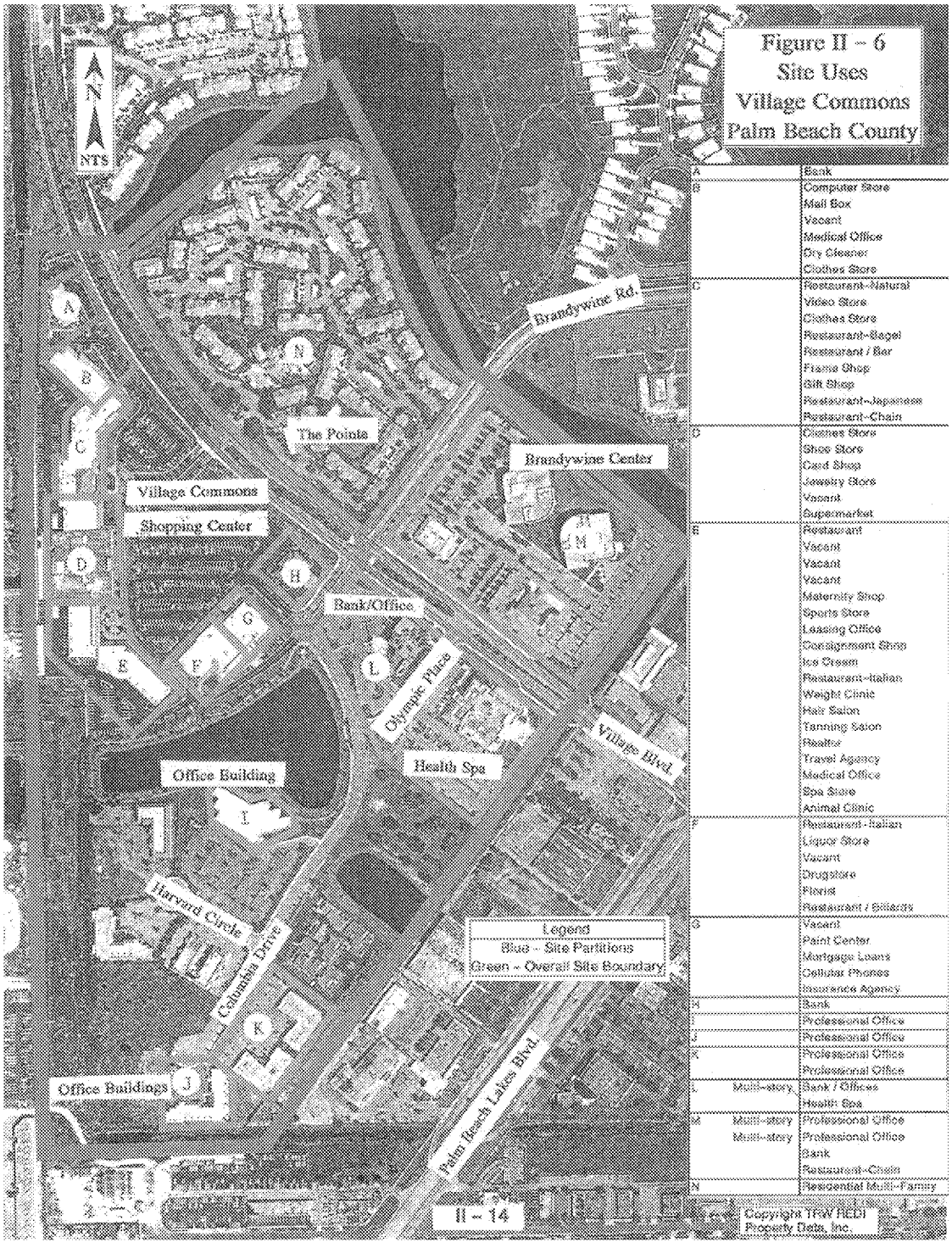
Village Commons Shopping Center. The Village Commons Shopping Center included the following:

- A supermarket and drug store;
- Eight restaurants ranging from natural foods to Japanese to bagels;
- Retail stores including computers, clothing, video, framing, gifts, shoes, cards, jewelry, maternity, sporting goods, consignment, ice cream, paint, cell phones, liquor, and flowers; and



Source: *FDOT Trip Characteristics Study of Multi-Use Developments*, Tindale-Oliver & Associates, final report, December 1993, p. II-11

Figure 14. Village Commons site layout as depicted in the FDOT report (18).



Source: *FDOT Trip Characteristics Study of Multi-Use Developments*, Tindale-Oliver & Associates, final report, December 1993, p. II-14

Figure 15. Village Commons tenant details as depicted in the FDOT report (18).

- Service establishments such as banks, mail shipping, dry cleaning, a leasing office, a weight clinic, a hair salon, a tanning salon, real estate, a travel agency, an animal clinic, insurance, and a mortgage company.

The shopping center was 170,740 gross sq ft in size. Its largest tenant was a supermarket encompassing 23% of the overall center space. There were a significant number of restaurants in the shopping center, composing 19% of the center space. Banks composed 6% and office space composed 4%. Despite being a large component of the overall shopping center, restaurants were not separated in the data analysis because the pedestrian count data did not separate between restaurant and non-restaurant volumes, thereby eliminating the possibility of developing reasonably accurate survey expansion factors for restaurant and non-restaurant trips.

Brandywine Center: Sit-Down Restaurant. The Brandywine Center contained four buildings: a sit-down chain restaurant, a bank, and two office buildings. The restaurant in Brandywine Center was 9,100 gross sq ft. The bank and office buildings are included in the next section.

Office Buildings. Village Commons had a total of nearly 300,000 sq ft in office buildings. The two three-story office buildings in Brandywine Center totaled 122,870 sq ft (of which 4% was in a bank) and were located approximately 1,500 ft from the Village Commons Shopping Center. Although sidewalks and crosswalks were available for pedestrian use, the fact that Village Boulevard was a four-lane divided roadway possibly would discourage pedestrian movement between the Brandywine and Village Commons centers. An office building was located at the northeast corner of Harvard Circle, approximately 1,800 ft from the Village Commons Shopping Center. It totaled 96,270 sq ft. The three office buildings located along Columbia Drive totaled 45,524 sq ft and were approximately 1,800 ft from the Village Commons Shopping Center. A multi-story office/bank building located at the southeast corner of Brandywine Road and Village Boulevard bounded by Columbia Drive and Olympic Place totaled 32,917 sq ft (of which 18% was in a bank). It was located approximately 800 ft from the Village Commons Shopping Center. Persons leaving this office building were not interviewed.

The Pointe. The Pointe development is a residential multifamily development containing 317 units. Its occupancy was estimated to be approximately 93% on the survey date. The FDOT research project was not allowed to conduct origin-destination surveys at the Pointe. Village Commons residential internal trips were estimated using Village Commons vehicle count data and average residential internal trip rates observed at the other two sites. The approximate center of the Pointe is located 900 ft from the supermarket at Village Commons Shopping Center.

Health Spa. There is a health spa located in the area bounded by Village Boulevard and Olympic Place. It encompasses 46,929 sq ft. An origin-destination survey was not conducted at the health spa, and no trips to the health spa were identified during the surveys conducted at other uses at the Village Commons site.

Data Collection

Origin-destination interviews were conducted at 14 stations throughout Village Commons. Different expansion factors were developed for each site (i.e., residential, office, and commercial land use categories) based on pedestrian counts, vehicle counts, and vehicle-occupancy counts. Table 86 lists the numbers of useable surveys collected at each land use.

Analysis of Internal Capture

Table 87 summarizes the overall internal capture found at the individual Country Isles land uses. In order to more fully understand these overall internal capture rates for each land use, it was necessary to investigate internal capture rates for pairs of land uses. Those data follow.

Table 86. P.M. peak-period usable surveys and sample rate—Village Commons.

Land Use	Exit Movements	Usable Interviews	Percent Interviewed
Office	718	78	11%
Retail	1,216	253	21%
Sit-Down Restaurant	167	27	16%
Residential	179	Not Interviewed	Not Interviewed
Total	**2280**	**358**	**16%**

Table 87. P.M. peak-period percent internal capture by land use—Village Commons.

Land Use	Percent Internal Capture as Origin Land Use	Percent Internal Capture as Destination Land Use
Office	7%	0%
Retail	7%	7%
Sit-Down Restaurant	7%	4%
Residential	27%	37%
Total	**9%**	**9%**

Table 88 presents the distribution of trip destinations for trips exiting each of the surveyed Village Commons land uses:

- Of trips leaving the office buildings onsite, 7% have an internal destination—6% to the shopping center and 1% to residential.
- Of the trips leaving the Village Commons Shopping Center, 7% were destined to an internal use, all residential.
- Of the trips leaving the onsite sit-down restaurant, 7% were destined to onsite destinations—half to the shopping center and half to residential.
- Of trips leaving the onsite residential, 27% were traveling to onsite destinations—25% to the shopping center and 2% to the fast-food restaurant. (The Pointe was not surveyed; these internal trip-making estimates are based on values derived at the other two FDOT research sites and on observed balancing of trips into and out of the Village Commons uses.)

Table 89 presents the distribution of trip origins for trips entering each of the surveyed Village Commons land uses:

- None of the trips entering the office buildings onsite had an internal origin.
- Of the trips entering the Village Commons Shopping Center, 7% (same as for exiting) arrived from an internal use—3% each from office and residential and less than 1% from the sit-down restaurant.
- Of the trips traveling to the onsite, sit-down restaurant, 4% came from onsite uses, all from the residential.
- Of the trips entering onsite residential, 37% came from an onsite origin—30% from the shopping center, 4% from office, and 2% from the sit-down restaurant.

Boca Del Mar

The Boca Del Mar site is located in southwest Palm Beach County. The mixed-use site is situated in the southwest quadrant of the intersection of Powerline Road and Palmetto Park Road. The commercial component of the site encompasses 42 acres. Figures 16 and 17 show the layout of Boca del Mar, and Figure 18 shows the tenant land uses and locations for the eastern portion of Boca del Mar. The western portion is all residential.

Boca del Mar was surveyed on July 21, 1993. Origin-destination interviews were conducted at 20 different locations within the site. Based on field observations, there appeared to be an ample parking supply to support the site land uses and there was no charge for parking at the site. There was no formal fixed-route transit system serving the site.

Site Composition

Boca Del Mar has six major development components:

1. Garden Shops at Boca;
2. Palms Plaza;
3. A multi-story office building at the northwest corner of the site;

Table 88. P.M. peak-period percent distribution of internal trip destinations for exiting trips—Village Commons.

Origin Land Use	Destination Land Use						
	Office	Retail	Restaurant	Residential	Total Internal	External	Total
Office	—	6	0	1	7	93	100
Retail	0	—	0	7	7	93	100
Sit-Down Restaurant	0	4	—	4	7	93	100
Residential	0	25	2	—	27	73	100

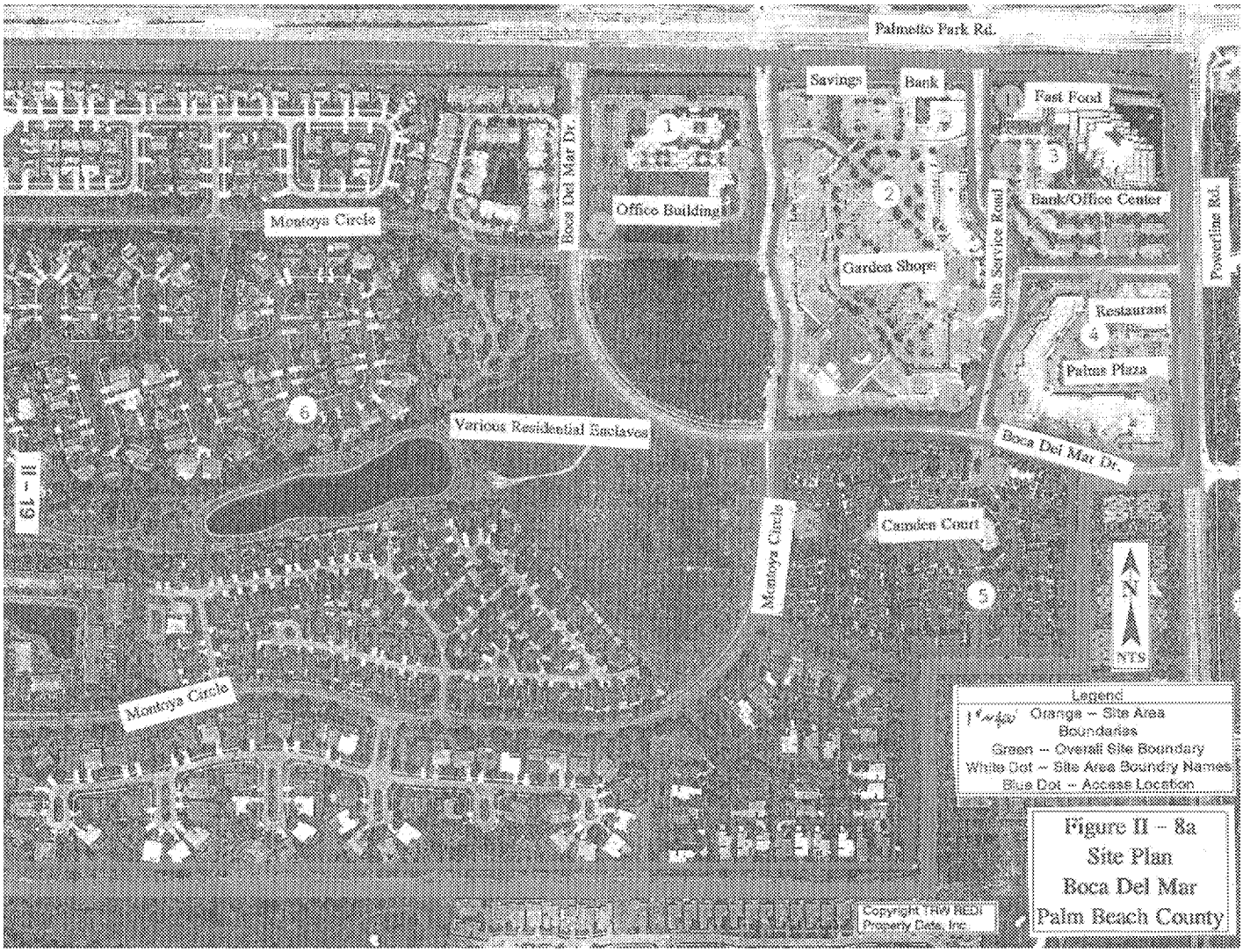
Table 89. P.M. peak-period percent distribution of internal trip origins for entering trips—Village Commons.

Origin Land Use	Destination Land Use			
	Office	Retail	Restaurant	Residential
Office	—	3	0	4
Retail	0	—	0	30
Sit-Down Restaurant	0	<1	—	2
Residential	0	3	4	—
Total Internal	0	7	4	37
External	100	93	96	63
Total	**100**	**100**	**100**	**100**

4. A multi-story bank and office building at the northeast corner of the site;
5. Camden Court, a multi-family residential complex on the south side of the site; and
6. Various residential areas to the west of the site.

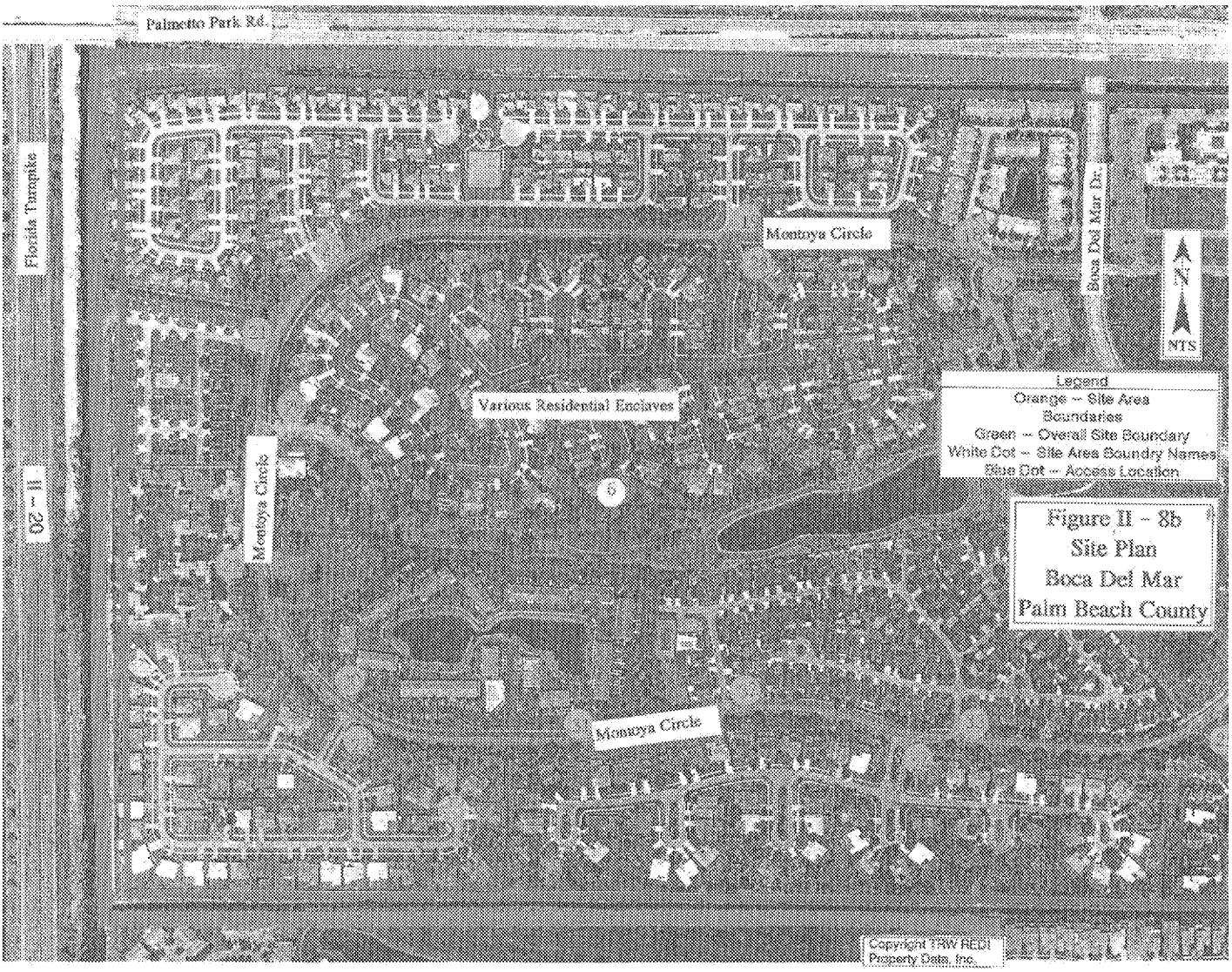
Please note that only the Camden Court residential area was considered internal to the mixed-use site for NCHRP Project 8-51 because insufficient surveys and counts were conducted at the "various residential areas" to enable consistent treatment of the survey responses.

Total commercial square footage in Boca del Mar was 501,254 with 41% retail (207,787 sq ft) and 59% office (293,467 sq ft). There were 1,144 total dwelling units of



Source: *FDOT Trip Characteristics Study of Multi-Use Developments*, Tindale-Oliver & Associates, final report, December 1993.

Figure 16. Boca del Mar eastern portion site layout as depicted in the FDOT report (18).



Source: *FDOT Trip Characteristics Study of Multi-Use Developments*, Tindale-Oliver & Associates, final report, December 1993, p. II-20.

Figure 17. Boca del Mar western portion site layout as depicted in the FDOT report (18).

which 513 were single family detached, 517 were townhouses, and 114 were apartments. The total number of dwelling units within Camden Court was 190.

All land uses located within the site were accessible via a service road system that bisects the site. All vehicular trips between site land uses could be made without having to use the arterial road system adjacent to the site.

Proximity of Commercial Competition

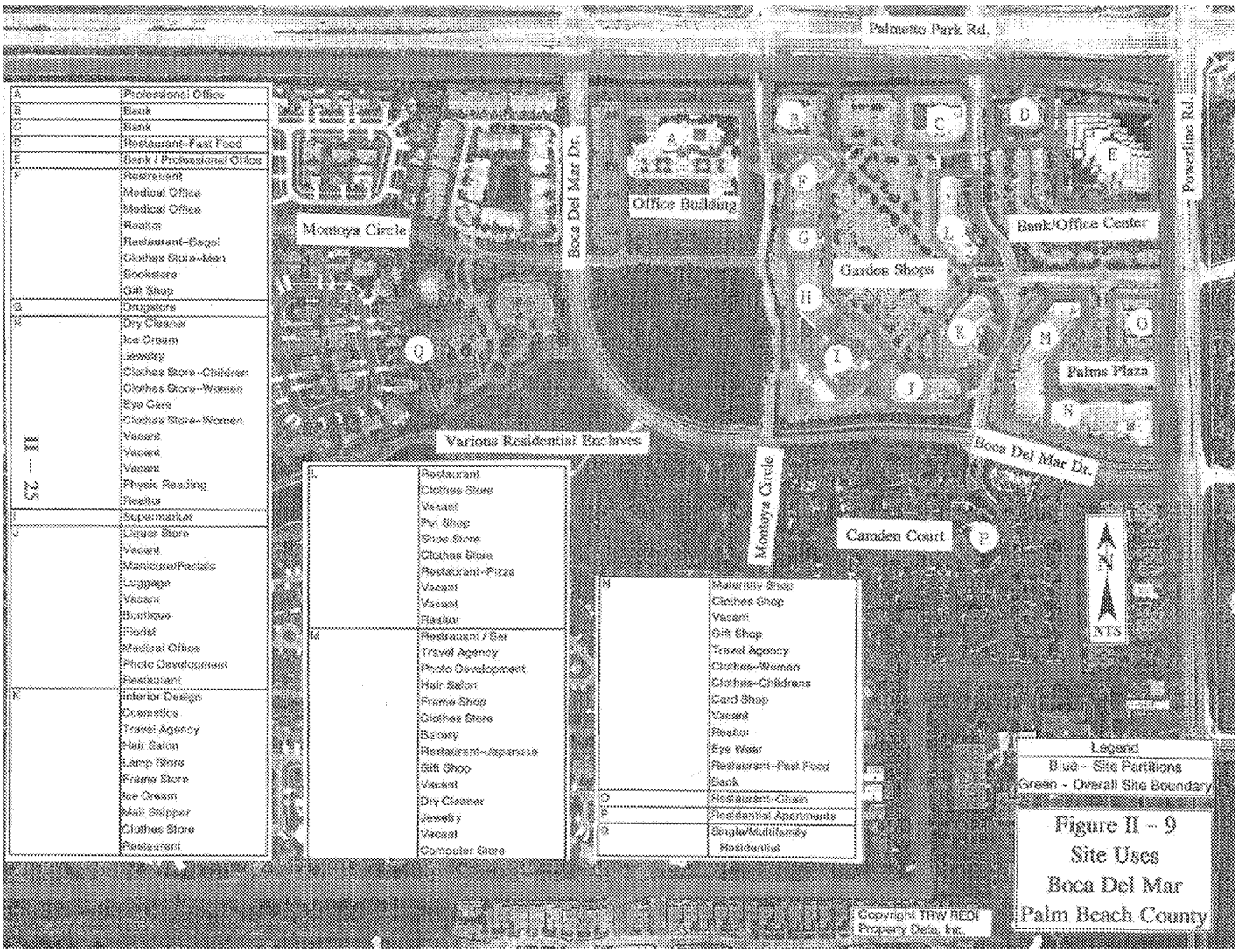
Immediately to the north of the Boca Del Mar site was a competing shopping center with several similar retail businesses, including a supermarket. However, the site was older than Boca del Mar and, in the opinion of the original FDOT research team, its general appearance (e.g., landscaping, site entrance) was not as appealing.

Site Components

The descriptions that follow are grouped according to how land uses are aggregated for the data collection and data analysis.

Garden Shops at Boca. The Garden Shops at Boca was the retail center of the mixed-use site. Its 52 tenants included the following:

- A supermarket and a drugstore;
- Six restaurants;



Source: *FDOT Trip Characteristics Study of Multi-Use Developments*, Tindale-Oliver & Associates, final report, December 1993, p. II-25.

Figure 18. Boca del Mar east end tenant details as depicted in the FDOT report (18).

- Various retail stores including men's, women's, and children's clothing; books; gifts; ice cream; jewelry; liquor; luggage; cosmetics; lamps; framing; pet supplies; a boutique; and a florist; and
- Various services including a medical office, real estate, dry cleaning, eye care, a psychic reader, manicure/facials, photo development, interior design, a travel agency, a hair salon, and a mail shipper.

The shopping center was 140,686 gross sq ft in size. Its largest tenant was a supermarket encompassing about 29% of the overall center space. Restaurants composed 10% of the center space, banks composed 5 percent, and office space composed 7%. The Garden Shops were approximately 95% occupied at the time of the survey.

Palms Plaza Shopping Center. The Palms Plaza Shopping Center was oriented facing away from the Garden Shops at Boca. The most direct path between their primary parking areas was approximately 1,100 ft. Palm Plaza had 27 tenants, including

- Four restaurants, ranging from a major sit-down restaurant chain to Japanese to fast food;
- Various retail stores including clothing, baked goods, gifts, computers, jewelry, maternity wear, cards, and eye wear; and
- Various services including a travel agency, photo development, a hair salon, framing, a dry cleaner, a travel agency, a real estate agency, and a bank.

Table 90. Usable P.M. peak-period surveys and sample rate—Boca del Mar.

Land Use	Exit Movements	Usable Interviews	Percent Interviewed[1]
Office	139	30	22%
Retail	1,672	267	16%
Fast-Food Restaurant	100	33	33%
Residential	108	95	88%
Total	**2,019**	**425**	**21%**

[1] Also interviewed were 18 (or 11%) of the 168 inbound residential motorists.

The shopping center was 63,070 gross sq ft in size. Restaurants composed 25% of the center space, banks composed 4 percent, and office space composed 7%. The remaining 64% was the mix of convenience retail and service businesses. The shopping center was approximately 80% occupied at the time of the survey.

Stand-Alone Fast-Food Restaurant. The Boca Del Mar Site had one stand-alone, fast-food restaurant. Its size was 4,031 sq ft.

Office Buildings. The Boca del Mar had two office buildings. The multi-story office complex on the west side of the site had surface parking around the building plus secured underground parking. Its size was 114,881 sq ft and it was located approximately 800 ft from the Garden Shops at Boca. There were a variety of professional businesses including some medical offices located within the office complex. This building was surveyed.

A 178,586 sq ft, multi-story office center was located on the northeast corner of the Boca del Mar site. Located in the office building are a bank (2% of the total square footage) and professional offices including a number of medical offices. Permission to obtain traffic counts at the access points and origin/destination surveys at this part of the site was not granted by the site property manager.

Camden Court. Camden Court was a residential multifamily community located immediately to the south of the retail shopping center. Camden Court included 190 apartment units, with an occupancy of 97% on the survey date. The approximate center of Camden Court was located 900 ft from the supermarket at the Garden Shops at Boca.

Data Collection

Origin-destination interviews were conducted at 20 stations throughout Boca del Mar. The data collection conformed to the methods used for the other Florida sites reported here. Different expansion factors were developed for each site (i.e., residential, office, and commercial land use categories) based on pedestrian counts, vehicle counts, and vehicle-occupancy counts. Table 90 lists the numbers of useable surveys collected at each land use.

Analysis of Internal Capture

Table 91 summarizes the overall internal capture found at the individual Boca del Mar land uses. To more fully understand these overall internal capture rates for each land use, it was necessary to investigate internal capture rates for pairs of land uses. The following includes the data.

Table 91. P.M. peak-period percent internal capture by land use—Boca del Mar.

Land Use	Percent Internal Capture as Origin Land Use	Percent Internal Capture as Destination Land Use
Office	0%	0%
Retail	4% for Garden Shops at Boca 7% for Palms Plaza 5% overall	7% for Garden Shops at Boca 1% for Palms Plaza 5% overall
Fast-Food Restaurant	24%	3%
Residential	44%	35%
Total	**8%**	**7%**

Table 92. P.M. peak-period percent distribution of internal trip destinations for origin land uses—Boca del Mar.

Origin Land Use	Percent Internal Trips by Destination Land Use[1]						
	Office	Shopping Center	FF Rest	Residential	Total Internal	External	Total
Office	—	0	0	0	0	100	100
Garden Shops at Boca	0	----	<1	4	4	96	100
Palms Plaza Shopping Center	0	----	0	0	0	100	100
Retail – Total	0	—	<1	3	4	96	100
Fast-Food Restaurant	0	18	—	6	24	76	100
Residential	0	42	2	----	44	56	100

[1] Calculated to exclude trips within the same land use.

Table 92 presents the distribution of trip destinations for trips exiting each of the surveyed Boca del Mar land uses. Separate sets of values are listed for the Garden Shops at Boca, for the Palms Plaza Shopping Center, and for the combined trips exiting both shopping centers:

- None of the surveyed trips leaving the office buildings onsite had an internal destination.
- Of the trips leaving the Garden Shops, 4% were destined to an internal use; none of the trips leaving Palms Plaza were.
- When combined, the two shopping centers sent less than 1% of the surveyed trips to the free-standing, fast-food restaurant and 4% to the onsite residential area.
- Of the trips leaving the onsite, free-standing fast-food restaurant, 24% were destined to onsite destinations, 18% to the shopping centers, and 6% to residential.
- Of trips leaving onsite residential, 44% were travelling to onsite destinations—42% to the shopping centers and 2% to the fast-food restaurant.

Table 93 presents the distribution of trip origins for trips entering each of the surveyed Boca del Mar land uses. Separate sets of values are listed for the Garden Shops at Boca, for the Palms Plaza Shopping Center, and for the combined trips entering both shopping centers:

- All of the trips entering the office buildings onsite had an external origin.
- Of the trips entering the Garden Shops at Boca, 4% arrived from an internal use; 1% of the trips entering the Palms Plaza Shopping Center also arrived from an internal use.
- When combined, the two shopping centers received 3% of their inbound trips from onsite uses—1% from fast food, and 2% from residential.
- Of the trips traveling to the onsite, free-standing, fast-food restaurant, 3% arrived from onsite uses—1% from the shopping centers and 2% from residential.

Table 93. P.M. peak-period percent distribution of internal trip origins for destination land uses—Boca del Mar.

Origin Land Use	Percent Internal Trips by Destination Land Use[1]					
	Office	Retail – Garden Shops	Retail – Palms Plaza	Retail – Total	FF Rest	Residential
Office	—	0	0	0	0	0
Retail	0	----	----	----	1	32
Fast-Food Restaurant	0	1	0	1	—	4
Residential	0	3	1	2	2	—
Total Internal	0	4	1	3	3	35
External	100	96	99	97	97	65
Total	**100**	**100**	**100**	**100**	**100**	**100**

[1] Calculated to exclude trips within the same land use.

- Of the trips entering onsite residential, a total of about 35% arrived from an onsite origin—almost 32% from the shopping centers and nearly 4% from the fast-food restaurant.

Comparison of Findings for Pilot Study Sites and Florida Sites

Similarities and Differences Among the Developments

The three MXDs surveyed in this project's pilot studies—Mockingbird Station, Atlantic Station, and Legacy Town Center—are similar in terms of the uses they have and the general proximities of their non-residential uses. All three are highly interconnected. All three are very walkable in their central areas (where commercial uses are located). All three have specialty retail and a range of restaurants from specialty coffee shops to high-end restaurants. All three have a cinema. Most commercial and retail businesses in each of the three developments are small; a few would be considered medium-sized. All have a variety of restaurants. Only Atlantic Station has a large retailer—a national chain department store.

However, there are differences. Mockingbird Station is very compact. Driving between internal destinations is an inconvenience compared with walking. The maximum walking distance is about 700 ft. There is a rail transit station next to and directly connected to the development and transit is used as a significant mode of access; that station is also served by six bus routes. The apartment building sits in the middle of and on top of the central commercial building. Mockingbird Station has no hotel.

Atlantic Station's main residential area extends away from the commercial area and is up to 3,400 ft away. There is a major grocery store there. There is also the retail department store, the only one among the three developments. Transit service that is used by Atlantic Station patrons and residents is via a dedicated shuttle to a nearby MARTA rail station about a mile away. One MARTA bus route serves the area conveniently, and almost no use was made of it by persons going to and from Atlantic Station.

While Mockingbird Station and Atlantic Station both have midtown locations and were redevelopment sites in the middle of fully developed areas, Legacy Town Center is an outer suburban development within a rapidly developing area. At the time of the survey, the area surrounding Legacy Town Center is fully or almost fully developed. Others are in various stages of partial development. Overall the area within about 2 miles is roughly two-thirds developed. Transit is virtually unused and has little presence although a hotel shuttle does provide service for its patrons to nearby destinations. While Legacy Town Center is well connected internally, its land uses tend to be more concentrated into specific areas of the site.

Hence, while the three study sites are truly integrated MXDs, they are not a truly homogenous trio of samples. This is similar to most land use categories included in the ITE trip generation database, although these three developments are more similar than those included in many ITE land use categories. It is also important to note that the three developments represent a range of typical conditions in which MXDs are developed.

The three Florida sites—Village Commons, Country Isles, and Boca del Mar—are less compact than the sites surveyed in this project. The Florida developments are structured sets of development pods separated by parking lots or streets; they are less well connected, less compact, and also have fewer interacting uses than the three developments surveyed in this project.

The six developments together could be considered representative of the range of types of MXDs in the range of ½ to 3 million gross sq ft of development. They are much larger and more diverse than a corner development that might consist of an office building that includes retail and restaurant uses. On the other extreme, the six developments are not as fully self-contained as a downtown or even a major suburban activity center; hence, use of the data from these developments should not be considered applicable to either very small MXDs or downtowns without having data that confirm similarities.

Findings from this project were compared with those contained in *NCHRP Report 323: Travel Characteristics at Large-Scale Suburban Activity Centers (26),* based on limited data in that report on internal capture. As noted previously, suburban activity centers—probably due to their size and greater mix-use uses and choices—have a broader range of internal capture percentages. While the surveys conducted obtained slightly different data, internal capture for *segments of suburban activity center populations* ranged between 6% and 68% with averages among activity centers surveyed ranging from 14% to 58% for specific population types (e.g., office employees).

Internal Trip-Making

Tables 94 through 97 summarize the internal capture percentages found for the three developments surveyed as part of this project plus the three Florida sites (P.M. data available only). The tables show internal capture percentages for the origin ends of trips as well as for the destination ends, similar to what was shown in the findings for each development. As is shown in previous tables, there are no values for trips between the same land uses because ITE trip generation rates already reflect trips within the same land use on the same site. Bold italicized percentages are the highest for each land use pair combination.

Table 94. Unconstrained internal capture rates for exiting trips, all sites—A.M. peak period.

Origin Land Use	MXD Site	Destination Land Use					
		Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	Atlantic Station		*28*	5	0	—	0
	Legacy Town Center		0	8	0	—	0
	Mockingbird Station		—	*63*	*1*	—	—
	Boca Del Mar		—	—	—	—	—
	Country Isles		—	—	—	—	—
	Village Commons		—	—	—	—	—
Retail	Atlantic Station	*29*		*13*	0	—	0
	Legacy Town Center	17		6	*14*	—	0
	Mockingbird Station	—		—	—	—	—
	Boca Del Mar	—		—	—	—	—
	Country Isles	—		—	—	—	—
	Village Commons	—		—	—	—	—
Restaurant	Atlantic Station	*31*	*14*		0	—	*3*
	Legacy Town Center	9	2		*4*	—	1
	Mockingbird Station	25	—		3	—	—
	Boca Del Mar	—	—		—	—	—
	Country Isles	—	—		—	—	—
	Village Commons	—	—		—	—	—
Residential	Atlantic Station	1	*1*	0		—	0
	Legacy Town Center	1	*1*	7		—	0
	Mockingbird Station	*2*	—	*20*		—	—
	Boca Del Mar	—	—	—		—	—
	Country Isles	—	—	—		—	—
	Village Commons	—	—	—		—	—
Cinema	Atlantic Station	—	—	—	—		—
	Legacy Town Center	—	—	—	—		—
	Mockingbird Station	—	—	—	—		—
	Boca Del Mar	—	—	—	—		—
	Country Isles	—	—	—	—		—
	Village Commons	—	—	—	—		—
Hotel	Atlantic Station	*75*	*14*	6	0	—	
	Legacy Town Center	0	0	*9*	0	—	
	Mockingbird Station	—	—	—	—	—	
	Boca Del Mar	—	—	—	—	—	
	Country Isles	—	—	—	—	—	
	Village Commons	—	—	—	—	—	

Table 94 shows and compares the distributions of internal trip destinations for exiting trips during the A.M. peak period. Data are available for only the three sites surveyed for this project. It is helpful to compare the internal capture percentages by land use pair.

Table 94 shows a range of internal capture percentages among the three developments for many of the land use pairs—for example, for trips from office to restaurant, the percentages found were 5%, 8%, and 63%, respectively. The percentages are a product of a number of factors, including the amounts of office and restaurant space exchanging interacting trips; the proximity and quality of connections between the interacting land uses (data available for those two factors); similar off-site opportunities; and the relative attractiveness of the destination as that type of land use (data not available for the last two considerations). For example, the 63% office to restaurant at Mockingbird Station results in part due to a 200-ft walking distance to a popular specialty coffee shop. The relationships of internal capture percentage to trip end constraints and proximity are examined later in this chapter.

The highest percentages found for each land use pair in Table 94 result from actual survey findings. The fact that lower percentages occurred elsewhere means only that the conditions—mainly balance between origin and destination land use demands for the trips between them plus the proximity (or other factors for which data are not available)—were not as ideal. These highest percentages represent the most unconstrained interchanges surveyed among the six sites—that is, the prevailing conditions reflect the best match resulting in the most interactions between the two land uses from among the developments surveyed.

Of the cells in Table 94 where morning peak period data for all three developments are available, only two cells show one percentage substantially higher than the other two: office-to-restaurant and residential-to-restaurant, both at Mockingbird Station. Both of these involve a popular coffee shop very close to the apartment building entrance and the office building entrance. It is natural that a high percentage of those types of trips would go to the adjacent onsite coffee shop during the A.M. peak.

Table 95 shows similar comparisons for the P.M. peak-period exiting trips. Data are available for all six developments.

Table 95. Unconstrained internal capture rates for exiting trips, all sites—P.M. peak period.

Origin Land Use	MXD Site	Destination Land Use					
		Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	Atlantic Station		6	3	0	0	0
	Legacy Town Center		0	1	2	0	0
	Mockingbird Station		9	4	2	0	.....
	Boca Del Mar		0	0	0	.....	.....
	Country Isles		20	0	0	.....	.....
	Village Commons		6	0	1	.....	.....
Retail	Atlantic Station	2		19	13	4	1
	Legacy Town Center	1		29	26	0	5
	Mockingbird Station	1		20	7	4	.....
	Boca Del Mar	0		0	3	.....	.....
	Country Isles	1		2	5	.....	.....
	Village Commons	0		0	7	.....	.....
Restaurant	Atlantic Station	1	41		3	8	7
	Legacy Town Center	2	10		18	6	3
	Mockingbird Station	3	38		3	2	.....
	Boca Del Mar	0	18		6	.....	.....
	Country Isles	.....	.....		.....	.....	.....
	Village Commons	0	4		4	.....	.....
Residential	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	2		.....	.....
	Country Isles	0	25	2		.....	.....
	Village Commons	0	25	2		.....	.....
Cinema	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	.....	.....	.....	.....		.....
Hotel	Atlantic Station	0	16	68	2	0	
	Legacy Town Center	0	5	33	0	0	
	Mockingbird Station	.....	.....	.....	.....	.....	
	Boca Del Mar	.....	.....	.....	.....	.....	
	Country Isles	.....	.....	.....	.....	.....	
	Village Commons	.....	.....	.....	.....	.....	

Because there are more percentages, there are fewer cells where one value far exceeds all others when at least three values are given.

Table 96 shows a similar comparison for entering trips during the morning peak period. No cell containing three percentages has a single value far exceeding the others. The higher percentages are for interchanges that typically involve few trips. The high percentages in this table involve trips entering Atlantic Station's coffee shop from the grocery and to the grocery from the office building. Both of these types of trips would be for convenience and would possibly go to the closest location available, although more specialized needs might require trips to/from external locations.

Table 97 shows internal capture percentages for entering trips during the P.M. peak period. Many cells show consistent percentages or a range with values spread throughout. A few cells show three or more percentages and a single value much higher than others. These are to office from retail (Atlantic Station); from residential to office (Legacy Town Center); and from restaurant to retail (Mockingbird

Table 96. Unconstrained internal capture rates for entering trips, all sites—A.M. peak period.

Destination Land Use	MXD Site	Origin Land Use					
		Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	Atlantic Station		*4*	1	0	—	*3*
	Legacy Town Center		3	9	*3*	----	0
	Mockingbird Station		----	*14*	1	----	----
	Boca Del Mar		—	—	—	—	—
	Country Isles		----	----	----	----	----
	Village Commons		—	—	—	—	—
Retail	Atlantic Station	*32*		3	5	—	*4*
	Legacy Town Center	0		*8*	*17*	----	0
	Mockingbird Station	----		----	----	----	----
	Boca Del Mar	—		—	—	—	—
	Country Isles	----		----	----	----	----
	Village Commons	—		—	—	—	—
Restaurant	Atlantic Station	21	*50*		0	—	*6*
	Legacy Town Center	1	1		18	----	*6*
	Mockingbird Station	*23*	----		*20*	----	----
	Boca Del Mar	—	—		—	—	—
	Country Isles	----	----		----	----	----
	Village Commons	—	—		—	—	—
Residential	Atlantic Station	0	0	0		—	0
	Legacy Town Center	0	*2*	4		----	0
	Mockingbird Station	0	----	*5*		----	----
	Boca Del Mar	—	—	—		—	—
	Country Isles	----	----	----		----	----
	Village Commons	—	—	—		—	—
Cinema	Atlantic Station	—	—	—	—		—
	Legacy Town Center	----	----	----	----		----
	Mockingbird Station	----	----	----	----		----
	Boca Del Mar	—	—	—	—		—
	Country Isles	----	----	----	----		----
	Village Commons	—	—	—	—		—
Hotel	Atlantic Station	0	0	*4*	0	—	
	Legacy Town Center	0	0	3	0	----	
	Mockingbird Station	----	----	----	----	----	
	Boca Del Mar	—	—	—	—	—	
	Country Isles	----	----	----	----	----	
	Village Commons	—	—	—	—	—	

Table 97. Unconstrained internal capture rates for entering trips, all sites—P.M. peak period.

Destination Land Use	MXD Site	Origin Land Use					
		Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	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	0	.....	.....
	Country Isles		2	—	0	—	—
	Village Commons		0	0	0	—	—
Retail	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		1	2	.....	.....
	Country Isles	*8*		0	3	—	—
	Village Commons	3		1	3	—	—
Restaurant	Atlantic Station	*2*	*29*		1	2	*5*
	Legacy Town Center	0	12		*14*	2	*5*
	Mockingbird Station	1	16		2	*3*	—
	Boca Del Mar	0	1		2	.....	.....
	Country Isles	0	27		3	—	—
	Village Commons	0	0		4	—	—
Residential	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	4		.....	.....
	Country Isles	0	23	—		—	—
	Village Commons	*4*	30	2		—	—
Cinema	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	—	—	—	—		—
Hotel	Atlantic Station	0	*17*	*71*	5	0	
	Legacy Town Center	0	13	10	*12*	*1*	
	Mockingbird Station	—	—	—	—	—	
	Boca Del Mar	.....	.....	.....	.....	.....	
	Country Isles	—	—	—	—	—	
	Village Commons	—	—	—	—	—	

Station). Atlantic Station has almost twice as much retail as any of the other six developments; it has the only department store and that store is immediately next to the office building. That may explain the relatively higher portion of P.M. trips entering office from retail. Very few trips enter office buildings during the P.M. peak period. For those that do, it is not surprising that most trips from residential would begin close by in Legacy Town Center. More distant trips from home would be expected to wait until the next day. Because of the compactness of Mockingbird Station, many people were seen leaving restaurants during happy hour and strolling along the fronts of stores and entering a few to look at what was being sold. Atlantic Station and Legacy Town Center are somewhat less compact although they offer a similar opportunity. The Legacy Town Center area had more off-site shopping opportunities nearby than did Mockingbird Station or Atlantic Station. Hence, the differences shown in Table 97 appear logical. The three Florida developments are far less compact and would be expected to have less of this activity.

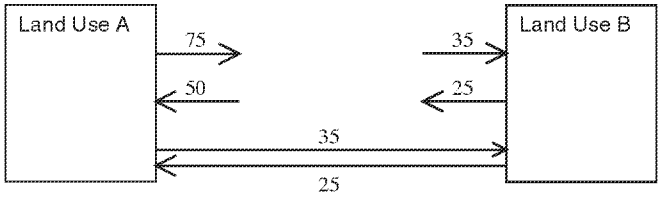


Figure 19. Example of unconstrained demand and balancing of internal trip interchange.

Internal capture percentages in the previous tables are similar for some land use pairs but not for others. One reason for this is the balance between land uses. If two land uses are balanced for the purpose of trip generation interaction, Land Use A would want to send as many people to Land Use B as Land Use B would want to receive from Land Use A.

However, consider a case where Land Use A wants to send 75 trips to Land Use B, but Land Use B only wants to receive 35 trips from Land Use A (see Figure 19). Land Use B will receive all the Land Use A trips it wants: it can be considered to be unconstrained. There are more than enough Land Use A trips to satisfy Land Use B demand; however, Land Use A demand to send trips to Land Use B is constrained because Land Use B will accept only half of the trips Land Use A wants to send. Examining the opposite direction, Land Use B wants to send 25 trips to Land Use A, and Land Use A wants to receive 50 trips from Land Use B. Because all of the Land Use B trips can be accepted by Land Use A, Land Use B is unconstrained in that direction, but Land Use A is constrained.

When internal trips are constrained, they cannot occur, and the travel demand must be satisfied externally. Figure 20 shows what happens in these two examples. Land Use A wants to send 75 trips to Land Use B. Only 35 of those trips can go to Land Use B internal to the development, so the other 40 trips have to seek Land Use B externally. This is based on the assumption that people make trips for a purpose (e.g., eat lunch), and if that purpose cannot be satisfied internally where it is most convenient, the trip maker will have to find someplace to eat externally.

Therefore, returning to Table 94, the (major) differences between the internal trip capture percentages that appear in this table are attributable in many cases to the balance, lack of constraints, or other factors that exist for some zone pairs—

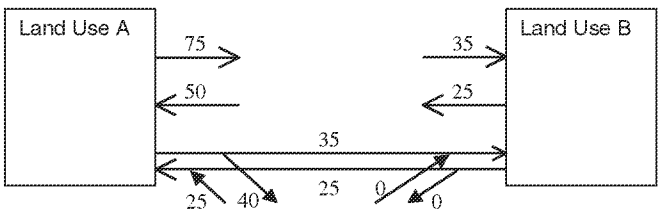


Figure 20. Continuation of Figure 19 example showing external trips resulting from internal constraints.

for example, for Mockingbird Station, 63% of the trips from office goes to internal restaurants, while at Atlantic Station and Legacy Town Center, the corresponding trips amounted to 5% and 8%, respectively. At Mockingbird Station there was a specialty coffee restaurant less than 200 ft from the office building. No other restaurants were open in the development in the morning. The office building had no internal coffee or snack shop. There was a steady stream of people going between the office building and that restaurant during the morning peak period. The other two developments each had similar restaurants; however, they had roughly 3 to 5 times the office space, they were several blocks away, and Atlantic Station's office building had a coffee stand in its lobby during the morning peak. It is no surprise that the Mockingbird Station capture rate is much higher than that for the other two developments.

Table 98 contains a comparison of land use development unit ratios and internal capture rates for land use pairs in Tables 94 through 97 for which one internal capture percentage is much higher than the other two. Table 98 displays relative constraints on trips in the form of the ratio of development units, which is somewhat of a surrogate for total trips made. For exiting trips, the higher the ratio of origin development units to development units, the constraint is greater (i.e., the fewer the development units at the destination end). For entering trips, the lower the ratio, the constraint is greater (i.e., the fewer the development units) at the origin end of the trip. Hence, a high internal capture percentage for exiting trips could be expected where there is a low development unit ratio and proximity. For example, for P.M. peak-period trips from retail to residential at Legacy Town Center, 196,000 sq ft of retail were feeding trips to 1,360 units of residential (144 sq ft of retail per dwelling unit) at an average distance of 1,240 ft, resulting in 26% internal trip capture. On the other hand, for the same interchange, Country Isles had 109,000 sq ft of retail feeding 368 residential units (296 sq ft of retail per residential unit) at an average distance of 1,525 ft, resulting in 4% internal capture. The origin end trips were more constrained at the destination end at Country Isles (about half as many units receiving trips). In addition, the separation was greater, further constraining trips from retail to residential.

Such is the case for most of the examples shown in Table 98. Except for P.M. peak-period entering trips, constraints imposed by development unit ratios and greater proximity distances result in the lower internal capture percentages.

Conclusions

As Table 98 shows, lower ratios and higher proximity tend to result in higher capture rates. The highest percentages of internal capture are associated with lesser levels of constraint and higher proximity. Only additional data will confirm

Table 98. Comparison of internal capture by development unit ratios and proximities for selected land use pairs.

Land Use		Site[1]	Development Units[2]		Ratio[3]	Proximity (ft)[4]	Internal Capture (%)	Comments
Origin	Destination		Origin	Destination				
Morning Peak-Period Exiting Trips (from Table 94)								
Office	Restaurant	AS	551	1.6	344	1,000	5%	Proximity similar to LTC; most constrained at destination.
		LTC	311	5.1	61	1,200	8%	Proximity similar to AS; slightly more constrained than MS.
		MS	115	1.5	77	200	63%	Closest proximity; close to least constrained at destination.
Residen-tial	Restaurant	AS	798	1.6	499	2,300	0%	Farthest separation; most constrained at destination.
		LTC	1,360	5.1	267	1,470	7%	Moderate proximity; somewhat constrained at destination.
		MS	191	1.5	127	100	20%	Closest proximity; least constrained at destination.
Afternoon Peak-Period Exiting Trips (from Table 95)								
Office	Retail	AS	551	435	1.29	660	6%	About middle for both proximity and constraint at destination.
		LTC	311	196	1.59	975	0%	Third longest separation; third most constrained at destination.
		MS	115	156	0.74	320	9%	Close to least constrained at destination; closest proximity.
		BDM	316	151	2.09	1,125	0%	Second longest separation; second most constrained at destination.
		CI	75	109	0.69	775	9%	Least constrained at destination; third closest proximity.
		VC	315	121	2.60	1,600	6%	Most constrained at destination; longest separation.
Retail	Residential	AS	435	798	0.55	2,280	13%	Second most constrained at destination; longest separation.
		LTC	196	1,360	0.14	1,240	26%	Least constrained at destination; third longest proximity.
		MS	156	191	0.82	170	7%	Most constrained at destination; closest proximity.
		BDM	151	1,144	0.13	825	3%	Least constrained at destination; second longest separation.
		CI	109	368	0.30	1,525	4%	Moderate constraint and proximity.
		VC	121	317	0.38	900	7%	Most constrained at destination; moderate proximity.
Restau-rant	Residential	AS	65	798	.081	2,360	3%	Third least constrained at destination; longest separation.
		LTC	69	1,360	.051	1,325	18%	Third least constrained at destination; third longest separation.
		MS	29	191	.152	200	3%	Most constrained at destination; closest proximity.
		BDM	34	1,144	.030	1,100	6%	Least constrained at destination; fourth longest separation.
		CI	21	368	.057	1,600	----	Second longest separation; second most constrained at destination.
		VC	42	317	.132	600	4%	Second most constrained at destination; second closest. proximity.
Morning Peak-Period Entering Trips (from Table 96)—no instances of one internal capture percentage much higher than at least two others								
Afternoon Peak-Period Entering Trips (from Table 97)—no instances of one internal capture percentage much higher than at least two others								
Retail	Office	AS	435	551	0.79	895	31%	Third least constrained at origin; second closest proximity.
		LTC	196	311	0.63	975	6%	Third most constrained at origin; third longest separation.
		MS	156	115	1.36	150	5%	Close to least constrained at origin; closest proximity.
		BDM	151	316	0.48	1,125	0%	Second most constrained at origin; second longest separation.
		CI	109	75	1.45	775	2%	Least constrained at origin.
		VC	121	315	0.38	1,600	0%	Most constrained at origin; longest separation.
Residen-tial	Office	AS	798	551	1.45	3,100	0%	Second most constrained at origin; farthest separated.
		LTC	1,360	311	4.37	900	57%	Close to least constrained at origin, second closest proximity.
		MS	191	115	1.66	225	2%	Third most constrained at origin; closest proximity.
		BDM	1,144	316	3.62	2,000	0%	Third least constrained at origin; second farthest separated.
		CI	368	75	4.91	1,000	0%	Least constrained at origin; third closest proximity.
		VC	317	315	1.01	1,750	0%	Most constrained at origin; third farthest separated.

Table 98. (Continued).

Land Use		Site[1]	Development Units[2]		Ratio[3]	Proximity (ft)[4]	Internal Capture (%)	Comments
Origin	Destination		Origin	Destination				
Restaurant	Retail	AS	65	435	0.15	430	28%	Most constrained at origin; second closest proximity.
		LTC	69	196	0.35	500	17%	Least constrained at origin.
		MS	29	156	0.19	300	50%	Second most constrained at origin; closest proximity.
		BDM	34	151	0.23	800	1%	Third most constrained at origin; third longest proximity.
		CI	21	109	0.19	1,200	0%	Second most constrained at origin; second longest separation.
		VC	42	121	0.35	1,100	1%	Least constrained at origin; second longest separation.

[1] AS = Atlantic Station; LTC = Legacy Town Center; MS = Mockingbird Station; BDM = Boca del Mar; CI = Country Isles; VC = Village Commons.
[2] All development units are in gross sq ft except residential, which is in dwelling units; development units shown for restaurant during morning peak are for those restaurants that were open.
[3] Origin development units/destination development units. For exiting trips, this constraint at destination end is represented by highest ratio. For entering trips, highest constraint at origin is represented by lowest ratio.
[4] Separation between interaction land uses based on average weighted by trips (rounded to closest 100 ft).

whether other similarly unconstrained and high proximity examples will demonstrate similar internal capture findings.

Where the highest internal capture percentage accompanies both the least constrained and highest proximity, the reported internal capture percentage is probably close to the maximum the researchers would expect to find. These percentages could be considered unconstrained internal capture percentages. However, where the highest internal capture percentage for a land use pair and period is associated with either a moderately high constraint and/or a proximity significantly farther than the minimum, the researchers expect that future surveys could find higher internal capture percentages. For now, the highest internal capture percentages reported in this report for each land use pair and time period should be considered the documented unconstrained internal capture percentages and should be used as unconstrained values.

In general, the three developments surveyed for this project are more compact, are better connected, and have more component land uses than do the three Florida developments. Additionally, the three developments surveyed for this project generally have higher internal capture percentages. This confirms—at least based on the available data—that internal capture can be increased through the use of more interacting land uses, better connectivity, and/or more compactness. Compactness or proximity is addressed later in this section.

Unconstrained internal capture between individual land uses ranges from a low of none found to highs of over 60%. The comparisons also show a wide range of internal capture rates between land use pairs. This results from a number of factors, the most important and projectable of which (at time of zoning) is the balance between land uses within a development. To demonstrate this phenomenon, consider an office building with 20 employees who want to go out for lunch at an onsite restaurant. The restaurant has eight seats. If all employees want to go there, only eight can be seated. The restaurant seating constrains the interaction between the two land uses. Now compare that development to the next similar development down the street where 25 office employees want to go to a restaurant with 16 seats. At that location, as many as 16 employees can go to that restaurant, so even though the restaurant is again the constraint, the interaction is greater. For the third example, consider that 25 office employees can go to an onsite restaurant with 40 seats. In this example, all 25 employees can be seated. In fact, more could be seated. In this example, the office building is the constraint.

Hence, with differing balances of the land uses making up the six surveyed developments, it is understandable that the internal trip capture percentages vary among them. Some of the differences may be explained by the travel distances between trip origins and destinations—that is, proximity. Proximity is addressed in a later section. In addition, there are other factors not quantified in this research that may also affect internal capture such as attractiveness of specific businesses, demographics of trip-makers, and alternative opportunities for similar destinations at nearby developments (i.e., competing opportunities). While these may influence internal trip capture, they may not be known at the time a development is proposed, so it would be difficult to project those characteristics even if a method of projection was available.

Tables 99 through 102 show the highest values from Tables 94 through 97. The values of Tables 99 through 102 show how much internal capture was achieved by the best balances between interacting land uses. In terms of the office/restaurant example described previously, the values of Tables 99 through 102 demonstrated the most unconstrained individual conditions observed at the six developments.

Although it is very possible that MXDs with other balances of development may experience even higher percentages, at

Table 99. Proposed unconstrained values for percent distribution of internal trip destinations for exiting trips—A.M. peak period.

Origin Land Use	Destination Land Use[1]					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	28%	63%	1%	N/A	0%
Retail	29%	N/A	13%	14%	N/A	0%
Restaurant	31%	14%	N/A	4%	N/A	3%
Residential	2%	1%	20%	N/A	N/A	0%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	75%	14%	9%	0%	N/A	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 are accounted for within ITE trip generation rates.

Table 100. Proposed unconstrained values for percent distribution of internal trip destinations for exiting trips—P.M. peak period.

Origin Land Use	Destination Land Use[1]					
	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 are accounted for within ITE trip generation rates.

Table 101. Proposed unconstrained values for percent distribution of internal trip origins for entering trips—A.M. peak period.

Origin Land Use	Destination Land Use[1]					
	Office	Retail	Restaurant	Residential	Cinema	Hotel
Office	N/A	32%	23%	0%	N/A	0%
Retail	4%	N/A	50%	2%	N/A	0%
Restaurant	14%	8%	N/A	5%	N/A	4%
Residential	3%	17%	20%	N/A	N/A	0%
Cinema	N/A	N/A	N/A	N/A	N/A	N/A
Hotel	3%	4%	6%	0%	N/A	N/A

[1] Corresponds to ITE *Trip Generation Handbook* Table 7.2; N/A signifies no data or interchanges within same land use categories that are accounted for within ITE trip generation rates.

Table 102. Proposed unconstrained values for percent distribution of internal trip origins for entering trips—P.M. peak period.

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

[1] Corresponds to ITE *Trip Generation Handbook* Table 7.2; N/A signifies no data or interchanges within same land use categories that are accounted for within ITE trip generation rates.

this point the researchers had no evidence to verify the possibility of higher percentages. Hence, for the purpose of this research project, the researchers concluded that a conservative approach is to use the values of Tables 99 through 102 in the proposed estimation process developed in this project. At a future time, if subsequent surveys using similar procedures show even higher percentages, those results could be incorporated into Tables 99 through 102.

Proximity Effects

Data collected in the pilot study and Florida surveys provided the basis for evaluating proximity effects on internal capture. This analysis was performed to test the hypothesis that travel distance between locations of interacting land uses would affect the degree of interchange between those land uses.

The analyses used surveyed interchanges and walking distances between origin and destination. All three pilot study developments had similar pedestrian environments—outdoor sidewalks adjacent to buildings, mostly along internal two-lane streets or parking lots. Most sidewalks are landscaped with trees, although in Mockingbird Station some sidewalks have no trees. In most cases, the sidewalks are at least 10-ft wide in commercial areas. No sidewalk was considered too narrow for people to walk or pass conveniently. Mockingbird Station has an elevator and one main set and two supplemental sets of stairs between the ground and second levels serving the cinema, a few restaurants, and the DART rail station and bus transfer center. Although the elevator and stairways undoubtedly impede some people in Mockingbird Station, so few destinations required using the stairs that they were not considered further.

The three Florida sites are more spread out with most of the land uses in pods. Each pod is conveniently walkable within. Many of the pods are not interconnected by sidewalks, but are accessible by walking or driving across parking aisles or lots. However, each of these development pods is clearly designed to encourage internal interaction among land use activities.

Data collected and compiled as part of this project provide an indication of the effect of land use proximity on internal capture. It was observed that as distance increases, the level of interaction (i.e., the internal capture) declines. To quantify this relationship, internal capture rates derived from intercept surveys were plotted against proximity of pairs of land uses. All land use pairs for the three newly surveyed pilot study sites and the three Florida sites surveyed in the mid-1990s were plotted.

To illustrate this concept, the top chart in Figure 21 shows the internal capture observed at the six mixed-use sites for trips *from* retail/restaurant uses *to* residential uses. The bottom chart shows internal capture observed *to* residential *from* retail/restaurant. In the charts, each plot point represents a single mixed-use site. From left to right (i.e., closest to farthest), the points represent Mockingbird Station, Legacy Town Center, Boca del Mar, Village Commons, Country Isles, and Atlantic Station.

A key premise about internal capture is that for a trip from one land use to another at a mixed-use site, one direction of travel must be unconstrained (in terms of internal capture) and the other must be constrained. In some instances, the internal capture rates in both directions of travel are in perfect balance and are, therefore, both constrained.

In Figure 21, the presumed unconstrained direction is designated as a large dot and the presumed constrained direction as a small dot. If a site is constrained in the top chart, it must be unconstrained in the bottom chart; if a site is constrained in the bottom chart, it must be unconstrained in the top chart. Each site must have an unconstrained value in one direction or the other. In addition, the unconstrained internal capture values should exceed the constrained values on each individual chart.

In the top chart, internal capture values at the unconstrained sites decrease from around 16% at a proximity of 700 ft to around 5% at a proximity of 2,200 ft. In the bottom chart, internal capture of greater than 50% (at a proximity of 200 ft) decreases to about 20% at a proximity of 1,500 ft.

For many land use pairs, the database consists of only three data points representing unconstrained internal capture—two in one direction and one in the other. It is difficult to reach definitive conclusions about the effect of land use proximity on internal capture with so little data. To improve the likelihood of defining a reliable relationship between proximity and internal capture, data for various land use pairings with potentially common characteristics were grouped and examined. For example, trips to or from retail might have the same proximity-capture characteristics as trips to or from restaurants. As a result of that analysis, two proximity relationships were identified, as Figure 22 shows.

Each point in the figure represents a measured unconstrained internal capture rate for a particular pair of land uses at a single mixed-use site. The *x*-axis in the figure is the proximity distance. The *y*-axis is normalized to represent the percent of the highest unconstrained value for the particular land use pair.

The square-shaped dots in the figure represent the proximity and internal capture values for all land use pairs with residential as the destination, for the origin end of the trip. In other words, these are a combination of the rates

- From office to residential,
- From retail to residential,
- From restaurant to residential,
- From hotel to residential, and
- From cinema to residential.

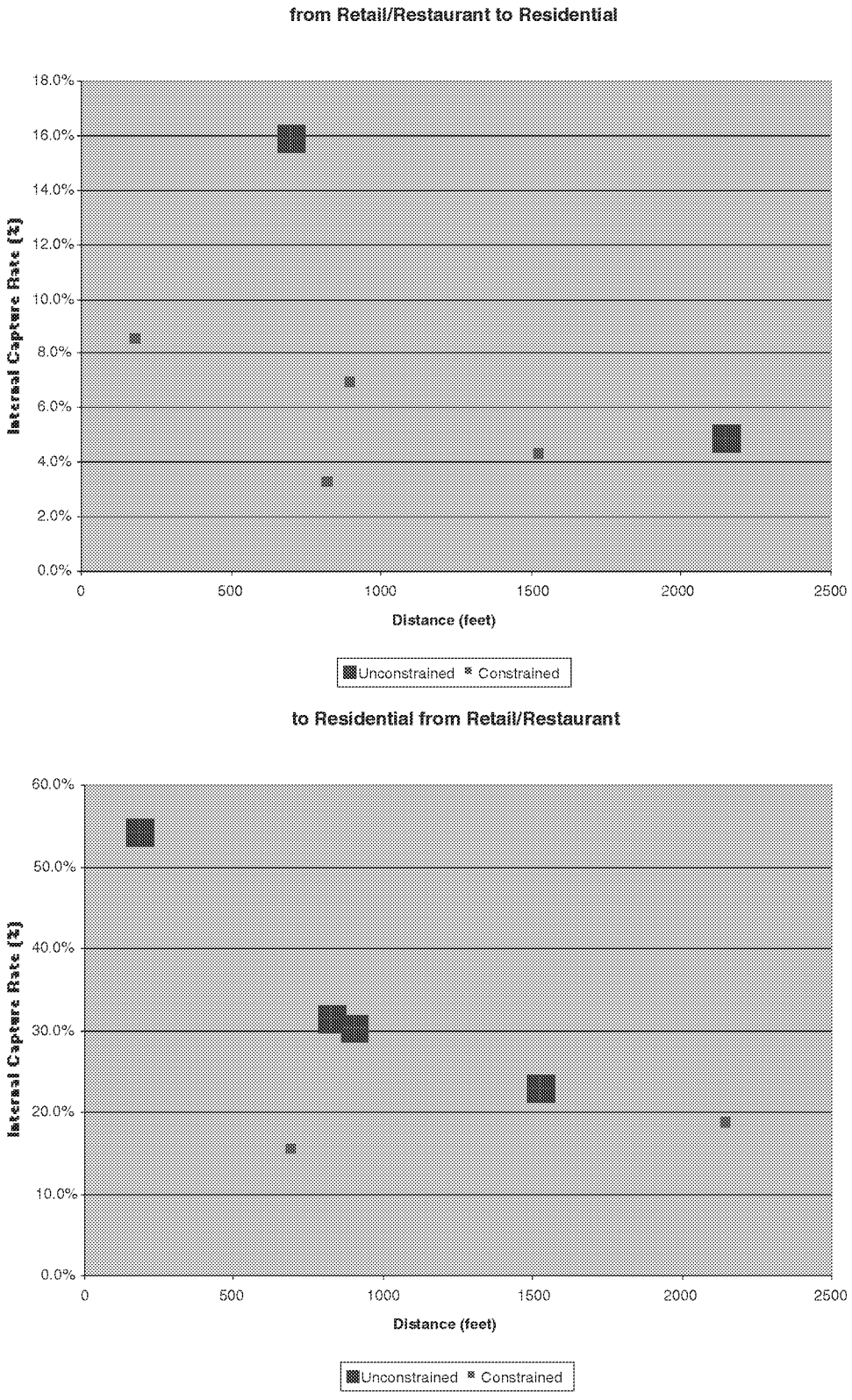


Figure 21. Example of relationship between internal capture percentage in unconstrained and constrained directions (between residential and retail/ restaurant land use pair).

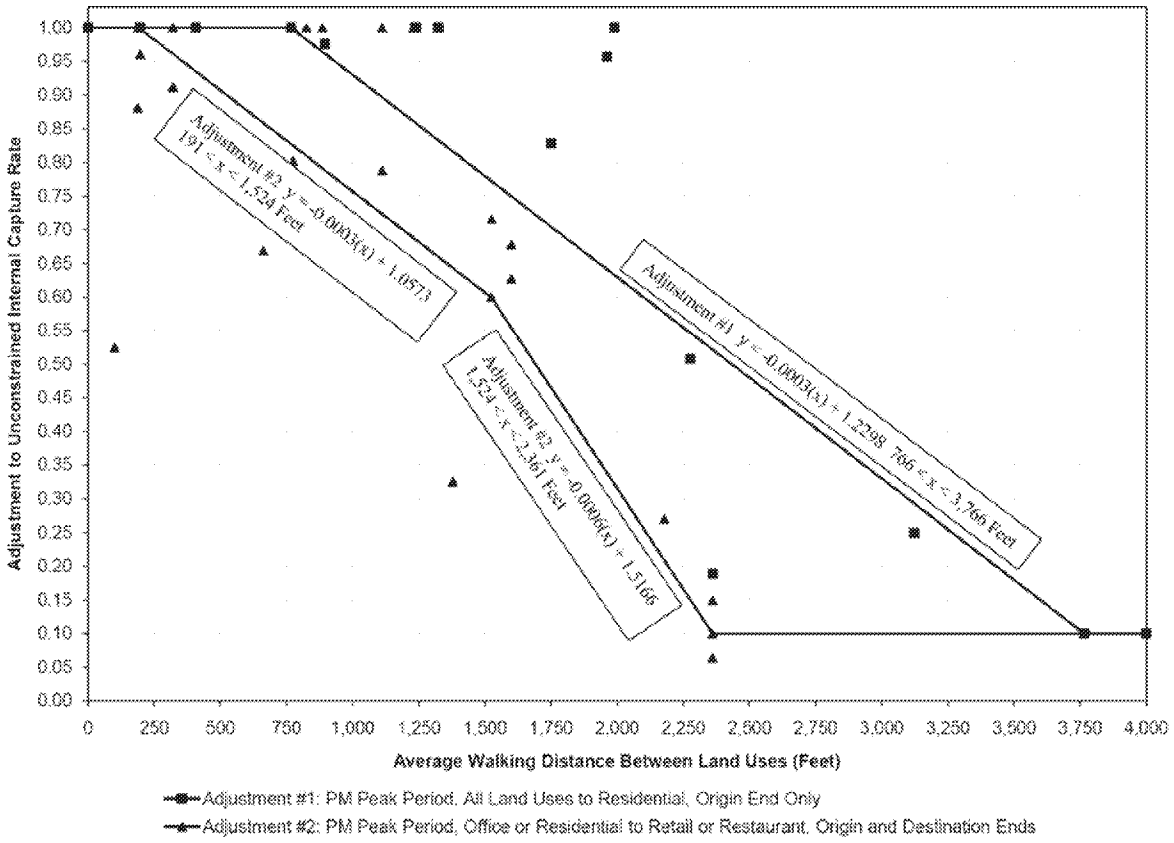


Figure 22. Relationship between proximity and unconstrained internal capture percentage for P.M. peak-period trips for land use pairs and directions with confirmed proximity effects.

The best-fit curve for these data points is shown in the figure as Adjustment #1. The *R*-square for the curve is 0.58. This curve is used in the estimation procedure described later in this chapter to account for land use pair proximity adjustments to unconstrained internal rates.

The triangular-shaped dots in the figure represent the proximity and internal capture values for all land use pairs with either office or residential as the origin and retail or restaurant as the destination, for both the origin and destination ends of the trip. In other words, these are the rates

- From office to retail,
- From office to restaurant,
- From residential to retail,
- From residential to restaurant,
- To retail from office,
- To restaurant from office,
- To retail from residential, and
- To restaurant from residential.

The best-fit curve for these data points is shown in Figure 22 as Adjustment #2. The curve is actually two straight lines that intersect at a proximity distance of 1,524 ft. The *R*-square for the less-than-1,524-ft curve is 0.50. The data at longer distances does not track with that equation and was grouped to create a second intersecting line; that line connected from the extreme end points of the upper line to the midpoint between the two points for the longest proximity distance in this data subset.

The best-fit curve equations in Figure 22 intersect the *x*-axis at proximity distances above which there would presumably be no internal capture. However, at the study sites, internal capture was measured between land uses at the extreme limits of all six mixed-use sites where data were collected. To account for this assumed synergy between land uses no matter how far apart as long as they are both within the mixed-use center, both proximity adjustment lines in the figure are terminated at an arbitrary minimum *y*-axis value of 0.10 (i.e., at 10% of the unconstrained values). This then leaves a minimal internal capture percentage at long distances.

Note that these proximity adjustment relationships represent only a fraction of all potential land use pairs (only 13 proximity adjustment factors out of a total of 60 directional internal capture rates for the 6 land uses). For the remaining 47 land use pairs, a definitive relationship between proximity and internal capture rate could not be established with the available data.

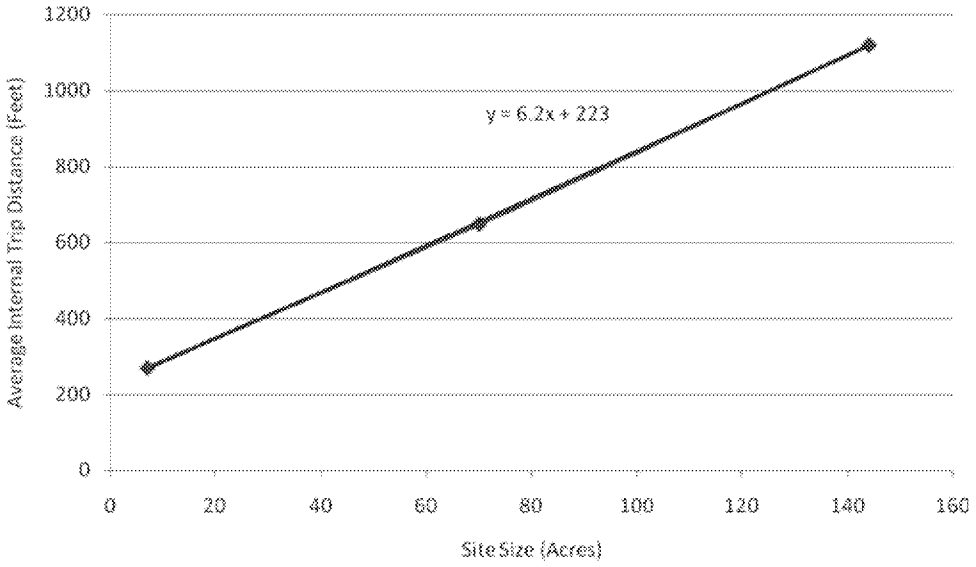


Figure 23. Relationship between average internal travel distances and site size (Mockingbird Station, Atlantic Station, and Legacy Town Center).

Use of Figure 22 requires information from a site plan showing different land uses. During early stages of development planning, it is unlikely that such a layout will always be available; however, a development site will have been defined. Hence, there is a need to be able to estimate travel distances for internal trips based on knowing only site size.

There is no end to the variety of potential site layouts for a given parcel of land, but reasonable assumptions can be made. In the case of internal trip capture estimation, it is prudent to err on the conservative side—that is, to underestimate internal capture rather than to overestimate capture. A few basic assumptions to arrive at a maximum travel distance can be applied. These could include a distance from the property boundary to the building doors and the internal block configuration.

Figure 23 shows the site size and average separation distances between interacting land uses for Mockingbird Station, Atlantic Station, and Legacy Town Center. The straight line relationship may be coincidental since there are differences in the site configurations and layouts of the component land uses. Figure 23 may provide a basis for estimating separation distances if there is no site plan or conceptual land use plan available when an analysis is performed, but this should be validated and refined in further studies.

Procedure for Estimating Internal Capture at a Proposed MXD

The estimation procedure developed in this project is essentially an extension and enhancement of the current ITE method documented in the ITE *Trip Generation Handbook*, 2nd edition (*1*). The recommended method enriches the ITE method in the following manner:

- Adds an A.M. peak-hour period to the existing P.M. peak-hour period;
- Adds three land uses—restaurant, hotel, and cinema—to the existing office, retail, and residential uses;
- Expands the basis for the A.M. and P.M. peak-hour internal capture factors from three developments in one state to six developments in three states and also broadens the types of MXDs included in the database; and
- Adds a proximity adjustment for some land use pairs.

Midday and daily periods, which are included in the ITE *Trip Generation Handbook*, were not addressed since those periods are rarely used in typical TIS and would have increased the data collection cost beyond the available resources. The recommended estimation method consists of the following 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 developed in this project to estimate the number of potential internal trips between each pair of land uses. Include an adjustment for proximity (also developed in this project).
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.

The user of this estimation methodology is cautioned that each MXD has unique characteristics that influence the extent of internal trip capture. Such characteristics include, but are not limited to the following:

- The number and magnitudes of complementary land uses;
- The layout of the land uses relative to each other;
- Specific businesses, residence types, and other component characteristics within each land use category;
- Proximity and connectivity between each pair of land uses;
- Design characteristics of the development and its internal transportation system;
- Specific characteristics of the development's access and parking; and
- Competing opportunities outside the development.

The user is further cautioned that estimates of internal capture for trips between specific pairs of land uses are based on data collected for between one and six surveyed developments. Clearly, additional data on internal capture at existing MXDs would help improve confidence in the accuracy of the internal capture estimates and might result in different internal capture rates.

The researchers believe that the successful but limited validations conducted for this estimation method do confirm that the results provide accurate approximations of external trip generation for typical MXDs consisting of typical office, retail, restaurant, residential, cinema, and hotel land uses. The researchers also believe these approximations are consistent with the accuracy of trip generation estimates for single-use developments as portrayed in such references as *Trip Generation,* 8th edition (*2*). The researchers also believe this methodology provides an advancement and improvement over a similar method described in *Trip Generation Handbook,* 2nd edition (*1*).

The estimation procedure is presented step-by-step in the order it would be performed by the analyst:

- Step 1: Determine whether the methodology is appropriate for your application.
- Step 2: Define the pertinent site characteristics.
- Step 3: Calculate single-use trip generation for the site components.
- Step 4: Estimate the unconstrained internal capture rates for all land use pairs at the site and add adjustments for proximity.
- Step 5: Calculate the balanced internal trips between all land use pairs.
- Step 6: Calculate the overall internal capture rate for the site.

One product of this procedure is an estimate of internal trip capture between pairs of land uses in the development for which internal capture data exist. Users of this estimation procedure are encouraged to carefully and completely read earlier parts of this chapter to understand the background and data supporting this procedure:

- The internal capture estimation methodology and its logic,
- Descriptions of the six developments from which the data behind the estimation methodology were collected,
- Survey findings from the six development sites, and
- The following instructions for use of the estimation methodology.

If the analyst understands the concept of "internal capture balancing" as described earlier in this chapter, these basic instructions should suffice. At the end of this chapter, additional guidance is provided for the analyst who understands the concepts, but who is *unsure of the mechanics* of a specific step. Additional guidance is also provided for the analyst who *thoroughly understands the basic concept and its data limitations,* appreciates the uniqueness of each mixed-use site, and is interested in investigating the potential internal capture impacts of the nuances of a particular site.

Tables 103 through 106 show an automated spreadsheet tool that can be used to compute internal capture and external trip generation for MXDs. The entire workbook consists of six separate worksheets in two sets—one for weekday A.M. street peak-hour estimates and one for weekday P.M. street peak-hour estimates. This description covers the A.M. street peak hour only. The six worksheet and tables in which the A.M. sheets are shown are

- **Table 103** (Worksheet 1): Estimator Input/Output Worksheet—A.M. Street Peak Hour;
- Not shown here (Worksheet 2): Estimator Input/Output Worksheet—P.M. Street Peak Hour;
- **Table 104** (Worksheet 3): Estimator Intermediate Calculations—A.M. Street Peak Hour;
- Not shown here (Worksheet 4): Estimator Intermediate Calculations—P.M. Street Peak Hour;
- **Table 105** (Worksheet 5): Estimator Updated ITE *Trip Generation Handbook* Table 7.1 With Proximity Adjustment (*1,* Ch. 7); and
- **Table 106** (Worksheet 6): Estimator Updated ITE *Trip Generation Handbook* Table 7.2 With Proximity Adjustment (*1,* Ch. 7).

Table 103. Estimator input/output worksheet—A.M. street peak hour (A.M. sheet 1 of 4).

NCHRP 8-51 Internal Trip Capture Estimator			
Project Name:		**Organization:**	
Project Location:		**Performed By:**	
Scenario Description:		**Date:**	
Analysis Year:		**Checked By:**	
Analysis Period:	**AM Street Peak Hour**	**Date:**	

Table 1-A: Base Vehicle-Trip Generation Estimates (Single-Use Site Estimate)						
Land Use	Development Data (*For Information Only*)			Estimated Vehicle-Trips		
	ITE LUCs[1]	Quantity	Units	Total	Entering	Exiting
Office				0		
Retail				0		
Restaurant				0		
Cinema/Entertainment				0		
Residential				0		
Hotel				0		
All Other Land Uses[2]				0		
Total				0	0	0

Table 2-A: Mode Split and Vehicle Occupancy Estimates						
Land Use	Entering Trips			Exiting Trips		
	Veh. Occ.	% Transit	% Non-Motorized	Veh. Occ.	% Transit	% Non-Motorized
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						
All Other Land Uses[2]						

Table 3-A: Average Land Use Interchange Distances (Feet Walking Distance)						
Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						

Table 4-A: Internal Person-Trip Origin-Destination Matrix						
Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		0	0	0	0	0
Retail	0		0	0	0	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	0	0	0	0		0
Hotel	0	0	0	0	0	

Table 5-A: Computations Summary			
	Total	Entering	Exiting
All Person-Trips			
Internal Capture Percentage			
External Vehicle-Trips[3]			
External Transit-Trips[4]			
External Non-Motorized Trips[4]			

Table 6-A: Internal Trip Capture Percentages by Land Use		
Land Use	Entering Trips	Exiting Trips
Office		
Retail		
Restaurant		
Cinema/Entertainment		
Residential		
Hotel		

[1]Land Use Codes (LUCs) from *Trip Generation Informational Report*, published by the Institute of Transportation Engineers.
[2]Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator
[3]Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-A
[4]Person-Trips

Estimator Tool Developed by the Texas Transportation Institute for NCHRP Project 8-51

Table 104. Estimator intermediate calculations—A.M. street peak hour (A.M. sheet 2 of 4).

Project Name:	
Analysis Period:	AM Street Peak Hour

Table 7-A: Conversion of Vehicle-Trip Ends to Person-Trip Ends						
Land Use	Table 7-A (D): Entering Trips			Table 7-A (O): Exiting Trips		
	Veh. Occ.	Vehicle-Trips	Person-Trips	Veh. Occ.	Vehicle-Trips	Person-Trips
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						

Table 8-A (O): Internal Person-Trip Origin-Destination Matrix (Computed at Origin)						
Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		0	0	0	0	0
Retail	0		0	0	0	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	0	0	0	0		0
Hotel	0	0	0	0	0	

Table 8-A (D): Internal Person-Trip Origin-Destination Matrix (Computed at Destination)						
Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		0	0	0	0	0
Retail	0		0	0	0	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	0	0	0	0		0
Hotel	0	0	0	0	0	

Table 9-A (D): Internal and External Trips Summary (Entering Trips)						
Destination Land Use	Person-Trip Estimates			External Trips by Mode		
	Internal	External	Total	Vehicles[1]	Transit[2]	Non-Motorized[2]
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						
All Other Land Uses[3]						

Table 9-A (O): Internal and External Trips Summary (Exiting Trips)						
Origin Land Use	Person-Trip Estimates			External Trips by Mode		
	Internal	External	Total	Vehicles[1]	Transit[2]	Non-Motorized[2]
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						
All Other Land Uses[3]						

[1] Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-A

[2] Person-Trips

[3] Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator

Table 105. Estimator updated ITE *Trip Generation Handbook* (*1*, p. 93) Table 7.1 with proximity adjustment (sheet 3 of 4).

Table 7.1 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	1.000
	To Restaurant	63%	4%	1.000	1.000
	To Cinema/Entertainment	0%	0%	1.000	1.000
	To Residential	1%	2%	1.000	1.000
	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	1.000
	To Restaurant	20%	21%	1.000	1.000
	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

Table 7.1a 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%	20.0%
	To Restaurant	63.0%	4.0%
	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%	42.0%
	To Restaurant	20.0%	21.0%
	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 106. Estimator updated ITE *Trip Generation Handbook* Table 7.2 with proximity adjustment (sheet 4 of 4).

Table 7.2 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	1.000
	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	1.000
	From Hotel	4%	2%	1.000	1.000
To RESTAURANT	From Office	23%	2%	1.000	1.000
	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	1.000
	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%	0%	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

Table 7.2a 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%	8.0%
	From Retail	0.0%	0.0%
	From Restaurant	8.0%	50.0%
	From Cinema/Entertainment	0.0%	4.0%
	From Residential	17.0%	10.0%
	From Hotel	4.0%	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%	14.0%
	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%	0.0%
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%

The following description of the computational process has been put into the form of these spreadsheets, and there is an accompanying Excel spreadsheet workbook to automate the computations. It is intended that the spreadsheet be used to perform computations. The spreadsheet workbook is explained for the A.M. street peak hour and consists of the four spreadsheets shown in Tables 103 through 106. The P.M. street peak-hour estimate is prepared identically. The estimator—either automated or manual—was designed to have a cover sheet that contains all input and output of interest, with look-up data and intermediate computations on the subsequent spreadsheets. The description that follows uses the spreadsheet as an example.

Step 1: Determine Whether the Methodology Is Appropriate for Your Application

The procedure should only be used for estimating internal capture at an MXD that has characteristics resembling the sites from which the internal capture rates have been derived. This step screens/eliminates sites for which the procedure is appropriate.

- **Development Type:** The MXD should be a single, physically and functionally integrated development on a single block or a group of contiguous blocks with three or more revenue-producing uses, with internal pedestrian and vehicular connectivity, and with shared parking among some or all uses. The site should have sufficient parking supply to meet demand although the most convenient parking may sometimes fill during peak periods.
- **Development Location:** The MXD should be downtown fringe, general urban, or suburban. It should not be located either within or adjacent to a central business district (CBD).
- **Development Size:** The MXD should have at least 100,000 sq ft of building space within an overall acreage of up to roughly 300 acres. The MXD can be a single site, a block, or a district or neighborhood (with multiple interconnected or interactive blocks within a defined boundary); however, this procedure should not be used for a SAC composed of different adjacent, but not directly connected, land uses.
- **Land Use Mix:** The MXD should consist of a combination of at least three of the following uses: retail, restaurant, office, residential, hotel, and cinema. Internal capture for land uses beyond these six should be considered to be zero (unless comparable survey data for other land uses are provided) because there are no supporting data from which to derive an appropriate percentage. In addition, if a substantial portion of the land use at a mixed-use site is outside these six land uses, the reported internal capture rates might not be appropriate.
- **ITE Trip Generation Database:** The MXD should not already be covered in the ITE trip generation database as reported in the latest edition of *Trip Generation* (*2*). Current ITE land use classifications that already account for internal trip-making include shopping center, office park with retail, office building with ground floor retail or onsite cafeteria, and hotel with limited retail and restaurant space.
- **Time Period for Analysis:** The internal capture rates contained in this methodology cover the weekday A.M. and P.M. peak periods for adjacent street traffic. Weekday peak period internal capture rates are not appropriate for estimating weekend internal capture—or weekday midday internal capture—or daily internal capture unless survey data for those periods become available.

Step 2: Define the Pertinent Site Characteristics

In this step, the following data describing pertinent site characteristics are assembled:

- The specific land uses in the mixed-use site in sufficient detail so that vehicle or person trip generation can be estimated for each individual land use (described in Steps 2A and 2B); and
- Building proximity for each pair of land uses (described in Step 2B).

The source of much of this information is a proposed site plan, if one exists. If a site plan is not available, assumptions must be made about general site layout, individual land uses, sharing of parking, and the internal pedestrian circulation system.

Step 2A: Identify Land Uses

Identify specific land use components of the MXD and assign them into the six classifications—office, retail, restaurant, residential, cinema, and hotel—covered by the estimation procedure. Any component land uses that do not fit into those six classifications or are too unique to be considered normal for a classification should be kept separate. If in doubt, keep a land use separate from the six listed classifications.

Define the land use components in as much detail as possible. The greatest detail will allow for greatest precision in trip-generation estimates. The internal capture relationships quantified in this methodology are provided at the aggregated land use level. It is important to separate the retail and restaurant uses in this step because they exhibit different internal cap-

ture characteristics. If the restaurant component is expected to be only a minor portion of the overall retail component of the MXD (e.g., a traditional shopping center), assume the site has no restaurant component.

Enter the development units by land use in sub Table 1-A of Table 103 and the corresponding sub table in the P.M. peak period Worksheet 2 (not shown). ITE land use codes are found in the ITE *Trip Generation* report (*2*). The "quantity" is the number of development units. "Units" are the applicable development units such as dwelling units or gross sq ft of building floor area. Undefined shopping center space should all be classified as just that—shopping center (ITE land use classification Code 820 or similar applicable classification). No guesses should be made as to how it may break out into cinema, restaurant, and so forth, unless that has already been determined in the development plan.

Step 2B: Determine Proximity

Determine the walking distance between each pair of interacting land uses within the MXD. This component of the estimation procedure requires particular consistency in application. If there is only one building of each land use classification (e.g., one apartment building and one office building), enter the distance between the entrances of each building. If there is a group of buildings or businesses of one land use category in an area, the distance used should be the weighted (by trip generation) average of distances between each pair of buildings of the interacting land uses.

For each pair of interacting land uses, determine the actual walking distance along the most direct and reasonable path. Do not use the airline (i.e., shortest direct) distance. For the A.M. street peak hour, there are no proximity adjustments, so the distances are not entered into sub Table 3-A of Table 103; however, proximity distances are to be entered into sub Table 3-P of Worksheet 2 for the P.M. street peak-hour analyses.

Step 3: Calculate Single-Use Trip Generation for the Site Components

In this step, trip generation is estimated for each land use within the MXD. The procedure accounts for (1) trip-generating characteristics of the specific land uses (described in Step 3A) and (2) vehicle occupancy (described in Step 3B).

Mode split is not applied here because it is assumed that the ITE trip generation data, which was almost all collected in suburban areas, is almost totally by motor vehicle. There is typically no or very limited transit and walking for trips to and from development sites.

The recommended approach is to work in person trips rather than in vehicle trips, but the analyst can begin from vehicle trips and use mode split and vehicle occupancy to generate person trips. If the analyst wishes to work in assumed ITE conditions (no adjustments for mode split or vehicle occupancy), then it is workable to perform all calculations in this step (skipping Steps 3B and 3C) and all subsequent steps in vehicle trips. In this case, input mode split as 100% vehicle occupancy is 1.00; these will cause the inherent ITE values to be reflected through the process.

Step 3A: Estimate Trip Generation

Enter vehicle trips in the two right columns of Table 103, sub Table 1-A for the A.M. peak hour and in corresponding sub Table 1-P on Worksheet 2 for the P.M. peak hour. For each land use within the MXD, estimate single-use trip generation individually. Then, sum the individual estimates into the six aggregated classifications: office, retail, restaurant, residential, cinema, and hotel. Do not combine development units into the six classifications and then use one single-use trip generation rate or equation to estimate trip generation for the aggregated land use. If specific land uses are not known at the time of analysis, use a more general category—for example, at zoning, no specific retail categories may be known, so "shopping center" may be the best approximation.

The nationally accepted method of estimating site trip generation is to use ITE *Trip Generation* report (*2*) trip generation rates, equations, and data and apply them as described in the ITE *Trip Generation Handbook* (*1*). However, local agencies may have special local rates they prefer to use. Locally determined rates accepted by the reviewing agency can also be used. The choice of trip generation rates/equations should be discussed with the review agency prior to preparing the estimates.

Analysts should keep track of the directional split (inbound/outbound) of the generated trips for each land use. Directional trips are essential to the proper balancing of internal travel demand within the MXD (described in Step 4). If beginning directly with person trips, see the last paragraph of Step 3C.

Step 3B: Enter Vehicle Occupancy

Enter vehicle occupancy for the trips generated by each land use in Table 103, sub Table 2-A for the A.M. peak hour and corresponding sub Table 2-P of Worksheet 2 for the P.M. peak hour. The vehicle occupancy can be different for entering and exiting vehicles. The vehicle occupancy rate should be based on local data if possible. It is acceptable to use an overall average vehicle occupancy rate based on a survey of a similar mixed-use site or to use land use specific vehicle occupancy rates based on surveys of nearby similar land uses. Metropolitan planning organization (MPO) data could also

be used to derive relevant averages for comparable trips in the region. It is important to use vehicle-occupancy rates that reflect travel during the analysis period. Do not use daily vehicle-occupancy rates.

Step 3C: Enter Mode Split for MXD

This is the mode split for the MXD. It does not apply to the base trip generation rates. Percentages of trips by transit and non-motorized mode (e.g., walk, bike) may be different by direction. Enter the percent of directional trips by each mode for each land use in Table 103, sub Table 2-A for the A.M. peak hour and corresponding sub Table 2-P of Worksheet 2 for the P.M. peak hour. The product of Step 3B is an estimate of the number of person-trips in vehicles entering and exiting each of the mixed-use development land uses. It is important to use mode of access distributions that reflect travel to and from the MXD *during the analysis period,* not daily.

Step 3D: Compute Person Trips

Using the vehicle trips entered in Table 103, sub Table 1-A, and vehicle occupancies entered in sub Table 2-A, compute directional trip generation for each land use:

Person trips = vehicle trips × vehicle occupancy.

Enter the person trips in Table 104, sub Table 7-A for A.M. trips. There are corresponding tables in Worksheet 2 for computing P.M. estimates.

Step 4: Estimate the Unconstrained Internal Capture Rates for All Land Use Pairs at the Site

In this step, unconstrained internal capture rates that are appropriate for the subject development site are determined. This determination begins with the base internal capture rates documented in this research (described in Step 4A); the rates are then modified to account for specific proximity characteristics of the subject site (described in Step 4B).

Step 4A: Estimate Base Internal Capture Rates

Internal trip capture rates are provided for land use pairs involving the following generic land use classifications: office, retail, restaurant, residential, hotel, and cinema. Trip generation estimates were made in Step 3 for specific types of land uses. For estimating internal capture, land use classifications should be combined into the above general categories before continuing into the estimation process—for example, for a development containing apartments and townhouses, for estimating internal capture, these would be combined as residential.

When applying the internal capture estimation methodology, use the percentages from the third and fourth columns of sub Table 7.1 and sub Table 7.2 within Tables 105 and 106. Each sub table contains both A.M. and P.M. peak-hour data. If a local survey has been conducted using data collection and compilation procedures described in this report, the resulting internal capture percentages may be used. Users are cautioned that data gathered in a method different than the data collection methods described in this report may not be applicable and could produce inaccurate internal capture estimates.

For land uses other than the six classifications provided herein, users should assume no internal capture (unless comparable survey data for other land uses are provided). The percentages in Tables 105 and 106 are **not applicable** to other land uses. They are also only for the weekday A.M. and P.M. peak periods and should not be used for other periods.

In some cases, review agencies may set policies to limit the percent internal capture they will permit to be applied based on their own justifications. Such limitations would represent agency policy to use what they consider more conservative trip generation estimates (e.g., to avoid the possibility of underestimating trip generation) and are not to be confused with the findings of this project.

Step 4B: Apply Proximity Adjustment Factors (P.M. Peak Period Only)

The unconstrained internal capture values presented in Tables 105 and 106 represent rates to be expected between land use pairs that are not constrained by proximity. As some land use pairs become farther apart, the unconstrained internal capture rates will decline. This step accounts for the specific proximity characteristics of the MXD.

Proximity adjustment factors are presented below for only the land use pairs for which the available data clearly demonstrates a direct relationship between proximity and internal capture rate. These are comprised of only P.M. peak-period trips; no proximity adjustments are available for the A.M. peak period:

- From all land uses to residential and applicable only to the trip origin end;
- From office to retail or restaurant, applicable at both origin and destination trip ends; and
- From residential to retail or restaurant, applicable at both origin and destination trip ends.

These factors are only applicable during the P.M. peak hour. If a land use pair is not included in the above list, use

Table 107. Proximity adjustment factors for P.M. peak hour internal capture rates.

From Land Use	To Land Use	Proximity Distance	Equation to Calculate Proximity Adjustment Factor[1]
Office	Residential	770–3,760 ft	Factor = 1.23 – 0.0003 x (Distance)
Retail	Residential	770–3,760 ft	Factor = 1.23 – 0.0003 x (Distance)
Restaurant	Residential	770–3,760 ft	Factor = 1.23 – 0.0003 x (Distance)
Cinema	Residential	770–3,760 ft	Factor = 1.23 – 0.0003 x (Distance)
Hotel	Residential	770–3,760 ft	Factor = 1.23 – 0.0003 x (Distance)
From Land Use	**To Land Use**	**Proximity Distance**	**Equation to Calculate Proximity Adjustment Factor[2]**
Office	Retail	190–1,524 ft	Factor = 1.06 – 0.0003 x (Distance)
		1,525–2,360 ft	Factor = 1.52 – 0.0006 x (Distance)
Residential	Retail	190–1,524 ft	Factor = 1.06 – 0.0003 x (Distance)
		1,525–2,360 ft	Factor = 1.52 – 0.0006 x (Distance)
Office	Restaurant	190–1,524 ft	Factor = 1.06 – 0.0003 x (Distance)
		1,525–2,360 ft	Factor = 1.52 – 0.0006 x (Distance)
Residential	Restaurant	190–1,524 ft	Factor = 1.06 – 0.0003 x (Distance)
		1,525–2,360 ft	Factor = 1.52 – 0.0006 x (Distance)

[1] Use 1.00 proximity factor for distances shorter than 770 ft and 0.10 for distances longer than 3,760 ft.
[2] Use 1.00 proximity factor for distances shorter than 190 ft and 0.10 for distances longer than 2,360 ft.

the Table 105 and Table 106 unconstrained internal capture values without adjustment.

Locate the appropriate land use pair and direction in Table 107. Compare the MXD proximity to the proximity thresholds in the table:

- If the proximity is less than or equal to the value in the third column of Table 107, use the unconstrained internal capture values in Table 105 or Table 106, whichever is appropriate. Remember that sub Table 7.1 values in Table 105 will be applied to the outbound trips; sub Table 7.2 values in Table 106 will be applied to inbound trips.
- If the proximity is within the range shown in the third column of Table 107, use the equation provided in the fourth column to calculate the proximity adjustment factor. Enter the proximity adjustment in the right column of sub Table 7.1 of Table 105 and in sub Table 7.2 of Table 106.
- If the value calculated in the fourth column is a proximity adjustment factor of less than 0.10, use the minimum value of 0.10 in subsequent steps.
- For each row of sub Table 7.1, multiply the P.M. peak-hour adjustment factors in Column 4 by the P.M. proximity adjustment factor in the right column of that table. Place the resulting product in the right column of sub Table 7.1a of Table 105. Repeat the same for sub Table 7.2 in Table 106.
- Enter the adjusted internal capture percentage in the right columns of sub Table 7.1a in Table 105 and in sub Table 7.2a in Table 106.

Step 4C: Calculate Proximity-Adjusted Unconstrained Internal Trips at Origin (Outbound) and at Destination (Inbound)

In Table 104, sub Tables 7-A(D) and 7-A(O) show the proximity adjusted internal vehicle and person trips at the origin and destination, respectively. Be sure that any mode splits from Table 103 sub Table 2-A have been incorporated.

In Table 104, each cell in the 8-A(O) and 8-A(D) sub tables is computed as follows:

1. Multiply the direction trips in Table 104, sub Table 7-A(O) (e.g., office exiting trips) by the Table 105 sub Table 7.1 internal capture percentages (e.g., A.M. peak hour 1% to residential).
2. Place the product in Table 104, sub Table 8-A(O). Do the same for the entering trips.
3. Complete the 8-A sub tables of Table 104 in the same manner.

P.M. street peak-hour internal trips can be computed the same way using the corresponding P.M. tables.

Step 5: Calculate the Balanced Internal Trips between All Land Use Pairs

Estimate balanced demand volume by direction by comparing the values in the corresponding cells of sub Tables 8-A(O) and 8-A(D) for each land use pair and select the lower value.

This step is to balance the estimates of directional internally captured trips between the interacting land uses. This must be performed for two reasons:

1. Estimates for each land use are based on the quantity of that land use and its capacity to send or receive internal trips. There is no assurance without balancing that there is enough capacity on the receiving end to accept as many trips as are being sent.
2. The total trips sent internally (i.e., captured trips) from one use to another must equal the number being received at the other end of the trip. Both numbers must be the same.

Figure 20 shows this process. To perform this computation, person trips begin from Table 104, sub Tables 8-A(O) and 8-A(D). Compare corresponding cells and select the lowest figure (i.e., the fewest unconstrained internal trips). For example, compare the "from retail to office" cell. If sub Table 8-A(O) shows 4.4 trips and sub Table 8-A(D) shows 70.4 trips, select the lower value (i.e., 4.4) and enter it into the "retail to office" cell of Table 103, sub Table 4-A in round numbers (4, in this example). Complete sub Table 4-A of Table 103 in this manner. These are the estimated internal trips.

As shown above, P.M. street peak-hour estimates can be computed using the corresponding tables.

Step 6: Calculate the Overall Internal Capture Rate for the Site

In Table 104, sub Tables 9-A (D) and 9-A(O) are used to summarize internally captured trips and compute the external trips. This is started in person trips. Column 2 of sub Table 9-A(D) is computed by summing the office column of sub Table 4-A of Table 103. Column 4 comes directly from Table 104, sub Table 7-A(D), Column 4. The external trips in Column 3 are the difference between the total and internal person trips in each row.

The right three columns in sub Table 9-A(D) are computed by multiplying the external vehicle trips in Column 3 of that table by the applicable mode split percentage in the two right columns of sub Table 2-A of Table 103. The transit external trips are computed by multiplying the transit mode split percentage (Column 3, sub Table 2-A) by the number of external person trips (sub Table 9-A(D), Column 3). Non-motorized person trips are calculated similarly. For vehicle trips, use the equation of

$$\text{vehicle trips} = \frac{\left(\begin{array}{l}\text{external trips} - \text{transit trips} \\ - \text{non-motorized trips}\end{array}\right)}{\text{vehicle occupancy}}$$

where the vehicle occupancy comes from Table 103, sub Table 2-A, Column 2.

For the bottom row in sub Tables 9-A(D) and 9-A(O), there are no internal trips (no data to support such estimates). Values are taken directly from Table 103, sub Table 1-A, the right two columns. Totals from sub Tables 9-A(D) and 9-A(O) are then entered in Table 103, sub Table 5-A. The entering and exiting values in Row 1 of that table are the totals from Column 4, sub Tables 9-A(O) and 9-A(D). The total in Column 2 is the sum of the entering and exiting volumes. The second row of sub Table 5-A is the sum of Column 2 of sub Tables 9-A(O) and 9-A(D) divided by the sub Table 5-A, Row 1 entries then multiplied by 100%. The remaining entries in sub Table 5-A are taken from sub Tables 9-A(D) and 9-A(O) in a similar manner. Sub Table 6-A is computed using the row figures in sub Tables 9-A(D) and 9-A(O).

Use the corresponding tables to compute P.M. street peak-hour estimates.

Reminder

The previous computational description follows a spreadsheet workbook designed to have a cover sheet that contains all input and output of interest, with look-up data and intermediate computations on the subsequent worksheets. It is intended that the spreadsheet workbook be used to perform computations. If performed manually, analysts may wish to reorder component tables to provide a more logical order.

Additional Guidance

Site Location

The researchers recognize there is internal capture for developments other than single, physically and functionally integrated MXDs (such as CBDs and SACs). The concept of unconstrained internal capture rates constrained by the mix and proximity of land uses also applies to those development patterns. However, the data reported herein include only developments that satisfy the "mixed-use" definition used in this report.

Mixed-Use Development Already in ITE Trip Generation Database

In a typical shopping center that is included in the ITE *Trip Generation* report (*2*), the site restaurants are convenience restaurants that feed off the retail visitors (rather than serve as destination restaurants). In some MXDs, some of the restaurants may be oriented to the convenience of internal users and not draw heavily from outside the development. These may be snack shops, fast food, or other small restaurants rather than full-scale restaurants that are destination eating places. Analysts may wish to consider them part of a shopping center use if the retail uses generate a large portion of the convenience

restaurant business. If this is to be done, it is suggested that not more than the first 5% of overall retail/restaurant square footage be considered as convenience restaurant. This should exclude all destination and free-standing restaurants. In such a case, if greater than 5%, assume the amount above 5% to be restaurant—generate trips accordingly and keep this portion separate for determining the internal capture rates. Add the convenience restaurant square footage to the retail space.

The ITE *Trip Generation* report (*2*) and the *Trip Generation Handbook* (*1*) already include several types of MXDs. Current ITE land use classifications that already account for internal trip-making include the following:

- **Shopping center:** shopping-center trip-generation rates are based on retail developments that already normally include restaurant, cinema, and limited other entertainment uses; however, "if a shopping center is planned to have out-parcel development of a significantly different land use classification or a very large percentage of overall gross leasable area, the site could be considered a mixed-use development for the purpose of estimating site trip generation" (*1*).
- **Office park with retail:** "A subdivision or planned unit development containing general office buildings and support services such as banks, restaurants and service stations arranged in a park- or campus-like atmosphere should be considered as an office park (ITE Land Use Code 750 form ITE *Trip Generation* report)," not as an MXD (*1*).
- **Office building with ground floor retail or onsite cafeteria:** "An office building with support retail or restaurant facilities contained inside the building should be treated as a general office building (Land Use Code 710) because the trip generation rates and equations already reflect the presence of such support uses" (*1*).
- **Hotel with limited retail and restaurant space.** "A hotel with an onsite restaurant and small retail falls within Land Use Code 310 and should not be treated as a MXD" (*1*).

Land Use Split between Retail and Restaurant

The internal capture rates presented earlier in Tables 103 through 106 treat retail and restaurant as separate land uses. To use these rates, it is necessary to differentiate between retail and restaurant uses at the mixed-use site. It is possible that the analyst will only know total retail (i.e., retail plus restaurant) square footage. In that situation, two different approaches are suggested for estimating internal capture:

1. Assume the same retail/restaurant split found at the six sites for which data were available; and
2. Assume and test different retail/restaurant splits (within a reasonable range) to determine whether the retail/restaurant split changes site trip generation and internal capture significantly.

The six-step estimation procedure is merely a mathematical technique for estimating internal capture; the researchers are not trying to suggest how to adhere to specific local TIA requirements.

Proximity of Land Uses

If the analyst knows (or can confidently assume) the land uses and their sizes but does not know their proximities, the analyst must prepare at least a schematic site plan. Do *not* simply assume that each pair of land uses consists of buildings adjacent to each other (e.g., within 200 ft). At the minimum, test different proximities and observe their effects on overall internal capture at the mixed-use site.

If development information is not yet detailed enough to permit a direct estimate of proximity distances, use the site size and Figure 23 to estimate the average probable separation, then use that distance for the proximities between each land use pair. This will produce rough estimates of internal capture, at least related to proximity. As the site plan evolves, use more specific information for proximity.

The recommended approach is to separate each land use into blocks, with a block being the building faces along both sides of a street (see Figure 24). Locate the centroid of the entrances of a specific land use for each block and measure distances between each block of that land use and the other interacting land use. If there are multiple blocks, then make measurements between all pairs of blocks and use the weighted average distance, using trip generation involved in each interchange as the weighting factor.

Figure 24 shows an example of a multi-block scenario. If the dots represent the centroid of the entrances for Land Use A in each block, and if d_1 and d_2 are the respective distances to Land Use B in Block 3, then the weighted average distance between Land Uses A and B is

$$\frac{d_1 \times (\text{sq ft in Block 1 of Land Use A}) + d_2 \times (\text{sq ft in Block 2 of Land Use A})}{(\text{sq ft in Blocks 1 and 2 of Land Use A}).}$$

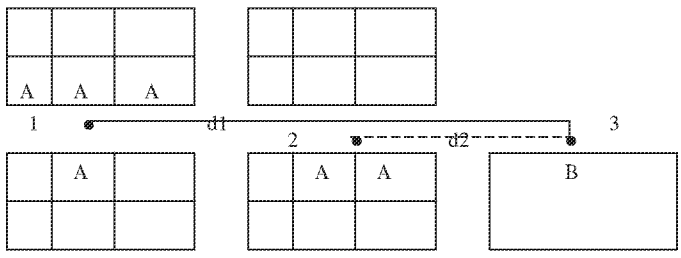


Figure 24. Sample blocks including Land Uses A and B.

Proximity Adjustment Factor

The proximity adjustment factors presented previously are based on the observed effects of changing walk distances on internal capture rates between land use pairs. These walking distances were measured along available routes that did not require the use of stairways or other obstacles or delaying factors. The paths were also along clear, adequately wide walkways in very good repair.

Mode Share of Internal Trips

The great majority of internal trips to a site will be either walked or driven onsite (many sites also accommodate bicycle travel)—that is, few internal trips within a site will use major public streets either on the periphery of the development or internal to the development. An exception will be trips driven within a multi-block area of complementary and interacting land uses.

For those MXD sites or areas where all internal trips will be walked, bicycled, or driven onsite (on private internal streets or through parking areas), the mode of access to the site should be used to factor vehicle external trip generation for the analysis period. The ITE trip generation rates and equations generally incorporate suburban mode splits. Limited observations within the ITE dataset point toward about 2% of the trips arriving by walking, bicycling, or transit. This would be a reasonable assumption to apply to ITE data. The other 98% arrives as either vehicle drivers or passengers.

After arriving on the site, internal trips that could or might be driven will be limited by (1) the convenience (or lack thereof) of driving versus walking, and (2) the availability of a motor vehicle for the trip. Some MXDs may also have internal shuttles. Hence, it is a reasonable assumption that the beginning point for internal trips by personal vehicle will be no higher than the mode of access to the site and possibly far lower if the development is walkable.

The mode split is used at the end of the process to determine the number of external person trips being taken by personal vehicle, transit, and non-motorized modes such as bicycle or walking. The mode split can be derived from surveys of similar land uses near the study site or from other estimates relevant to the study location and land uses (e.g., regional or localized travel data available from MPOs or other credible sources).

Pass-By Trips

"The application of pass-by trip reductions should be applicable to (mixed-use) sites. However, none of the internal trips can be of a pass-by nature because they do not travel on the adjacent (external) street system" (*1*, p. 100). Pass-by trip percentages are applicable only to external trips—those trips that enter or exit the adjacent street system. They should be applied after the external trips are estimated, not to the base vehicle-trip generation.

Unconstrained Internal Capture Rates

The unconstrained internal capture rates presented in Tables 99 through 102 reflect data collected at as many as six MXDs. For several of the land uses, the potential sums of internal capture rates appear to be illogical—for example, the sum of 124% for internal capture for trips to office in the P.M. peak hour (see Table 102) is impossible. However, these "illogical" sums will not occur for three reasons:

- **First, they would require unlikely balances of interacting land uses.** For example, to maximize the inbound office internal capture rate during the P.M. peak hour, the retail space would need to be 20 times the office space and the restaurant space would be half of the office space; a mix with so little office is essentially a shopping center. While the internal capture for trips to the office from retail would be high, the opposite would not be the case. The overall internal capture rate would be modest.
- **Second, the proximity adjustment factors will reduce the effective unconstrained internal capture rates** because of the possibility that all office and residential uses will not be located within 200 ft of all retail and restaurant at the mixed-use site.
- **Third, it appears to be mathematically impossible for all unconstrained maximum internal capture percentages to occur at the same time within a development because each maximum requires a different ratio of development units for the pair of land uses involved.** For example, using Tables 99 through 101, for the A.M. peak to achieve 65% internal capture for trips from office to restaurant, restaurant would need to have $6\frac{2}{3}$ times the square footage of the office for a balance to be achieved (the ratio of sq ft of each land use to achieve a complete balance between sending and receiving land uses necessary to obtain the unconstrained internal capture percentage). To achieve the 28% internal capture of trips from office to retail, the square footage of office would have to be $28\frac{2}{3}$ times the square footage of retail. The office to residential is 0% due to the value in Table 101. So, for 100,000 sq ft of retail, office would have to have 87,500 sq ft of office and about 239,700 sq ft of restaurant to reach 91% internal capture. At average size of about 5,000 sq ft per restaurant, that would amount to 48 restaurants, a very unlikely balance—and that is only the balance results

for trips from office. To achieve the maximum for internal trips to office, office square footage needs to be ½ times the retail square footage, which would not maximize trips in the opposite direction. To maximize trips from restaurant to office, the office would have to have 4½ times the square footage—again, different from what would be required for the opposite direction to maximize. Following the same process, one can quickly see that it is mathematically impossible to achieve all unconstrained internal capture percentages concurrently for a given MXD. In the unlikely occurrence that the sum of internal trips should total over 100% of the total trip generation for a land use, it is recommended that the total internal trips be reduced to 100%, and the interchanges from the affected land use to other interacting land uses be proportionally reduced. This would not yield a total internal capture of 100 percent; rather, it would be one interchange and one direction that would be estimated to be 100%.

Validation of Estimation Procedure

This estimation procedure was tested against development and cordon count data for several developments and found to replicate actual results for MXDs fairly well. The validation procedure and results are described in Appendix F.

CHAPTER 4

Conclusions, Recommendations, and Suggested Research

This chapter pulls together the conclusions, recommendations, and lessons learned during this project. Statements made herein are intended to help practitioners use the results of this project either to estimate internal capture for MXDs or to add to the database and perhaps further refine the methodology and tools provided.

Existing Practice

Internal capture for MXDs is of most interest to those who either prepare or review TIAs for such developments, but transportation planners and developer consultants are also interested in internal capture and the resulting external trip generation. Some additional uses include planning for TODs and preparing environmental impact statements or assessments.

ITE provides a recommended practice for estimating internal capture and associated external trip generation for what it calls "multi-use developments." As described, those developments have characteristics similar to the common definition used for MXDs. The research team accepted the two terms as used as being essentially equal. The ITE method documented in their *Trip Generation Handbook* (*1*) is the most widely used technical method.

The other widely used approach is a policy-determined flat percentage reduction in external trips. Such percentages are established by local planning, zoning, or transportation engineering officials for use in TIAs prepared to support applications for zoning, subdivision, site plan approval, or access permits. The percentages are usually arbitrarily selected for use throughout the jurisdiction. These percentages are most typically in the range of 10%, but were found to range from less than 5% to as much as 25%. Most percentages are conservative compared with internal capture data found in past research and this project. Other approaches found included tables of applicable rates and a formula to modify ITE estimates.

The ITE method covers only trips among the three most frequent components of MXDs—office, retail, and residential. Data are available for the weekday P.M. peak hour, for midday, and for what is called "daily," but which is drawn from data collected between noon and 6:30 P.M. The ITE method has nothing for the A.M. peak hour. The policy percentages mentioned above are applied to each analysis period used.

There is some limited use of invalid applications for internal capture estimation. The two found most frequently were use of shared parking reduction percentages and metropolitan area travel forecast model intrazonal trip percentages. Shared parking reductions apply only to parking accumulations in a parking facility serving multiple uses; the percentage reduction applies only to parking accumulation, not trip generation. Intrazonal trips apply to complete traffic analysis zones used in regional travel forecast models. Zones may range from a block to a square mile. Intrazonal trips are for the complete zone and are not applicable to portions of a zone. Estimates are also accurate only to a regional level, not a development site level. Neither method should be used for estimating internal capture for MXDs.

Six land uses are the most frequent components of MXDs—office, retail, restaurant, residential, cinema, and hotel. Most major MXDs have all of these. Most other MXDs have at least four. MXDs come in all sizes and layouts: some are vertically integrated and developed in one block, some are spread over several or many blocks with land uses well mixed or concentrated in interconnected single-use areas. Six MXDs analyzed in this project ranged in size from 7 and 300 acres. All were single developments from one master plan developed either to integrate fully all land uses or otherwise to promote interaction between onsite land uses. There are other larger MXD types of developments such as SACs and even new towns or very large self-contained urban sections. These last two types were not covered in this project because it was felt that they act differently than does the MXD of 300 acres or less and because they are far less frequently found in most states of the country.

With the increase in emphasis on livability, compact cities, and smart growth in general, MXDs have become more popular. Many are found in midtown-type urban areas (i.e., the central portion of a city or urban area that is outside the CBD but has higher densities than suburban or general urban and may include an outlying business district). Others are found in suburban locations and a few in urban peripheries. The research team did not include downtowns because they would be very difficult to survey and do not develop as one project or development and, therefore, would not need a TIA for the downtown.

During the period this project was active, the research team received dozens of calls asking for internal capture data for land uses and time periods not included in the ITE method. Requests were most frequently received for

- A.M. peak-hour internal capture rates;
- Land uses not included in the ITE method—most notably hotels, cinemas, and restaurants; and
- Very large MXDs in outlying areas.

Available Data

There are very limited data available that are capable of supporting internal capture rate estimation methodology that can use information that is *available at the time of zoning*. Three Florida surveys plus three pilot studies conducted for this project were the only surveys with enough detail to develop internal capture methodology

- For both A.M. and P.M. peak hours;
- For use with information that is available at the time of zoning requests and can be reliably projected;
- That provides the ability to analyze the effect of proximity of land uses to each other; and
- That is sensitive to differences in land use mix.

Some cordon counts have been completed for various periods and could be used for validation testing, but, by themselves with land use information, they do not provide what is needed to develop a sensitive procedure. More data are needed.

Internal Capture Estimation Methodology

Expanded ITE Methodology

This project expanded the database from three to six developments and, after considering options, expanded the ITE method to

- Add the weekday A.M. peak hour;
- Add restaurant, cinema, and hotel land uses;
- Create a land use classification structure that would permit disaggregation of the six land uses to more detailed categories should enough data become available;
- Include the effects of proximity (i.e., convenient walking distance) among interacting land uses to represent both compactness and design; and
- Provide a method that could easily be put in spreadsheet form.

This method was tested for its ability to estimate external vehicle trip generation. The existing ITE method estimates produce about one-half of the estimation error that raw ITE trip generation rates produce. The method developed in this project cuts the estimation error in half again, or roughly to about one-fourth of the raw trip generation rates.

The recommended method is described in Chapter 3. The researchers recommend its use for developments of up to 300 acres. Additional data and/or further testing could validate its use for larger developments, but that has not yet been attempted. The researchers do **not** recommend use of this method for downtowns, SACs, or new town types of development; the researchers do not believe it will be applicable.

The method produced has a component that estimates the effects of proximity. Unfortunately, the database is small enough for the P.M. period that factors could only be developed for some land use pairs. Absence of A.M. peak-hour data from the Florida studies precluded any A.M. proximity factors from being developed. This project's estimation method generally produced slightly closer P.M. estimates with the proximity factor included. It is recommended for use, but it is also recommended that when additional data becomes available, attempts should be made to develop proximity factors for more land use pairs.

Suggested Modifications to Existing ITE Procedures

As mentioned previously, the recommended estimation method builds on the current ITE internal trip capture procedures contained in the second edition of the *Trip Generation Handbook* (*1*). Incorporation of this project's recommendations could be accomplished by performing the following:

- Expanding Tables 7.1 and 7.2 of the *Trip Generation Handbook* (*1*) to include all six land uses covered in this report; and
- Adding the proximity adjustment to be made after the unconstrained internal capture estimates are performed but before the balancing process.

The data collection procedures could be modified to include those recommended in this project, including the next section.

Data-Collection Methodology

A methodology and procedural instructions were developed for the selection of data-collection sites and for the data collection itself. Those procedures were used to conduct surveys at three MXDs. The procedures were refined as a result of the experiences and lessons learned. Appendix C describes the recommended method.

The researchers recommend that additional data be collected. The researchers suggest that MXDs selected meet at least the following criteria:

- Be representative of typical MXDs being developed or being planned so the data will be of use for years to come; the area in which the MXD is located should also be representative;
- Have at least four land uses so that most land use pairs are included;
- Have owners or managers who will permit the needed surveys to be conducted;
- Be easy to conduct a large enough sample for an affordable cost (in 2006 dollars, each survey cost about $50,000 to set up and conduct and to summarize the resulting data);
- Be generally in the range of 300 to 500 acres or less; and
- Be economically successful (by appearance), be mature (i.e., fully occupied for at least a year), and be in an area that is mostly developed.

It is expected that NCHRP will turn over the results of this project and its data to ITE for inclusion in its database. ITE is also the body that issues recommended practices for this type of methodology. Organizations that collect additional internal capture data are encouraged to provide a copy of the data and analyses to ITE for further use and future refinement to what was produced in this project.

Recommended Changes to the Procedures Used in This Project

Based on the experience of collecting and using data following procedures initially recommended for this project, four changes are recommended for consideration to improve the quality and content of data:

1. **Conduct inbound interviews in addition to exit interviews.** Although there is developer/manager resistance to inbound interviews, they would increase the accuracy of the survey data. Questions about the previous trip before the one being interviewed drew some illogical results and included many trips made before the peak period of interest. If the development owner/manager resists giving permission, attempt to conduct inbound interviews in locations where business will not be impeded. Office building and residential building lobbies are good places for conducting inbound interviews.
2. **Delete the questions about the previous trip if inbound interviews can be conducted.** The researchers found inconsistencies and confusion associated with responses to those questions.
3. **Add a time for the previous trip's arrival at the interview building if no inbound interviews can be conducted.** The time is needed to determine whether it was made during the A.M. or P.M. peak period.
4. **Consider adding a question seeking induced trip information.** An add-on question to attempt to determine induced trips was asked as part of the Legacy Town Center interviews. Respondent understanding about the question was inconsistent, so the results were not reported herein. However, it was evident that some of the internal trips made may have been induced or resulted from having proximate interacting land uses. The question asked whether the respondent would have made the trip being discussed if the selected destination did not exist within Legacy Town Center. A substantial number of respondents answered affirmatively—that is, they said they would not have made the trip had it required travel outside Legacy Town Center. Hence, such a trip would not represent a reduction in external trips: it would be an addition—made internally.

Lessons Learned

Several lessons were learned in this project that will be of interest to researchers and practitioners in this field.

- **Detailed data are very scarce and expensive to produce.**
- **There has been little willingness of sponsors to fund data-collection efforts** since the advent of the current ITE estimation method and adoption of flat reduction percentages by numerous agencies.
- **Due to the shortage of data, there is significant apprehension on the part of development review agencies about whether trip generation at MXDs is actually less than the sum of its free-standing components**—that is, if there is actually internal capture.
- **Owners/managers of some developments are reluctant to permit surveys.** They have concerns about the interviews discouraging patrons from doing business at the MXD. In all three pilot studies conducted for this project, permission was gained to conduct only exit interviews—not inbound interviews. This was based on owner/manager belief that patrons would not be bothered after they had already done their business in a particular establishment where the interviews would be conducted.
- **Data clearly show that there is internal capture in the ranges previously documented.**

- **The recommended method did produce estimates of external vehicle trips that represent counted volumes quite closely.** While results varied in accuracy among the developments tested, the recommended method was the closest of the methods tested in four of five cases for which directional volumes were available for both A.M. and P.M. peak hours. For two other sites with partial data, the recommended method was clearly the best for one and it was approximately equal to the existing ITE method for the other. In total, the recommended method displayed about half the estimation error of the existing ITE method (13% versus 23%, respectively), both of which are well below the error using just raw ITE trip generation rates (53%).

Suggested Research

Although this project has made progress in estimation of internal capture, the database is still sparse and much that is thought to be logical about MXD travel characteristics is still unproven and even largely untested. The research team recommends that the following additional research be performed:

- **Collect more data at MXDs.** Data are needed from at least six more sites that have five to six land uses.
- **Test the applicability of the existing methodology for MXDs of different sizes, character, and land use components independent of the additional data collection.** Use validation tests similar to those used in this project. The only data needed are a complete directional cordon count for the A.M. and P.M. peak hours plus development data and a good site plan from which to estimate proximities.
- **Attempt to determine what differences design characteristics of MXDs have on external travel.** Parking availability, degree of direct interconnection, and vertical versus horizontal integration are three such characteristics.
- **Ascertain the effect of off-site competing opportunities on internal capture.** There may be a method of using GIS data and external trip data from the recommended surveys to ascertain these effects.
- **Devise and add a survey question to ascertain induced trip information.** This would permit an assessment of whether MXDs result in induced trips because of the internal opportunities. Note that such a question was asked during one of the three pilot studies, but respondents frequently had a difficult time grasping the concept of an "extra trip that might otherwise not have been made."

Application in Practice

Estimation Methodology and Data-Collection Framework

This research project developed an improved estimation methodology and data-collection framework for use in estimating internal trip capture in MXDs during weekday A.M. and P.M. peak periods. The estimation methodology is based on weekday A.M. and P.M. peak-period survey data from three MXDs in Texas and Georgia (conducted as part of this project) plus similar weekday P.M. peak-period data from three developments in Florida (conducted prior to this project). The six developments surveyed ranged from about 7 to 300 acres in size and had between four and six primary land uses each.

This report presents a technical advancement beyond the internal capture method published in the *Trip Generation Handbook*, second edition, published by the Institute of Transportation Engineers (*1*). The researchers believe that the limited validations conducted for the proposed estimation method confirm that the results provide accurate approximations of external trip generation for typical MXDs consisting of typical office, retail, restaurant, residential, cinema, and hotel land uses, consistent with the accuracy of trip generation estimates for single-use developments as portrayed in such references as *Trip Generation*, eighth edition (*2*).

User Instructions and Cautions

At the time of publication of this report, the approach developed in this research had not yet been advanced through the ITE process for development of recommended practices and, therefore, it should not yet be considered as an ITE–approved methodology.

This report presents information in Chapter 3 on how to use the proposed estimation procedure, but the researchers and the overseeing NCHRP project panel felt it is important to encourage users to adhere to the following instructions and cautions in using the proposed estimation methodology:

- **Identify specific land use components of the MXD and classify them into the six classifications**—office, retail, restaurant, residential, cinema, and hotel—covered by the estimation methodology. Any component land uses that do not fit into those six classifications or are too unique to be considered normal for a classification should be kept separate. No internal capture is estimated in the proposed methodology for trips between uses within each of these categories (e.g., two or more different retail uses).
- **For each land use within the MXD, estimate single-use trip generation individually.** Then, sum the individual estimates into the six aggregated classifications: office, retail, restaurant, residential, cinema, and hotel. Do not combine development units into the six classifications and then use one single-use trip generation rate or equation to estimate trip generation for the aggregated land use.
- **When applying the internal capture estimation methodology, use the percentages suggested in Chapter 3 unless local data are available from developments similar to the development being analyzed.** Users are cautioned that data

gathered in a method different than the data-collection methods described in this report may not be applicable and could produce inaccurate internal capture estimates.

- **Do not apply the internal capture percentages from this report to other land uses.** Internal capture estimates were not developed for land uses beyond the six classifications provided herein. The extent of the internal capture for other land use pairs has not been tested as part of this project.

The results presented in this report are based on surveys of six MXDs and validation was limited to seven such MXDs. As a result, some members of the project's advisory panel strongly recommend that additional research, data collection, and validation testing be conducted before the method is adopted for use in TIAs. Furthermore, caution should be exercised in the application of this methodology—for example, it cannot be concluded that the methodology will be appropriate for MXDs that differ significantly from those surveyed in this project in terms of

- Regional context, including competing opportunities outside the development;
- Access and parking;
- Scale of the development;
- Complementary land uses, including specific pairs of business types;
- Specific residence types,
- Other component characteristics within each land use category;
- Proximity and connectivity between each pair of land uses, especially the layout of the land uses relative to each other;
- Other characteristics such as proximity to transit and pedestrian access within and around the site; and
- Colder locations that might limit or constrain pedestrian traffic.

Request for Additional Data

Users are encouraged to collect and contribute additional data using the data-collection procedures described in this report. Such data could be used to further enhance the accuracy of the proposed methodology and/or expand the number of land use classifications covered by the methodology. New data should be forwarded to the Institute of Transportation Engineers, 1627 I Street, Suite 610, Washington, D.C. 20006-4007 or by email to ite_staff@ite.org.

References

1. *Trip Generation Handbook,* 2nd edition, Institute of Transportation Engineers, Washington, D.C., 2004.
2. *Trip Generation,* 8th edition, Institute of Transportation Engineers, Washington, D.C., 2008.
3. *Mixed Use Development Handbook,* Urban Land Institute, Washington, D.C., 2003, pp. 4–5.
4. *Transportation Planning Handbook,* 2nd edition, Institute of Transportation Engineers, Washington, D.C., 1999, pp. 561–562.
5. American Public Transportation Association. "Transit Resource Guide." *Transit-Oriented Development, No. 8.* 2005. www.apta.com/research/info/briefings/briefing_8.cfm accessed August 23, 2005.
6. Steele, S.R. "Reducing Trip Generation Through Project Design," *1991 International Conference Compendium Papers,* Institute of Transportation Engineers, Washington, D.C., 1991.
7. Cervero, R. "Urban Design Issues Related to Transportation Modes, Designs and Services for Neo-Traditional Developments," tmip.fhaw.dot.gov/clearinghouse/docs/udes/cervero.pdf, accessed Oct. 30, 2004.
8. "Neighborhood Vitality: Balancing Land Uses at a Community Scale—Community/Neighborhood Team Discussions," March 4, 2004, www.sactaqc.org/resources/negotiation/community_neighborhood/landuse_balance.htm, accessed October 30, 2004.
9. Filion, P.; McSpurren, K.; and Huether, N. "Synergy and Movement Within Suburban Mixed Use Centers: The Toronto Experience," *Journal of Urban Affairs,* Urban Affairs Association Winter 2000, p. 427; www.blackwell-synergy.com/links/doi/10.1111/0735-2166.00064/abs, accessed October 30, 2004.
10. Guttenplan, M.; Davis, B.; Steiner, R.; and Miller, D. "Planning-Level Areawide Multimodal Level-of-Service Analysis: Performance Measures for Congestion Management," *Transportation Research Record 1858,* Transportation Research Board of the National Academies, Washington, D.C., 2003, pp. 61–68.
11. LUTRAQ. 1000 Friends of Oregon, www.friends.org/resources/lut_reports.html, accessed August 2005.
12. Reiff, B., and Kim, K.-H. *Statistical Analysis of Urban Design Variables and Their Use in Travel Demand Models,* Oregon DOT, Salem, Oregon, November 2003, www.odot.state.or.us/tddtpau/modeling.html.
13. Ewing, R., and Cervero, R. "Travel and the Built Environment," *Transportation Research Record 1780,* Transportation Research Board of the National Academies, Washington, D.C., 2011, pp. 108–111.
14. Kittelson & Associates. *Trip Generation for New Urbanist Developments,* prepared for Florida DOT, August 2004, pp. 7–1.
15. Gordon, S., and Peers, J. "Designing a Community for Transportation Demand Management: The Laguna West Pedestrian Pocket," *Transportation Research Record 1321,* Transportation Research Board, National Research Council, Washington, D.C., 1991, pp. 138–145; p. 144 cited.
16. *Site Impact Handbook,* Florida DOT, Tallahassee, April 1997, p. 55.
17. *Districtwide Trip Generation Study, Task 5, Final Report,* Walter H. Keller, Inc., Florida DOT, District IV, March 1995.
18. *FDOT Trip Characteristics Study of Multi-Use Developments,* Tindale Oliver & Associates, Inc., Florida DOT District IV, Ft. Lauderdale, December 1993, p. V-39.
19. "Trip Generation for Mixed-Use Developments," Colorado/Wyoming Section Technical Committee, *ITE Journal,* Institute of Transportation Engineers, Washington, D.C., February, 1987; pp. 27–32.
20. "The Brandermill Planned Unit Developments Traffic Generation Study, Technical Report," JHK & Associates, Alexandria, VA, June 1984.
21. ITE trip generation survey, www.zoomerang.com/reports/public_report.zgi?ID=L2263NJNHL4U, accessed October 31, 2004.
22. Steiner, R. "Trip Generation and Parking Requirements in Traditional Shopping Districts," *Transportation Research Record 1617,* Transportation Research Board, National Research Council, Washington, D.C., 1998, pp., 28–37; p. 29 cited.
23. Sosslau, A.; A.B. Hassam; M. M. Carter; and G.V. Wickstrom. *NCHRP Report 187: Quick Response Urban Travel Estimation Techniques and Transferable Parameters: User's Guide,* Transportation Research Board, National Research Council, Washington, D.C., 1978.
24. Mehra, J., and Keller, R. *Development and Application of Trip Generation Rates,* FHWA/PL/85/003, Federal Highway Administration, January 1985, pp. 32–36.
25. "San Diego Shared Parking Study," JHK & Associates, San Diego, California, July 1996.
26. Hooper, K. *NCHRP Report 323: Travel Characteristics at Large-Scale Suburban Activity Centers,* Transportation Research Board, National Research Council, Washington, D.C., 1989.
27. Zietsman, J. "The Traffic Impact of Suburban Multi-Use Developments." Master of Engineering Thesis, University of Pretoria, Pretoria, South Africa, September 1993.
28. Zietsman, J., and H.S. Joubert. "Quantifying the Change in Travel Patterns as a Result of Smart Growth." *Proceedings of the ITE 2002 Annual Meeting and Exhibit,* Philadelphia, PA, August 2002.

29. Cervero, R. "Land Uses and Travel at Suburban Activity Centers," *Transportation Quarterly,* Vol. 45, 1988; pp. 479–491.
30. Handy, Susan. "Travel Behavior Issues Related to Neo-Traditional Developments—A Review of the Research," tmip.fhwa.dot.gov/clearinghouse/docs/udes/handy.pdf, accessed October 30, 2004.
31. Steiner, Ruth. "Residential Density and Travel Patterns: Review of the Literature," *Transportation Research Record 1466,* Transportation Research Board, National Research Council, Washington, D.C., 1994; pp. 37–43.
32. Ewing, Reid; Dumbaugh, Eric; and Brown, Mike. "Internalizing Travel by Mixing Land Uses," *Transportation Research Record 1780,* Transportation Research Board, National Research Council, Washington, D.C., 2001, pp.115–120; pp. 117–118 cited.
33. Rutherford, Scott; McCormack, Edward; Wilkinson, Martina. "Travel Implications of Urban Form: Implications from an Analysis of Two Seattle Area Travel Diaries," tmip.fhwa.dot.gov/clearinghouse/docs/udes/mccormack.stm, accessed October 30, 2004.
34. Lewis, Laurence. "Celebration Traffic Study Reaffirms Benefits of Mixed-Use Development," *HDR Transportline,* Vol. 14, No. 2, September 2004.
35. Walters, Gerard; Ewing, Reid; Schroeer, William. "Adjusting Computer Modeling Tools to Capture Response to Smart Growth: or 'Poking at the Project Like a Lab Rat,'" *Transportation Research Record 1722,* Transportation Research Board, National Research Council, Washington, D.C., 2000; pp. 17–26.
36. Khattak, Asad, and Stone, John. *Traditional Neighborhood Development Trip Generation Study,* FHWA/NC/2005-05, Center for Urban & Regional Studies, Department of City and Regional Planning, University of North Carolina, Chapel Hill, North Carolina, February 2005.
37. "Office Worker Spending Patterns," *Research Quarterly,* Vol. 11, No. 1, International Council of Shopping Centers, New York, NY, Spring 2004.
38. *TCRP Report 95: Land Use and Site Design; Chapter 15: Traveler Response to Transportation System Changes,* Transportation Research Board of the National Academies, Washington, D.C., 2003.
39. Lund, Hollie M.; Cervero, Robert; and Wilson, Richard W. "Travel Characteristics of Transit-Oriented Development in California," California DOT, January 2004.
40. *Evaluation of Potential Measures For Achieving Modal Targets,* Cogan, Owens & Cogan; Alta Planning & Design; and David Evans & Associates; Portland Metro, Portland, OR; July 2005, p. 110.
41. "Summary of Traffic Impact Study Guidelines for Selected Texas Cities," Barton-Aschman Associates, Inc., TexITE, November 1993.
42. "Traffic Impact Studies—Current Practices," *The Urban Transportation Monitor,* August 5 and September 2, 1994.
43. "Concurrency Management System, Capital Improvements Element," Appendix A, Chapter 9, Section 8 in *Capital Improvements Inventory and Analysis, City of Destin, Florida,* www.cityofdestin.com/pages/community%20development/cp/CH09AGOP060404final.htm, accessed October 30, 2004.
44. "Policy For Traffic Impact Studies," City of Tempe, www.tempe.gov/traffic/impacts.htm, accessed October 30, 2004.
45. *Traffic Impact Study Manual,* City of San Diego, July 1998.
46. *Guidelines for Traffic Impact Analysis of Land Developments,* City of San Jose, June 1994, pp. 15–16.
47. *Guide for the Preparation of Traffic Impact Studies,* California DOT, December 2002, p. 4.
48. *INDEX PlanBuilder Planning Support System, Release 9.3, Indicator Dictionary,* Criterion Planners, Portland, OR, November 2008; pp. 92–102.
49. *"GRTA DRI Review Package, Technical Guidelines,"* Georgia Regional Transportation Authority, January 14, 2002, pp. 7–8, www.grta.org/doc/PDF_files/dri_technical_guidelines_final_112901.pdf, accessed October 30, 2004.
50. Survey Results—Multi-Use Trip Generation: Internal Capture Rates Questionnaire," Zoomerang, www.zoomernag.com/reports/public_report.zgi?ID=L2263NJNHL4U, accessed October 31, 2004.
51. *Crediting Low-Traffic Developments: Adjusting Site-Level Vehicle Trip Generation Using URBEMIS,* Nelson/Nygaard Consulting Associates, San Francisco, CA, August 2005.
52. *Software User's Guide: URBEMIS2002 for Windows With Enhanced Construction Module,* Jones & Stokes Associates, Sacramento, CA, April 2005.
53. Ewing, Reid. "Beyond Density, Mode Choice, and Single Purpose Trips," *Transportation Quarterly,* Vol. 49, Issue 4, 1995, pp. 19–21.
54. *Shared Parking,* Urban Land Institute, Washington, D.C., 1983.
55. *Trip Generation Handbook,* 1st edition, Institute of Transportation Engineers, Washington, D.C., 1999.

APPENDIX A

Trends In Mixed-Use Development

MXD has become a popular way for developers to offer several different types of building products within a single development under the current land use zoning system. However, MXD has not always been implemented in its existing forms.

Brief Background

In earlier times when the transportation system did not yet have mechanized technologies, convenient walking or (horse) riding distances limited how far the necessary goods and services could be from residential and work locations. In urban areas, convenience services and goods had to be within a few blocks of home. Support business services and goods had to be close to other businesses. Employment and housing locations had to be close to each other. This led to the close proximity of complementary uses, often in the same or adjacent blocks. Many businesses were operated by their owners who lived on the upper floors of the building housing their business.

However, this led to some undesirable living conditions. Unhealthy and unattractive industries and housing often coexisted next to each other in an era when noise, air quality, and waste handling were nowhere near to what they are today. In an effort to separate noxious industry from housing and create better and healthier urban environments, cities adopted land use zoning. This became viable as transportation became much better and made it possible for employees to live much farther from work places. This began with horse drawn and electric trolley suburbs and became popular after the automobile became commonly available to most families. By the period immediately following World War II, outlying areas of central cities and separately incorporated suburban municipalities that could provide more protected and pristine environments had become very popular for residence locations.

With the changes in residence preferences and widespread availability of private motor vehicles came changes in other developments. Retail was provided first at or near major intersections, initially in small combinations of separate buildings containing different businesses, then in small shopping centers, and then in larger shopping centers. Employment was still concentrated in downtowns initially, but then gradually began appearing in industrial areas or parks (industry), or free-standing buildings or parks (office). Restaurants were located at high-traffic locations, usually free standing. The same occurred with entertainment buildings (mostly single-screen cinemas). Hotels were located in downtowns, but motels were located along main arteries and highways.

As developers found that there was indeed interaction between some land uses that they could capitalize from and cities realized that several uses could be mixed to the benefit rather than detriment to public health, safety, and welfare, MXD began to reappear. At first, it was difficult to mix some uses because zoning ordinances were oriented to separating different uses and protecting several of these uses. Zoning variances and special-use permits were required as exceptions to zoning ordinances. As successful experiences occurred, zoning ordinances were modified to permit additional uses in some zoning categories and developers proposed mixes under individually negotiated PUDs. As more success evolved, more latitude was permitted, both in zoning ordinances and in zoning application practice. Today most zoning ordinances still give preference to single-use development. However, MXD is commonly approved and many zoning ordinances have one or more mixed-use categories that permit certain mixes of land use.

Modern Mixed-Use Development

Currently MXD is found in two primary forms:

- a traditional building type resembling a district of different land uses (such as neighborhood centers) that reemerged in the latter half of the 20th century after having been undermined by the:
  - widespread adoption and implementation of single-use zoning, and

  - post World War II rush to the suburbs that entailed not only lower densities, but also a development template that separated uses such as shopping malls, subdivisions, and office parks; and
- mixed-use centers, often developed on a single interconnected site, that contain several uses that may or may not be fully interactive. This largely suburban building model became the norm for developers and was ingrained in local zoning and building codes intended to protect suburban homeowners from some of the noxious uses found in cities.

Early Examples

MXD initially re-emerged as downtown revitalization projects beginning in the 1950s with projects such as:

- Penn Center in Philadelphia (1954) – an office, hotel, and retail project developed according to a master plan by the city planning commission, and implemented by several developers;
- Charles Center in Baltimore (1957) – a private, nonprofit corporation formed to manage downtown redevelopment under contract to the city. The project includes office, retail, residential, and hotel facilities, as well as a live theater and extensive pedestrian plazas; and
- Prudential Center in Boston (1959) – a privately financed project in a downtown renewal area containing two office towers, four commercial/retail buildings, apartment buildings and a civic center.

Some of the early projects outside downtowns were close in suburbs. Two examples were:

- Century City in Los Angeles (1961) – one of the first large scale, office oriented suburban mixed-use centers in the U.S., built on a former movie studio lot, and presently housing many entertainment business headquarters; and
- Crystal City in Arlington, Virginia outside Washington, D.C. (1964) – this private project includes apartments, office space, retail, hotels, movie theaters, and recreational facilities, and became a stop on the Washington subway in the 1970s.

The 1960s also saw the first major mixed-use office tower, the John Hancock Building in Chicago, which opened in 1969. Different floors have different uses, beginning at the bottom with retail and commercial, parking, office, and topped off with residential. The mixed-use projects of the 1960s pioneered the concept of dramatic interior spaces—large atriums and gallerias—in modern buildings. A notable example is Peachtree Center in Atlanta, where the atrium and other design concepts incorporated into the Atlanta Hyatt Regency Hotel were emulated in many projects throughout the country and the world. Among the hallmarks of the mixed-use projects of the 1960s was their residential orientation, their relative openness to surrounding areas, and their design according to architectural principles of the international style, which was not good at creating attractive people places.

The 1970s: Megastructures

The number of mixed-use projects expanded rapidly from only 23 in the 1950s and 1960s, to 65 begun in the 1970s, and over 100 in the 1980s, according to an ULI survey. In the 1970s, many of these projects became enclosed and internally focused, a result of the growing popularity of enclosed shopping malls, the growing problems in central cities, and the interest in defensible space. One of the most influential suburban mixed-use projects of the time was the Houston Galleria, which was planned around a central shopping center in one of the most affluent communities in the region at the time. The three commercial elements—office, retail, and hotel, became the most popular mix of land uses in projects developed in the 1970s and 1980s. The development has become the core of what has become the dominant suburban center in the region. Other notable projects in this period were the IDS center in Minneapolis, the Illinois Center in Chicago, the Embarcadero Center in San Francisco, and the former World Trade Center in New York. Although great attention was given to architecture and interior spaces, the projects were increasingly isolated fortresses, cut off from the surrounding city. While a financially successful commercial formula had been found, vastly expanding the number of such projects, the residential component had largely disappeared.

The 1980s: Greater Openness

Development of mixed-use projects in the 1980s became smaller scale, more open, more suburban, and more residential. Projects were developed on much smaller scales, evidence of the concept's continuing evolution and greater acceptance of mixed-use projects in smaller scale and more suburban environments. Residential uses were found in half of the projects surveyed by ULI, a sharp rebound from the 19 percent of the 1970s. The emphasis in planning and design moved from the buildings to the setting, and greater attention to streetscapes and urban design. The design style shifted to more of postmodern and historicist themes, greater openness and sensitivity to the total environment, greater use of historic rehabilitation, and more infusion of entertainment and cultural uses. Notable projects of the period include:

- Miami Lakes Town Center – part of a large scale planned community, driven by the developers' belief that every town needs a hub where people can gather to eat, shop, and socialize;
- The Atlanta Galleria – numerous high-rise office buildings and a hotel/retail complex are arranged around a park;

- Janns Court – a small mixed use building with cinema, retail, office, and residential uses that helped in the revitalization of the Third Street Promenade in Santa Monica; and
- Princeton Forrestal Village – office, retail, and hotel uses around a main street in a suburban office park.

Recent Trends: Town Centers and New Urbanism

The movement among planners and architects toward a new urbanism or traditional neighborhood design philosophy began to have an impact on developers in the 1990s. Two of the most noted projects in the 1990s were Reston Town Center in Reston, Virginia, and Mizner Park in Boca Raton, Florida. They served as suburban models of creating higher density and vibrant urban places in the suburbs. Reston Town Center was built on one of the last remaining undeveloped parcels in the new town of Reston, Virginia. It was an 85-acre (34 hectare) mixed-use center located in a 460-acre town district identified in the original 1962 master plan. At the opening in 1990, there were two office towers, a Hyatt Regency Hotel, a cinema, and retail space in the configuration of a main street town center, surrounded by structured parking. Later additions included more office space, significant amounts of high density housing, and more open space, creating perhaps the largest such town center built to date. The streetscape plan recalls European shopping streets and public squares as well as such American prototypes as Country Club Plaza in Kansas City. The main street is narrow with parking allowed to slow traffic and make pedestrians more comfortable. At the ground level, a variety of retail street fronts were accommodated to create a vibrant pedestrian experience.

Mizner Park used a very different mix, with much greater residential presence, although the same attention to design and public spaces as in Reston Town Center, to create a new town center for Boca Raton. The first phase included four mixed-use buildings surrounding a two block long public park, and containing 156,000 sq ft (15,000 square meters) of specialty retail space with six restaurants and an eight-plex cinema, 106,000 sq ft (985,000 square meters) of office space, 136 apartments over the stores, a performing arts amphitheater, a museum, and structured parking. The projects' careful attention to urban design and sense of place has created an around the clock activity that helps enliven the city's downtown core. The central space contains two public streets enhanced with pavers and a plaza, and offering on street parking in front of the stores.

This period also saw the development or expansion of transit projects in the South and West, offering an opportunity to include transit in mixed-use centers. Some of the early examples included Orenco Station in Hillsborough, Oregon, and Cascade Station near the Portland International Airport, both served by Portland's MAX light rail line; the Arlington Town Square, a redevelopment in Arlington Heights, Illinois, around a commuter rail station; Mockingbird station in Dallas; Lindbergh City Center in Atlanta; and numerous developments adjacent to Washington, D.C.'s Metro rail station, especially in Montgomery and Arlington counties. While transit was an essential part of most new urbanist thinking, most of the early mixed-use developments were significant by its absence. This appears to be finally changing.

Trends and Outlook

MXDs have become an accepted development product, and will possibly expand as designers, developers, and lenders develop greater familiarity and facility with creating these projects. They will continue to evolve, as they have in the past. The near term outlook, however, allows for forecasting how upcoming developments will look.

Forecast

Main Street Theme

The main street element is expected to continue as a central theme, as projects will possibly be arranged around pedestrian friendly streets, blocks, and squares. Projects will continue to be porous, creating pedestrian appeal even as they complicate the collection of traffic and parking data.

Welcoming the Big Box

The financial success of the big box retailers is expected to continue, despite their conventional formats, which are abhorrent to most new urbanist designers. They have started to adapt their concepts to more urban and street front applications, and out parcels are being created in some town centers allowing them to be part of the financial success, but slightly out of the way, and perhaps largely unrelated to the rest of the center.

Flexible Opportunities for Offices

While the office market has been weak in much of the U.S., as well as Europe and Asia, mixed-use centers will be attractive to many office users looking for a quality of life experience. It will be important to maintain flexibility, with limited office buildings incorporated into mixed-use center plans, and, as with big boxes, other opportunities on adjacent parcels.

Mixed-Use Opportunities in Obsolete Malls

Conventional shopping malls, as with big box retailers, are stereotypes of suburban sprawl—isolated, single-use developments that stand apart from their surrounding neighborhoods, oriented inwardly to vast climate-controlled shopping arcades, with a physical presence characterized by monolithic, overscaled, and blank architectural forms, and surrounded by a sea of parking. Fortunately, as shopping mall developers rush

to refresh the mall format and redevelop obsolete mall sites, there is a tremendous opportunity to think big, expand the field of vision, and break the mall's island syndrome. This will take advantage of the extensive amount of developable land in urban locations, and often involve opening up the street grid to adjacent neighborhoods. In addition, many communities will seize the opportunity to use the mall as the core of a redevelopment district, adding significant amounts of adjacent housing.

Life Style Centers: A Moving Target

A hot trend in retailing that adds to the mix has been the development of what are commonly called life style centers. These tend to include highly branded retailers able to move out of conventional malls as well as nationally recognized retailers. The other hallmarks of such centers are generally an open-air setting, greater attention to architectural design, and a clustering of restaurants, all adding to a festive atmosphere for shoppers. Their growing popularity has resulted in the term being highjacked by other centers missing some of these components. For the sake of this study, however, it is important to recognize that life style centers can be part of a MXD or a standalone project.

From Mixed-Use Developments to Mixed-Use Districts

The growing appreciation for mixed-use projects has created a constituency for a broader appreciation for going beyond individual developments to larger planned districts, and a philosophy of planning increasingly known as placemaking. Such mixed-use districts will possibly open up much greater possibilities, since they vastly broaden the supply of properties and developers able to build single-use residential, retail, or office projects, within a district circumscribed with a street and lot structure, development targets, and possibly financing. While a mixed-use project requires an especially sophisticated developer, a mixed-use district, whether planned by a master developer or a city, can create many development parcels suitable for single-use development, but in support of a broader mixed-use district. Studying the travel patterns for such a district will require a data survey plan that acknowledges the possibility for a one-stop experience, and significant internal capture of travel. The following is a concise review of the future trends anticipated for the primary components of mixed-use developments, *subject to local market demand.*

Future Trends

Retail

Retailers and retail developers will continue to explore innovative ways to merchandise products to achieve a marketing advantage in a highly competitive business sector that is battling Internet sales for the retail dollar. Not only will many major regional retail centers be remade or replaced, but the form of separate stores and smaller centers will also continue to change. Convenience and price seem to be dominating this sector, leading to high visibility, larger stores with narrower ranges of merchandise (i.e., big box store approach extending to larger versions of stores that have been traditionally smaller, such as jewelry). This development approach in its mixed-use version would include complementary outparcel development with other retail and restaurants.

Office

Office space will continue to be included in many free standing and business district mixed-use developments as well as suburban commercial concentrations. This space may be located in multi-use buildings or as separate buildings either integrated into or adjacent to the other types of development listed below.

Residential

The new urbanist approach of integrating convenience retail and some restaurants into compact residential developments should continue, especially in downtown and midtown (the central portion of a city or urban area that is outside the CBD but has higher densities than suburban or general urban and may include an outlying business district) infill and redevelopment areas and new commercial centers. There will likely also be more medium- and large-scale developments with relatively conventional PUD layouts that will contain a mix of uses (mainly residential), some intended to be complementary and some more to provide developers with a product mix but not necessarily true synergistic mixed uses.

Hotels

Some hotels will be developed as parts of mixed-use developments in business districts, in downtown, midtown, and suburban locations. Some will be built without food service but will have adjacent independent restaurants that can provide lunch and dinner meals independent of the hotels. Some hotels will be tied to major office developments but less frequently to retail and very rarely to residential developments.

Restaurants

Restaurants will continue to make good outparcel development since they need exterior exposure and convenient parking. Restaurants will also continue to be integrated into some developments but will normally not make up a significant per-

centage of total floor area. Restaurant types will also continue to be very sensitive to the demographics of their immediate surrounding market areas as well as pass-by traffic characteristics. Outparcel restaurants may or may not be synergistic with adjacent retail development; they will serve local market demand and often be synergistic with other types of adjacent development.

Entertainment

Theater, nightclub, bowling alleys, and similar types of entertainment are largely most active on evenings and weekends, although there are specific and unfortunately unpredictable exceptions. Most will continue to seek locations where parking can be shared with daytime uses (e.g., retail, office). Some will continue to be used to draw patrons past retail space to try to increase retail business volumes. Combinations of entertainment with hotels are expected to be infrequent since the synergy has not proven to occur frequently. Combinations with restaurants will still occur. Major, single use entertainment developments such as theme parks will continue to attract outparcel development including hotels, restaurants, and retail, depending on the type of entertainment facility.

Other

True mixed-use developments, especially those in business or town centers, may include just about any types of development that meets local market demand. In addition to the above uses, these could include government offices and services (e.g., post offices), entertainment, and other civic/community facilities. Only market demand, imagination, compatibility of buildings and activities, and development economics will limit uses in these developments.

Development Trends in Mixed-Use Projects

Interviews by the research team with several developers, planners, and local officials revealed that mixed-use projects are being commonly developed in several scales, in several types of venues, and in several types as shown in Table A-1. The scales and venues lists are typical of those mentioned. The types listed in the third column were the most commonly mentioned, but other examples were occasionally discussed.

The current three land uses most commonly included in MXD are retail (in almost all MXDs as either the primary or a secondary use and virtually always including restaurants), residential, and office. Entertainment, in the form of movie theaters, and hotels are occasionally included, and usually make up a small percentage of the square footage.

Synergy Among Uses

A hypothesis of this research was that synergy among all uses is key to both internal trip capture and development profitability. However, virtually all MXD developers, architects, and planners said that market demand drives almost all decisions regarding development components and synergy influences only location—and that within only some larger retail-dominated developments.

It was widely agreed that residential cannot be provided in enough quantity to financially support ground floor retail unless residential is very large and retail is small and convenience oriented. In addition, developers and retail tenants are reluctant to have first floor lobbies occupy significant frontage

Table A-1. Most commonly mentioned MXD types.

Scales	Venues	Types (mainly combinations of retail,[1] office, residential)
1. Small part block development 2. Full block 2–3 story with ground floor retail 3. Modified shopping center with mixed uses side-by-side or split on multiple levels 4. Multiple block town center 5. Full MXD with retail and major office components There was no discussion of large districts or major midtown or suburban activity centers as being trendy in either current or projected MXD.	1. Infill midtown or suburban sites 2. Redevelopment or upgrading of existing developments (usually older shopping centers) 3. Initial components of larger development (said to be less possibly viable) 4. Later component of larger developments as town center (usually 1–4 blocks) 5. Major commercial component of larger development on a single block or "superblock"	1. Retail with small office or residential components 2. Retail with small (usually 2nd floor) office component and possibly also upstairs residential component 3. Side-by-side combinations of retail with residential and/or office 4. Major office or residential with ground floor retail 5. Big box retail with smaller retail and upstairs residential and/or office 6. Major retail, with entertainment to draw more patrons through retail, plus some office and (usually) side-by-side residential

[1]All references to retail in this summary include restaurants as a major component. Virtually all current MXDs of any size have a major percentage of restaurants.

in a retail block. Developers claimed that with two exceptions, residential units within a MXD with office usually do not lead to many residents working within the development. The two exceptions are when (1) the office space is live-work type space (combined live-work units or small boutique office units that are directed to serve the type of residential tenant in the building—not many of these) and (2) when there are very large quantities of dwelling units that house the types of employees that work in a large quantity of office or other on-site businesses.

There was more concern about synergy among retail tenants, and the concern was expressed more by the retail tenants rather than developers. Some major retailers have experienced their shoppers commonly patronizing specific other retailers, so they want to be near those retailers. At the same time, they feel their patrons do not want to be near other retailers so they will either avoid some developments or require a location away from the less desirable retailer. Developers try to accommodate those preferences, sometimes varying rental rates or other lease arrangements accordingly.

Entertainment, primarily large multi-screen movie theaters, is sought out in MXDs with major retail components. They are located strategically to draw patrons past retail stores. This is viewed as adding value for retailers and rent potential for the developers. Major synergy is believed to exist in such developments.

Office is considered to have little synergy with other uses other than directly supportive service retail. As with residential, office is not viewed as being able to be the almost sole support of internal retail space. Restaurants, if properly selected, can benefit from some synergy but all need to be able to draw from the entire local area market. Hotels may also be found in some MXDs. Again, hotels are included if market demand exists in the area and are rarely included based primarily on demand generated internal to the development.

Selecting Uses

As mentioned previously, each land use included by a developer must normally stand on its own based on area market demand. Hence, for estimating internal trip capture, competing opportunities should be considered if developers' practices are felt to be valid.

Interviews with developers yielded no set formula for selecting the component land uses. Developers tend to include the uses (and often tenants or tenant types) that they have most experience with, although several mentioned that the market has been causing them to mix (more) uses than they had included before. The vast majority of MXDs known to the research team have a primary use. The primary use has normally been retail, but sometimes has been either office or residential.

Secondary uses are included in a full range of percentages of square footage from almost equal to the primary use to a very small percentage. Tertiary uses make up small percentages in all but the large developments.

Site Layout and Synergy

Although there are exceptions, the trend in MXDs appears to be following two basic forms:

- town center with ground floor retail facing the street and residential and/or office on upper levels. These may include one or multiple blocks. Larger developments may have other uses such as a theater or hotel; and
- mixed-use off-street development using a pedestrian-oriented spine or block-type layout (somewhat resembling a modified shopping center layout) with buildings facing or backing up to parking fields.

There are also combinations of the above with one or more internal streets flanked by small and sometimes large uses plus larger buildings (e.g., big box retailers) facing their own parking fields. Sometimes some parking is provided below ground or on upper levels.

Different land uses may be integrated or side-by-side. The developers, architects, and planners addressed the question of which arrangement is best; there is no clear answer as to which works best for developers. Many reasons were given as advantages or disadvantages for each approach. The reasons included ownership, structural requirements and costs, parking requirements (tenant or city), tenant or buyer preference, developer experience, timing and phasing of development, market demand, and developer or tenant risk were all given as reasons one way or the other. It appears that both integrated and side-by-side approaches will continue to be widely used.

Parking versus Connectivity or Integration

MXDs with large retailers (big box or department store) often are shaped by the parking preferences of the major retailers. Some are willing to be in a fully shared parking situation. Others will only locate where their full complement of parking is directly adjacent to (and sometimes right in front of) their store. Some may even buy their building pad and the land that is designated as their parking (traditional major shopping center practice by some department store companies). Since those retailers are often the key to the development's success, tenant parking requirements play a big role in site layouts.

In developments having big box retailers, the strong trend is to have them face or back up to their parking. This is most frequently accomplished in one of two ways:

- traditional shopping center style; or
- provide a front door entrance to a town center street but line the front of the building with smaller stores; place park-

ing at the rear with a prominent entrance from that side. Teaser parking (parallel or angle) is placed on the street in front of the store to make parking look convenient and available, but most is behind the store or in an adjacent well marked garage.

Developers are more concerned with having each land use component work on its own than with providing internal connectivity. Few uses have internal building connections as their primary access because they all must serve area demand rather than just internal building demand. On the other hand, developers want the building entrances to be convenient to each other. Relative to internal trip capture, driving trips to most uses will consist of finding a parking place then walking to the primary and other destinations—that is, park once and walk to other destinations. The exception to that is the large MXD containing big box retail that may be laid out so driving to a second retailer may be necessary due to the distances between major tenants.

Walking Distance: Planner/Architect Recommendations versus Developer Experience

Several planners and architects spoke of ¼ mile and even longer acceptable walking distances. However, several developers reported that acceptable walking distances for their developments range from 600 to 1,000 ft. There were no hard data reported or referenced, but some cited tenant preferences or requirements, which are likely influenced either by tenant surveys or their own or lenders' risk considerations.

Consideration of internal trip capture should consider walking distance between the major uses and probably should consider the developer range of acceptable distances since they are possibly influenced by actual common experience rather than high ends of acceptable ranges. Alternatively, the second method would be to conduct user surveys in a variety of MXDs to establish acceptable walking distances.

Shared Parking and Internal Trip Capture

Shared parking is a feature of virtually all current MXDs. The extent of sharing depends on the uses, tenants, and layout. In current practice, the amount of spaces provided is driven by tenant preferences first, then perceived risk (developers or lenders), local requirements, and finally actual estimated demand.

Tenant requirements must be met for the developer to secure a lease or purchase. Some tenants are flexible and some are not. The location and market influence tenant flexibility. For example, tenants are possibly more flexible in Manhattan than in a peripheral greenfield site. How badly a tenant wants to locate in the particular site may also drive flexibility.

Hence, in developing a site, the developer needs to assess (1) what is necessary for the financial pro forma, (2) market demand for particular uses, (3) requirements of specific tenants or land use types, and (4) city requirements. This applies to land uses, tenants, and shared parking.

During discussions of MXD considerations at a 2006 Urban Land Institute conference on placemaking, not one single developer or city official mentioned traffic impacts or access requirements as an influence on major development decisions. They did mention the necessity to provide good access and to meet applicable traffic impact requirements, but reducing trip generation was not mentioned as a primary concern or influencing factor. On the other hand, shared parking was frequently mentioned as an important ingredient for making a development viable because of parking costs (land consumption or garage spaces) and/or space limitations.

Some developers were aware of and use ULI's *Shared Parking* report, but most reported tenant or local requirements override the numbers provided in the report (*1*). Where shared parking is used (to some extent in most MXDs), proper access and location to make sharing work seems to be employed. This is required to sell the sharing to tenants and purchasers. Therefore, in considering internal trip capture, site layout and walking distances must be considered. The mere mixing of uses on a site or in an area will not provide a true characterization of the possible sharing of parking or how internal circulation occurs between component buildings.

Transit-Oriented Development

As expected, there was only limited discussion and experience with TOD. Much was conceptual due to limited actual development experience by most participants. However, what came through very clearly relative to development trends was that all component uses and spaces must stand on their own in the market. Proximity to transit may provide an addition to demand, but it is not considered sufficient to support development on its own. As a result, current developer thinking is that the TOD should respond to local market demand near the site and provide close and convenient access to transit. Building entrances facing transit station entrances as well as close proximity were suggested as key features.

Transit serving tenant uses in TODs are primarily office and residential, and those can be significant only if the adjacent transit serves connecting destinations for those uses. Hence, mode split estimates need to consider not only local transit proximity, but also the extent of service and the destinations served. TCRP Report 128 describes research on TODs for similar types of considerations as were being examined by NCHRP Project 8-51. That project included an assessment of trip generating characteristics of residential TODs. Data collected in that project were limited to only external cordon counts. That project found that TODs did result in lower vehicle trip generation than what is reflected in the ITE *Trip Generation* report, so mode split should be considered (*2*).

Bottom Line

Developers are the ones who create MXDs. Their financial results depend on designing the developments correctly, which means they need to have a solid understanding about how such developments work. While developers seldom have the type of data transportation professionals seek, their experiences and considerations are valuable to help gain an understanding about how MXDs work.

For Developers

From the developer perspective, the following appear to be the prevailing developer combined bottom lines.

- All development projects must make money; financial considerations drive decisions for MXD.
- Developers build what sells in the particular location within the particular market.
- Market demand drives almost all decisions regarding development components and synergy influences only location—and that most frequently within only larger retail-dominated developments. Primary market demand for specific land uses is generated external to the development; any internally generated increment can be helpful but it cannot be the primary source for a successful *significant* project component.
- Retail (including restaurants), residential, and office are the primary, secondary and tertiary uses in MXDs. Movie theaters are used to draw potential retail patrons past store fronts. Hotels are sometimes included in response to area market demand.
- Developers cater to tenant risk limitations.
- Developers pursue projects they are comfortable with and are within their risk limitations.
- Developers follow popular trends that sell successfully.
- Tenant/purchaser requirements and preferences drive project and parking layouts once the design concept is established.
- Developers will adjust their projects to meet agency requirements if the remainder of the project is strong; otherwise they will go somewhere else if their formula for financial success cannot be met.
- Through their own surveys and tenant/purchaser acceptance, developers consider walking distances between destinations are acceptable up to a maximum of 600 to 1,000 ft.
- Internal trip capture is not a significant normal developer concern, but shared parking is; consideration of traffic impacts is a requirement but does not drive the project.

For Transportation Planners

The previous developer considerations and principles shape MXDs. They are also important for transportation planners to be able to understand how MXDs are normally to be designed and how users think they will use such developments. Based on the previous findings, the following are additional considerations related to internal trip capture.

- For internal trip capture, competing opportunities should be considered if developers' practices are felt to be valid.
- Relative to internal trip capture, driving trips to most uses will consist of finding a parking place then walking to the primary and other destinations—that is, park once and walk to other locations. The exception to that are the MXDs containing big box retail that may be designed so that driving to a second retailer may be necessary due to the distance from one entrance to the next.
- Therefore, in considering internal trip capture, site layout and walking distances must be considered. The mere mixing of uses on a site or in an area will not provide a true characterization of the possible sharing of parking or how internal circulation occurs between component buildings.
- Transit serving tenant uses apparently make up insignificant percentages of TODs other than office and residential, and those are significant only if the adjacent transit serves connecting destinations for those uses. Hence, mode split estimates need to consider not only local transit proximity, but also the extent of service and the destinations served.

Conclusions

Trip capture estimation should be able to cover all of the land use combinations expected to develop with some frequency. However, it is clear from the information in this chapter that the primary uses in today's and foreseeable MXDs are retail, restaurant, residential and office. Available resources should be concentrated on those uses, but any procedures developed should be adaptable to all common land uses.

References

1. *Shared Parking*, 2nd edition, Urban Land Institute, Washington, D.C., 2005.
2. Arrington, G.B., and Cervero, Robert. *TCRP Report 128: Effects of TOD on Housing, Parking, and Travel*, Transportation Research Board of the National Academies, Washington, D.C., 2008.

APPENDIX B

Land Use Classification System

Any procedure for estimating internal trip capture within MXDs must have to consider synergy between interacting land uses. That will require those land uses to be categorized and classified.

Desirable Classification System Characteristics

Requirements

It would appear that there are at least three absolute requirements for the land use classification system that will be used in the internal trip capture estimation process.

1. The classification system must be compatible with the ITE trip generation land use classification system since the internal trip capture procedure will be used with ITE trip generation rates.
2. The classification system must distinguish among complementary, interacting land uses.
3. The classifications must be able to be determined and existing or proposed development units quantified:
   - for proposed developments, as early as the zoning step of the development process, and
   - for existing developments, be clearly distinguishable in the field by data collection personnel.

Objectives

There are additional attributes that the classification system should have for successful and effective use in practice. The land use classification system should be:

- comprehensible – comprehensible to both technical analysts as well as agency reviewers and decision makers;
- sensitive – sensitive so internal trip capture estimates for different combinations of interacting land uses represent the true level of interaction between those uses;
- measurable – readily measurable with normally available information at the times when such information is needed;
- stable – stable so short term development fads can be easily accommodated; and
- universally applicable – applicable over all possible types of MXD.

Classifications

From information presented in Appendix A, the land use types that have been and appear for the future to be most frequently included in MXDs are:

- retail,
- restaurant,
- office, and
- residential.

Less frequent and smaller amounts of the following uses are and will be expected to be included in mixed use developments:

- hotel and
- entertainment.

Some additional land uses may be included in town centers and other special developments based on local market demands.

The review of existing documentation, examination of known MXDs, plus discussions with developers, architects, planners, and city planning and transportation officials identified subdivisions of the previous land use types that (1) frequently are included in MXDs and (2) are felt by developers and others to have different users or interaction characteristics. Table B-1 shows subcategories based on these considerations.

Retail

Convenience retail serves a very localized market plus some passersby. Dry goods draw from farther away and may be the

Table B-1. Common MXD land use categories and subcategories.

Land Use					
Retail	**Restaurant**	**Office**	**Residential**	**Hotel**	**Entertainment**
Convenience	Fast food	Medical	Single-family detached	No meeting facilities	Cinema
Full service	Sit down – no bar	General	Townhouse	• Low price	Other[a]
Discount	• Family	Live-work	Condo	• Mid price	
Other specialty	• Quality		Rental apartment	With meeting facilities	
Other	Sit down – with bar			• Low price	
	• Family			• Mid price	
	• Quality			• High price	

[a]During initial stages, categorize "other entertainment" as retail - other

primary trip destinations for shoppers at that location. However, developers and retailers believe that there are at least three market segments of shoppers (shown in Table B-1 as discount, mid-range, and high end) who shop at different types of stores and therefore should be considered separately. Convenience and dry goods retail cover most of the retail categories. All others can be covered with the other category since there (1) can be significant variability and (2) they normally appear in small percentages in a MXD, if at all.

Restaurant

Fast-food and sit-down restaurants clearly have different trip generation characteristics. They may or may not interact differently in a MXD, depending on whether they have drive-through service.

Office

Developers stated that much of the second or third floor office space in smaller MXDs is occupied by very small businesses. Some is live-work space, but most other businesses are just smaller and oriented to serving local business or other markets. For larger quantities of office space, especially for major office buildings on mixed-use sites, the general and medical office categories should suffice, although little medical office space has been found in the pilot and other studies. General and medical office uses have different trip generation characteristics. Whether internal trip capture differs significantly will need to be determined.

Residential

The four categories shown in Table B-1 are the most basic categories. Trip generation rates differ for some of these. It is not known if interaction with other uses will vary among these or other residential categories. It is possible that there would be more differences in internal trip capture if income or rent levels were to be known, but this is not always known at the zoning stage. At present, there is no distinction in trip generation characteristics for rent or sale price levels in the ITE database. Income or vehicle ownership would not possibly be known at the time of zoning. However, the four suggested subcategories would normally be known at the zoning stage.

Hotel

Hotels with and without meeting facilities should be easily distinguished, even at the zoning stage. It is felt that different room rate levels will draw different travelers who might shop or eat at different retail and restaurant facilities. At present, ITE trip generation data does not distinguish between room rate levels.

Entertainment

There are few common entertainment facilities in modern MXDs other than cinemas. Those that may appear occupy very small percentages of total development square footage. Hence, two subcategories should be sufficient.

Other

Some other uses are expected to be included in a few MXDs or as development trends change over time. When new uses begin to appear frequently, additional categories should be created.

Future Further Disaggregation

However, it could also be advantageous to collect detailed information so the land use classifications used for internal trip capture can be used for further disaggregated levels. One method to accomplish this would be to record the ITE land use classifications, which are needed anyway for the basic trip generation information. The normal ITE process is to provide a detailed description of the development so this should also aid future disaggregation if needed.

Other Classifications Related to Land Use

Context

There are standard transportation planning classifications to describe area types. MPOs use at least urban and rural classifications and may include downtown, midtown, fringe, and/or other classifications. Since the type of surrounding areas may influence internal trip capture by affecting competing opportunities and their attractiveness, it is recommended that area types be included in the classification system.

The following area types or contexts are recommended since they possibly involve different levels of interaction among uses within MXDs:

- rural,
- suburban,
- urban,
- midtown/suburban activity center (define as midtown or suburban business district or activity center [minimum office-retail-restaurant uses with at least 1 sq ft per area population with 100,000 sq ft minimum]),
- urban core (downtown or other regional CBD), and
- special district (industrial, educational, civic center, entertainment).

Development Type

It may be further helpful to classify the development by the type of site, as follows:

- single block (Mockingbird Station is an example),
- multiple block single development (Atlantic Station and Legacy Town Center are such examples), and
- district.

It may also be appropriate to include low-, mid- and high-rise sub-classifications within each category, although application may be difficult since some MXDs are composed of buildings of multiple heights, including low-, mid-, and high-rise buildings.

Internal Connectivity

The fourth component of land use classification that is likely to affect internal trip capture is internal connectivity. The quality and convenience of the internal connectivity will affect the attractiveness of internal destinations within a MXD relative to similar competing destinations outside the development.

Table B-2 lists eight different characteristics of internal connectivity. Data found from other sources and collected in this project were insufficient to relate internal trip capture to these characteristics. However, the characteristics do provide different quality, comfort, and convenience of connections among different uses within MXDs that may affect internal capture and be worth examining in future research.

In practice with real examples of MXD, nearly all examples included in the pilot studies and the other sites from which data were drawn fit into categories 5 through 7 in Table B-2. These were functionally very similar and probably do not warrant separate categories.

When employed in an estimation procedure, it may be appropriate to consolidate the classifications into a smaller number. After a database is established that includes all categories, the stratifications should become clear.

Internal Proximity

While not a land use characteristic per se, proximity between interacting uses will also influence internal trip capture. In land use terms, proximity may be more familiar as compactness (distance between buildings) or density (amount of building space per area of land). However, neither compactness nor density provides a true measure of convenience of internal travel. Proximity may be more accurately quantified by walking distance between interacting uses or maximum walking distance between building entrances internal to the development.

Proximity was examined as a variable in the pilot studies and estimation procedure. Proximity had an effect for a few land use pairs. The effect was uncertain for most pairs. Proximity should also be examined further as the database is expanded.

Conclusions

Characteristics of a MXD are proposed to be classified in an *ultimate* system consisting of five variables:

- land use,
- context,
- development type,
- internal connectivity, and
- internal proximity.

In the near term, however, available data will limit classifications to:

- land use,
- development type, and
- internal proximity.

Table B-3 contains the full system as proposed for initial implementation.

Individual sub-classifications have been proposed for each. The research team considers the classifications as a maximum breakout, having more divisions than a database can support. However, until a database is established with enough samples

Table B-2. Internal connectivity classifications.

Classification	Description		Comments
1. Fully integrated uses	Indoor	All uses combined under one roof with internal connections.	This may include multiple adjacent buildings with internal connections.
	Outdoor	All pedestrian circulation is internal to the development and provides direct connections between different uses. In addition, uses are well mixed and development is more or less continuous and not separated by parking facilities.	This classification has no internal streets or parking that must be crossed at grade to reach other destinations within the development.
2. Fully air conditioned grade separated	Multiple building or multiple block development that is connected by fully enclosed, air conditioned bridges or tunnels.		
3. Internal outdoor walkways	Multiple building development that is fully connected with on-site, internal walkways. Any pedestrian links across parking facilities are provided with specific pedestrian walkways.		Walking between buildings does not depend on walking along or across parking aisles. Some internal circulation may require crossing parking facilities.
4. Open bridges	Open air bridges connect different buildings in the development.		
5. Outside at-grade with priority street crossings	Pedestrians walk on street sidewalks. Mid-block pedestrian crossings and/or pedestrian crossings have priority at intersections.		Priority includes pedestrian activation after short wait (i.e., signals not timed for traffic progression).
6. Outside at-grade standard sidewalk system	Pedestrians use normal street sidewalk system and cross at street intersections with or without traffic signal control.		Standard connectivity for multiple block, street fronting development.
7. Informal	Pedestrian circulation requires walking through parking aisles or along streets without sidewalks.		
8. None	No viable pedestrian connections or they are too long to be convenient; driving is only reasonable way to reach some of the interacting uses.		Examples: (1) development flanks depressed highway and walking distance, even by bridge, is too long to be convenient; (2) development spread out beyond reasonable walking distance, such as a group of four adjacent outlet centers with restaurants extending over 3,000 ft by walking path. No internal trip capture estimated in such conditions.

Table B-3. Proposed ultimate land use classification system.

Context	Land Use[1]	Development Type[2]	Connectivity	Internal Proximity

• Rural
• Suburban
• Urban
• Midtown/suburban activity center[3]
• Urban core[4]
• Special district[5]
	• Retail
	  • Convenience
	  • Full service
	  • Discount
	  • Other specialty
	  • Other
	• Restaurant
	  • Fast food
	  • Sit down – no bar
	  • Family
	  • Quality
	  • Sit down – with bar
	  • Family
	  • Quality
	• Office
	  • Boutique
	  • Medical
	  • General
	• Residential
	  • Single-family detached
	  • Townhouse
	  • Condo
	  • Rental apartment
	• Hotel
	  • No meeting facilities
	  • Low price
	  • Mid price
	  • With meeting facilities
	  • Low price
	  • Mid price
	  • High price
	• Entertainment
	  • Cinema
	  • Other[6]
		• Single block
		• Multiple block single development interconnected
		• District
			• Fully integrated uses
			• Fully air conditioned grade separated
			• Internal outdoor walkways
			• Open bridges
			• Outside at-grade with priority street crossings
			• Outside at-grade standard sidewalk system
			• Informal
			• None[7]
				• Internal walking distance between interacting buildings

[1] It is also recommended that ITE land use classifications be recorded for each development for which data are collected since that classification is needed for trip generation analysis and it will allow for future disaggregation of these land use classifications if needed. For a full list of ITE trip generation land use classifications see *Trip Generation*, 8th edition, Institute of Transportation Engineers, Washington, D.C., 2009.

[2] May also include low-, mid-, high-rise sub-classifications within each category.

[3] Define as midtown or suburban business district or activity center (minimum office-retail-restaurant uses with at least 1 sq ft per area population with 100,000 sq ft minimum).

[4] Downtown or other regional CBD.

[5] Industrial, educational, civic center, entertainment.

[6] During initial stages, categorize "other entertainment" as retail–other.

[7] No internal trip capture estimated in such conditions.

to analyze relationships with internal trip capture, specific aggregation would be speculative.

The ultimate classifications proposed in this chapter should be considered as tentative and subject to consolidation. Consolidation employed for the research reported in this document was:

- Land use:
  - retail,
  - office,
  - restaurant,
  - residential,
  - hotel,
  - cinema;
- Development type:
  - single block
  - multiple block, single development interconnected; and
- Internal proximity:
  - internal walking distance.

APPENDIX C

Procedures for Internal Capture Surveys

This chapter describes a recommended procedural framework for conducting internal capture data collection at MXD sites. The framework collects the independent variable and internal trip making information required by the estimation methodology presented in Chapter 3. The audience of this chapter is the potential collector of internal capture data (whether typical traffic consultants, researchers, or public agency staff).

The recommended framework consists of six steps, starting with the definition of the specific purpose of the data collection effort and concluding with the proper processing of the on-site interview survey data. These steps are described in detail later in this chapter.

For the internal capture estimation method presented earlier in Chapter 3 to be effective, it must be based on consistent and correctly applicable data. Therefore, it is essential that there be consistency in the definitions used and the means by which internal capture data are collected. The data collection framework is structured to be straightforward, easily replicated, and adaptable to any potential mixed-use land use and development type.

The field data collection can be conducted with an experienced survey supervisor and low-cost or temporary personnel who are given specific training prior to initiation of the survey. The data collection procedure described in Steps 4 and 5 may at first appear to be onerous. However, all data listed will be needed for a typical internal capture trip generation analysis. Special or limited studies may require more, less, or different data. Prior to collection of any data the desired outputs should be examined and the necessary field data determined. Even for such special studies, the recommended framework presented in this chapter will provide a good foundation from which to work. However, if the resulting data are to be consistent with other data collected in accordance with NCHRP Project 8-51, the procedures described in this chapter should be followed. Any deviations to add more data should not change the basic data described herein.

The list of data to be collected for a typical analysis has been streamlined so that no extraneous data are collected. There are numerous types of information that could be interesting descriptors but that do not provide direct relevance to estimating internal capture. These extraneous data have been excluded from the data collection plan because requiring them would expand the volume of data to collect (and the cost), could intimidate or discourage a potential data collector, and could thereby hinder the collection of the important and relevant data. However, the entity conducting the survey may have other reasons to collect additional data.

Need for Quality Assurance and Control

An important component of the data collection effort is adherence to a quality assurance/quality control (QA/QC) program. The exact nature of the program should be at the discretion of the agency that is funding or conducting the data collection. However, at a minimum, a QA/QC plan should be developed at the outset and checks should be undertaken during each of the six framework steps.

An important consideration in the QA/QC process should be definition of the level of precision desired. This should be one of the first things determined for each survey. It is critical that the internal capture data be compatible among mixed-use developments. One quality assurance action is to carefully digest the definitions and descriptions of both the developments and the data to be collected and applied.

Methodology Framework

Step 1: Define Purpose of Data Collection

Step 1 provides the structure and scope for the survey. It is used to identify what is to be collected, how the data are to be used, and where to collect it.

Use of Data

The first step is to clearly specify the purpose of the internal capture data collection effort. There are two basic choices: (1) to study specific land use pairs in MXDs or (2) to determine internal capture rates for a development that is similar to a proposed MXD under consideration. In either case, the purpose may be to enhance the existing internal trip capture database or to establish internal capture rates for a similar MXD.

Under both choices, the data to be collected, the survey instrument, and the interview procedures remain the same. The only difference occurs in Step 2, when a data collection site is selected. Also important is how those data will be used. Is it to assess traffic impacts of a proposed development on roads in an area that already experiences congestion during certain periods, or will the data be used in a special generator estimate of trip generation for a regional forecast of daily travel? The specific use will influence selection of the study site as well as the season, day of week, and time-of-day when surveys should be conducted.

Site Selection

At first glance, it may seem that any MXD could be selected for data collection. However, mixed-use sites are rarely identical and often are very different from each other. Their differences may, in some cases, cause only small changes in internal capture. However, some seemingly minor differences (for example, in the proximity of uses or in an area with a different nearby land use mix) can cause substantial changes in internal capture. Therefore, it is important to select a development that is similar to the one to be analyzed or represented in the resulting database.

It is also important to collect the complete set of data to help identify differences that could explain the need to interpret the comparable sites for slightly different characteristics. In other words, although two sites may appear the same, when individual parameters are examined (e.g., actual walking distance between buildings), slight, yet important, differences may be revealed.

Site selection should consider:

- types or styles of development that the data will be used to analyze;
- development land uses and mix;
- size range of development;
- development maturity (is it fully occupied and sufficiently vibrant?)
- external conditions;
- representativeness of the development in relation to sites the data will support analysis of;
- external conditions, including competing opportunities, modes of access, economic strength of the area; and
- willingness of the development(s) owners and/or managers to permit the surveys in a manner needed for the surveys.

Timeframe

An important element to establish when defining the data collection purpose is the timeframe for which internal capture data are desired or required. Internal capture rates at a mixed-use site may vary by the time-of-day, day of the week, season of the year. Therefore, select the following:

- time-of-day such as the morning peak hour for the site, morning peak hour for the adjacent street, evening peak hour for the site, and evening peak hour for the adjacent street, and other peak hour of generator if it may be subject to traffic impact analysis;
- day of the week (weekday, Saturday, or Sunday); and
- season or month of the year (e.g., typical month, holiday shopping season, summer, school-in-session).

In terms of data that would be useful for the enhancement of the overall internal capture database, refer to Step 2 for suggested timeframes for particular land use pairs.

Step 2: Select an Appropriate Site

If the purpose of the data collection effort is to enhance the existing internal capture database, selection of an appropriate mixed-use site should be based on the following criteria.

- The site should be of a density and magnitude for which the potential for intra-site walk trips is significant.
- Individual land uses should be totally accessible *internally* either by pedestrian pathways or by streets completely within the development being surveyed (i.e., no vehicular travel required to make trips between internal points on streets on or beyond the periphery of the development).
- The mix of land uses should be representative of current or anticipated trends in mixed-use development.
- The land uses at the site should interact with each other. If one component of the mixed-use site does not have definitive synergy with any other on-site use (i.e., the number of on-site trips to or from that land use are miniscule or unlikely), the overall mixed-use site should be rejected because it really does not act like a true mixed-use site. Table C-1 shows the land use pairs the researchers concluded are best suited to both produce significant internal trip capture based on data reviewed to date and exist

Table C-1. Priority land use pairs for data collection.

Land Use	Land Use						
	Retail - Convenience	Retail - Other	Restaurant	Office	Residential	Hotel	Entertainment
Retail (Convenience)		√	√	√	√	√	√
Retail (other)			√	√	√	√	√
Restaurant				√	√	√	√
Office						√	
Residential							
Hotel							
Entertainment							

in significant quantity in current and anticipated MXDs. Trip capture data collection should be prioritized for these uses.

- The mix of land uses should be transferable. If a particular mixed-use site has a truly unique land use or tenant or setting, the internal capture data may not be applicable to other sites.
- The site should be fully occupied (or nearly so), mature (at least three years old), and considered successful locally.
- The area in which the development is located should also be mature and mostly built-out with a pattern of development normal for that type of area.
- Buildings are conveniently accessible to each other, both by distance and by accessibility.
- Parking is shared between land uses; the percentage of reserved spaces should be minor.
- The data collection program should be able to isolate the trips to, from, and within the development.
  - There should be locations where representative samples of trip making to and from each individual land use can be surveyed.
  - To that end, it is essential that through traffic not complicate data collection at the site. Ideally, there should be no through traffic.
  - Where tube traffic counters are to be used, the design of external access points should be such that mechanical counting techniques will produce accurate vehicle counts (e.g., short driveway throats make it difficult to place tube counters to work properly), or if not, manual or video counts should be employed.

If the purpose of the data collection effort is to determine internal capture at a site similar to a proposed MXD, the analyst should take a slightly different approach. First, the analyst must define the proposed MXD in terms of the independent variables collected in Step 3. In other words, compile the descriptive data for the proposed MXD as if it was the data collection site.

Armed with that information, selection of a similar site may be possible. Identify a mixed-use site (1) with the same land uses, (2) a similar balance of land uses, (3) with similar site layout characteristics, (4) that is at least three years old, and (5), if possible, that is located near enough so that competing opportunities are similar. In addition, follow the previous criteria.

When data are to be collected for a similar development, it is always valuable to verify acceptance of transferability with the agency that will review and decide whether to accept the results. Advance concurrence with site selection and procedures usually alleviates the possibility of having to collect data elsewhere.

Step 3: Obtain Permission to Collect Data at Study Site

After an appropriate MXD site is selected for the data collection, it will be necessary to obtain the permission from the site owner or property manager. It is not possible or appropriate to collect the necessary data (especially the on-site interviews of site visitors, patrons, and workers) without their permission and cooperation. In most cases, the owner or manager will communicate with internal businesses, landlords, etc. In some cases, the survey supervisor may need to make direct contact to gain full permission.

A primary objective of property management is to keep property ownership and property tenants content by, if possible, maintaining the status quo. One means of achieving this objective is to prevent the occurrence of any problems for the customers, visitors, workers, etc. of their property tenants. To that end, the analyst should contact property management by phone and mail/email, and then meet as necessary to discuss the purpose and procedures of the data collection effort.

During each contact, the analyst should convey an understanding of the need (1) to not impede patrons and (2) to not

divulge proprietary or sensitive information. An incentive for property management to cooperate is to offer to include a site-specific question during the interview process (and to offer the opportunity to receive the survey results or a copy of the study report). If a good working relationship can be developed, property management can often help tailor the intercept sampling procedure for the site and to interpret the survey results.

Step 4: Compile Descriptive Data on Characteristics of Site

After a subject site is selected, all information listed in Table C-2 needs to be collected and compiled. Most of these data will quantify the independent variables that have been demonstrated to affect internal capture at the mixed-use site.

Step 5: Collect Internal Trip Capture Data

The on-site internal trip capture data collection effort must be comprised of at least two components.

1. Counts of people entering and exiting each establishment where interviews are being conducted. These counts are used as controls for expanding interview samples (since complete interviews will not be obtained from every person entering and exiting) to represent all people entering and exiting the establishment.
2. In-person intercept interviews of people as they enter/exit a building (or significant use within a building) to determine the origin/destination, mode and purpose of trips internal to the mixed-use site. Other data collection options such as mail-back questionnaires, employee surveys, and visitor surveys do not obtain all the information required to understand and accurately quantify internal capture at the study site.

It is highly recommended that cordon counts of all persons by mode entering and exiting the survey site be made during the survey. This will provide information on mode of ingress/egress as well as the number of external trips being generated. This also provides the basis for an approximate check of expanded interview data.

Step 5 is subdivided into eight specific steps/decisions that need to be completed to conduct a successful field survey.

Step 5A: Specify Purpose of Internal Capture Data Collection

Step 1 in the overall data collection framework requires the analyst to define the specific purpose of the data collection effort. It should be repeated here and with specific reference to the following questions and issues.

- Within the specific MXD, is internal capture to be measured between selected pairs of buildings or throughout the entire site?
- Specify the timeframe of interest for determining internal capture. Plan to collect internal capture data for one or more of the following periods:
  - street peak hour – collect for at least one-half hour before to one-half hour after the known peak hour (i.e., for at least two hours total) to make sure the peak hour during the survey is actually covered. Check current ITE definition for the complete street peak hour definition to ensure the correct peak hour is selected (the weekday street peak hour is currently the highest 60 minutes of site plus adjacent street traffic within 7 A.M.–9 A.M. and 4 P.M.–6 P.M.) (*3*);
  - peak hour of generator – determine the highest morning or afternoon hour of trip generation from trip generation counts at the survey site. Survey from ½ hour before the beginning of the peak until ½ hour after the end of that peak hour;
  - midday – collect from 1 hour after the A.M. street peak hour to 1 hour before the P.M. street peak hour unless a shorter period has been established with the review agency for the resulting analysis; and
  - daily – Collect survey data during the active part of the 24-hour period (e.g., when businesses are open; between about 6 A.M. and 10 P.M. for typical residential).
- Specify the preferred day of the week (weekday, Saturday, or Sunday), based on the period analyses are to cover. If a weekday, select a typical day of the week for the land uses to be surveyed.
- Specify the preferred season of the year (holiday shopping, summer, school-in-session), based on the period analyses are to cover.

Step 5B: Identify Buildings or Uses at Which to Collect Internal Capture Data

Identify the specific buildings at which to collect internal capture data. This will include all buildings and occupants or a representative sample of each. Specifics will depend on resources available, the site size, the number of land uses to be surveyed, and agreements with the agency that will need to accept the survey results. Generally, for a single time period, it is desirable to have at least 50 usable interviews per land use (30 minimum). Generally sample sizes of less than 30 are avoided to ensure the sample results benefit from the central limit theorem that says the sampling distribution of the means will approach that of a normal distribution even if the population being sampled is not normally distributed (*4*).

Table C-2. Descriptive data for MXD sites.

Data	Specific Information Desired	Comments
Overall Characteristics of Site	Name	Record the common name for the overall mixed-use development site
	Development Type	Specify whether the site is contained within a single-block, multiple blocks or a district
	Site Maturity	Record the year the site opened. If opened in stages, also specify the date of the latest significant building opening.
	Primary Tenant(s)	Determine the primary tenant (i.e., the tenant that serves as the primary driving force behind the overall site being developed as a mixed-use site); some sites may have more than one major (anchor) tenant.
	Other Land Uses within Site	List the other land uses within the site. Use standard nomenclature. ITE trip generation land use classifications are preferred.
	Building/Area Names and Addresses	If the overall site is subdivided into sectors with different names or building addresses, identify them.
Physical Characteristics of Site	Site Plan	Obtain a site diagram, sketch, plan, or aerial photo of the site, preferably to scale. The diagram should show: • overall site layout with building footprints, • building entrances and pedestrian pathways, • access points from street system, and • parking supply.
	Site Area, Size, and Density	Record total site acreage. Record number of development units for each building or area (gross square footage, number of dwelling units); at a minimum, collect dwelling units listed for each ITE trip generation land use category. Identify the developed portions by phase for developments to be expanded (if applicable).
	Locations and Types of Access	Document the overall site access plan for motorists (including delivery and service vehicles), pedestrians (including transit patrons), and bicyclists, including: • location of each access point, • type of traffic control at or serving each access point (i.e., signalized or unsignalized), and • transit stops and station entrances along with existing or planned transit service.
	Internal Circulation Facilities	Locate the internal roadways and driveways used by motorists. Locate the pathways for pedestrians (and describe whether pathways are enclosed, covered, or open-air). Locate the pathways or lanes designated for bicyclists, if any.
	Location and Quantity of Parking	Document the location of single-use or shared parking facilities. • Record the quantity of spaces in each facility. • Document the type of parking facility (e.g., surface, garage). • Assess how much of the development truly shares parking. • Record the daily/hourly cost for parking.
Characteristics of Individual Buildings within Mixed-Use Site *(This information is needed for each individual building or area.)*	Building Size	Quantify the building size in development units such as office building square footage (GSF), amount of leased retail space (GLA), number of restaurant or theater seats, or number of residential units. Also obtain the number of stories.
	Primary Land Use	Identify the primary land use within the building as being either retail, restaurant, office, residential, hotel, entertainment, or other. If more than 5 percent of the building square footage is occupied by a secondary use, treat it as a separate land use so internal capture can be quantified. For both the primary and secondary land uses in a building site, classify them in accordance with ITE Trip Generation Land Use codes (*1*). List the ground floor uses separately since counts may be needed for each.

	Space Allocated to Individual Land Uses	Quantify the space allocated to primary and secondary land uses (any exceeding 5 percent of the building). Since it may be desired to estimate trip generation for specific land uses, it is suggested that the land uses be disaggregated by the following land use categories (which are more detailed than the seven general land use categories listed above):
		• For retail, subdivide into:
		  • Convenience (e.g., grocery, drug store, bank, dry cleaner)
		  • Full service
		  • Discount Other/specialty Other

(continued on next page)

Table C-2. (Continued).

Data	Specific Information Desired	Comments

Characteristics of Individual Buildings within Mixed-Use Site (*This information is needed for each individual building or area.*)	Space Allocated to Individual Land Uses	• For restaurant, subdivide into:
		  • Fast-food
		  • Sit-down with no bar
		  • Family
		  • Quality
		  • Sit-down with bar
		  • Family
		  • Quality
		• For office, subdivide into:
		  • Boutique
		  • General
		  • Medical (nearly all space is doctor offices and medical related uses that serve patients)
		• For residential, subdivide into:
		  • Single-family detached
		  • Townhouse
		  • Condominium
		  • Rental apartments
		• For hotel, subdivide into:
		  • High price
		  • Mid-price with meeting facilities
		  • Mid-price with no meeting facilities
		  • Low-price
		• For entertainment, subdivide into:
		  • Cinema
		  • Other
		• For other, specify the use

	Building Occupancy	Quantify the building occupancy (e.g., occupied office, retail, and apartments, not just leased). In a multi-tenant building, contact the property manager, leasing agent, or owner to obtain occupied space data.
	Building "Primary Access Point" or "Center of Gravity" if multiple access points are available	Determine the main access point. If multiple access points exist, designate the "center of gravity" (or "access point") for the building. One characteristic of a mixed-use site that has a significant effect on internal capture is the proximity of its complimentary uses. To measure this proximity, the trip end points must be defined at a certain level of precision. For some buildings (for example, a multi-story office building), the center of gravity seems obvious (in this example, the building lobby). However, for multi-tenant retail buildings, the definition of center of gravity is much less clear. For the purposes of internal capture data collection and data analysis, the following convention for determining a building center of gravity is used: • for an enclosed retail mall with more than one anchor store, use inside entrances for anchor stores. It is important to use the location of the mall-side, not outside, entrance; • for an open-air community or neighborhood shopping center or for an enclosed mall with a single anchor store, use the location of the main entrance for primary tenant. The primary tenant could be a grocery store, any other big box or a discount store; • for an office building, use the office lobby; • for a hotel, use its lobby or registration desk; • for a restaurant, use its main customer entrance; • for a residential site, use its approximate center of gravity of the ground floor dwelling unit entrances; and • for an entertainment facility, use its main lobby. Another possibility is to disaggregate all data to individual building entrances. In that case, no center of gravity needs to be determined. In any case judgment will often need to be used. Three examples of centers of gravity include: • midway between two entrances on the same building face if both have similar levels of inbound and outbound volumes; • center of block face with numerous entrances; and • center of block for a land use covering an entire block with entrances on each side, each with similar volumes.

Table C-2. (Continued).

Data	Specific Information Desired	Comments
	Building Proximity	Measure proximity of the building to each other building in the mixed-use site. Measure as walking distance along pedestrian facilities between building "centers of gravity" (as defined previously). The desired level of precision for each of the above measurements is 10 percent of the approximate total distance or 100 ft, whichever is less.
	Connectivity between Buildings (Not currently part of recommended procedure, but a consideration in evaluating internal connectivity)	Rate the connectivity between the building and each other building in the mixed-use site, using the following scale: • fully-integrated uses – the pedestrian connection between uses is direct and internal to the development, and does not require crossing a parking facility at-grade; • outside sidewalks with at-grade, priority street crossings – pedestrians use street sidewalks. Any street crossings (whether midblock or at intersections) assign priority to pedestrians; and • informal – the pedestrian connection requires walking through parking aisles or along streets without sidewalks.
	Parking Supply	Rate the parking supply within 600 ft of the building entrance for building tenants and visitors, in particular its convenience. Rate as either ample or limited (based on availability of parking at the ITE *Parking Generation* report rates) (2). Report total parking spaces and rates if any. Indicate number of spaces reserved for each land use and any time restrictions.
Setting/Context of Site within Surrounding Region[1]	Location within Urban Area	Classify location of the overall site as either rural, suburban, urban, midtown/activity center, urban core, or special district
	External Competition for Individual Components of Site (Not currently part of recommended procedure, but may influence internal capture)	Consider the degree to which off-site land uses will compete with those on-site and assess if that will affect how representative the candidate site will be to the survey. A development with extreme off-site competition may have fewer internal trips than one with almost no competition. Selected data collection sites should be representative of typical conditions or of a similar proposed development to be analyzed.
[1] Quantification of the site setting and context measures is facilitated if a GIS linkage is provided for the mixed-use site.		

Step 5C: Identify Intercept Locations at Study Sites

Identify all means/routes of entering or exiting the building (or significant use within the building) whether to make an internal or external trip. Identify the entrances/exits that can be used to make a trip internal to the mixed-use site, whether by foot, bike, or vehicle. At each of these latter entrances/exits, select an interview location.

It is not necessary to interview at external site access points where only external trips from specific single-use buildings can be made, but these must be counted (person trips by mode) instead. This is because all trips directly between on-site buildings and the external transportation system are (1) external, (2) can be added to trip interview data from that building, and (3) can be counted as person trips by mode. Usually this condition only occurs when a garage has access directly to an external street. Pedestrian access does not assure that the person is actually going external unless it is a direct connection to a transit station or an off-site garage. Table C-3 provides guidance on where to conduct surveys.

Table C-3. Survey and count requirements for several sample locations.

Survey Site Location	Survey and Count Requirements
Office building connected to a retail building by walkways at several levels in a fully-integrated mixed-use site; office building has elevator/stairs to parking garage	Survey at either end of each walkway connecting the office and retail uses. Count (1) each walkway connecting office and retail and (2) people entering/leaving the office building via the garage or any other entrance.
Stand-alone office building situated near or adjacent to a retail shopping center; parking provided on surface and below-grade (accessed via elevator or stairs in office building); pathway to retail leads to/from building lobby	Survey everyone who passes through lobby or who uses garage (because a person could drive to the adjacent retail site and thus would be considered an internal trip). Count at lobby and garage entrances.
Regional mall with nearby office and residential uses	Survey at the mall entrances Count each mall entrance separately (including any outside entrances for anchor stores).

Step 5D: Identify Count Locations at Study Sites

The data collection program must include a count of all people (not simply vehicles) entering or exiting the building at which interviews are being conducted. Therefore, appropriate count locations must be identified. These will usually be doors to the property being surveyed (count people entering and existing), garage access points (count vehicles and occupants); there may be other access points.

The count should keep track of entering and exiting people separately. The counts will be used for two purposes:

1. person trip generation count for establishment being surveyed and
2. for computing an expansion factor to be applied to the interview data.

Separate data are necessary for survey factoring and for determining an overall internal capture rates for the surveyed site. Table C-3 provides guidance on the extent of a count program for sample mixed-use sites.

The survey should include interviews at as many establishments as possible while obtaining the desired number of interviews per land use during each survey period. Interviewers should be deployed to representative establishments within each land use. Under the best scenario, interviews will be conducted at each establishment. If that is not possible, conduct interviews at a representative cross-section within each land use. When using the sampling approach, deploy interviewers to the busiest locations in each land use. If interviewers are assigned to low volume access points, they will not complete many interviews. This may be partially offset by having interviewers intercept people at multiple adjacent establishments.

A competent interviewer (actively approaches people to get interviews, responses are complete and accurately recorded) located at a moderately active entrance should be able to complete interviews with at least 10 people per hour. However, activity levels will vary and typically result in a range of 5 to 20 completed interviews per hour. An average interviewer should be able to obtain completed interviews from one out of every three to four persons approached. Recognize that some interview candidates will decline to participate or have been interviewed previously and not want to participate again.

Step 5E: Determine Staffing Requirements

For mixed-use sites, it is desired to conduct 50 or more interviews per land use per survey time period. This may not be possible for land uses that are small or are relatively inactive during the survey time period (e.g., weekday morning retail). One way an interview sample can be expanded is by conducting interviews during the same time periods over multiple days.

The survey supervisor should determine how many surveyors are needed, based on the survey location requirements described in Step 5D and on the minimum sample requirements described previously. If there is a steady stream of pedestrians at a survey location, a rate of 20 complete interviews per hour is a reasonable expectation for each surveyor. For less active locations, estimate 5 to 10 complete interviews per hour for well-trained interviewers who are experienced at approaching strangers. When estimating manpower requirements, it is important to assess the pedestrian traffic flow to be intercepted.

Step 5F: Develop Survey Instrument and Other Data Collection Forms

Interviews of persons are typically conducted as they leave a single land use or building within the site. Each interview can obtain information on both the trips ***to*** and ***from*** the surveyed building and to and from the overall mixed-use site. Figure C-1 provides a sample list of interview questions. The questions are written for exit interviews at building or garage access points (i.e., interviews of people as they leave a location). If the interview is to be conducted as people enter the location, the form shown in Figure C-2 should be used. In general, interviews should be conducted in both directions. However, if that is impossible, complete interviews conducted in one direction can yield usable data since information is asked in each interview for one outbound and one inbound trip.

If the survey will be conducted at the cordon driveway or other type of location, the supervisor may need to revise the questions to capture the last (for exit interviews) or first (for inbound interviews) on-site stop. Other modifications may be needed for special locations or applications. The survey supervisor should make sure that the questionnaires to be used fit the conditions as well as collect the desired data. In general, use of questionnaires such as those shown in Figures C-1 and C-2 will be adaptable to nearly any standard survey and can be automated if desired. Each item is needed for a complete analysis or for checking responses. However, some survey sites may need supplemental questions to firmly and clearly establish the characteristics of the trips being reported.

The field survey form should include a space for the interviewer to record the date, the name of the development, the interviewer's location within the site, the time each interview begins, as well as the interviewer's name. It is important that every single item be filled out completely and accurately for each interview. Omissions can make an interview unusable. Inaccurate entries, guesses, or incomplete entries will also invalidate an interview, wasting both time and money.

Interviews will be completed for a sample of all persons exiting establishments or the site. Factoring will be used to expand the survey data to represent the universe of trips

As persons DEPART intercept as they leave a specific entrance

Interviewer name:_____ **Building:** _____ **Date:** _____ **Start Time:** _____ **A.M. P.M.**

1

→→ Hello. May I please have a moment of your time to ask you a couple of questions for a Mockingbird Station survey?

Building Entrance	Time	**Where are you headed now?**			**How are you going to get there?**	**Where did you come from *immediately before* you came to [name place being exited]**			**How did you travel from there?**	**What time did you arrive here on that trip?**	**How did you *initially* travel to (name the study site) today?**	
		1. Within (name study site) 2. Outside (name study site)	1. Office 2. Retail 3. Restaurant 4. Residential 5. Medical office 6. Cinema 7. Hotel/motel 8. Other (specify)	Specify business/building	1. Auto driver 2. Auto passenger 3. Walk 4. Rail 5. Bus 6. Bicycle	1. Within (name study site) 2. Outside (name study site)	1. Office 2. Retail 3. Restaurant 4. Residential 5. Medical office 6. Cinema 7. Hotel/motel 8. Other (specify)	Specify business/building	1. Auto driver 2. Auto passenger 3. Walk 4. Rail 5. Bus 6. Bicycle		0. I live here 1. Auto driver 2. Auto passenger 3. Bus 4. Rail 5. Walk 6. Bicycle	If not as driver, did you have an auto available for your trip here? 1. Yes 2. No
										am pm		
										am pm		
										am pm		
										am pm		
										am pm		
										am pm		
										am pm		
										am pm		
										am pm		
										am pm		
										am pm		
2	3	4	5	6	7	8	9	10	11	12	13	14

Figure C-1. Sample exit interview questionnaire.

Intercept persons as they look like they will ENTER a specific entrance

Building entrance: _____ **Interviewer name:** _____ **Date:** _____
1 2

Time	**Are you headed into (name of establishment where you are interviewing)**	**Where are you coming from?**			**How did you travel to get here?**	**Before you were at (prior place) where were you before then? (Immediately prior to last place)**			**About what time did you arrive there?**	**How did you travel to get there?**	**How did you *initially* travel to (name survey site) today?**	
	3. Yes 4. No (If "no," terminate interview)	1. Within (name survey site) 2. Outside (name survey site)	9. Office 10. Retail 11. Restaurant 12. Residential 13. Medical office 14. Cinema 15. hotel/motel 16. Other (specify)	Specify business/building	7. Auto driver 8. Auto passenger 9. Walk 10. Rail 11. Bus 12. Bicycle	3. Within (name survey site) 4. Outside (name survey site)	9. Office 10. Retail 11. Restaurant 12. Residential 13. Medical office 14. Cinema 15. Hotel/motel 16. Other (specify)	Specify business/building		1. Auto driver 2. Auto passenger 3. Walk 4. Rail 5. Bus 6. Bicycle	7. I live here 8. Auto driver 9. Auto passenger 10. Bus 11. Rail 12. Walk 13. Bicycle	If not as driver, did you have an auto available for your trip here? 3. Yes 4. No
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
									am pm			
3	4	5	6	7	8	9	10	11	12	13	14	15

Figure C-2. Sample inbound interview questionnaire.

Location: _____ Counter: _____ Date: _____ Hour Starting ____:00 am pm

Minutes after hour	Direction	Business/Place							
		1	2	3	4	5	6	7	8
:00 to :15	In								
	Out								
:15 to :30	In								
	Out								
:30 to :45	In								
	Out								
:45 to :00	In								
	Out								
1	2	3	4	5	6	7	8	9	10

Figure C-3. Sample door count form.

represented in the survey. Counts of all persons exiting the survey locations (or all locations) will be needed to develop the expansion factors. This expansion process will need to be developed as part of the survey design so the proper counts can be made. Figure C-3 shows a manual count form that can be used to count people exiting (or entering) each door of each establishment where interviews are to be conducted or that the interviews are to represent. This form or an automated equivalent can be modified to meet specific survey site needs.

Cordon counts may also be needed for factoring and/or checking total external trips. These counts should be directional and by travel mode. Vehicle occupancies should be counted since the recommended estimation methodology (and therefore survey methodology) is for person trips. Counts should cover all access points. Figure C-4 shows a manual cordon count form that can be used for this type of survey. This form can be automated or modified as needed for specific survey conditions.

Step 5G: Recruit and Train Field Personnel

After recruiting the survey field personnel, the survey supervisor should conduct a training exercise. Some personnel will need to conduct door counts—the counts of people entering and existing establishments to be surveyed. Some personnel will conduct interviews. Generally the most outgoing and assertive staff will make the best interviewers. Retiring personalities should not be deployed as interviewers but may make good counters.

The interviewers should be made familiar with the survey instrument through practice of intercept interviews. The same is true for counters. All survey personnel should be provided with maps showing each location where counts and/or interviews are to be performed. The survey supervisor should include on each map the overall MXD site with names of buildings, tenants, and areas to which interviewees might refer as well as the specific location and movements the counter or interviewer is to handle.

Field surveys are not trivial. They require thorough preparation and training as well as good supervision. Most surveys of this type will require one supervisor for each 10 to 15 interviewers and counters. Specifics of the survey site, including size and distribution of survey personnel, may increase or decrease the number of supervisors needed.

Step 5H: Conduct Field Data Collection

Inbound and Outbound Door Counts. As noted previously, total person counts are needed at each location where intercept surveys are to be conducted. If several adjacent

Location: _____ Counter: _____ Date: _____ Hour Starting ____:00 am pm

Minutes after hour	Direction	Personal Vehicles				Motorcycles		Delivery/Service Trucks		Walk	Bike
		Occupants				Riders		Occupants			
		1	2	3	4+	1	2	1	2+		
:00 to :15	In										
	Out										
:15 to :30	In										
	Out										
:30 to :45	In										
	Out										
:45 to :00	In										
	Out										
3	4	5	6	7	8	9	10	11	12	13	14

Figure C-4. Sample cordon count form.

establishments are to be surveyed, one counter may be able to count multiple doors concurrently. This will depend on sight lines and placement of the counter. A counter should only be assigned those movements to count that can easily be seen while looking in one direction. Requiring a counter to look in multiple directions will result in missed persons entering or exiting doors being counted.

As mentioned previously, every establishment door where interviews are conducted must have entering and exiting people counted. Counts should be made by 15-minute periods beginning on the hour or half hour when the survey begins. Counts should be made for the complete survey period.

The survey supervisor should have extra personnel to provide short breaks for the counters to use restrooms. It is suggested that breaks be permitted every two hours. With cell phones now in common use, they can be used by survey personnel to request restroom breaks, if needed before scheduled breaks. Survey personnel should be cautioned to stay hydrated, especially on hot days, but not to drink so much that frequent trips to restrooms are needed.

Counters should be trained in what they are to do. Training should be completed prior to the survey. Training often requires at least four hours and often more. It can be beneficial to begin the first day's survey an hour early to make sure the survey personnel are comfortable with their job before the survey period actually starts. On the first survey day, the supervisor should walk each counter to the assigned survey location. The supervisor should make clear what doors and movements are to be counted and where on the form each movement should be recorded (form for each counter should be set up in advance). The supervisor should ask each counter if he or she has any questions to make sure instructions are clear.

After the survey begins, the supervisor should circulate among the counters to check to see that counts are being made and recorded correctly. Common problems are line of sight obstructions (unanticipated or resulting because counter moved), inattention, recording counts in the wrong column, not keeping track of time, talking to another counter, and socializing with passersby.

Interviews. The survey supervisor should carefully recruit and select interviewers. The ideal interviewer is outgoing, assertive, willing to approach and talk to strangers, sounds professional, and understands the purpose and procedure for the interviews. The survey supervisor will need to train all survey personnel, but spend more time with the interviewers. It is recommended that each interviewer perform a few practice interviews under supervision prior to beginning actual surveys.

On the first survey day, the supervisor should walk each interviewer to the assigned interview location. The supervisor

should make clear what doors and movements for which interviews are to be conducted and make clear where the inbound and outbound trips are to be recorded. If appropriate, the supervisor should also discuss the strategy for approaching people to interview. The supervisor should ask each counter if he or she has any questions to make sure instructions are clear. Practice or test interviews are recommended. It may be beneficial to begin interviews an hour early the first shift worked by each interviewer to make sure the interviewer is comfortable and approaching and interviewing people correctly.

After the survey begins, the supervisor should circulate among the interviewers to check to see that candidate respondents are being approached professionally and that interviews are being conducted and recorded correctly. Common problems include:

- shyness in approaching people to interview,
- not asking questions correctly or leading respondents by guessing answers for them,
- incomplete recording of responses,
- not asking all questions,
- not keeping track of time,
- talking to another survey staff member, and
- socializing with passersby.

The selection of a representative and sufficient sample of workers, shoppers, visitors, and residents at the survey site is critical to the success of the survey. Therefore, the survey supervisor should closely monitor the real-time progress of the intercept surveys to make adjustments as necessary to achieve the representative and sufficient sample, keeping in mind the stated objectives for data collection effort. This may require redeployment of interviewers to different locations that have more activity or making other changes that will increase the number of usable interviews for each land use.

Cordon Counts. One counter should be assigned responsibility for each cordon count location. Since the counter must be able to count not only vehicles, but also vehicle occupants as well as pedestrians and bicyclists, the counter will need to be close to where the cordon crossing is located. Ideally the counter can be immediately adjacent to the driveway, street, garage entrance, or other cordon location. In some cases, two adjacent cordon locations will be so close together that a single counter can count both with accuracy. In either case, each form should be set up specifically for the location(s) to be counted.

A counter should only be assigned those movements to count that can easily be seen while looking in one direction. Requiring a counter to look in multiple directions will result in missed persons and vehicles crossing the cordon line. Counts should be made by 15-minute periods beginning on the hour or half hour when the survey starts. Counts should be made for the complete survey period.

The survey supervisor should have extra personnel to provide short breaks for the counters to use restrooms. It is suggested that breaks be permitted every two hours. Cell phones can be used by survey personnel to request restroom breaks, if needed before scheduled breaks. Survey personnel should be cautioned to stay hydrated, especially on hot days, but not to drink so much that frequent trips to restrooms are needed.

Counters should be trained in what they are to do. Training should be completed prior to the survey. On the first survey day, the supervisor should walk each counter to the assigned survey location. The supervisor should make clear what movements are to be counted and where on the form each movement should be recorded (form for each counter should be set up in advance). The supervisor should ask each counter if he or she has any questions to make sure instructions are clear.

After the survey begins, the supervisor should circulate among the counters to check to see that counts are being made and recorded correctly. Common problems are line of sight obstructions (unanticipated or resulting because counter moved), inattention, recording counts in the wrong column, not keeping track of time, and socializing with passersby.

Use of Electronic Recording Devices. A number of electronic survey recording devices, including laptop computers, are now available. They can be successfully used for these counts and interviews, if they are set up in formats that are easily used. Formats that do not allow counters or interviewers both ease of use and logical positioning of response only invite confusion and errors. For example, use of an electronic intersection turning movement count board for a door count where several doors are to be counted by one person will probably not present a logical input format and lead to errors.

Step 5I: Supervise in Field

Survey supervisors should have a survey check procedure developed as part of the QA/QC procedure suggested at the beginning of this chapter. This procedure should be in place prior to training. The check procedure should include assignments of supervisors to check each counter and interviewer and how to perform the check. Supervisors should observe interviewers at work and suggest refinements in their approach and conduct of interviews. Spot checks of interview records should be made early in the first interview period to make sure the responses are both logical and complete. Supervisors should understand that errors in procedure usually continue until corrected. If not corrected, interviews for an entire day could be lost as unusable. The same is true for counts.

It is important for the supervisors to keep circulating among those being supervised. Even though the counts or interviews

are being performed correctly, other supervisory needs may arise. Common needs include complaints from business or landlords wanting survey personnel to relocate or stop their survey, unexpected movements that are being missed by the survey, too much activity for one person to cover, "no" activity to count or interview, business opened or closed unexpectedly, and survey staffer unable to perform as needed.

Step 5J: Check Data after Each Period

The survey supervisors should perform a check of the counts and interviews immediately after each survey period. The check should be included in the QA/QC plan, but should generally include at least the following:

- Counts:
  - count covers full period;
  - inbound and outbound balances are logical;
  - variations by 15-minute period are logical;
  - modal splits are within the expected ranges;
  - vehicle occupancies are in expected ranges;
  - for cordon counts, it is desirable to total the counts to see if they appear reasonable, particularly the balances between inbound and outbound;
  - for door counts, for each land use, compare inbound and outbound totals to make sure the balance appears logical; and
  - if discrepancies are found, determine if corrections can be made, and if not, schedule a recount(s) as needed.
- Interviews:
  - times of interviews are recorded;
  - are responses within range of permitted choices (i.e., are codes consistent with choices available)?
  - are write-in responses complete and understandable?
  - destination for outbound trip is logical and mode fits origin-destination pair;
  - origin of inbound trip is logical for reported time of trip (i.e., was it really the immediately prior trip?); is time reported for that trip logical for immediately prior trip?
  - check response to whether a vehicle was available for trip; is it logical for reported mode of trip?
  - is mode of access to site logical given mode reported for these trips? and
  - where discrepancies or errors appear to exist, review forms with interviewer (call as soon as possible while memory still clearest) to determine if corrections can be made or if interviews must be discarded. If necessary, repeat interviews where prior interviews had to be discarded.

After the survey has been completed in the field, the supervisor should complete the checking of all counts and interviews. Those that are unusable should be deleted. Erroneous counts should have been repeated. Small percentages of unusable interviews should be deleted. Large numbers should have been repeated.

Step 6: Process Internal Capture Data

For each survey site (establishment), the analyst should determine the number of usable interviews. Under normal circumstances, 50 or more usable interviews should be available for each land use (100 desirable, 30 minimum). In some cases, this will not be possible because the land use will not be active (e.g., retail closed during A.M. peak hour) or because the quantity of development in a land use category will be small. That number can be compared to the total door counts for the same period. The sampling percentages can be calculated by dividing the number of usable interviews by the number of people counted in the same direction (inbound or outbound). The same can be performed for each land use by aggregating all establishments within specific land uses.

Since the interviews represent a sample, the next step is to compute an expansion factor to expand the sample to represent the total for that universe. This can be accomplished in at least two ways:

- by land use (normal approach):
  - separate each interview record into individual trip records; there will be one or two usable trips in each interview record depending on how many occurred during the survey period;
  - aggregate by land use numbers of inbound and outbound trips (aggregate to the interview end of the trip) reported during the survey period from those interviews; this includes both trips reported in the interview if they were during the designated survey period (T_L for each direction);
  - aggregate door counts to the land use level (C_L for each direction);
  - determine number of development units (e.g., gross square feet) covered by interviews and the number of development units for which no interviews were conducted (in cases where only a portion of establishments within a given land use were interviewed); calculate a sample percentage for each land use (S);
  - the expansion factor (F_L) for reported trips for each land use and each direction will be: $F_L = (C_L/T_L)/S$; and
  - apply directional land use expansion factor F_L to each trip record; and
- by establishment:
  - separate each interview record into individual trip records; there will be one or two usable trips in each

Table C-4. Sample summary format—outbound trips.

From	To					
	Internal				External	Total
	Land Use 1	Land Use 2	Land Use 3	Etc.		
Land use 1	Number or %	Number or %	Number or %	Number or %	Number or %	100%
Land use 2						100%
Land use 3	4 (4%)	8 (8%)	20 (20%)	0 (0%)	68 (68%)	100 (100%)
Etc.						100%
External						100%

interview record depending on how many took place during the survey period;

- aggregate by establishment the numbers of inbound and outbound trips (aggregate to the interview end of the trip) reported during the survey period from those interviews; this includes both trips reported in the interview if they were during the designated survey period (T_E for each direction);
- aggregate by establishment the door counts (CE for each direction);
- for each establishment surveyed, compute the expansion factor to apply to trips to and from that establishment; it will be the establishment's directional door count divided by the establishments usable trips in the same direction (CE/TE);
- determine number of development units (e.g., gross square feet) covered by interviews and the number of development units for which no interviews were conducted (in case where only a portion of establishments within a given land use were interviewed); calculate a sample percentage for each land use (SE);
- Apply directional establishment expansion factor FL to each trip record for each establishment (Ei), then sum to aggregate trips to the land use level, or
- FEi = (CEi/TEi)/SE; and
- those expansion factors are then applied to trip records for each surveyed establishment; the sum equals the total for that land use.

After the expansion factors are applied at either the land use or establishment levels, a summary of internal capture can be created. This should be performed for each end of a trip and in the inbound and outbound directions; that is:

- Land Use A – outbound trips to internal destinations at each other land use, plus outbound trips to external destinations; and
- Land Use A – inbound trips from internal origins at each other land use, plus inbound trips from external origins.

Tables C-4 and C-5 show a format for this summary. Using the trip records and expansion factors from the survey, sum the expanded trips in origin-destination format. This should be a straight forward process to begin from the origin end of trips and sum to produce a table similar to Table C-4. This provides a distribution for all trips departing a given land use (the example shown is referred to as Land Use 3). Some trips will end in the same land use, although at another establishment. Some trips will travel to other internal land uses. Some will leave the surveyed development and travel to an external destination. All trips must travel to either an internal or external destination. For Land Use 3, those outbound trips will total 100 percent. Hence, each of the entries in the Land Use 3 row can be converted to percentages. For example, if there are 100 outbound trips from Land Use 3 and 8 trips travel to Land Use 2, then 8 percent travel to Land Use 2. Since this is internal, 8 percent were internally captured by Land Use 2 (see Table C-5).

ITE has a large trip generation database built from counts of external traffic (vehicle trips) from single-use developments (or at least single classifications). ITE trip generation data excludes internal trips. For the Table C-4 data to match the ITE definition, internal trips must be deleted. Table C-5 shows

Table C-5. Sample summary format—outbound trips (ITE definition).

From	To					
	Internal				External	Total
	Land Use 1	Land Use 2	Land Use 3	Etc.		
Land use 1						
Land use 2						100%
Land use 3	4 (5%)	8 (10%)		0 (0%)	68 (85%)	80 (100%)
Etc.						100%
External						100%

Table C-6. Sample summary format—inbound trips.

From	To				
	Internal				External
	Land Use 1	Land Use 2	Land Use 3	Etc.	
Land use 1			Number or %		
Land use 2			Number or %		
Land use 3			Number or %		
Etc.			Number or %		
External			Number or %		
Total			**100%**		

how that is accomplished. Movements between establishments within the same land use are not considered; they are deleted from the trip table. Table C-5 shows the hypothetical results with the trips internal to Land Use 3 deleted. The internal trips to other land uses remain. The total trips external to Land Use 3 remain the same as do the external trips, which are the trips of most interest in transportation impact studies.

Trips also travel into the surveyed development and its land uses. A similar summary of inbound trips can be created as Table C-6 shows. These numbers and percentages may be different than the numbers in Table C-4. Logic supports such a finding. For example, in a MXD with retail, restaurants, and office, the restaurants will send few P.M. street peak hour (e.g., 5–6 P.M.) trips to office uses because few, if any, office workers will travel to their office at that time. However, restaurants may receive a significant percentage of their 5–6 P.M. trips from internal office uses (people going for an early dinner, drinks, or hors d'oeuvres). Hence, it would be logical to expect different directional percentages between office and restaurant during the P.M. street peak hour.

References

1. *Trip Generation, 7th Edition, Vol. 3: User's Guide,* Institute of Transportation Engineers, Washington, D.C., 2003, p. iv–viii.
2. *Parking Generation,* 3rd edition, Institute of Transportation Engineers, Washington, D.C., 2004.
3. *Trip Generation, Volume 1 of 3: User's Guide,* Institute of Transportation Engineers, Washington, D.C., 2008, p. 7.
4. *Fundamental Research Statistics for the Behavioral Sciences,* John T. Roscoe; Holt, Rinehart and Winston, Inc., 1969.

APPENDIX D

Pilot Survey Experiences and Lessons Learned

This appendix describes experiences and lessons learned in conjunction with the pilot studies. Survey results are described in Chapter 3.

The project panel requested that the two initial pilot study sites have different character—one a TOD and the other large enough to require driving to complete at least some internal trips. Two developments were sought that would meet those general criteria. A third development was later added courtesy of a different sponsor.

Site Survey Permissions

Permissions

The first step after selection of the preferred steps was to obtain permission from the owners or managers of the selected developments. The initial phone conversation requested permission to:

- conduct brief interviews of people entering or leaving buildings and businesses during weekday A.M. and P.M. peak periods (two days each);
- count people entering and exiting each entrance where surveys were being conducted; and
- conduct a (person trip) cordon count around the development(s) site being surveyed.

The owner or manager was also requested to provide information quantifying development characteristics, a site plan, and other information needed to complete the survey and analyze the results per the procedures described in the interim report. The initial phone conversation was followed up with a letter or email message requesting permission and describing the surveys to be conducted.

One of the initial sites selected for surveys was Mockingbird Station (a TOD) in Dallas, Texas. Mockingbird Station had been the subject of several different types of studies since opening. The on-site management company provided permission to conduct surveys. The management company wanted to review each survey instrument to make sure questions or information was not intrusive. A commitment was made not to impede movement to and from businesses or residences and to accept interview refusals without question. Only exit interviews were permitted. Each survey crew member had to be identified with a badge issued by the management company. The management company was very cooperative and helpful before and during the survey.

The second site was Atlantic Station in Atlanta, Georgia. Even though Atlantic Station had opened less than a year earlier, ownership there had changed from a single developer who had welcomed studies of the development to several different owners with varying levels of interest. Owners were primarily concerned about having patrons and residents interviewed and did not want to risk customers not wanting to do business at a place where interviews were being conducted. Permissions were secured with some limitations about where interviews could be conducted. Only exit interviews were permitted. Some access/parking-related information was to be provided by the parking operator rather than be collected directly.

The third development added later was Legacy Town Center in Plano, Texas. The sponsor for that survey specified a scenario unrelated to this NCHRP project, but which permitted a development meeting this project's requirements. Although the master developer was still active on an adjacent block of land, this development, too, had multiple developers and owners. In the end, only one owner declined to permit interviews. However, again there was concern about the effect of inbound interviews on business. As a result, the inbound trip information was obtained by asking outbound respondents about the trip they had made to reach the building from which they were exiting. Unfortunately, that information was often incomplete or for trips outside the time periods of interest. The results were surveys with much more outbound than inbound trip data.

Lessons Learned

The permissions process took much longer than had been experienced by the researchers in past surveys. The researchers had recommended the first two sites because the owners had previously welcomed the attention and information that resulted from different types of case studies. However, changes in ownership from original developers to owner-operators or investors using operating companies made obtaining permissions significantly more challenging at all three developments. In the case of Atlantic Station, the development has been structured so it may be possible for each commercial block and each residential project to be sold to separate owners. Since surveys to determine internal capture need to cover samples of all different land use types in the survey area, diverse ownership will make it much more difficult to obtain the necessary permissions.

One of the considerations for future surveys of this type should be the ownership structure of the buildings or businesses to be surveyed. From this experience, it would appear that original developers (who will be more interested in reduced traffic impacts due to internal capture) are possibly more willing to have surveys conducted and single local owners may also be easier to interest.

An additional aid would be a completed survey report so the owners-managers are able to see an example of what will be conducted. There was considerable reluctance to be involved in something new with uncertain results, although most of the owner-manager representatives were able to grasp the concept of internal capture after extended discussions.

Even if favorable ownership structures are encountered, the complexity of the owner-tenant relationships may result in a longer approval period than for single-use or single manager-operator developments. A period of one month should be allowed for a site, but if difficulties arise, it could take two or even three months to secure complete permissions and authorizations to proceed.

Finally, the limitation to only exit interviews means that data for inbound trips must come from the exit interviews. A compromise could be to conduct exit interviews at retail, restaurant, and cinema establishments and attempt to obtain interviews in both directions elsewhere. Where only exit interviews are permitted, it should be recognized that the inbound data may be limited and that interviewers need to persist to obtain complete information for the inbound trips.

Field Data Collection

Surveys

The surveys were built around exit interviews. The objective was to obtain for both A.M. and P.M. peak periods a sample of travel patterns involving internal and external trips for each land use type. Interview information included both origin and destination land use types, time and mode of trip, original mode of access to the development. The owners-managers demanded brief interviews.

While the intent was to interview at every land use type represented within each study area, it was recognized from the beginning that interviews would not be able to be conducted at all entrances (permissions withheld at some; number of entrances to cover) all the time. It was also understood that the interviews would represent a sample of the total trips made at interview locations because people could not be detained for their interview until the interviewer completed a previous interview. Hence, counts of people entering and exiting entrances where surveys were being conducted were necessary. Interviews were conducted at every entrance at Mockingbird Station (over 50). At Atlantic Station there were too many entrances to interview at all of them and permissions could not be obtained for all businesses so sampling had to be performed by land use (factored proportionally by square footage within each land use).

In addition to interviews and door counts, person trips by mode were counted at each cordon location plus some added locations where needed to separate different types of destinations. For example, at both developments some parking areas for certain buildings were cordoned off or otherwise partitioned from general parking and it was necessary to count entrances to those areas separately.

Surveys were conducted between 6:30 A.M. and 10:00 A.M. and between 4:00 P.M. and 7:00 P.M. The same interview approach was used at all three developments. The research team secured about 40 temporary personnel for each survey to conduct interviews or perform counts. Not all persons worked all shifts; since much of each development was retail space and since most retailers did not open until 10 A.M., fewer personnel were needed for the A.M. peak. Three members of the research team supervised the surveys.

Cordon counts were conducted at all cordon locations for at least one A.M. and one P.M. survey period. As applicable, inbound and outbound counts were made by the following modes:

- personal vehicle:
  - 1 person,
  - 2 people,
  - 3 people,
  - 4+ people;
- motorcycle;
- delivery truck;
- walk; and
- bike.

Mockingbird Station had no on-site transit routes (both light rail and bus transit serve a transit station adjacent to the site). A shuttle connects Atlantic Station to a nearby MARTA rail station; the shuttles were surveyed separately. One bus route passed along two sides of Legacy Town Center.

Door counts were made both inbound and outbound during interview periods. Whenever interviews were being conducted on a building face, all doors were counted on that building face for that period.

Interviews were conducted at both developments 6:30 A.M.–10 A.M. and 4 P.M.–7 P.M. beginning on a Tuesday afternoon and ending on a Thursday morning. With minor exceptions, all interviews were conducted at building access points as people exited the building. Interviewers were assigned either single entrances where activity was heavy or groups of entrances where they were close together and activity was low to moderate. Interviewers were instructed to interview everyone they could, but not to try to have anyone wait to be interviewed while another interview was being completed. Interviewers were to be assertive in trying to initiate interviews but were told to accept refusals without question. Interviewers assigned to multiple entrances were to watch people enter business and try to intercept them as they departed. It was estimated that effective interviewers were turned down about one-third of the time.

On the average, interviewers were able to complete interviews with 10 to 15 percent of all exiting individuals. Productivity varied by the amount of activity at the assigned location, the assertiveness of the interviewers, and the interviewer skill. All personnel were trained prior to the first shift. A few trainees were not used as a result of unsuccessful training. Some others were either reassigned to counting jobs or discharged during the first shift if supervisor checks showed that the interview approach or results were insufficient. About 25 percent of the original personnel did not work after their initial shift.

The plan for all three developments was to interview as many people as possible using about 20–25 interviewers in the P.M. peak (when all businesses were open) and a lesser number during the A.M. peak commensurate with the number of businesses open. This required interviewing at different locations each day, although some of the lower activity entrances were covered both days.

At Mockingbird Station, inbound interviews were also conducted at the entrance from the DART rail station that is served by two rail lines and six bus routes. The purpose was to ascertain modes of access. At Atlantic Station, interviews were conducted on the shuttles operating between Atlantic Station and the MARTA Art Center rail station for the same reason. Interviews were also conducted inbound at a few locations to intercept walkers and bikers entering Atlantic Station's business district from the adjacent residential portions of the development. Use of buses for trips to and from Legacy Town Center was almost non-existent. No special interviews were conducted for that mode.

Cost and complexity were the two primary reasons given in telephone conversations with consultants and public agencies about why more internal capture studies had not been conducted. The research team elected to cap the survey team size at about 40 people during the P.M. peak for cost considerations. The cost for temporary labor to conduct the surveys may differ by location, and it did for the Dallas, Atlanta, and Plano surveys, but the direct cost for the Atlanta team was approximately $19,000 using a temporary employment agency and personnel classified as interviewers.

In all three cases the temporary employment agency had difficulty securing the requested 40 persons. In one city, a second agency was used to provide people. In another city, the agency provided a large percentage of people who could work some but not all shifts. All count data were compiled by 15-minute period. All interviews were maintained as separate trip records.

Lessons Learned

The cordon counts were easily completed for all three developments with no problems. They were easy enough so people who could not successfully perform the interviews (or did not want to do interviews) could accurately complete the counts. Men were assigned locations that were out of view of passing pedestrians (e.g., some parking garage entrances). Supervisors made it a priority to locate counters so they would be visible but not distractions to passersby. Supervisors also walked by every isolated location at least hourly. All personnel also had cell phones and the supervisors' phone numbers in case an emergency arose or relief was needed. No safety or security difficulties or concerns were reported by any of the survey team at any development. Use of cell phones and men in isolated locations was successful.

Some interviewers, despite successful training, were not successful because they were not effective at approaching people quickly enough to get their attention. Assertiveness was the deficiency in most cases. Despite practice interviews in a training atmosphere, the only way to confirm a good interview approach is in the field with practice interviews under watch by a supervisor. This should be conducted in advance of initiating surveys.

Despite a clothing specification given to the temporary employment agencies, at two locations a few of the personnel were not attractively dressed and probably discouraged people from talking with the interviewers. In such a case, those interviewers should be assigned to counting or sent home to change clothes.

With as many as 40 temporary employees on a survey team, a range of capabilities will exist. For a survey of this complexity, at least three supervisors are needed to be able to both check and circulate to all sites. The most frequent supervision was needed to:

- answer initial judgment questions related to interview responses (e.g., how to record trips to walk the dog);
- locate interviewers so they could intercept exiting patrons from multiple doors;
- identify and separate interviewers talking with each other instead of focusing on exiting patrons (a problem in low activity locations);
- schedule breaks and place "floaters" in those locations;
- deliver water to survey personnel near mid-shift time; and
- respond to cell phone calls for help (usually questions or approval to relocate to more active or convenient spot).

Development Data

Development Characteristics

Data describing the characteristics of the developments were acquired from the on-site management company for Mockingbird Station, from the parking operator on behalf of the management companies for Atlantic Station, and from the various owners and management companies at Legacy Town Center. Because trip generation surveys need to be linked to occupied development areas rather than total area, the research team requested both total and occupied square footage or other development units, current at the time the surveys were conducted.

On-site management companies sometimes do not have information on occupied areas. That information is usually maintained by the leasing offices, or agents, which are often separate offices or even handled by separate companies. In the case of Mockingbird Station, leasing was handled by the management company for office space, by another office of the management company for residential, and an outside company for retail and restaurant. The management company ultimately assembled information.

The diversity of ownership of Atlantic Station would have posed a similar situation for Atlantic Station. However, the parking operator needed the same information for its own surveys being conducted during a similar timeframe. Hence, the research team was able to obtain the development data after the parking operator assembled the information. Both development and occupancy data for Legacy Town Center had to be obtained from the applicable owner, management company, or leasing agent.

Lessons Learned

MXDs may have separate ownerships in what seems like a single development. Occupied space inventories are usually maintained by the leasing (or sales) units, which may or may not be parts of the ownership or on-site management organization(s). Ownership that is more diverse may lead to more diverse sources for the development and occupancy data. However, after permissions have been obtained to conduct the survey, obtaining the development data becomes somewhat easy. However, it may take several follow-up calls to obtain a complete set of information.

APPENDIX E

Florida Survey Questionnaires

Source: *FDOT District IV Trip Characteristics Study of Multi-Use Developments,* Tindale-Oliver & Associates, Appendices to Final Report, December 1993, Appendix B, pp. 6–9.

FDOT Trip Characteristic Study
Multiuse Developments
Office Survey Form

Date: _____ INTERVIEWER: _____ Weather: AM _____ Comments: _____

Site Location: _____ Weather: NOON _____

_____ Weather: PM _____

(1) Time	(2) Do you work in this building? 1. Work 2. Visitor 3. Courier 4. Delivery 5. Banking 6. Medical 7. Shop/Retail 8. Eat 9. Other	(3) What mode of transportation did you use to get here? 1. Car - Driver 2. Car - Passenger 3. Car - Drop Off 4. Walk 5. Bicycle 6. Taxi 7. Bus 8. Motorcycle 9. Other	(4) Where did you last stop prior to coming here? 1. Home 2. Friend's Home 3. Another Office 4. Restaurant 5. Daycare/School 6. Medical 7. Gas Station 8. Bank 9. Movie Theater 10. Shop/Retail 11. Other	(5) What is the address or nearest intersection where you came from? Enter address/ intersection information on form.	(6) Were any stops made within this development on the way to this building? 1. Yes 2. No	(7) Names of all stops within this development	(8) Would you have driven by this building if you did not stop here today? 1. Yes 2. No	(9) Where will you/ next stop be after you leave this building? 1. Home 2. Friend's Home 3. Another Office 4. Restaurant 5. Daycare/School 6. Medical 7. Gas Station 8. Bank 9. Movie Theater 10. Shop/Retail 11. Other	(10) What mode of transportation will you use to get there? 1. Car - Driver 2. Car - Passenger 3. Car - Drop Off 4. Walk 5. Bicycle 6. Taxi 7. Bus 8. Motorcycle 9. Other	(11) What is the address or nearest intersection where you are going to? Enter address/ intersection information on form.	(12) Are you going to make any additional stops within Century Blvd/Dallas Town Development? 1. Yes 2. No	(13) Names of all stops within this development	(14) What is your home Zip Code?

QC REVIEW: _____ DATE: _____ DATA ENTRY BY: _____ DATE: _____ COMMENTS: _____

Figure E-1. FDOT office survey form.

FDOT Trip Characteristic Study Multiuse Developments Residential Survey Form (Incoming)				Date: ____________ INTERVIEWER: ________________ Site Location: ______________________________ ______________________________			Weather: AM______________________ Weather: NOON______________________ Weather: PM______________________	
(1) Time	(2) Are you arriving at your home in Fairlake at Westout? 1. Home 2. Visitor 3. Courier 4. Delivery 5. Employ/Work 6. Other	(3) Was the mode of transportation being used to make the trip. 1. Car - Driver 2. Car - Passenger 3. Car - Drop Off 4. Walk 5. Bicycle 6. Taxi 7. Bus 8. Motorcycle 9. Other	(4) What was the purpose of your visit at the place where you just came from? 1. Work 2. Shop/Retail 3. Home 4. Recreation 5. Daycare/School 6. Medical 7. Gas Station 8. Bank 9. Movie Theatre 10. Other	(5) What was the name of the place where your trip started? Enter the name of the place interviewee is coming from.	(6) What was the address or nearest intersection where you just came from? Enter address/intersection information on the form.	(7) Did you make any stops in Country Isles / Indian Trace before coming to Fairlake or Westout? 1. Yes 2. No	(8) Enter the names of all stops within the Country Isles / Indian Trace Development	(9) What is your home Zip Code?

QC REVIEW: ____________ DATE: __________ DATA ENTRY BY: ____________ DATE: __________ COMMENTS: ______________________________

Tindale-Oliver & Associates OSD_RESI.WK1

Figure E-2. FDOT residential survey form (incoming).

FDOT Trip Characteristic Study
Multiuse Developments
Residential Survey Form (Outgoing)

Date: _____ INTERVIEWER: _____ Weather: AM_____

Site Location: _____ Weather: NOON_____

_____ Weather: PM_____

(1) Time	(2) Are you coming from your home in Fairlake or Weston? 1. Home 2. Visitor 3. Courier 4. Delivery 5. Empy/Work 6. Other	(3) Now the mode of transportation being used to make the trip. 1. Car - Driver 2. Car - Passenger 3. Car - Drop Off 4. Walk 5. Bicycle 6. Taxi 7. Bus 8. Motorcycle 9. Other	(4) What is the purpose of your trip today? 1. Work 2. Shop/Retail 3. Home 4. Restaurant 5. Daycare/School 6. Medical 7. Gas Station 8. Bank 9. Movie Theatre 10. Other	(5) What is the name of the place where you are going? Enter the name of the place you are going on the form.	(6) What is the address or nearest intersection where you are going? Enter address/ intersection information on the form.	(7) Will you make any stops in Country Isles / Indian Trace before arriving at that destination? 1. Yes 2. No	(8) Enter the names of all stops within the Country Isle / Indian Trace Development	(9) What is your home Zip Code?

QC REVIEW: _____ DATE: _____ DATA ENTRY BY: _____ DATE: _____ COMMENTS: _____

Tindale-Oliver & Associates: OSD_RESO.WK1

Figure E-3. FDOT residential survey form (outgoing).

APPENDIX F

Validation of Estimation Procedure

Estimation Procedure

The estimation procedure was applied to seven different developments for which at least land use information, peak hour cordon counts, and proximity information were available. Four of these developments provided data for this study; the other three did not. The validation test was to see how well the estimation procedure could begin with ITE trip generation data and reproduce the external vehicular cordon volumes. Five of the developments had directional cordon traffic volumes available for both peaks. These developments included:

- Mockingbird Station,
- Legacy Town Center,
- Atlantic Station,
- Crocker Center (independent site, Boca Raton, Florida), and
- Mizner Center (independent site, Boca Raton, Florida).

Two developments had on non-directional P.M. peak period counts available. They were:

- Boca del Mar and
- Southern Village (independent site, Chapel Hill, North Carolina).

The validation test compared four different estimation methods to determine which method produced the results closest to the cordon counts:

- the estimator described in this report,
- the estimator, but without the proximity adjustment,
- the existing ITE estimation method, and
- unadjusted ITE trip generation.

Development data and approximations of surveyed mode split and vehicle occupancies were input to the estimation procedure. Table F-1 shows the ITE land use codes used to estimate single-use vehicle trip generation for component land uses of the seven developments. Where businesses were closed during a peak period and there were no observed trips to or from the business (e.g., cinema during A.M. peak), no trips were included in the validation estimate.

Southern Village had additional land uses (a school and park-and-ride lot) that were not included in the internal capture estimate; those were handled as additional land uses. Information provided in the source document was used as the basis for the trip generation estimate. Table F-2 shows the results numerically. Figures F-1 through F-4 graphically compare the results for the five developments for which complete data were available. Error comparisons were also made and are shown in Table F-3.

Table F-2 rows contain data as follows:

1. Counted at cordon: vehicles(persons) counted using site driveways;
2. Estimator output: directional volume of vehicles (persons) estimated with recommended estimation method:
   - First four columns: volumes as described,
   - Last four columns: percent internal trips;
3. From survey – directional volume of vehicles (persons) derived from survey:
   - First four columns: volumes as described,
   - Last four columns: percent internal trips;
4. Estimator/counted: ratio of estimated trips divided by counted trips in respective columns; and
5. Unadjusted/counted: estimate using raw ITE trip generation divided by counted trips

Table entries for Southern Village contain additional rows to account for land uses that do not qualify for internal capture under the recommended procedure.

Table F-2 shows comparison of external vehicle and person trips estimated by each method. Also shown are estimated internal capture percentages. The most important results are

Table F-1. ITE land use codes used in validation.

Land Uses		ITE Land Use Code
NCHRP Project 8-51 Classification	Subgroup	
Office	-	710
Retail	-	820
Restaurant	Quality sit down	931
	High turnover	932
	Fast food, no drive-through	933
	Fast food with drive-through	934
Cinema	-	444
Hotel	-	310
Residential	Single family detached	210
	Apartments	220
	Townhomes	230
Additional Land Use		
Port and terminal	Park-and-ride lot	090

the external trip estimates. Figures F-1 through F-4 show the comparisons of vehicle trips for both A.M. and P.M. peak periods and both inbound and outbound directions. In Figure F-1, it is evident that for the A.M. peak hour inbound vehicle trips, the NCHRP estimation methods—both with and without the proximity adjustment—produce the best results for three of the five developments; the current ITE method is closest for one site and slightly better than the NCHRP method for another site. Atlantic Station is more closely estimated by both unadjusted trip generation and the current ITE method. The current ITE method is better than raw trip generation, but the method developed in this project is even closer to the counts.

Figure F-2 shows similar results for A.M. peak hour outbound vehicle trips with the recommended estimator (both with and without the proximity adjustment) producing the best results for four of the five developments. This time Mizner Center is better estimated by raw trip generation and the current ITE method. As with the previous comparison, the ITE method is an improvement on raw trip generation.

The P.M. inbound comparison shown in Figure F-3 shows that the NCHRP method with proximity adjustment produces the closest estimates for two sites, with the methods with and without proximity about equal for the two sites, and the raw ITE trip generation closest for one site. Again, Mizner Center was better estimated by another method (this time raw trip generation), but the other four are best estimated by the recommended method.

Figure F-4 shows the comparison for P.M. peak hour inbound trips. As for the other time periods and directions, one or the other of the NCHRP methods produces the closest estimates in four of the five cases. The methods with and without proximity adjustments are each best for one MXD while both yield approximately the same results for two MXDs. In this case, Boca Center is better estimated using the existing ITE method.

In total, the recommended method—with or without the proximity adjustment—produces more reliable estimates for four of the five developments.

The results for the other two developments—Boca del Mar and Southern Village—show two different patterns. For Boca del Mar, both the existing ITE and recommended methods produce significantly low estimates, but are closer than the recommended method without proximity adjustments or the ITE method. The raw estimate is above the actual external count, but it and the ITE method are the closest of the estimates (about 4 percent closer than the recommended method with proximity adjustment). For Southern Village, the results are very different. The recommended method (both with and without proximity adjustments) produce estimates very close to the counts.

Table F-3 may quantify the degree of accuracy or error more clearly, recognizing that the statistics presented represent the sum of combined results. The average error shown is the simple sum of the percent deviations from the counts as derived in Table F-2. On average, as a group the estimates all exceed the counts (for example, the recommended method with proximity adjustment is an average of 4 percent). This is very misleading and not relevant for single developments because overestimates and underestimates tend to cancel each other out. What may be of value in those percentages is that they could result in the sum total trip generation of several developments in an area. However, that is not what is being validated here.

More applicable is the absolute average error, which is the sum of the magnitudes of the errors averaged over the five

Table F-2. Summary of estimator validation comparisons.

Development/data	Vehicle Trip (Person Trips)				Percent Internal Trips (Peak Period)			
	A.M. Peak Hour		P.M. Peak Hour		A.M.		P.M.	
	In	Out	In	Out	In	Out	In	Out
Mockingbird Station								
Counted at cordon	272(385)	128(213)	367(595)	353(586)				
Estimator output	259(329)	107(165)	422(565)	412(588)	19%	32%	33%	33%
From survey					35%	46%	36%	42%
Estimator/counted	0.95(0.85)	0.84(0.77)	1.15(0.95)	1.17(1.00)				
Without proximity adjustment								
Estimator output	Same	Same	422(563)	411(586)	Same	Same	33%	33%
Estimator/counted	Same	Same	1.15(0.95)	1.16(1.00)				
With ITE *Trip Gen Handbook* data								
Estimator output	322(409)	156(242)	537(715)	523(745)	No data	No data	15%	15%
Estimator/counted	1.18(1.06)	1.22(1.14)	1.46(1.20)	1.48(1.27)				
Unadjusted ITE *Trip Generation* report								
Estimator output	399	233	798	832	0%	0%	0%	0%
Unadjusted/counted	1.47	1.82	2.17	2.36				
Atlantic Station								
With proximity adjustment								
Counted at cordon	962(1012)	455(502)	1023(1396)	1038(1260)				
Estimator output	796(843)	252(308)	962(1126)	1151(1342)	17%	37%	36%	34%
From survey					40%	30%	41%	42%
Estimator/counted	0.83(0.83)	0.55(0.61)	0.94(0.81)	1.10(1.07)				
Without proximity adjustment								
Estimator output	Same	Same	938(1097)	1124(1310)	Same	Same	38%	36%
Estimator/counted	Same	Same	0.91(0.79)	1.08(1.04)				
With ITE *Trip Gen Handbook* data								
Estimator output	952(1130)	398(484)	1232(1445)	1604(1750)	No data	No data	16%	13%
Estimator/counted	0.99(1.11)	0.87(0.96)	1.29(1.04)	1.55(1.39)				
Unadjusted ITE *Trip Generation* report								
Estimator output	1122	473	1690	1992	0%	0%	0%	0%
Unadjusted/counted	1.17	1.03	1.65	1.92				
Legacy Town Center								
Counted at cordon	734(819)	641(779)	933(1187)	955(1122)				
Estimator output	736(906)	690(850)	1003(1236)	912(1123)	15%	16%	34%	36%
From survey					32%	25%	48%	44%
Estimator/counted	1.00(1.11)	1.08(1.09)	0.95(1.04)	0.95(1.00)				
Without proximity adjustment								
Estimator output	Same	Same	923(1136)	831(1023)	Same	Same	39%	42%
Estimator/counted	Same	Same	0.98(0.96)	0.87(0.91)				
With ITE *Trip Gen Handbook* data								
Estimator output	864(1065)	821(1009)	1231(1516)	1413(1740)	No data	No data	27%	24%
Estimator/counted	1.18(1.30)	1.28(1.30)	1.32(1.28)	1.48(1.55)				
Unadjusted ITE *Trip Generation* report	909	862	1598	1502	0%	0%	0%	0%
Unadjusted/counted	1.24	1.34	1.71	1.57				
Boca (ex-Crocker) Center								
Counted at cordon	488	219	281	532				
Estimator output	525	189	342	461	13%	26%	32%	31%
From survey					No data	No data	No data	No data
Estimator/counted	1.08	0.86	1.22	0.87				
Without proximity adjustment								
Estimator output	Same	Same	342	461	Same	Same	32%	31%
Estimator/counted	Same	Same	1.22	0.87				
With ITE *Trip Gen Handbook* data								
Estimator output	617	271	385	502	No data	No data	26%	33%
Estimator/counted	1.26	1.24	1.37	0.94				
Unadjusted ITE *Trip Generation* report	655	295	566	678	0%	0%	0%	0%
Unadjusted/counted	1.34	1.35	2.01	1.27				

(continued on next page)

Table F-2. (Continued).

Development/data	Vehicle Trip (Person Trips)				Percent Internal Trips (Peak Period)			
	A.M. Peak Hour		P.M. Peak Hour		A.M.		P.M.	
	In	Out	In	Out	In	Out	In	Out
Mizner Center								
Counted at cordon	220	145	547	328				
Estimator output	239	99	417	388	13%	25%	29%	35%
From survey					No data	No data	No data	No data
Estimator/counted	1.09	0.68	0.76	1.18				
Without proximity adjustment								
Estimator output	Same	Same	412	383	Same	Same	30%	35%
Estimator/counted	Same	Same	0.75	1.17				
With ITE *Trip Gen Handbook* data								
Estimator output	267	134	425	402	No data	No data	27%	32%
Estimator/counted	1.21	0.99	0.78	1.23				
Unadjusted ITE *Trip Generation* report	272	137	613	585	0%	0%	0%	0%
Unadjusted/counted	1.24	0.94	1.12	1.78				
Boca del Mar								
With proximity adjustment								
Counted at cordon	-	-	2187	← 2-way				
Estimator output	-	-	915	895	-	-	26%	28%
From survey					No data	No data	7%	8%
Estimator/counted	-	-	0.83	← 2-way				
Without proximity adjustment								
Estimator output	-	-	689	676	-	-	44%	47%
Estimator/counted	-	-	0.62	← 2-way				
With ITE Trip Gen Handbook data								
Estimator output	-	-	839	831	-	-	33%	35%
Estimator/counted	-	-	0.76	← 2-way				
Unadjusted ITE Trip Generation report	-	-	1241	1209	-	-	0%	0%
Unadjusted/counted	-	-	1.12	← 2-way				
Southern Village								
Counted at cordon	-	-	1336	← 2-way				
Estimator output	-	-	546	438				
Additional trips for non MXD uses	-	-	97	290				
Total estimated	-	-	645	731	-	-	11%	13%
From survey					No data	No data	No data	No data
Estimator/counted	-	-	1.03	← 2-way				
Without proximity adjustment								
Estimator output	-	-	537	429	No data	No data	N/A[a]	N/A[a]
Additional trips for non MXD uses	-	-	97	290				
Total estimated	-	-	637	722				
Estimator/counted			1.01	← 2-way				
With ITE Trip Gen Handbook data								
Estimator output			574	466	-	-	6%	8%
Additional trips for non MXD uses	-	-	97	290				
Total estimated	-	-	671	756				
Estimator/counted			0.99	← 2-way				
Unadjusted ITE Trip Generation report			633	512	-	-	0%	0%
Additional trips for non MXD uses	-	-	97	290				
Total estimated	-	-	730	802				
Unadjusted/counted			1.15	←2-way				

[a] Person trips not known for non-MXD uses

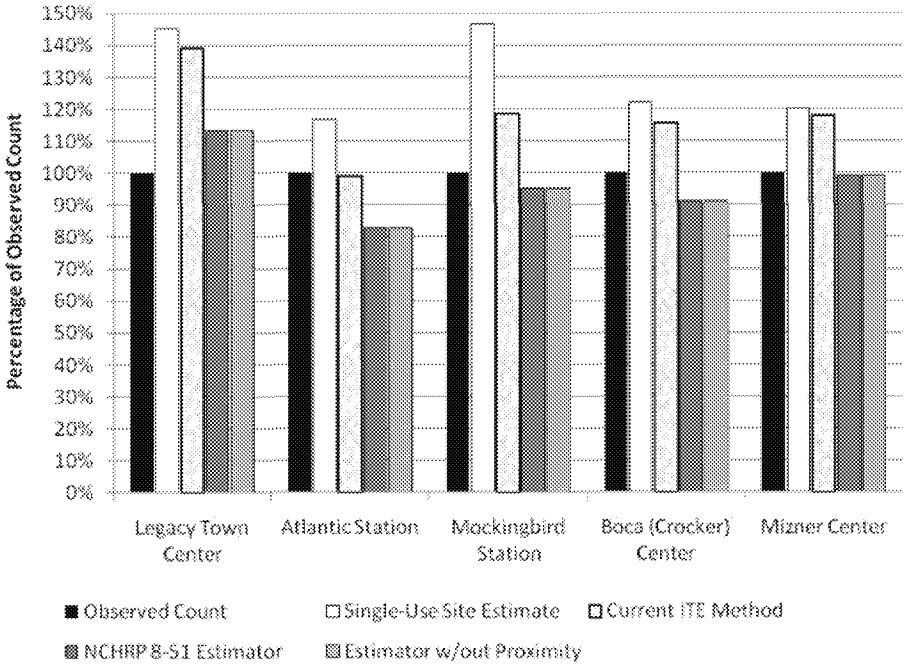


Figure F-1. Comparison of estimates to cordon counts: A.M. peak-hour inbound direction.

developments. This shows more clearly what deviations—above or below actual—were found. Clearly, by examining the figures and Table F-3, it is easy to determine that the raw trip generation greatly overestimates external vehicle trip generation for the validation sites. The existing ITE method is a major improvement from raw trip generation. The recommended method brings the estimates significantly closer to actual. Note that the difference between the actual and absolute value of the errors shows that there are both overestimates and underestimates occurring.

The standard deviation shown in Table F-3 better represents the estimated probable magnitude of error that might

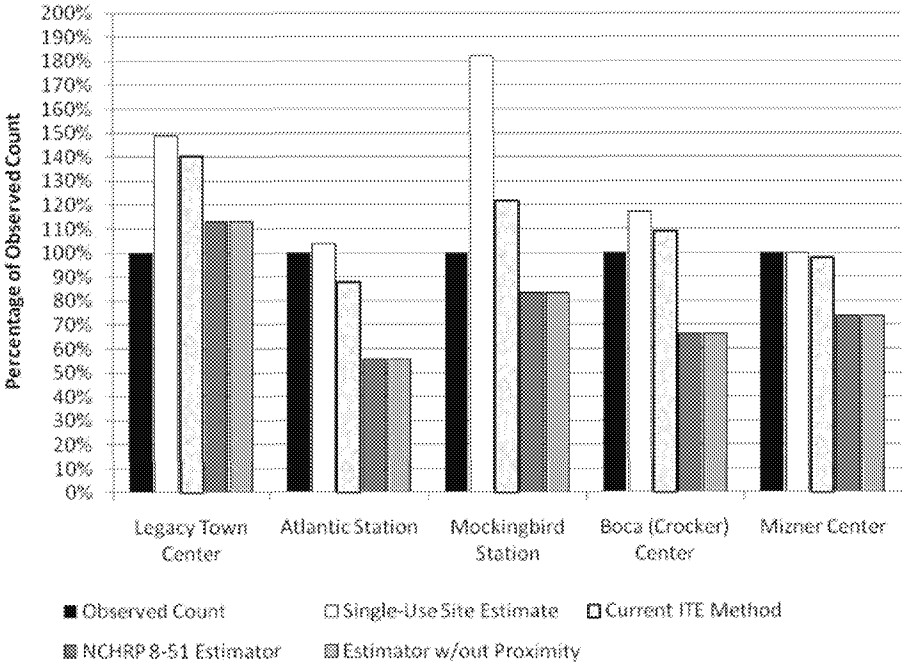


Figure F-2. Comparison of estimates to cordon counts: A.M. peak-hour outbound direction.

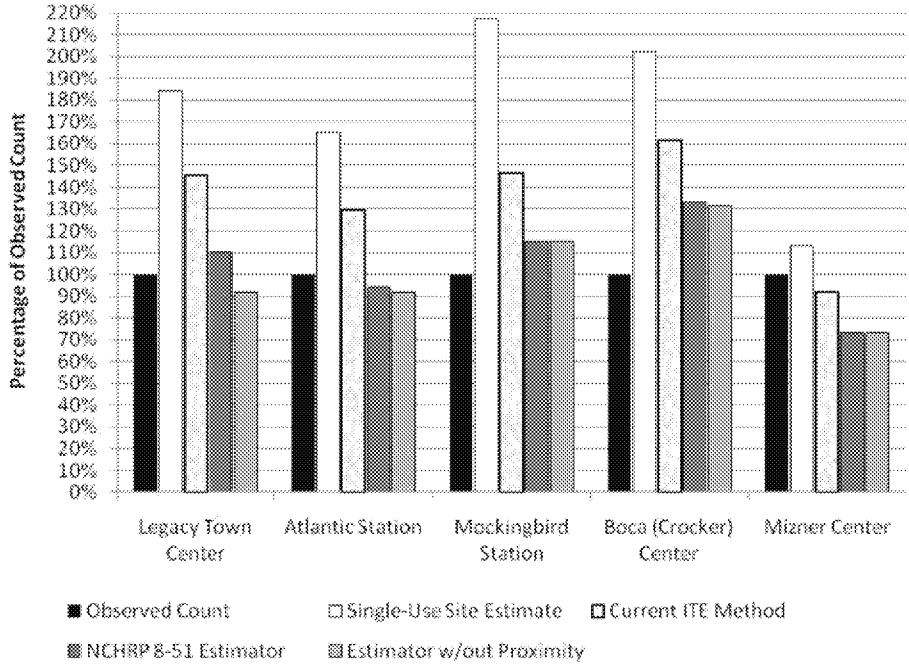


Figure F-3. Comparison of estimates to cordon counts: P.M. peak-hour inbound direction.

occur using these estimation methods. Again, the relative magnitudes of error among the methods place them consistently in the same order.

It is clear that the recommended method provides more accurate estimates. Since the existing ITE method was developed from data from three of the six developments used in this NCHRP project, the recommended method can only be viewed as being a further improvement.

The standard deviations for the recommended method, both with and without proximity adjustment, are about 20 percent of the actual external inbound and outbound volumes. This is less than the variations in the raw ITE nondirectional trip generation rates for the component land uses. For example, for the land uses listed in Table F-1, the standard deviations for their A.M. and P.M. peak hour trip generation rates are all in excess of 50 percent of the mean.

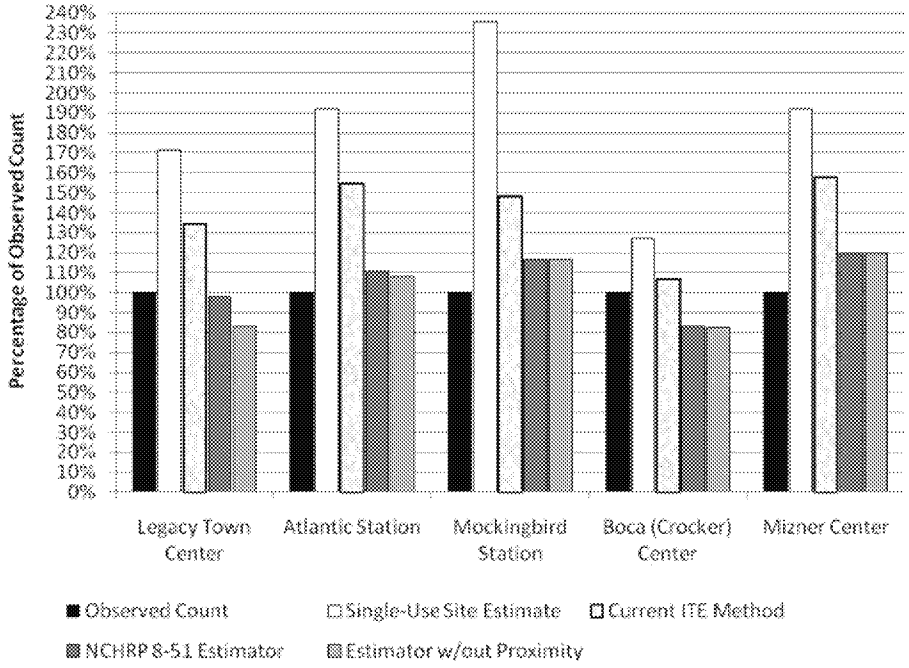


Figure F-4. Comparison of estimates to cordon count: P.M. peak-hour outbound direction.

Table F-3. Comparison of error statistics.

Error Type	Raw ITE Trip Generation	Existing ITE Method	Recommended NCHRP Method		Explanation
			With Proximity Adjustment	No Proximity Adjustment	
Average error	+55%	+26%	-4%	−7%	Average error for sum of all sites
Absolute average error	55	28	17	17	Average magnitude of error per site
Standard deviation	68	34	20	19	Expect two-thirds of site estimates within this error range

Not clear, however, is whether or not the proximity adjustment adds any current value. The validation results show no significant statistical benefit. It has sufficient data only for the P.M. peak period (and less of that than would be desired). There is no A.M. proximity adjustment recommended at this time. On the other hand, the only examples for which the results were better without the proximity adjustment was when both variations of the new method were overestimating. In all cases the proximity adjustment either has no significant effect or renders the estimate more conservative (higher).

Conclusions

The validation supports two principal findings:

1. The recommended method does produce noticeably more accurate results than either raw ITE trip generation estimates from the ITE Trip Generation report or the existing method described in the *Trip Generation Handbook*. This is true with or without the proximity adjustment.
2. The proximity adjustment, available at this time for the P.M. peak period, tends to make slightly more conservative estimates but overall does not, at this time, improve accuracy over a group of estimates. It can produce significant effects for larger developments.

It would be logical for ITE to consider the recommended method for inclusion in the next edition of its *Trip Generation Handbook*. The researchers recommend this since it could increase trip generation estimation accuracy. The advisory committee that ITE uses to review potential new material may wish to test further both the existing method and the recommended method with more MXDs for which it can obtain the needed data. This could help to determine if the proximity adjustment shows enough added value in its current form to be included in the next edition.

In addition, the research team confirmed the desirability and need for more surveys to expand the database. Six samples are far better than three. Addition of several more could possibly provide the basis for confirming the value of the proximity adjustment.

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation