# MULTIMODAL TRADE-OFF ANALYSIS IN TRAFFIC IMPACT STUDIES

## FINAL REPORT

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# EXECUTIVE SUMMARY

Florida is one of the fastest growing states in the nation and it attracts a significant number of visitors on an annual basis. The state is expected to continue to grow and the population is expected to increase to over 20 million by the year 2025. This rapid growth places a substantial demand on Florida's infrastructure and the funding needs for new highways and capacity improvements far exceed the available resources in Florida. On the Florida Intrastate Highway System (FIHS), nearly $46 billion of needs and only $16 billion in funding were identified over the next 20 years. The state has come to understand that we can no longer build our way out of congestion. Other methods such as increasing the ability to manage and operate the system, reducing demand through better coordination of transportation and land use, and providing choices to travelers for using alternative modes are major themes of the Florida Transportation Plan, which guides Florida Department of Transportation (FDOT) activities.

The Florida Statutes were amended in 1999 to allow local governments to establish multimodal transportation districts (MMTDs) to promote development that favors pedestrian, bicycle and transit modes over the automobile, to develop professionally accepted techniques for measuring Level of Service (LOS) for automobiles, bicycles, pedestrians, transit and trucks, and to assist local governments in implementing multimodal LOS analysis. The FDOT has developed a series of tools to assess the LOS of each of the modes (automobile, truck, transit, pedestrian, and bicycle) and has established criteria and processes for the designation of MMTDs and areawide LOS measures. The MMTD can be used to promote mixed-use, interconnected, and dense land uses that are pedestrian and transit friendly in urban form and design. This project extends the analysis completed as a part of the development of the Multimodal Transportation Districts and Areawide Level of Service Handbook, developed by the Florida Department of Transportation. The long-term goals of this project are to define how to analyze the tradeoff between different land use-transportation configurations and to establish methods to reduce the impact fees or local access fees for development within multimodal environments.

## Objectives of the Research

The primary objective of this research was to develop an issue paper that defines an approach to multimodal tradeoff analysis in traffic impact analysis. A research strategy is developed to address the long-term goal of developing an approach to multimodal tradeoff in traffic impact studies.[1] This project assumes that the MMTD is the foundation for multimodal tradeoff analysis. As such, it focuses both on areas for further development of the MMTD and the extension of that into, and the development of, multimodal tradeoff analysis.

## Findings and Conclusions

The research team reviewed the literature related to the connection between land use and transportation, the state of practice in Florida with respect to multimodal transportation planning,

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[1] In the context of this research, multimodal tradeoff analysis should be distinguished from the National Cooperative Highway Research (NCHRP) Project 8-36, Task 7, which seeks to understand the multimodal tradeoffs that are made by state departments of transportation when they put together statewide transportation plans. See section 1.1 of the report for a description of that project.

and other approaches to multimodal tradeoffs both within Florida and throughout the United States to assess the opportunities for multimodal analysis and to develop a research agenda towards the development of multimodal tradeoff analysis.

The literature on the connection between land use and transportation suggest that traditional neighborhoods, which have the characteristics desired in MMTDs – high density, mixed land use, with a gridded street network and transit-oriented design features, have the potential to reduce the number of vehicle trips taken and the vehicle miles of travel (VMT). However, the applicability of these studies to Florida is less well understood, because most of the previous studies were conducted in well-established traditional neighborhoods that have high regional accessibility. These locations can be contrasted with many developments in Florida, which are of lower density, less connectivity, and lower regional accessibility.

The Florida Department of Transportation is a national leader in the area of multimodal LOS measures, analysis techniques and software. However, these multimodal techniques are not currently incorporated into other major planning tools, like regional and statewide travel demand models and site impact assessment, that are a part of the routine practice of planners in the Florida Department of Transportation, in regional and local planning agencies, and in consulting firms that are developing traffic impact assessments for developers.

Approaches to multimodal analysis are considered both with respect to transportation modeling and other aspects of transportation planning. Three major issues in conducting multimodal planning using the existing four-step modeling process are identified: (1) the use of traffic analysis zones (TAZs) as a unit of analysis; (2) the method of incorporating land use models into transportation modeling; and (3) the lack of understanding of the demand for walking and bicycling. The use of TAZs as a unit of analysis does not support multimodal analysis because walking trips are not generally considered in models because they take place within, rather than between, TAZs. The existing land use models do not support multimodal analysis because they do not consider differences in land use configuration and they do not accommodate induced demand and other changes in land use that occur as a result of changes in the transportation network during the modeling period. The land use patterns at the origin or production point determine the modes that are available for the first journey and whether modes other than the automobile will be available for the rest of the tour. The features of MMTDs, such as mixed land use, highly connected sidewalk and roadway networks and transit-oriented design features are not typically included in land use models as input variables or factors that can be modeled. Micro-simulation, TRANSIMS – an activity-based modeling system, dynamic traffic assignment (DTA) and integrating multimodal modeling within the four-step modeling process are considered in this issue paper.

Several approaches to multimodal tradeoff and analysis are considered: (1) the Real Accessibility Index (RAI) which was developed by the University of Virginia (FHWA 2002); (2) the Smart Growth Index (USEPA 2002), which was designed as a GIS-based sketch tool; (3) Portland's Systems Development Charges (SDC), which are used to calculate one-time capital costs for new development (Henderson, Young & Company, *et al.* 1997); (4) various applications of multimodal concurrency in Florida communities; (5) variety of approaches to concurrency that are used by local governments in the State of Washington (Trohimovich 2001);

(6) Montgomery County, Maryland's Local Area Transportation Review (M-NCPPC 2002); (7) fiscal impact assessment, which has been developed by Fishkind and Associates under contract with the Florida Department of Environmental Protection (Fishkind & Associates, 2002a,b); and (8) Florida's Efficient Transportation Decision Making Process (ETDM) (FDOT 1999). The research team recommends the state develop two levels of analysis: a generalized approach, which would include sketch planning tools, spreadsheet applications, and look-up tables, and a detailed modeling approach, which would incorporate the multimodal tradeoff analysis into existing and proposed analysis tools, such as site impact assessment, the statewide modeling platform, and other analysis tools, such as the ETDM and Fiscal Impact Assessment.

The project team recommends that the FDOT develop a long-term strategy that takes an approach similar to Portland's SDC, which provides a comprehensive and coordinated system that integrates transportation and land use planning with transportation modeling and the charging of impact fees. It incorporates modal master plans with long-range transportation plans for all modes to develop an inventory and the associated costs of facilities. This could provide a long-term and comprehensive approach for the State of Florida. However, such an approach would require major improvements in regional transportation modeling and in the monitoring of results of coordinated land use-transportation planning.

Several constraints on the implementation of multimodal analysis are identified and discussed. These include: (1) the state of research on multimodal impacts; (2) the state of modeling in Florida; (3) issues associated with incorporating MMTDs into the concurrency framework; (4) institutional arrangements for transportation and land development regulation in Florida; and (5) the measurement of multimodal Level of Service.

Based upon the advantages and disadvantages of the various methodologies for multimodal analysis and the constraints in the current environment for multimodal analysis, several areas for further research are identified in two categories: (1) the scope of analysis; and (2) two approaches to analysis – a generalized approach and a detailed modeling approach. Research associated with the scope of analysis address the details contained in the proposed MMTDs including: (1) the assessment and development of tools to assess Developments of Regional Impact (DRIs); (2) the assessment and development of tools that have a significant impact on the adjacent roadway network but do not have sufficient jobs or residential populations to qualify as a MMTD; (3) development of standards for multimodal assessment near schools; (4) alternative approaches to multimodal LOS analysis; and (5) the incorporation of parking pricing and availability into the MMTDs and multimodal tradeoff analysis. Additional research is needed to develop a generalized and detailed approach to multimodal tradeoff analysis. Such an approach would require consistency between the detailed and the generalized modeling approach. The detailed approach to multimodal tradeoff analysis will require additional research on: (1) incorporation of MMTDs into the site impact assessment process; (2) data collection for the evaluation of multimodal districts; (3) incorporating multimodal analysis into planning model structure; (4) use of microsimulation for multimodal tradeoff analysis; and (5) fiscal impact analysis for MMTDs. Additional research is also necessary to develop a generalized approach to multimodal tradeoff analysis. Finally, the Florida Department of Transportation should leverage this research effort by supporting research that is being conducted on these topics at the national level. FDOT should support the national research

efforts in three areas of general interest: (1) documenting differences in travel behavior (e.g., trip generation, pass-by traffic, internal capture, and mode split) between conventional suburban development and other alternative forms of development (e.g., traditional neighborhood development, Main Street developments); (2) incorporating multimodal analysis into travel demand modeling; and (3) creating safe ways for children to walk and bicycle to school.

**MULTIMODAL TRADE-OFF ANALYSIS IN TRAFFIC IMPACT STUDIES**

## 1. INTRODUCTION

Currently, Florida is one of the fastest growing states in the nation and additionally attracts a significant number of visitors on an annual basis. Recent forecasts predict that the state's population will increase to over 20 million by the year 2025 (U.S Census Bureau 2002). This rapid growth places a substantial demand on Florida's transportation infrastructure. Recognizing this fact, the State of Florida has passed growth management legislation beginning in the mid-1970s to address the impacts of growth. In the 1985 Growth Management Act (F.S.A. §163), the state incorporated a requirement for concurrency, to address the concern that new infrastructure, including transportation, be available "concurrent" with the impact of development. This legislation has been amended several times to address the issues in its implementation. A recent amendment is the Urban Infill and Redevelopment Act of 1999 (F.S.A. 163.3180). It seeks to encourage the use of alternative modes to the automobile, which was included in this act through the establishment of MMTDs and a multimodal areawide LOS. The applicable portion of the legislation addressing multimodal planning and the associated policy goals is as follows:

*(1)(b) Local governments shall use professionally accepted techniques for measuring Level of Service for automobiles, bicycles, pedestrians, transit, and trucks. These techniques may be used to evaluate increased accessibility by multiple modes and reductions in vehicle miles of travel in an area or zone. The Department of Transportation shall develop methodologies to assist local governments in implementing this multimodal level-of-service analysis. The Department of Community Affairs and the Department of Transportation shall provide technical assistance to local governments in applying these methodologies. . . .*

*(15)(a) Multimodal transportation districts may be established under a local government comprehensive plan in areas delineated on the future land use map for which the local comprehensive plan assigns secondary priority to vehicle mobility and primary priority to assuring a safe, comfortable and attractive pedestrian environment, with convenient interconnection to transit. Such districts must incorporate community design features that will reduce the number of automobile trips or vehicle miles of travel and will support an integrated multimodal transportation system.*

*(b) Community design elements of such a district include: a complementary mix and range of land uses, including educational, recreational, and cultural uses; interconnected networks of streets designed to encourage walking and bicycling, with traffic-calming where desirable; appropriate densities and intensities of use within walking distance of transit stops; daily activities within walking distance of residences, allowing independence to persons who do not drive; public uses, streets, and squares that are safe, comfortable, and attractive for the pedestrian, with adjoining buildings open to the street and with parking not interfering with pedestrian, transit, automobile, and truck travel modes.*

*(c) Local governments may establish multimodal level-of-service standards that rely primarily on non-vehicular modes of transportation within the district, when justified by an analysis demonstrating that the existing and planned community design will provide an adequate*

*level of mobility within the district based upon professionally accepted multimodal level-of-service methodologies. The analysis must take into consideration the impact on the Florida Intrastate Highway System (FIHS). The analysis must also demonstrate that the capital improvements required to promote community design are financially feasible over the development or redevelopment timeframe for the district and that community design features within the district provide convenient interconnection for a multimodal transportation system. Local governments may issue development permits in reliance upon all planned community design capital improvements that are financially feasible over the development or redevelopment timeframe for the district, without regard to the period of time between development or redevelopment and the scheduled construction of the capital improvements. A determination of financial feasibility shall be based upon currently available funding or funding sources that could reasonably be expected to become available over the planning period.*

*(d) Local governments may reduce impact fees or local access fees for development within multimodal transportation districts based on the reduction of vehicle trips per household or vehicle miles of travel expected from the development planned for the district.*

Following through with the provisions set forth in the Urban Infill and Redevelopment Act of 1999, the Florida Department of Transportation has developed a series of tools to assess the LOS for each of the modes (transit, pedestrian and bicycle) and has established criteria and processes for the designation of MMTDs and areawide LOS measures. This project, Multimodal Trade-Off Analysis (MMTA) in Traffic Impact Studies, seeks to extend the analysis techniques developed in the MMTDs and Areawide Level of Service Handbook, developed by the Florida Department of Transportation (FDOT 2003). The long-term goals of this project are to define how to analyze the tradeoff between different land use-transportation configurations and to establish methods to reduce the impact fees or local access fees for development within MMTDs.

## 1.1 Scope of Multimodal Tradeoff Analysis

The purpose of MMTA is to develop a methodology to compare different land use-transportation configurations that are evaluated by local governments. In doing so, the MMTA should recognize the need to provide incentives for developments that reduce their impact on the adjacent State Highway System. The MMTA should accommodate the following principles:

➢ New development should pay a portion of the cost of facilities that it requires, and existing development should not pay all of the cost for the facilities to support the new development nor should the community pay the cost in reduced LOS.
➢ Public facilities should be constructed within a reasonable time period in order to achieve and maintain local standards for new development without decreasing the LOS for existing residents and businesses.
➢ Developers and builders should have predictability about the type and timing of development and amount of development fees and exactions required by local governments.

Currently Cambridge Systematics (CS) is engaged in a National Cooperative Highway Research Program (NCHRP) project that seeks to understand the multimodal tradeoffs that are made by State Departments of Transportation (DOTs) when putting together their statewide

multimodal transportation plans.  In the first phase of that project, which was completed in 2001, they developed a framework (see Figure 1, below) for multimodal tradeoff analysis that addresses agency wide goals and objectives across the range of agency program areas (Cambridge Systematics 2003).  For example, a state may face the choice between statewide system preservation and a fixed guideway transit investment in a major urban area.  When such a multimodal tradeoff analysis is considered, the state DOT may consider the diversion of funds from the state preservation program to a transit capital program to fund the state's match for a specific urban area.  The multimodal tradeoff analysis can be made with respect to the projects that require the diversion of funds from one program area to another at a different geographic scale, or it can be used to analyze the impact on several program areas of an increase in funding (Cambridge Systematics 2003, p. ES-6).  In the current phase, which is scheduled for completion in June 2003, they are applying that framework using data from state departments of transportation.  An initial case study was carried out in cooperation with the Washington State Department of Transportation (NCHRP 2003).

**Figure 1.  Generalized Framework for Multimodal Tradeoff Analysis**
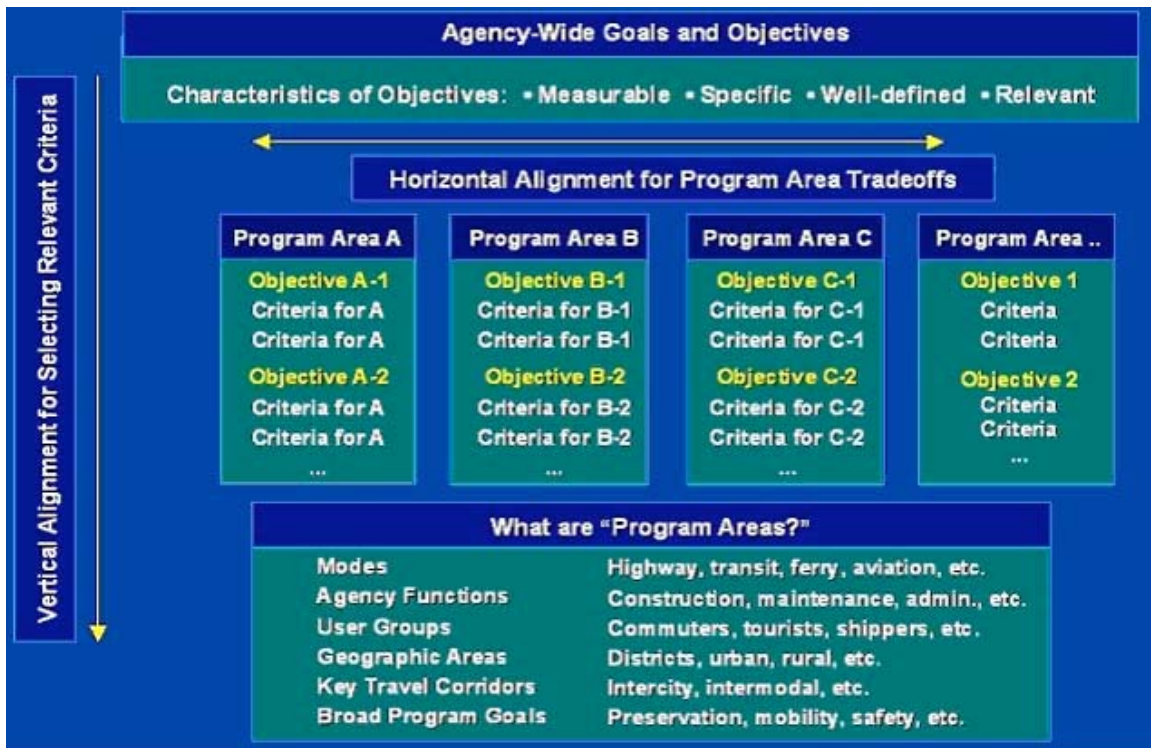


Source: Cambridge Systematics 2003.

The research being completed in this contract can be contrasted with this and other research efforts.  Both multimodal tradeoff research efforts share the common goal of ensuring that all modes of transportation are considered in transportation planning, but they differ in the scale of their analysis. The research on multimodal tradeoff that is being conducted by Cambridge Systematics considers the tradeoff at a statewide level or within specific program areas at the statewide level or smaller geographic areas.  This multimodal tradeoff in traffic impact studies focuses on the assessment of the multimodal impact of development projects at

the local and regional level but not at a statewide or program area level. The multimodal tradeoff in traffic impact studies at the local level can be contrasted with multimodal planning that takes place in many local jurisdictions throughout the country. Cities like Davis, California, Ft. Collins, Colorado and Portland, Oregon are highly praised for their multimodal planning. The purpose of this project is to identify places that both engage in multimodal planning and have developed tools to conduct multimodal tradeoff analysis in traffic impact studies.

To better understand the importance of multimodal tradeoff analysis at the local and regional level it is useful to understand the process that a local planner faces when asked to analyze the potential traffic impacts of a proposed development or changes to land use designation. Typically the analyst can consider the following basic factors:

➢ An estimate of the generation of vehicle trips using the *Trip Generation Manual* published by the Institute of Transportation Engineers (ITE) (ITE 1997).
➢ Reductions in the external (to the development) vehicular traffic generated by the development by using estimates of the amount of internal capture (trips that can be served within a mixed-use development), a "pass-by" reduction (for vehicle trips that otherwise were on the network "passing-by" and do not add additional vehicle-miles traveled to the network), and a mode split reduction (reduction in vehicular traffic for use in pedestrians, bicycle and transit modes). The reductions in trips are usually based on negotiated reduction factors (or percent of the total trip generation) based on precedence and professionally accepted studies at similar developments.
➢ Distribution and assignment of these vehicle trips to the highway network using either manual or computer modeling methods.
➢ A determination of the LOS resulting from the addition of new vehicular trips on the network and a comparison of this resulting LOS with standards established for the Florida Intrastate Highway System (FIHS) or standards established in a LGCP.
➢ Where significant impacts occur, based on the percentage of traffic on each segment that is new and a result of the development and the estimation that substandard LOS will occur, a proportionate share of the costs to improve the impacted facilities to bring them to an acceptable LOS is assessed to the developer.

For developments or major land use changes that occur in suburban or previously undeveloped areas, this analysis technique is relatively straightforward. The results of the analysis lead to a clear understanding of the new vehicular traffic that is added to the system and the ability to assess what the costs to improve these facilities will be. However, much has changed in Florida since these basic traffic-engineering principles were encoded in our growth management process for traffic impact studies.

The funding need for new highways and capacity improvement projects far exceeds the available resources in Florida. Along the FIHS, nearly $46 billion of needs and only $16 billion in funding were identified over the next 20 years in Florida. The practical reality is that we can no longer build our way out of congestion. Increasing the ability to manage and operate the system, reducing demand through better coordination of land use and transportation, and providing choices to travelers for using alternate modes are major themes of the Florida Transportation Plan, which guides all of the Department's activities.

The Florida Statutes recently were amended to allow local governments to establish MMTDs, which are similar to the transportation concurrency exception areas (TCEA), to promote development that favors pedestrian, bicycle and transit modes rather than automobiles. The MMTD can be used in lieu of or in conjunction with these TCEAs to promote mixed-use, interconnected, and dense land uses that are pedestrian and transit friendly in urban form and design. Developers, both in Florida and throughout the country, are increasingly seeking multimodal options to reduce or eliminate their anticipated impacts on the transportation network in other areas. Traffic impact analysis reviewers within the Department of Transportation, Department of Community Affairs and local governments are challenged to properly assess these proposals. This project assumes that the MMTD is the foundation for multimodal tradeoff analysis. As such, it focuses both on areas for further development of the MMTD and the extension of that into, and the development of, multimodal tradeoff analysis.

This report focuses on the multimodal tradeoff that FDOT district personnel and local governments make while evaluating project proposals that come before them. Within this context, the tradeoff is being made among various land use-transportation configurations. In order to understand the nature of the tradeoff, it is useful to consider some of the differences in the impact on the transportation system associated with two types of developments, conventional suburban development and traditional neighborhood development[2] (TND) (see Figure 2). TND has a mix of land uses, an interconnected street network, high density of development and pedestrian and transit-oriented development. In contrast conventional suburban development is characterized by low-density of land uses, separation of land use, less connected system of roadways and a lack of facilities for transit, bicycles and pedestrians.

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[2] Traditional Neighborhood development is also called, neo-traditional development and New Urbanism. The differences between these three terms are beyond the scope of this paper. For convenience, TND will be used to refer to all of these concepts and the associated land use and transportation configuration. Multimodal transportation districts are based on many of the principles of TND.

**Figure 2. Comparison of suburban-style and neotraditional street layout.**
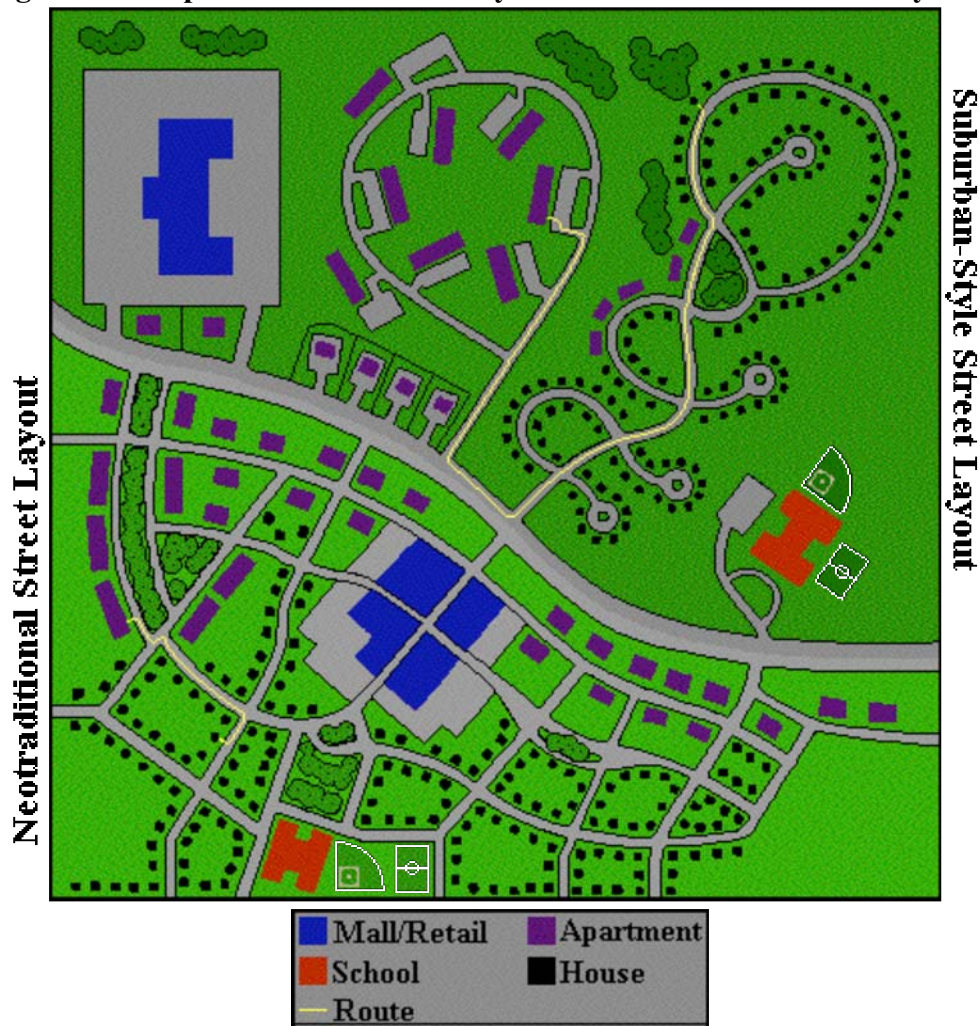


Source: Oregon Department of Land Conservation and Development, 2001

A multimodal tradeoff analysis should recognize the differences in transportation characteristics of these two styles of development.  The conventional suburban development concentrates automobile travel on the adjacent arterial and does not support trips by modes other than the automobile.  As shown in Figure 2 with the yellow line, if 6-year old Jimmy wants to go to his friend Billy's house that is located a quarter of a mile away, his mother would need to drive over a mile including a portion of the trip on the major arterial in order to get there.  In contrast, if Jimmy lived in a traditional neighborhood and wanted to go to Billy's house he could easily walk or bicycle by himself, and, even if his mother had to drive him there, she would have no need to drive along the major arterial.  If one considers the difference in the journey to school and to the regional shopping mall in Figure 2, one begins to understand the potential for reduced traffic impacts associated with the TND and other development with its characteristics.

The argument in support of TND is that it has the potential to reduce the impact on the transportation system, and in particular the adjacent arterial, in several different ways: (1) reduced automobile trip generation; (2) higher rate of internal capture; (3) more trips by

alternative modes of travel; and (4) more trip chaining that includes a different activity pattern that chains a series of trips together.  Other research suggests that overall trips may increase in TND, but vehicle trips may stay constant, increase or go down (Boarnet and Crane, 2001).  In addressing multimodal tradeoff it is important to understand the scale at which the tradeoff is occurring. The issue of scale makes this analysis difficult because it highlights differences in the needs of users of specific modes of transportation.  Pedestrians generally go shorter distances than any other users of the transportation system.  Many advocates of TND suggest that people are not willing to walk more than a quarter of a mile and other studies suggest that people may walk farther for some activities (e.g., recreation and in connection with transit trips) (see Steiner 1996).  Bicyclists are willing to travel longer distances but are sensitive to the volume and speed of traffic when riding on roadways.  Transit users will also go longer distances but they will be sensitive to some of the same factors as pedestrians with respect to access to transit.  The importance of the MMTA can be seen on major arterials adjacent to developments.  Not only are many of these arterials unsightly, but also they are the workhorses of the transportation system in that they support the needs for both regional traffic flow and local accessibility.  Developments that reduce their impact on the adjacent arterial by providing local accessibility will allow it to better perform its function of providing regional mobility.

The fundamental goal of the multimodal tradeoff is to provide a means to understand the tradeoff between various urban forms.  This tradeoff analysis requires attention to detail.  As New Urbanism and TND have become more popular, developments have sprung up that contain some, but not all of the components of TND (including features that focus on the aesthetic aspects of design rather than the functional aspects that have the potential to reduce impacts on the transportation network).  Thus, TND will be used to represent developments that contain the following characteristics:  interconnected roadway network, high density, mixed use, and transit-oriented development.  In order to justify this decision, it is useful to consider the importance of each of the features separately, to the exclusion of others, to understand their impact on the transportation network.  For example, if a development has high density but is only serving residential or commercial needs the effectiveness of the higher density is lost because a pedestrian or bicyclist does not have a mix of places to go nor does s/he have the ability to easily get from one point to another.  Mixed-use development without connectivity or density does not support modes other than the automobile because the user would be required to walk long distances between uses and the low-density of development does not support transit.  A lack of connectivity will move most of the trips onto the adjacent arterials rather than within the development.

## 1.2 Organization of the Document

This document is organized into several sections that develop a framework for MMTA; its primary function is to identify issues associated with MMTDs and the development of multimodal tradeoff analysis.  In doing so, it provides an overview to the literature, reviews best practices in multimodal analysis, and makes recommendations for additional research in the development of multimodal tradeoff analysis.  Because of the multiple functions of this issue paper, it is intended to provide an overview of a variety of issues rather than a comprehensive assessment of any single issue.

The document is organized into six chapters, each of which covers a different aspect of the issue of multimodal tradeoff analysis.  In Section 1, the importance of multimodal tradeoff analysis is introduced and the stage is set for the organization of the rest of the document.  In Section 2, the literature review, studies on the connection between land use and transportation are explored to understand the potential for reduced impact of certain forms of development on the transportation system.  In Section 3, the general state of practice with respect to the various components of the Florida transportation planning process are outlined to provide the policy framework for the implementation of multimodal transportation planning.  In particular, site impact assessment, transportation concurrency, and transportation modeling are discussed.  Next, in Section 4, other approaches to multimodal analysis that have been developed for conducting multimodal tradeoffs, both within Florida and throughout the United States, are presented and critiqued.  In Section 5, the assessment of the opportunities for multimodal analysis are presented and discussed.  Finally, in Chapter 6, recommendations for data collection needs and a broader research agenda are developed.

## 2. LITERATURE REVIEW

A highly interdependent relationship exists between land use and transportation. In order for development to occur, adequate transportation capacity must be available to serve it, but improvements in transportation infrastructure both increase land-use values and mobility due to increased accessibility. Both of these prompt additional pressure for new development. Ideally, investments in transportation infrastructure should be coordinated with the development of adjacent land. However, maintaining the balance between development and transportation capacity is difficult. The availability of transportation infrastructure often lags behind development creating a cycle in which transportation improvements become reactive to land-use changes rather than being coordinated with or preceding development. New investments in transportation, in turn, cause pressure for additional development and an increase in traffic due to improved mobility and accessibility resulting in an overall lower LOS for the adjacent roadways.

One of the first steps in quantifying this land-use and transportation relationship is to recognize that specific land-use variables (i.e. density, land-use mix, accessibility, etc.) will not necessarily reduce vehicular traffic when measured separately. One must view these variables as part of the "bigger picture" and realize that it is the overall combination that will ultimately work to reduce automobile usage. Thus it is often difficult to single out the effects that a specific land use variable may have on vehicular traffic. The majority of literature examining land use variables does so in the context of other variables, therefore making it difficult to extract the direct effect of a single variable. Furthermore, determining the exact relationship and interaction that these variables have when combined with each other can prove to be an even more difficult task. However, it is indeed helpful (as well as necessary) to examine these variables individually as a means to determine just how they can fit into the multimodal tradeoff analysis.

A substantial amount of literature exists regarding the impacts of alternative land use configurations on transportation, but its applicability to Florida is less well understood. Many current studies have been performed in older neighborhoods that are mixed-use, high density, and have a gridded street network. Many cities in Florida however, are newer and do not necessarily incorporate all of these elements. This fact must be taken into consideration when using the literature as a basis for determining potential multimodal trade-off analysis.

One of the most important elements to consider in a multimodal district is density. Since sprawl is most commonly defined as low-density development that is dispersed away from a population center, one way to capitalize on the public investment in transportation would be to develop nodes of high-density development that could accommodate all modes of transportation. In addition to density, the area should also contain a land use mix, such as retail, office, residential, entertainment, and recreational, that promotes alternative forms of transportation such as walking, bicycling or transit usage. If residents of an area have useful destinations within a reasonable distance of their residence, then they will be more likely to use their automobile less. This is where the third dimension of the street network is key. It would be futile to have a high density and good mix of land use if accessibility is poor. Residents will not choose alternative modes of transportation to get to their job or a shopping center if they must go in a circuitous manner to get there or if they deem it unsafe or inconvenient. A functional, grid-like street network is necessary so that residents can have multiple paths of travel and high

accessibility to their destinations.  The availability of side paths and other off-road facilities will also increase accessibility for bicyclists and pedestrians.  The presence of density, connectivity and mix of land uses in close proximity will offer the opportunity for residents to use alternative modes.  However, the overall question of whether or not travelers will abandon their automobile for other modes of transportation will not depend entirely upon the characteristics of the land use-transportation system.  Unless travelers feel safe and are not inconvenienced by the alternative modes (at both the origin and destination of their travel), they will not abandon their automobile.

There is currently a large amount of literature on the subject of urban form and, more specifically, density, land-use mix, and connectivity, and accessibility.  However, there has been much difficulty in empirically determining the relationship between travel behavior and characteristics of land use and the built environment.  It has been the consensus of many (Cervero and Gorham 1995, Handy 1992, Friedman *et al.* 1994, Cervero and Radisch 1996, Rutherford *et al*. 1996; see Ewing and Cervero 2001) that land-use factors do indeed have an effect on travel, but the exact effect of those factors has been difficult to sort out.  Ewing and Cervero summarize more than 50 studies to establish elasticities of demand for vehicle trips and vehicle miles traveled with respect to variables in the built environment (see Table 1).  For example, a 1% increase in local density results in a relatively small reduction of 0.05% in the number of vehicle trips and in the number of vehicle miles traveled.

| Table 1. Typical Elasticities of Travel with Respect to Built Environment | | |
|---|---|---|
| | Vehicle Trips (VT) | Vehicle Miles Traveled (VMT) |
| Local Density | -.05 | -.05 |
| Local Diversity (mix of land use) | -.03 | -.05 |
| Local Design | -.05 | -.03 |
| Regional Accessibility | -- | -.20 |
| Source: Ewing and Cervero 2001, p. 111 | | |

This literature review is a survey of literature pertaining to the land-use and transportation connection.  Highlighted in the review are studies that effectively show the impact of certain land-use variables on vehicular traffic mostly on the local, neighborhood level.  Cumulatively, these studies show a potential for reductions in vehicles miles traveled (VMT), changes in mode split to bicycling and walking and transit associated with a high-density, mixed-use, transit oriented style of development.  However, as Ewing and Cervero (2001) suggest, their review of the literature seeks to explain four types of travel variables, trip frequencies (rate of trip making), trip lengths (either in time or distance), mode choices or modal splits and cumulative person miles traveled (PMT), and vehicle miles traveled (VMT) or vehicle hours traveled (VHT).  The role of socioeconomic characteristics is also an important component of travel behavior.  They reach the following conclusions about the various outcomes of these travel studies:

➢ Trip frequency appears to be largely independent of land use variables, instead it is more closely related with socioeconomic characteristics.
➢ Any decrease in automobile trips with higher density, greater accessibility or land use mix is paired with increases in transit, bicycling or walking trips.

➢ Trip lengths are shorter at more accessible locations for both home end (i.e., residential neighborhood) and non-home (i.e., activity centers) trips.
➢ Mode choice is most affected by local land use patterns. Transit use depends upon frequency of service, local densities and a mix of land uses.
➢ Contrary to conventional wisdom, for both transit and walking modes, employment densities at destinations are as important as, and are possibly more important than, residential densities.

The literature review in this report is thus intended to be illustrative rather than comprehensive. For more comprehensive reviews, see Handy1996a, Boarnet and Crane 2001, Crane 1999, Badoe and Miller 2000, and Ewing and Cervero 2001.

## 2.1 Density

Density is one of the most commonly measured elements of urban form. Densities can be characterized by residential densities in the neighborhood and employment densities that could potentially be located in the activity center of the district (Ewing and Cervero 2001). Each different study tests a variety of variables such as gross household density and gross population density as well as vehicle miles traveled (VMT) per household, VMT per person, overall trips per household and transit share of work trips and non-work trips to name just a few. The key to understanding density when trying to review the literature is to determine exactly which land use variables tested in each study are significantly related to specific travel variables, as Ewing and Cervero (2001) have done in their synthesis. Statistically, density is often considered a proxy for measuring other variables that are more difficult to quantify such as demographics and LOS (Frank and Pivo 1994). The effects of density have been most notably observed when comparing traditional, pedestrian-oriented neighborhoods and automobile neighborhoods. Cervero and Gorham (1995) compared sets of both of these types of neighborhoods in the San Francisco Bay Area and also in Southern California and found that residents of traditional neighborhoods walked and bicycled more than their counterparts in auto-oriented neighborhoods. They also averaged higher walking and bicycle mode share trip generation rates than those in automobile oriented neighborhoods. Parsons Brinckerhoff Quade and Douglas, Inc. (1993) also found that residents of less dense zones in suburban areas tend to generate more automobile trips per household than residents of high-density urban zones.

When examining the effects of density on travel in a neighborhood, it is also necessary to account for the sociodemographic characteristics of the population of the area such as income, household size, race, and age of residents. This is especially true for the variable of income. Low-income individuals tend to have lower rates of automobile ownership, live in clustered, high-density areas and use transit more than residents with higher incomes (Dunphy and Fisher 1996). Dunphy and Fisher conclude in their study that travel effects in high-density areas may be due to the characteristics of the residents in the area rather than the effects of the physical environment.

One of the issues that many studies fail to address is that of self-selection of individuals into specific neighborhoods. As Ewing and Cervero's (2001) summary of research studies suggests, socioeconomic characteristics interact with land use characteristics in travel behavior

of residents in TND.  Advocates of TND contend that these high-density areas with a high land-use mix will tend to result in an overall substitution of automobile use by other modes.  Steiner (1994) points out that the trend of less automobile usage in high-density developments assumes that residents of the area will choose to walk or use transit more often and make fewer and shorter automobile trips.  However, if these same residents do not choose other modes over the automobile, and instead make as many automobile trips as residents in low-density areas, the overall effect will be an increase in congestion, only at lower speeds.

| Table 2. Summary of Studies on the Effects of Density on Transportation Outcomes | | | | | |
|---|---|---|---|---|---|
| **Author** | **Location/Area** | **Method of Analysis** | **Independent Variables** | **Dependent Variables** | **Conclusions** |
| Cervero and Gorham (1995) | San Francisco Bay Area and Southern California | Comparison of two types of neighborhoods | · density | · transit and pedestrian mode choice | · traditional neighborhoods averaged higher walk and bicycle trips than did the automobile oriented neighborhoods |
| Dunphy and Fisher (1996) | Nationwide | Analysis of the 1990 National Personal Transportation Survey | · density | · VMT | · automobile usage is less in high-density areas |
| Parsons Brinckerhoff Quade and Douglas (1993) | Portland, Oregon | 1985 home interview survey and regional travel forecasting models and land use information | residential density · transit LOS · proximity to employment · quality of pedestrian environment | · household travel mode choice- | · low-density areas generate more automobile usage than high-density areas |
| Steiner (1994) | | Literature Review | | | · a greater potential exists for higher levels of walking and less driving in high density environments · higher density creates an opportunity for greater automobile usage, but in even more congested environments |

## 2.2 Land Use Mix

The idea of having a complementary land-use mix is a key factor in the functionality of a multimodal transportation district.  The downtown and other more local activity centers serve as the heart of the district providing shopping and business activity for the residents in the area and must contain a variety of retail, office, shopping, and entertainment establishments if it is to be

fully utilized by residents of the surrounding area. While it may seem intuitive that a diverse mix of land-use in the central area of a multimodal transportation district will undoubtedly have some kind of effect on travel, exactly what type of effect it will have is much less clear.

Cervero (1996) has determined three transportation benefits that often accompany an ideal land-use mix. First, and probably most obvious, is that if a suitable mix of land uses exists, such as offices, shops and restaurants, then people are more likely to walk to their destination rather than drive because the destination is within walking distance. This causes a higher non-motorized mode split and decreases VMT. Secondly, Cervero points out that trips in mixed-use areas tend to be more spread out over the day and week. This is caused by the presence of restaurants and other establishments that generate off-peak travel within the same area as offices that generate more traditional trips during the morning and afternoon times. Finally, mixed-use areas allow for shared parking arrangements due to the wide spectrum of establishments located in the area and the variability of each establishment's operating hours.

Loutzenheiser contends that walking is primarily a result of individual choice rather than a result of the physical elements of the built environment. In an analysis of the Bay Area Rapid Transit System (BART), it was determined that distance was the most important factor in the choice to walk. Additionally, the study found that areas that contained a retail-oriented activity center produced the greatest proportion of walk trips (Loutzenheiser 1997). A favorable land-use mix will perpetuate other modes of travel such as walking simply because of the fact that destinations are more likely to be within walking distance.

While there is little doubt that an area containing a mixture of uses will have a beneficial effect in terms of transportation impact, the presence of mixed-uses may not necessarily prove to reduce VMT in and of itself. The type and extent of a mixed-use area also affects how successful the area will be in reducing VMT and the number of trips. Often times, areas that are considered mixed-use do not reduce trip generation quite as much as expected (Steiner 1998). For an area to have a functional mix of land uses, it must provide residents in the surrounding area with establishments that suit their basic needs such as grocery and convenience stores in addition to restaurants and office space. If the shopping district contains specialty shopping or other establishments that attract residents from a large area and not just from the neighborhood, these particular establishments may increase trip generation from residents of other neighborhoods due to their uniqueness (Steiner 1998). In addition to appropriate shopping and eating establishments, a functional mixed-use area should have employment opportunities that suit the surrounding area.

In addition to having a functional type and extent of land-use mix in an area, scale is also important. Determining the proper scale of a multimodal district is not exactly a black and white issue and has been given relative inattention. Boarnet and Sarmiento (1998) contend that in order to affect travel behavior, the planning area should cover an area much larger area than 2 square miles due to the fact that many non-work trips tend to cover much larger areas. The area should be large enough to support a fixed-route transit system and have a large population in order to create a high-density area. However, the area must contain a central activity center in which residents are able to walk or bike.

# Table 3. Summary of Studies on the Effects of Land Use on Transportation Outcomes

| Author | Location/Area | Method of Analysis | Independent Variables | Dependent Variables | Conclusions |
|---|---|---|---|---|---|
| Miller and Ibrahim (1998) | Six regional municipalities in the greater Toronto area | Regression analysis using major traffic survey data from 1986 | · home based work vehicle kilometers traveled | · distance from the central business district<br>· population density | · average VKT per worker increases by about 0.25 KM for every KM the worker moves away from the CBD, as a measure of the effect of sprawl |
| Loutzenheiser (1997) | San Francisco Bay Area | Linear regression analysis using travel survey data of riders of the Bay Area Rapid Transit System (BART) | · extent mix of land uses around transit station<br>· type of land use around transit station | · probability of walking mode choice to transit stations | · transit stations with strong retail oriented environments produce the greatest proportion of walking |
| Cervero (2002) | Montgomery County, Maryland | Analysis of models that estimated the mode choice for residents accounting for land-use factors | · density<br>· mix of land use<br>· physical design of built environment | · mode choice | · mixture of land use and intensity significantly influence decisions to drive-alone, share a ride or use transit |
| Cervero (1996) | Eleven metropolitan areas throughout the united states. | Analysis of the American Housing Survey of 11 metropolitan statistical areas with a population greater than 1 million | · density<br>· land use | · commuting mode choice<br>· commuting distance<br>· household vehicle ownership | · retail shops located within 300 feet from a dwelling unit, individuals are more likely to use transit, foot or bicycle |
| Cervero and Radisch (1996) | Two San Francisco, California neighborhoods. | Comparison of a compact, mixed-use neighborhood and a suburban neighborhood | · trips per household | · auto oriented neighborhood<br>· traditional neighborhood | · compact, mixed-use, and pedestrian oriented neighborhoods have higher shares of pedestrian and bicycle work trips |
| Frank and Pivo (1994) | Washington; Puget Sound area | Statistical techniques were used to test hypothetical relationships between urban form and travel behavior | · urban form (gross population density, gross employment density, land-use mix | · mode choice (single-occupant vehicle, transit, and walking) | · land-use mix and density are related to mode choice |

**Table 3 contd. Summary of Studies on the Effects of Land Use on Transportation Outcomes**

| Author | Location/Area | Method of Analysis | Independent Variables | Dependent Variables | Conclusions |
|---|---|---|---|---|---|
| Steiner (1996) | Six traditional shopping districts in Oakland and Berkeley | Field observations; intercept surveys; mailback surveys | Mix of land use, scale of shopping activity, distance; sociodemographic characteristics of population | Probability of choosing to walk (logit model) to shopping | · distance most important factor in choice to walk; grocery shopping trips, availability of parking not found significant |
| Rutherford, McCormick and Wilkinson (1996) | Seattle, Washington | Survey of 663 households | · land-use mix | · trip generation · VMT | · presence of a mixed use neighborhood can reduce number of miles traveled per household |
| Boarnet and Sarmiento (1998) | Southern California | Regression analysis of non-work trip frequencies obtained from southern California travel diary data | · density | · non-work trip generation rates | · the correlation between land use and travel behavior is inconclusive. With the exception of urban design, other land use variables are statistically insignificant |

## 2.3 Street Network Connectivity

The pattern in which streets, sidewalks and entire blocks are designed does indeed have potential effects on travel behavior. The most direct effect of these designs is in individual mode choice. Areas with short blocks obviously have more intersections at which pedestrians can cross creating an environment that is conducive to the choice of walking because the routes of travel are more direct and of shorter distances. Additionally, pedestrians feel more comfortable walking on sidewalks along streets that have less traffic. Street design is also very closely related to accessibility, which is discussed in the next section. With a denser network of streets, the potential accessibility is greater because of the greater number of options for route choice. This dispersion of traffic causes each street to carry less traffic. Not only does this ease traffic flow on major arterials, but as mentioned previously, it also causes pedestrians on the sidewalk to feel much safer.

By determining how conducive the street pattern of an area is to promoting non-motorized mode choices, one must be able to quantify the connectivity of the streets in the area. Parsons Brinckerhoff Quade and Douglas, Inc. (1993) used a Pedestrian Environment Factor (PEF) in the Portland area in order to accomplish this. The PEF was characterized by four elements of the built environment: ease of street crossings, sidewalk continuity, local street characteristics, and topography. By using these parameters when analyzing traffic analysis zones (TAZs), a composite score could be assigned to each zone. The numbers varied from four to twelve with pedestrian-friendly areas receiving values of between nine and twelve and nonpedestrian-oriented areas receiving values of less than nine. The Multimodal Transportation

Districts and Areawide Level Of Service Handbook (FDOT 2003) includes methodologies for obtaining values for all of these parameters except for topography, which is due to the relatively flat nature of Florida. However, a comfort factor for pedestrians could be substituted for topography. Because Florida traditionally has high temperatures and heavy rainfall, this value could potentially measure the amount of tree cover and presence of benches and weather shelters on sidewalks. Zacharias (2001) addresses the role of physical comfort relating to weather conditions in addition to other factors such as ambient sound as well as entertainment and/or cultural representation. He argues that perhaps more attention should be given to visual detail and layout rather than physical detail of the built environment.

Holtzclaw *et al*. (2002) developed another method to quantify the connectivity of the street pattern. This method uses an equation:

Pedestrian/Bicycle Friendliness = Street Grid + Year Built + Bonuses

> where street grid = (# of census blocks)/(developed hectares)
> year built = a determined decimal number according to year built,
> bonuses = presence of traffic calming and bicycle lanes.

Using this methodology, Holtzclaw *et al*. (2002) were able to determine that pedestrian and bicycle friendliness along with total residential density and per capita income were the most consistent variables for explaining variance of VMT. In other words, lower VMT is associated with higher residential density and higher density of street network.

| Table 4. Summary of Studies on the Effects of Street Pattern on Transportation Outcomes | | | | | |
|---|---|---|---|---|---|
| **Author** | **Location/Area** | **Method of Analysis** | **Independent Variables** | **Dependent Variables** | **Conclusions** |
| Parsons Brinckerhoff Quade and Douglas (1993) | Portland, Oregon | 1985 home interview survey and regional travel forecasting models and land use information | residential density · transit LOS · proximity to employment · quality of pedestrian environment | · household travel mode choice- | · use of the PEF in travel models helps explain variation in auto ownership, mode choice and destination choice |
| Zacharias (2001) | | Literature Review | | | · addresses the aspect of individual choice in pedestrian environments |
| Ewing (1996) | Florida | Guidebook for pedestrian and transit friendly design | | | · guidelines for pedestrian and transit-friendly design |

| Table 4 contd. Summary of Studies on the Effects of Street Pattern on Transportation Outcomes | | | | | |
|---|---|---|---|---|---|
| **Author** | **Location/Area** | **Method of Analysis** | **Independent Variables** | **Dependent Variables** | **Conclusions** |
| Holtzclaw, Clear, Dittmar, Goldstein, Haas (2002) | Chicago, Los Angeles and San Francisco | · study develops models of travel data and analyzes results | · residential density<br>· transit service and access to jobs by transit<br>· availability of shopping<br>· proximity to jobs | · automobile ownership<br>· VMT | -land-use and urban design have significant effects of vehicle ownership and distance driven |

## 2.4 Organization Along the Corridor and Associated Accessibility

One of the key factors in the transportation and land-use relationship is organization along the corridor and the associated accessibility. Accessibility can be defined as a land-use element that is a reflection of the connectivity of a street network as well as the "intensity of opportunity at the analysis zone" (Sun *et al*. 1998, p. 12). Calthorpe (1993) outlines an organization along arterials that should support transit with centers of various scales from downtowns, to urban transit villages to neighborhood transit-oriented development. Significantly, this organization coordinates various levels of transit service with density, depending upon the scale of the center. Accessibility plays a major role in the overall functionality of an area. Areas that have high population densities but low accessibility will ultimately have higher levels of automobile usage due to the lack of opportunities. People will be forced to drive longer distances for work and non-work travel even though the majority of the population lives in a compact area. Density without local accessibility places a tremendous burden on the transportation infrastructure and the end result is likely more congestion.

In order for VMT to be reduced for work trips, employment must be accessible within the area. This is illustrated in a study performed in the San Francisco Bay Area. Using TAZs and census tract data, it was determined that jobs within 30 minutes among other factors such as household size, income and balance of land, had an effect on vehicle miles traveled (Kockelman 1997). In other words, regional accessibility is important in the trip to work.

Additionally, one must consider both neighborhood accessibility and regional accessibility. An example of good neighborhood accessibility would be gated country club developments with a shopping center. These areas tend to have a relatively good accessibility inside the development; however, most tend to only have one or two gated entrances. With the shortage of access to the adjacent roadway, traffic may concentrate at the access point and congestion may increase on the adjacent arterial.

There are instances where added accessibility might have the opposite reaction; one example is systems with elastic travel demand. As Levinson and Kumar point out, "improving accessibility in one corridor may increase demand in that corridor, worsening conditions in both

perpendicular corridors (east-west congestion will worsen if more traffic signal green time is given to north-south movements as an example) and in somewhat parallel corridors (increased demand from one origin due to travel time savings on one set of links increases travel times for other origins sharing unimproved links with the first origin)" (Levinson and Kumar 1994, p. 13).

A study by Ewing *et al.* (1996), found that vehicular trip rates all depend on the elasticity of total travel demand and of the substitution of walking and biking modes for vehicular travel. They state that if trip making is inelastic and mode substitution is minimal, this supports the theory that total trip rates and vehicle trip rates are independent of accessibility. This finding is most consistent with conventional trip generation models. Conversely, Ewing and Cervero (2001) find that vehicle trips and vehicle miles traveled are somewhat elastic. The elasticity of regional accessibility was greater compared to the elements of density, land-use mix and design.

Kockelman suggests quantifying accessibility using an equation from the gravity models. Kockelman goes on to state that measuring accessibility is very hard due to the lack of specific data on work; however, she develops a jobs-density variable which includes population density of home traffic analysis zones (TAZ) and of trip origin and destination TAZs (Kockelman 1997).

Sun *et al.* (1998) measured the variable accessibility using an accessibility equation. They concluded that accessibility along with density and land-use balance all significantly influence household travel patterns. In the study, they found that VMT was affected more by land-use variables than number of household daily trips. As an interesting aside, the study also found that a household with a car phone generates 52 percent more VMT and 22.9 percent more trips than households without a car phone (Sun *et al.*, 1998).

| Table 5. Summary of Studies on the Effects of Organization on Transportation Outcomes | | | | | |
|---|---|---|---|---|---|
| **Author** | **Location/Area** | **Method of Analysis** | **Independent Variables** | **Dependent Variables** | **Conclusions** |
| Ewing, DeAnna, and Li (1996) | Florida- Palm Beach and Dade Counties | ANOVA analysis of household trip rates | · accessibility measures<br>· density for residential zones<br>· jobs-housing balance | · household trips | · travel demand is inelastic and mode substitution is minimal; total trip rates and vehicle trip rates are independent of accessibility |
| Sun, Wilmot and Kasturi (1998) | Portland | ANOVA process to determine the effect of specific variables on travel | · density<br>· land use balance<br>· accessibility | · household daily trips | · well-balanced land-use development is an effective way of reducing congestion on emissions |
| Levinson and Kumar (1994) | Washington | | | | · describes a methodology for measuring accessibility |

**Table 5 contd. Summary of Studies on the Effects of Organization on Transportation Outcomes**

| Author | Location/Area | Method of Analysis | Independent Variables | Dependent Variables | Conclusions |
|--------|---------------|--------------------|-----------------------|---------------------|-------------|
| Kockelman (1997) | San Francisco Bay Area | | · household size<br>· accessibility<br>· general mix<br>· other sociodemographic variables | · VMT per household<br>· auto ownership<br>· total non work home based VMT<br>· personal vehicle mode choice<br>· walk/bike mode choice | · areas with a good accessibility and land-use mixing produce lower VMT |
| Handy (1992) | San Francisco Bay Area | Paired comparisons of four neighborhoods with high and low regional and local accessibility | · household size and composition | # of walking trips | · residents walk more in neighborhoods with high local accessibility |

## 2.5 Summary of Literature Review

Research shows that traditional neighborhoods that favor pedestrian, bicycle and transit travel have the potential to reduce the number of vehicle trips taken and the VMT. These neighborhoods are characterized as high-density, compact areas with a gridded street network in addition to a land-use mix that integrates shopping, work, and leisure into the residential area. However, the applicability of these results to Florida locations is less well understood. Most of the studies have been conducted in well-established traditional neighborhoods while much of Florida has developed more recently. These results may apply to some existing downtown locations in Florida, but they may be less applicable to more recently developed New Urbanist communities that do not have the high regional accessibility that is associated with downtown locations. While these suburban New Urbanist communities may have fewer non-work trips by automobile, they may have as many work trips by automobile as similar conventional suburban development. The basic conclusions of these studies include the notion that increasing overall accessibility of an area and creating activity centers for work and shopping at a close proximity will allow residents more options for reaching their destination instead of simply relying on the automobile for all of their trips. The urban form elements of New Urbanism are not simply another "flash-in-the-pan" and should not be hastily discarded. Substantial research validates the idea that, in certain settings, there is the potential for a reduction in the number of trips and the associated VMT. Depending upon the purpose of the trip, if residents are afforded the opportunity to use other modes of travel, many will do so and automobile usage will be reduced.

# 3. GENERAL STATE OF PRACTICE IN FLORIDA

Recognizing the substantial public interest in Florida's transportation infrastructure system, the Florida Department of Transportation (FDOT) and the Department of Community Affairs have developed a system of analysis tools that work together to determine the transportation impacts of proposed developments. The system is comprised of three sets of different but interrelated processes that are each discussed in this section. These processes include the site impact assessment, concurrency, and transportation modeling.

## 3.1 Site Impact Assessment

The purpose of site impact analysis and review is to assess potential traffic impacts resulting from development, determine mitigation strategies, plan for transportation requirements of future development and maintain a balance between land use and the quality of transportation services. While land development regulations are often determined and implemented by local governments, the FDOT has seen it fit to coordinate a statewide site impact analysis procedure due to the far-reaching effects that development has on the State Transportation System.

FDOT defines site impact as follows:

> …any effort by the Department to prepare an analysis of or conduct review of and analysis prepared by another party to estimate and quantify the specific transportation-related impacts of a development proposal, regardless of who initiates the development proposal, on the surrounding transportation network. The Department's impact assessment may be limited to the State Highway System (SHS) or, as will be defined later, on any affected roadway system as determined by the procedures established in this Handbook and the specific type of review being conducted (FDOT 1998, 1).

Site impact analysis is important for a number of different reasons, the most important being that it will ensure state transportation systems impacted by a proposed development will continue to operate at an acceptable LOS. This is especially important if the facility is part of the SHS and especially the FIHS. Additionally, site impact analysis allows local governments to ensure that proposed development is consistent with local government comprehensive plan goals and objectives as well as future land-use map elements.

Because FDOT is primarily concerned with ensuring adequate LOS standards on the SHS, particularly the FIHS, the need to perform site impact analysis is most pressing when a proposed development could create potential impacts affecting this system. When there are minimal potential impacts for a proposed development on the system, a detailed site impact analysis may not be performed by FDOT. However, local governments may require a site impact analysis due to impacts on other transportation systems. In this case, the FDOT may be requested to assist in the review of the analysis. The FDOT has explicitly addressed three situations in which a site impact analysis review is required: Developments of Regional Impact (DRIs), LGCP reviews, and other types of reviews such as campus master plans (CMPs), military base reuse plans or requests for access to roadways on the State Highway System.

In order to accomplish statewide site impact analysis in a uniform fashion, FDOT has developed a Site Impact Handbook and associated training courses.  The handbook addresses mandatory analysis and review requirements, offers guidance to agencies on when FDOT will be conducting these reviews and identifies how these reviews will be conducted.  The handbook creates a framework of basic processes that should be followed for all site impact analyses.  This framework consists of eleven steps including:  methodology development, existing conditions analysis, background traffic, trip generation (including internal capture and pass-by rates), trip distribution, mode split, assignment, future conditions, mitigation analysis, site access and parking, review and permitting.  The training course materials include a CD with many of the associated guidelines and regulations of the FDOT (FDOT 1998).

The FDOT Systems Planning Department is currently working with RS&H to develop Transportation Impact Program Software (TIPS) to help planners completing site impact assessment to standardize the information presented to them regarding the trip generation, internal capture, pass-by and special trip generators (Tyndall 2003).  The software automates trip generation rates for selected types of land uses and then uses information from the ITE Trip Generation Handbook (ITE 1997) to allow the planner to establish rates for internal capture and pass-by traffic associated with the development.   The application also contains a section to incorporate special trip generators into the calculation (Tyndall 2003).

Traditionally, analysis of potential traffic impacts of proposed development has been relatively straightforward, relying on a few basic factors.  If these developments occur in suburban or previously undeveloped areas, then traffic impact analysis techniques will produce results that can clearly show the effects that new vehicular traffic will have on the transportation system and also what the costs will be to improve the system in order to accommodate the new increase in vehicular traffic.  However, with the development of MMTDs and other techniques of multimodal analysis, it is now necessary to consider not just the street network level-of-service issues, but also the needs for transit[3], pedestrians and bicyclists and the potential for the reduction of automobile usage.

## 3.2 Concurrency

The concurrency requirement of Florida's Growth Management Act (GMA) integrates local comprehensive planning with development permitting.  As structured in the state law and the implementing regulations, each local government in Florida adopts a local comprehensive plan containing eight mandatory elements, four of which are of direct concern to the implementation of transportation concurrency.  The future land use map designates "proposed future general distribution, location and extent of the uses of land for residential uses, commercial uses, industry, agriculture, recreation, conservation, education, public buildings and grounds, and other public facilities, and other categories of the public and private use of land" [163.3177 (6) (a) FSA].  The traffic circulation element consists of the "types, locations, and extent of existing and proposed major thoroughfares and transportation routes" [163.3177 (6) (b) FSA].  Under the law and the

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[3] In the majority of the literature regarding transit, it is referred to in the context of fixed-route and fixed schedule transit as opposed to other forms of paratransit with more flexible routes and schedules.  However, it may be beneficial to examine the effects that paratransit may have on travel within multimodal districts.

implementing regulations, the capital improvements element identifies and provides funding for the public facilities needed to accommodate projected growth to meet the minimum LOS standard for those facilities [163.3177 (3) (a) FSA]. The capital improvements element should include a cost feasible plan for improvements for at least a five-year period. The intergovernmental coordination element shows the relationship and principles and guidelines to be used in coordinating the adopted comprehensive plan with the adopted comprehensive plan of adjacent municipalities, the county, adjacent counties, the region and the state comprehensive plan.

These four elements are coordinated through a process called consistency, which requires that each element of the plan be consistent with the others and with the regional and state plans (163.3177(10) (a) FSA). These four plan elements come together in the transportation concurrency management system that is included in the local comprehensive plan, which among other provisions identifies the LOS that will be allowed for all major roadway segments of the transportation system.

The local comprehensive planning process is coordinated with the permitting process in the land development regulations (LDRs). Local governments must implement land development regulations that prohibit issuance of a development permit resulting in a reduction of the LOS to below the established standard. To establish the coordination of these two processes at the local level, the concurrency legislation sets out three requirements for local government: (1) develop a concurrency management system as a part of the local comprehensive plan; (2) adopt LOS standards on all roadway segments other than local roads (e.g., collectors, arterials and limited access highways); and (3) implement concurrency as a part of the issuance of a development order.

As the concurrency system developed in Florida in the early 1990s, roadway concurrency was among the major areas of focus. In particular, an ongoing concern surfaced over the establishment of LOS standards on the State Highway System, the standards used for roadway concurrency, the perception that transportation concurrency was causing sprawl, the long lead time for building roads, the backlog of transportation projects, the meaning of the requirement that facilities be "available concurrent with development," and how to measure roadway concurrency (Boggs and Apgar 1991, Powell 1994, Rhodes 1991, Pelham 2001). Throughout the 1990s the GMA was amended to begin to address some of these concerns including the development of transportation concurrency management areas, project specific exceptions, long-term concurrency management systems, and MMTDs. Each of these types of enhancements to concurrency is described below.

### 3.2.1 Transportation Concurrency Management Areas (TCMA)

In 1992, legislation was passed that allowed the creation of a Transportation Concurrency Management Area (TCMA) (Powell, 1994). The purpose of a TCMA is to "promote infill development or redevelopment within selected portions of urban areas in a manner that supports the provision of more efficient mobility alternatives, including public transit" (FAC 9J-5.50055). The TCMA may be established in " a compact geographic area with an existing network of roads where multiple, viable alternative travel paths or modes are available for common trips"

[163.3180 (7) FSA].  An areawide LOS may be established for facilities with similar functions serving common origins and destinations [163.3180 (7) FSA].

### 3.2.2 Project Specific Exceptions

The 1993 amendments to the GMA created several new exceptions to address the concerns about sprawl, disincentives to redevelopment, and concerns about specific types of development that were being prevented because of the structure of the transportation concurrency management system (Durden *et al*., 1996).  Exceptions to transportation concurrency regulations are area-specific or project-specific (Durden *et al*., 1996) and are incorporated into local government comprehensive plans and land development regulations (LDRs).

Project-specific exceptions include: (1) urban redevelopment projects [163.3180 (8) FSA]; (2) *de minimus* projects [163.3180 (6)]; (3) projects that promote public transportation [163.3180 (5) FSA and 9J-5.0057 (7) FAC]; (4) part-time projects [163.3180 (5) (c) FSA]; and (5) projects for which private contributions are made [163.3180 (11) (c) FSA].  Urban redevelopment projects, which are located in an existing urban service area and that may reduce the LOS below the adopted standard, are not subject to the concurrency requirement for up to 110% of the roadway impacts generated by prior development [163.3180 (8) FSA].  Projects can be considered *de minimus* if the impacts do not significantly degrade the existing LOS, and the project is no more than twice the density or intensity of the existing project, or less than four units per acre for residential uses or a floor area ratio of 0.1 for non-residential uses [163.3180 (6) FSA].  A single development cannot exceed 0.1 percent of the maximum service volume at the LOS standard for the peak hour [163.3180 (6) FSA].  The cumulative impact of all *de minimus* developments cannot exceed three percent of the maximum service volume if the road is over capacity [163.3180 (6) FSA].  Local governments may exempt projects promoting public transportation, such as office buildings that incorporate transit terminals and fixed rail stations, by setting standards for granting this exception in the local comprehensive plan [163.3180 (5) (b) FSA and 9J-5.055 (7) FAC].  Projects, such as stadiums, performing arts centers, racetracks and fairgrounds, that are located within urban infill, urban redevelopment, existing urban service areas, or downtown revitalization areas (Powell, 1994) and pose only special part-time demands on the roads may be exempt from concurrency [163.3180 (5)(c) FSA].   Local governments may allow developers to proceed with the development of land notwithstanding a failure of the development to meet concurrency, and avoid a claim of a temporary taking, if developers are willing to pay their "fair share" of the cost of providing the transportation facility necessary to serve the proposed development [163.3180 (11) FSA].

### 3.2.3 Long-Term Concurrency Management Systems (LTCMS)

In addition to the TCMA, two area-specific exceptions were added in 1993: (1) long-term transportation concurrency management systems (LTCMS) [163.3180 (9) (b) FSA]; and (2) transportation concurrency exception area (TCEA) [163.3180 (5) (b) FSA].  LTCMS are established in areas with existing deficiencies.  To eliminate the backlog, a comprehensive plan is established that identifies the improvements to be made over a ten-year period, or in exceptional circumstances over a fifteen-year period.  The comprehensive plan must: (1)

designate specific areas where the deficiency exists; (2) provide a financially feasible means to ensure that existing deficiencies will be corrected within the ten-year period, and (3) demonstrate how development will be accommodated and the facilities and services (including roads and public transit) that will address the existing deficiency [9J-5.0055 (4) FAC].

### 3.2.4 Transportation Concurrency Exception Areas (TCEA)

The purpose of a TCEA is to "reduce the adverse impact transportation concurrency may have on urban infill and redevelopment and the achievement of other goals and policies of the state comprehensive plan, such as promoting the development of public transportation" [9J-5.0055 (7) FAC and 163.3180 (5) (b) FSA]. It can be established to promote three purposes: (1) urban infill development; (2) urban redevelopment; and (3) downtown revitalization. In a TCEA that is designed to promote urban infill, no more than ten percent of the land can be developable vacant land [9J-5.0055 (6) (a) 1.a FAC]. Specific development density and intensity thresholds must also be met [9J-5.0055 (6) (a) 1. b FAC].

During the 1999 Legislative session, several adjustments were made to transportation concurrency. In addition to the establishment of MMTDs and the development of rules to implement them, including the reduction of certain fees, the legislation allows urban infill and redevelopment areas to be a justification for a TCEA; (2) provides that the concurrency requirement does not apply to public transit facilities; (3) revises the requirement for establishment of the LOS on certain facilities on the FIHS; and (4) provides that a multiuse development of regional impact (DRI) may satisfy certain transportation concurrency requirements by payment of a proportionate-share contribution for traffic impacts under certain conditions.

### 3.2.5 Multimodal Transportation Districts (MMTD)

The goal of a multimodal transportation district is to facilitate the use of multiple modes of transportation, leading to a reduction in automobile use and vehicle miles traveled. MMTDs may be established for two types of development tracks: (1) development in existing areas, such as a central core of a municipality, where the focus is on the enhancement of existing elements and qualities, and guiding redevelopment and infill opportunities; and (2) new proposed development located outside of the traditional municipal area.

Community design features that provide an adequate level of multimodal mobility and accessibility within the district should support a multimodal transportation district. A multimodal transportation district should contain the following community design elements:

➢ Complementary mix of land uses, including residential, educational, recreational, and cultural uses
➢ An interconnected network of streets designed to encourage walking and bicycling with traffic calming, where desirable
➢ Appropriate densities and intensities of land uses within walking distance of transit stops

> Daily activities within walking distance of residences; public infrastructure that is safe, comfortable, and attractive for pedestrians; adjoining buildings open to the street; and parking facilities structured to avoid conflicts with pedestrians, transit, automobile, and truck travel

> Transit service within the designated area, or definitive commitment to the provision of transit. This definitive commitment should be found in local planning documents and in the approved capital improvements program. For new developments, transit connectivity to the major urban area must be included, or a definitive commitment for transit connections, again evident in both planning documents and approved capital improvements program (FDOT 2003, p. 12).

For a complementary mix of land uses, there are three basic criteria. The MMTD should have a minimum residential population of 5,000, a minimum ratio of population to jobs of 2:1, and provide scheduled transit service. The appropriate mix of land uses should include three or more significant land uses, such as retail, office, residential, hotel/motel, entertainment, cultural, recreational, that are mutually supporting and that include a physical and functional integration of project components, including connected and continuous pedestrian facilities. Areas with the most multimodal potential should have a wide variety of land uses including a solid residential base. The types of areas that are suitable for MMTDs include: urban centers, regional centers and traditional town or village (FDOT 2003). These uses were adapted from *Planning for Transit Friendly Land Use, New Jersey Transit, 1994* (New Jersey Transit 1994). In addition to the appropriate scale and mix of land use, the multimodal transportation district should have the urban form, or pattern of land uses that promotes transit, bicycle and pedestrian travel, including good intermodal connections. Within MMTDs, special consideration should be given to schools because of their high level of pedestrian, bicycle and transit potential. The major access routes to schools should have a LOS of B or better for bicycle and pedestrian modes

The appropriate density and intensity of development are summarized in Table 6 below, which is also Table 6 in the MMTDs and Areawide Level of Service Handbook (FDOT 2003, p. 25). In addition, a strong central core is an ideal land use structure for providing vitality and sustainability of the community and promoting the pedestrian activity necessary for a multimodal transportation district (see distances in Table 7 below). The development should have the highest density within the primary service area, which is defined at _ mile from the center and should include commercial, residential and retail uses. Between _ and _ mile, densities may decline but mixed uses including residential, retail and community facilities are recommended. Beyond the _ mile boundary lower densities are permitted (FDOT 2003). This pattern of land use intensity promotes a logical organization and a compatible mix of land uses that promote multimodal usage. These major activity centers should be located at key crossings along the major corridor to promote transit usage and access to intermodal transfer facilities.

**Table 6. Desirable Densities and Intensities for Multimodal Transportation Districts**

| Residential Land Use (units per acre) | Commercial Land Use (employees per acre) | Multimodal Potential and Transportation Compatibility |
|---|---|---|
| 15 + | 100 + | High multimodal potential. Densities support light-rail and other high capacity transit service. |
| 7 – 14 | 60 - 99 | Good multimodal potential. Densities support bus transit service. |
| 4 – 6 | 40 - 59 | Marginal multimodal potential, but possibilities for success exist. |
| 1 – 3 | 1 - 39 | Poor multimodal potential. Densities do not support pedestrian or transit services. |
| Source: New Jersey Transit 1994. As reprinted in FDOT 2003, p. 25. | | |

**Table 7. Recommended Maximum Separations of Land Uses Based on Trip Purpose**

| Trip Purpose | Maximum Trip Length Walking Mode | Maximum Trip Length Walking Mode |
|---|---|---|
| Home-Based-Shopping | 0.25 – 0.5 miles | 5 – 10 minutes |
| Home-Based-Social/Recreational | 0.5 – 1.0 miles | 10 – 15 minutes |
| Home-Based-Work | 1.0 – 1.25 miles | 20 - 25 minutes |
| Source: FDOT 2003. Adapted from Ewing1996. | | |

Finally, the MMTD should have a proper pattern of roadways that promote efficient and continuous circulation, maximizing the efficiency of transit and providing the greatest accessibility for pedestrians and bicyclists. Networks that have meandering, serpentine streets with numerous termini or cul-de-sacs limit opportunities for transit and pedestrian usage. A simple method to determine the connectivity of a network, the network for each mode for one square mile is defined and polygons placed over the applicable network. The street and transit network are defined as the roadway network, while the bicycle and pedestrian network includes shared-use paths and cul-de-sac connections (Figure 3 below). A network with good connectivity has 50 polygons per square mile. The diagram that follows shows an example of the polygon methodology for measuring pedestrian connectivity. The blue lines indicate the network. To determine the connectivity index, the closed polygons shown by the blue lines are counted. This example has good connectivity with 52 polygons.

**Figure 3. Connectivity Index**
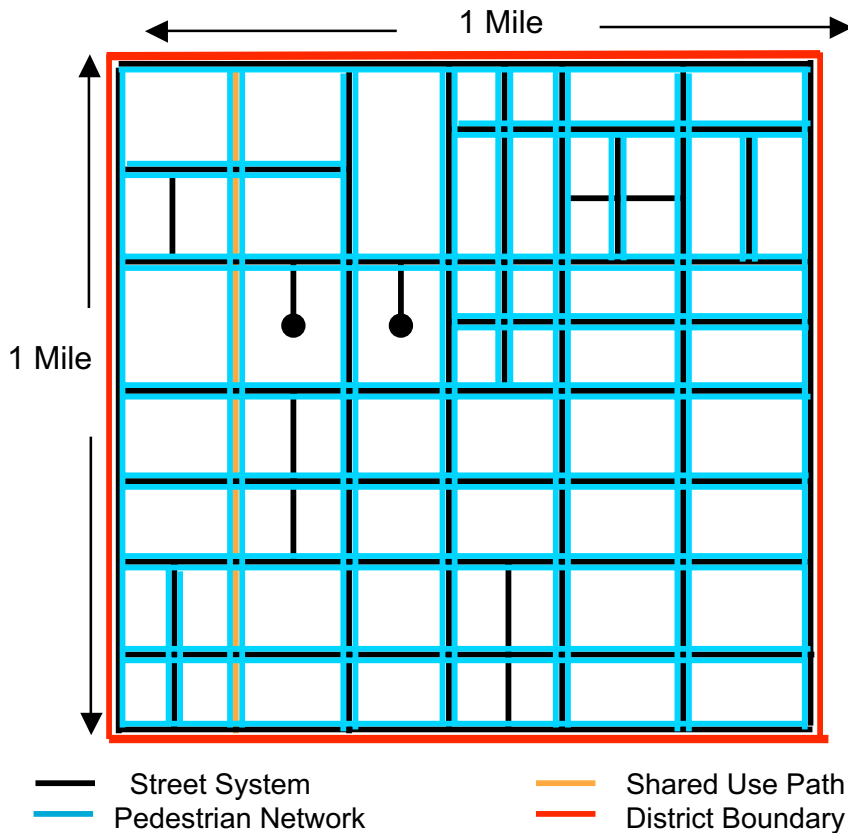


Source: FDOT 2003.

Two additional requirements for MMTDs to work well pertain to its connection to the local and regional surroundings. Good connections between modes should be incorporated into the transportation network and the district should have connectivity to regional and intercity multimodal transportation facilities and services.

### 3.2.6 Multimodal Level of Service Measures

The FDOT has developed LOS methodologies that engineers, planners, and decision-makers should use in the development and review of roadway users' quality/LOS (Q/LOS) at the planning and preliminary engineering level. The Quality/Level of Service Handbook (FDOT 2002) provides tools to quantify multimodal transportation services inside the roadway environment (i.e., inside the right-of-way). Two levels of analysis are included in the handbook: (1) "generalized" planning; and (2) "conceptual" planning. Generalized planning makes extensive use of statewide default values and is intended for broad applications such as statewide analyses, initial problem identification, and future year analyses. It is most appropriate when a quick, "in the ball park" determination of LOS is needed. Conceptual planning is used for more detailed and accurate applications than the generalized planning but does not involve comprehensive operational analyses. It is most appropriate when a solid determination of the

LOS of a facility is needed, such as in preliminary engineering applications, determining the design concept and scope for a facility (e.g., 4 through lanes with a raised median and bicycle lane), conducting alternative analyses, and determining a need when a generalized approach is simply not accurate enough.  Florida's LOS software (LOSPLAN), which includes ARTPLAN, FREEPLAN, and HIGHPLAN, is an easy to use tool for conducting these evaluations.  The methodologies used in the Q/LOS Handbook are based upon the following primary resource documents and analytical techniques using actual Florida roadway, traffic, and signalization data: (1) 2000 Highway Capacity Manual (Transportation Research Board 2000) methodologies for automobiles and trucks; (2) 1999 Transit Capacity and Quality of Service Manual (TCQSM) for buses (Transportation Research Board 1999); (3) Bicycle LOS Model for bicyclists (FDOT 2002); and (4) Pedestrian LOS Model for pedestrians (FDOT 2002).  The LOS methodologies for pedestrians, bicyclists and vehicles are summarized below.

3.2.6.1 Pedestrian Level of Service
        The FDOT has also developed a set of LOS techniques for pedestrians, bicycles, transit and automobiles that are combined in an areawide LOS measure.  In this section, the factors used in the calculation of each of these measures and how they are incorporated into an areawide level-of-service measure will be discussed.  The Pedestrian LOS Model measures the performance of a roadway with respect to pedestrians' primary perception of safety and comfort. The factors included in the model are as follows:

➢ Lateral separation elements between the pedestrian and motor vehicle traffic, such as
    ♦ Presence of sidewalk
    ♦ Buffers between sidewalk and motor vehicle travel lanes, including grass strips
    ♦ Presence of protective barriers, such as trees or swales within the buffer area, or on-street parking
    ♦ Width of outside travel lanes and bicycle lanes
➢ Motor vehicle traffic volume
➢ Motor vehicle speed (FDOT 2003, p. 43).

        Each of these factors is weighted within the model by relative significance.  A numeric score is computed and then converted to a LOS grade based on the numerical scale.  The equation for determining the Pedestrian LOS (PedLOS) can be found in the FDOT's 2002 Quality/Level of Service Handbook (FDOT 2002).  For pedestrian facilities that are crowded, a combination of FDOT and the 2000 HCM (Transportation Research Board 2000) method is possible.  The FDOT model measures pedestrian satisfaction with the walking environment in un-crowded walking conditions but the HCM may be more appropriate where facilities are adequate and heavily used.  When using both methods, the FDOT quality of service and HCM LOS should be determined and the worst outcome utilized.

3.2.6.2 Bicycle Level of Service
        The FDOT recently adopted a method for determining the quality/LOS for bicyclists that measures the performance of a roadway with respect to bicyclists' perception of quality, which appears to reflect the perception of safety and comfort.   The bicycle LOS considers the following factors along a roadway segment that affect the bicycle mode of travel:

- ➢ Total width of pavement
- ➢ Traffic volume in the outside lane
- ➢ Motor vehicle speed
- ➢ Percentage and number of trucks
- ➢ Pavement surface condition
- ➢ Availability of a designated bicycle lane or paved shoulder.

Each of these factors is weighted within the model by relative significance and a numerical score is calculated that is converted to a LOS grade based on the numerical scale. The equation for the Bicycle LOS (BikeLOS) can be found in the 2002 Quality/Level of Service Handbook (FDOT 2002).

3.2.6.3 Transit Capacity and Quality of Service

The transit LOS model, based on the Transit Capacity and Quality of Service Manual (TCQSM) (Transportation Research Board 1999), used to determine the LOS for transit riders along route segments was also recently adopted by the FDOT. The method evaluates the riders' perception of the quality of the bus route segment using various factors that are then weighted and used to calculate a numeric score for the frequency of service. A BusLOS of A is assigned when buses run on a headway of 10 minutes or less and an F when service runs less than once per hour. The BusLOS is then adjusted using the transit span of service, pedestrian LOS, presence of obstacles between sidewalks and bus stops, and the difficulty the pedestrian encounters in crossing the street.

3.2.6.4 Determining the Areawide LOS

The Multimodal Transportation District is composed of a network of facilities serving bicyclists, pedestrians, transit and motorists. The recommended minimum LOS standards for MMTDs are shown in Table 8.

| Table 8. Recommended Minimum LOS Standard for Multimodal Transportation Districts | | | | |
|---|---|---|---|---|
| | Pedestrian | Transit | Bicycle | Automobile |
| Transit-Oriented | C | C | D | FIHS/LGCP |
| Non-motorized Oriented | C | D | C | FIHS/LGCP |
| Source: FDOT 2003, p. 43. | | | | |

To determine the areawide LOS, the following steps are followed:

(1) **Determine major modal facilities.** Define the major modal facilities independently for each mode in the multimodal district. Primary facilities are defined, providing a network for users that may be different or overlap for each mode. Roadways classified as arterials, freeways, or toll roads are included. Neighborhood streets or shared use paths that serve attractions are considered as major bicycle and pedestrian facilities. Major bicycle corridors typically have vehicular speeds of 35 mph or less. Transit facilities will be based on the location of bus routes and it is essential to include pedestrian access to transit stops.

(2) **Establish user service areas by mode.** There are generally acceptable standards of the practical distance that pedestrians, bicyclists, and transit riders are willing to travel. The user ranges for the typical pedestrian and transit user is _ mile and for the

bicycle mode the typical distance is _ mile.  Determine the LOS for each mode on each facility.

(3) **Determine the percentage of households and employment within the user service area by modal facility.**

(4) **Determine the LOS for each mode on each facility.**  FDOT's 2000 version of ARTPLAN, the software used for computing multimodal arterial LOS at the conceptual planning level, is utilized for assessing the LOS for the different modes on each facility.  While all of the facilities on each defined modal network are used in the connectivity analysis, the LOS analysis is conducted only on those facilities that are classified as connectors or above.

(5) **Determine the average LOS scores for each of the modes, which provides an areawide LOS.**

(6) **Compare the average modal LOS with the LOS based on the percentage of households and employment located within the user service area.**  The higher the percentage of households and employment located within a service area, the higher the multimodal potential, and the average LOS is adjusted to reflect that potential (FDOT 2003, pp. 51).  Table 9, shown below, contains the comparison LOS.  Figure 4 contains a graphic example of the steps in determining the areawide LOS and make adjustments based on multimodal accessibility.  Table 10 contains an example of the adjustments to the areawide LOS.

(7) **Report the adjusted areawide LOS for each mode.**

| Table 9. Multimodal Accessibility LOS Criteria | |
|---|---|
| **% Households and Jobs within Service Area** | **Areawide LOS** |
| 90%-99% | Average Modal LOS or LOS A, whichever is worse |
| 80%-89% | Average Modal LOS or LOS B, whichever is worse |
| 70%-79% | Average Modal LOS or LOS C, whichever is worse |
| 60%-69% | Average Modal LOS or LOS D, whichever is worse |
| 50%-59% | Average Modal LOS or LOS E, whichever is worse |
| 1%-49% | LOS F |
| Source: FDOT 2003, p. 51 | |

**Figure 4:  Example of Determining Areawide Level of Service**
(Source: FDOT 2003, p.49 - 50)

*(A) Define the major modal facilities.*



Pedestrian Network
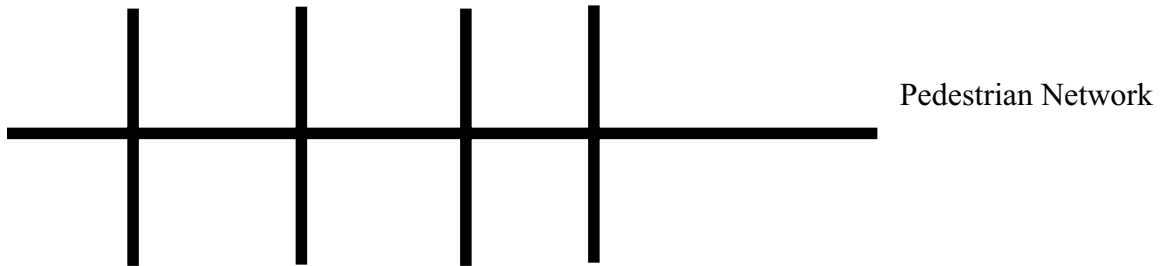
*(B) Establish user service areas by mode.*



Pedestrian Network
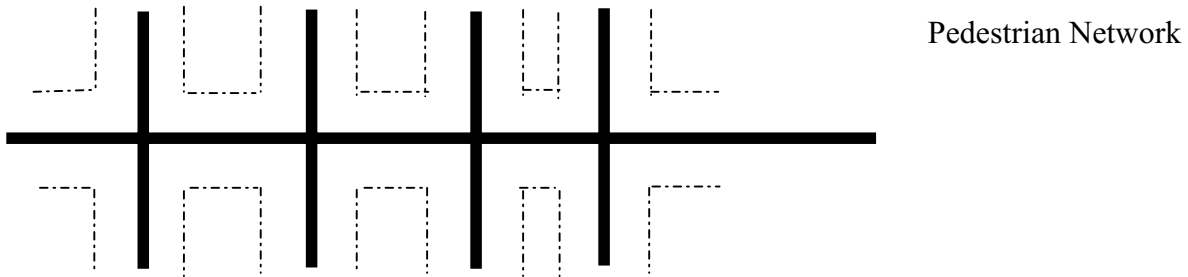
*(C) Determine the percentage of households and employment within the user service area by modal facility.*

Total Employment in District:          500
Total Households in District:          500

Total Employment in Defined Service Area:          250
Total Households in Defined Service Area:          250

Percentage of Employment in Defined Service Area:          50%
Percentage of Households in Defined Service Area:          50%
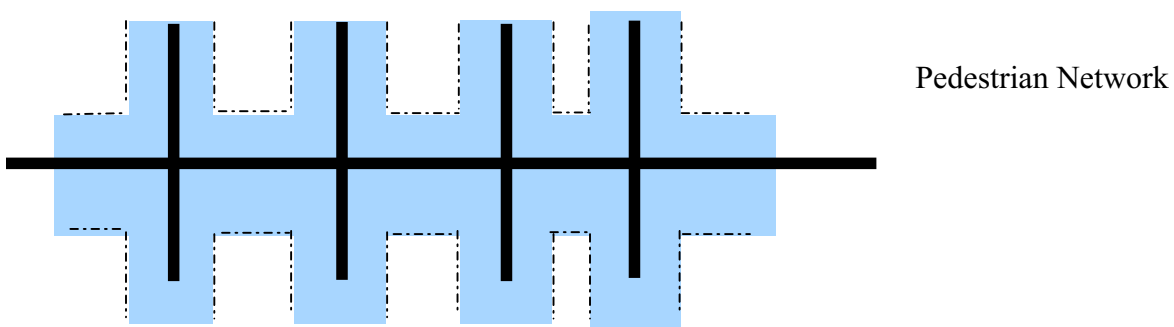


Pedestrian Network

*(D) Determine the LOS for each mode on each facility.*
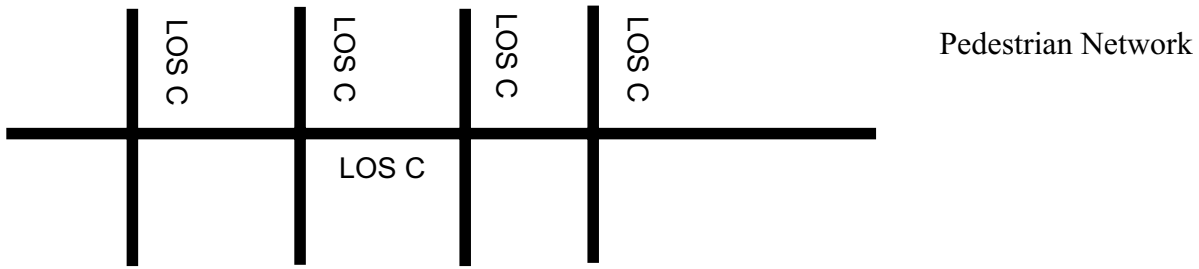


Pedestrian Network

LOS C · LOS C · LOS C · LOS C

LOS C

*(E) Determine the average LOS scores for each of the modes, which provides an areawide LOS*



Pedestrian Network
_____
Average LOS:  C

*(F) Compare the average modal LOS with the LOS based on the percentage of households and employment located within the user service area.*



Pedestrian Network
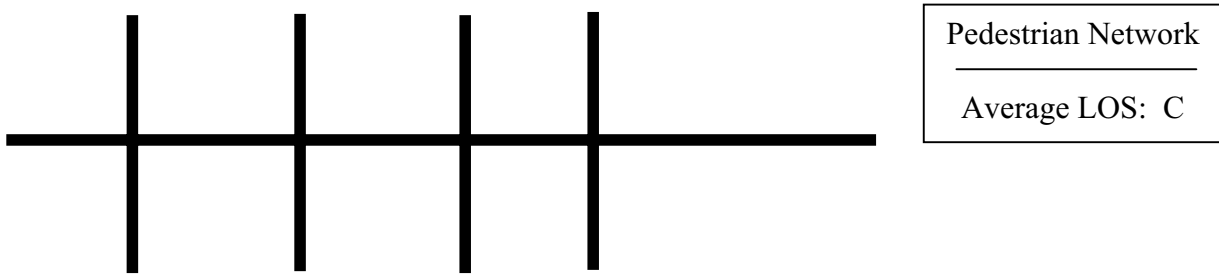
Average Modal LOS:  C
Percentage of Households:  50%
Percentage of Employment:  50%
_____
Areawide LOS:  E
(From Table 10)

*(G) Report the adjusted areawide LOS for each mode.*
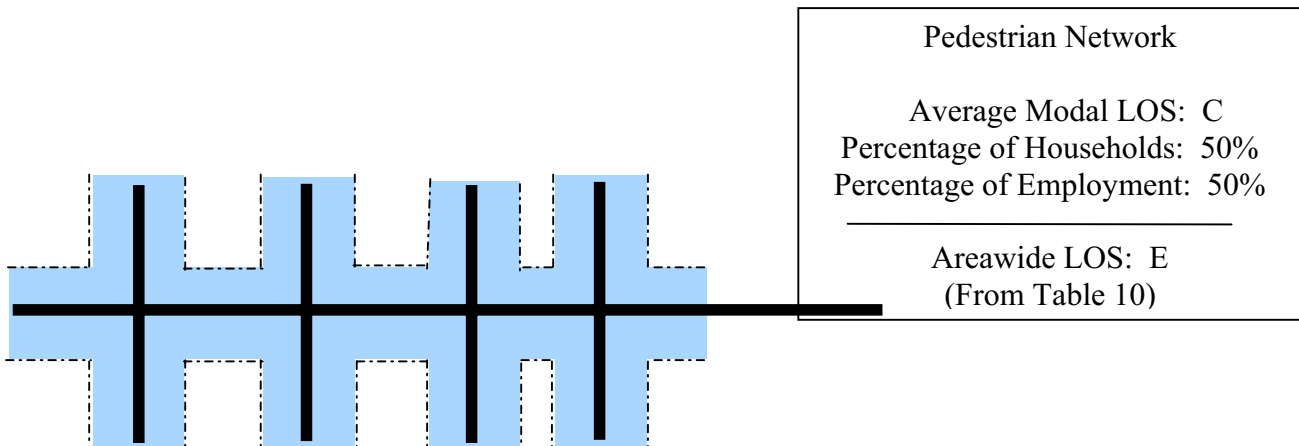
| Table 10.  Examples of Areawide LOS Adjustment | |
|---|---|
| Average Modal LOS | C |
| % Households and Jobs Within Service Area | 94% |
| Areawide Modal LOS | C, not A |
| Average Modal LOS | C |

| Average Modal LOS | C |
|---|---|
| % Households and Jobs Within Service Area | 54% |
| Areawide Modal LOS | E, not C |
| Source: FDOT 2003, p. 51. | |

In summary, the goal of the multimodal transportation district is to facilitate and promote the use of multiple modes of transportation. This goal is accomplished through appropriate design features, land use, network connectivity, and developmental patterns that are conducive to and support the use of modes of transportation other than the automobile. The tools that are being developed as a part of the MMTD are a part of a comprehensive strategy to reduce the impact of local and regional development projects on the adjacent roadways on the SHS. As such, the MMTD is seeking to make the conceptual leap from concurrency as a tool for regulating the actions of developers to concurrency management as a tool for better coordination of land use and transportation planning. Table 11 outlines the indicators for successful MMTDs, while the contra-indicators show what are not acceptable for a successful district.

| Table 11. Multimodal Transportation District Checklist | | |
|---|---|---|
| **Criteria for a Multimodal Transportation District** | **Indicators for a Successful Multimodal Transportation District** | **Contra-Indicators for a Multimodal Transportation District** |
| Appropriate Scale of Development | • Min. Residential Pop: 5,000<br>• Each 1-mile increase in size equals pop. Increase of 2,500<br>• Minimum Population/Jobs Ratio: 2 to 1.<br>• Provision of scheduled transit | • Doesn't meet job and population thresholds<br>• No transit service |
| Complementary Mix of Land Uses | • 3 or more significant land uses<br>• Physical integration of components | • Single land use |
| Land Uses Promoting Multimodal Usage | • Land uses that are mutually supporting | • Single land use |
| Acceptable Separation of Land Uses | • Different land use areas located within the typically acceptable range for walking (1/4 to _ mile) | • Land uses spaced too far apart for typical pedestrian comfort |
| Appropriate Densities and Intensities of Land Uses | • Minimum of 4 residential units per acre for marginal potential<br>• Minimum of 40 employees per acre for marginal potential | • Less than minimum residential units per acre and minimum employees per acre |
| Regional Intermodal Connectivity | • Regional intermodal connections present | • No regional intermodal service |
| Interconnected Multimodal Network | • Each modal network meets connectivity index standard using polygon methodology: recommended minimum of 50 polygons per square mile<br>• Connected street pattern, generally grid | • Poor connectivity on modal networks<br>• Unconnected street pattern with cul-de-sacs and dead ends |
| Acceptable Levels of Service for Each Mode | • Meets recommended Level of Service standards for each mode<br>• Transit oriented development pedestrian, transit, and bicycle LOS of C<br>• Non-motorized oriented development pedestrian and bicycle LOS of C and transit LOS of D | • Poor Level of Service |
| Acceptable Areawide Levels of Service for Each Mode | • Areawide Level of Service meets recommended standards | • Poor Level of Service |
| Source: FDOT 2003, p. 53. | | |

### 3.2.7. Implementation of Concurrency

A local government has significant discretion as to how it implements its transportation concurrency management system. Each local government defines which of the concurrency management strategies and area-wide exceptions it will allow and where they will be implemented. Table 11 compares the features of the various areawide strategies that local governments have available based on the features they contain. For major transportation facilities, each local government establishes a LOS for each of the major roadways [163.3177 (6) (b) FSA], on a scale from A to F, with A representing a free flow of traffic and F representing gridlock [163.3202 FSA]. Local governments then monitor the LOS. When a project is proposed, the planning staff of the local government will first determine the impacts of the development and then evaluate whether the capacity exists to accommodate those impacts. If adequate capacity exists, the application can be approved and a concurrency certificate issued. If there is insufficient capacity to accommodate the development, the planner will determine if the project is eligible for an exception based upon the location of the project (i.e., it is located in an area covered by area-wide exceptions) [9J-5.0055 (4) – (6) FAC; 163.3180 (5) – (9) FSA] or the special characteristics of the project (i.e., the project is eligible for a project-related exception) [163.3180 FSA]. If the developer is eligible for an exception, s/he may still be required to meet specific conditions associated with the project. Otherwise, the developer may be required to negotiate with the local government to establish conditions under which the development can be approved. Local governments are limited only by their creativity and flexibility in creating alternatives (Audirac *et al.*, 1992).

| Table 12.  Comparison of Multimodal Characteristics of Concurrency Areawide Tools | | | |
|---|---|---|---|
| **Multimodal Characteristic** | **TCMA** | **TCEA** | **MMTD** |
| Density Requirement | X | X | X |
| Must be Infill Oriented | X | X | --[1] |
| Minimum Size of Area | X[2] | -- | --[3] |
| Areawide LOS | X | -- | X |
| Multimodal LOS | -- | --[3] | X |
| Considers Land Use | --[3] | --[3] | X |
| Addresses Connectivity | X[2] | -- | X |
| | | | |
| (1) MMTDs can be used in redevelopment and infill areas and for proposed development outside of the traditional municipal area. | | | |
| (2) The TCMA may be established in "a compact geographic area with an existing network of roads where multiple, viable alternative travel paths or modes are available for common trips." -- [163.3180 (7) FSA] | | | |
| (3) These elements are discussed in the statutes, but no measure is provided. | | | |

The state's interest in the implementation of concurrency is described in the site impact assessment above. In its role of preserving the LOS on roadways on the SHS and the FIHS, the FDOT is involved in the review of local government comprehensive plans amendments, and other types of review including planned and programmed improvements, access management and corridor studies.

## 3.3 Transportation Modeling in Florida

Forecasting is an integral part of the urban transportation planning process in Florida. The term FSUTMS (Florida Standard Urban Transportation Model Structure) is used to represent a formal set of modeling steps, procedures, processes, software, file formats, and guidelines established by the Florida Department of Transportation (FDOT) for use in travel demand forecasting throughout the State. A general overview of the standard four-step modeling process is provided in Appendix B. A more detailed description of the basic four-step model used in Florida and special variations of the FSUTMS model currently in use throughout the state can be found in Appendix C.

In Florida, urban activity forecasts are generally the responsibility of the MPO staff. FDOT District staff is usually responsible for the initial definition of networks and the maintenance of travel demand models. Evaluations of results and data modifications are joint responsibilities. Currently, the four-step modeling process only uses basic socio-demographic variables to determine number of trips made by a household. Revisions to the model may be necessary in order for the model to successfully account for land-use factors like those found in multimodal districts (FDOT 1997).

Typical input data used by area-wide travel demand models in Florida consist of land use, population, employment and other economic activity measures. Base year information is typically obtained from Census data and local databases. Future year projections are developed through the use of land use allocation models or by other basic techniques including spreadsheet and expert panels. The Urban Landuse Allocation Model (ULAM) is the most commonly used land use allocation model in Florida with its installation in the Treasure Coast Regional Model (for Indian River, St. Lucie and Martin Counties), the Tampa Bay Regional Model (Citrus, Hernando, Pasco, Hillsborough, and Pinellas Counties), and Bay, Leon, Palm Beach, Broward and Charlotte Counties (ULAM 2003).

### 3.3.1 The Existing FSUTMS Model for Multimodal Analysis

#### 3.3.1.1 Overview
The traditional four-step travel demand forecasting process is used in the current TRANPLAN-based FSUTMS model. Forecasts of urban activity and descriptions of transportation networks are the primary inputs to a sequential demand model that normally consists of the following stages: generation, distribution, mode choice, and assignment. The urban activity forecasts in conjunction with the demand model sequence allow demand for travel to be predicted. Descriptions of highway and transit networks represent the supply services (FDOT 1997).

#### 3.3.1.2 Limitations and Applicability to Multimodal Analysis
Although this demand forecasting process works quite well to predict the demand for travel, it has certain inherent drawbacks for multimodal analysis. Many of the features of the software for the basic four-step modeling process – such as traffic analysis zones (TAZs), the generalized highway network, and the lack of specificity of land uses and their use as exogenous

variables in the model – limit the use of this model for evaluating multimodal environments. The use of TAZs as a spatial unit of analysis does not allow the consideration of intrazonal trips, which constitute the majority of walking trips, a significant portion of bicycling trips and most of the trips to access transit irrespective of the mode of access.  The use of generalized highway networks does not provide sufficient specificity to consider the completeness of sidewalk networks, the presence of off-road facilities, and the connectivity of residential streets and other pedestrian and bicycle facilities.  The lack of specificity in land use models limits their ability to determine the diversity of land uses in multimodal environments.  The use of the land use variables exogenous to the model does not allow the forecasting to consider the long-term transportation impacts of different land use configurations.

### 3.3.1.3 Application

The FSUTMS model is not currently being used effectively to evaluate multimodal environments in any location in Florida.

### 3.3.1.4 Application for Non-Motorized Projects

At this time the only application of the current FSUTMS model for non-motorized travel forecasting is in the Southeast Florida Regional Planning Model V.  This application separates out motorized and non-motorized trips from total trips for the three main trip purposes – home based-work (HBW), home-based other (HBO) and non-home based (NHB).  The model estimates the percentage of non-motorized trips by major trips purpose (HBW, HBO, NHB) between each pair of TAZs.  A logit model determines this percentage, and the utilities contain the following measures:

➢ Spatial separation (highway network distance between the two TAZs).
➢ A non-motorized friendliness index of the origin and destination TAZs.  The values are calculated for each TAZ, and the values for the origin and destination are averaged and used in the utility function (see Corradino 2001).

The model is applied between trip distribution and mode choice.  Most studies have found that non-motorized trips decrease with distance.  Thus, a logit trip elasticity curve is used that identifies the decrease of potential non-motorized trips as the highway distance increases.  The following variables are used to devise the non-motorized friendliness (NMF) index:

➢ Percentage of streets with sidewalks
➢ Percentage of streets that are easy to cross by pedestrians
➢ Area type, where area type refers to whether a location is in the central business district (CBD), at the CBD fringe, in an outlying business district, in a suburban or a rural area.

A composite rating (index) for a TAZ is the sum of the NMF for these three variables (Corradino 2001).

### 3.3.2 Changes in Travel Forecasting in Florida

The current FSUTMS model structure is based upon the TRANPLAN software package that was originally developed for "main frame" computers in the 1970s.  The Florida Statewide

Model Task Force, which is made up of modeling professionals from around the state of Florida, has recommended the TransCAD package replace TRANPLAN as the software platform for the travel demand forecasting in Florida. TransCAD is based upon the same basic four-step modeling process as TRANPLAN. FDOT has endorsed the recommendation of the Statewide Model Taskforce. Similar conversions have also been taking place in other states and urban areas that have used TRANPLAN in the past.

Another software package, TRANSIMS, which is an "activity based" modeling package, was also considered by the Statewide Model Task Force but was rejected because of the data requirements, model run time, and the cost of computer equipment needed to run the software. As is discussed in Section 4.2.2, the TRANSIMS software may be a better tool for multimodal analysis than the existing four-step modeling system.

3.3.2.1 The TransCAD Model for Multimodal Analysis

*3.3.2.1.1 Overview*
The TransCAD package includes a core set of transportation network analysis and operations research models, a set of advanced analytical models for specific applications, and a set of supporting tools for statistical and econometric analysis. These procedures can be used individually or in combination. TransCAD includes a set of analytic and graphical display tools for working with transportation networks. The tools also include intersection diagrams, which are a key visualization tool for transportation networks (Caliper Corporation 2003).

*3.3.2.1.2 Limitations and Applicability to Multimodal Analysis*
It is not known how the TransCAD software package is being used in other states with respect to evaluating Multimodal districts or similar types of development. The TransCAD package is more directly linked to geographic information systems (GIS) applications than TRANPLAN and has many of the same capabilities as some of the "micro-traffic simulation models". Some of these micro-traffic simulation functions provide better analysis tools for more detailed highway networks which include information about pedestrian and bicycle modes typically not found in the standard travel forecasting model. The transition of the TransCAD model towards the level of detail required for micro-traffic simulation and emphasis on other modes provide the potential for the TransCAD package to provide a better tool for evaluating multimodal districts than the existing TRANPLAN platform.

*3.3.2.1.3 Application*
Caliper Corporation was contacted and indicated that, to the best of their knowledge, TransCAD is not being used for multimodal trade-off analysis as defined in this study (Slavin 2003).

*3.3.2.1.4 Application for Non-Motorized Projects*
The Philadelphia urban area model includes a non-motorized travel-forecasting component (Rossi 2000). The modelers in Philadelphia own the TransCAD software but it is unknown if the non-motorized application is currently working with it.

## 4. APPROACHES TO MULTIMODAL ANALYSIS

Several approaches to multimodal analysis have been identified as a part of this project. In this section, approaches that have been used as a part of the four-step modeling process will be discussed first. Next, alternative approaches to modeling will be discussed. Finally, a variety of alternative approaches to multimodal analysis are identified and discussed. The advantages and disadvantages of these approaches are also discussed.

### 4.1 Multimodal Approaches in Traditional Travel Demand Modeling

The subject of multimodal approaches to the traditional four-step travel demand modeling process has been of particular interest to the profession over a decade. Several federal research studies have been conducted to understand the limitations of these models and to summarize the weaknesses of the existing approach and to document best practices (Harvey and Deakin 1993, Cambridge Systematics 1994, USDOT 1999, Parsons Brinckerhoff Quade & Douglas 2000). These research studies collectively document many of the limitations of these models; these limitations and how they might be addressed are discussed below. These studies also discuss the best practice. Probably of most direct interest to the multimodal tradeoff are the two most recent works. Parsons Brinckerhoff Quade & Douglas (2000) discuss the data collection needs for assessing transportation impacts of microscale design. They discuss the many micro-scale design variables – such as accessibility and connectivity, balance, density, diversity or mix of land use, neighborhood and transit-oriented design factors, pedestrian-oriented and bicycle-oriented design – that are a part of MMTDs. They also make recommendations on how to make short-term term improvements to travel demand models and how to enhance current travel forecasting models.

In their *Guidebook on Methods to Estimate Non-Motorized Travel,* Cambridge Systematics, who prepared the report for the USDOT (USDOT 1999), documents the factors in regional models that influence bicycling and walking, identifies the differences in forecasting between bicycle and pedestrian travel and identifies several categories of methods to estimate demand for bicycle and pedestrian facilities and provides examples of planning agencies that are using particular methodologies. These methods include: demand estimation comparison studies, aggregate behavior studies, sketch plan methods, discrete choice models, regional travel models, relative demand potential market analysis, facility demand potential, supply quality analysis bicycle and pedestrian compatibility measures, environmental factors, supporting tools and techniques, GIS and preference surveys. Rather than summarize this lengthy document, the research team would recommend that the reader consult that document. The rest of this section will discuss the conclusions of these studies with respect to the major weaknesses of the regional travel demand models and the ways that these concerns might be addressed.

While the practice has evolved over this period, three major interconnected issues remain of critical concern to multimodal analysis using the existing approach to travel demand modeling: (1) the unit of analysis in most approaches to travel demand modeling is based on traffic analysis zones (TAZs); (2) land use models do not support multimodal analysis; and (3) the level of demand for walking and bicycling is not well documented. The use of traffic analysis zones as a unit of analysis is of concern in travel demand modeling because the models

only include trips between zones but most walking trips take place within a single zone.  Thus, there is a mismatch between the level of detail in the model and the needs for multimodal analysis.  While there are many techniques to assess the demand for walking and bicycle trips, their applicability to a relatively suburban context, like much of Florida, is less well understood.

### 4.1.1 Multimodal Transportation Modeling

The standard four-step modeling process has been used for a number of multimodal applications in the past with mixed results.  The most common approach has been for transit planning applications using the model to forecast transit ridership for a variety of transit modes from fixed guideway transit to demand responsive paratransit type vehicles including jitneys and taxicabs.  A key component of the transit modeling process, which is related to multimodal districts is the evaluation of various modes of access to fixed bus or rail transit service.  The best example is the evaluation of walk access for downtown people mover studies in Miami.  These studies typically involve the development and evaluation of detailed pedestrian networks for downtown areas.  These detailed walk networks require the traffic zones in the study area to be subdivided into smaller TAZs (roughly one TAZ for each city block).  This approach could also be applied to multimodal districts with considerable amount of work involving the recoding of a walk network and restructuring of the traffic zone system in the multimodal district.

To incorporate multimodal transportation district (MMTD) features, the analysis zone should be as small as possible.  There is consensus that small zones are better than large zones for modeling purposes, but there are weaknesses and strengths in both cases.  One major weakness is that land-use models, in particular, and land-use planning, in general, deal with large zones, and so small zones are difficult for land use forecasting.  This is becoming less of a problem because of high-speed computers.  One alternative is to use a windowing system, whereby a more detailed analysis is completed for a user-defined area (i.e., a window).  A windowing system is not satisfactory for transit analysis because it is conducted on a larger scale.

TAZ systems are usually based on census geography, either groups of blocks or census tracts.  In most cases the zones and the associated networks are at too coarse a scale to reflect in any meaningful way most of the design features and policies that fall under the rubric of multimodal analysis.  Given this state of affairs, the MPO planner is faced with using either aggregate measures (usually in a post-processor format) or multimodal measures requiring substantial modifications to the databases used for travel demand forecasting.

The availability of more high-powered computing equipment now allows for subdividing the region into many more and smaller TAZs than in the past.  For example, in Honolulu, the new models now being developed will include zones that are small enough to be either totally within walking distance of transit or not.  MPOs developing more disaggregated models for pedestrian and bicycle analysis in the Midwest are using quarter sections as used in Chicago or even quarter-quarter sections as their small area zone system, which they contend supports a network of sufficient detail to be used for pedestrian and bicycle trips.

Census blocks relate primarily to physical blocks in urban areas and tracts or polygons frequently delineated by natural features outside the urban area.  The use of census blocks

provide a richer variation in demographic and land use data than the use of zones or even districts, which are generally combinations of zones.  The use of census blocks leads to questions of confidentiality, particularly when using U.S. census data since the Census Bureau is reluctant to present data that can be identified as coming from a single household.  Even when using census blocks, researchers are forced to use averages of demographic and land use attributes.

An even more detailed analysis can be performed if data are stored by individual parcels. Parcel data indicate the exact land use since, in almost all cases, a single parcel will contain a definable, if not singular use.  Parcel data tend to be more expensive to collect since it has to be performed at the local level.  What is perhaps more of a challenge is that forecasting parcel level data tends to be difficult and may not be politically correct.  A further problem arises from the fact that private sector activities frequently are kept secret and do not necessarily follow the time frame envisioned by planners.

For those regions with sufficiently detailed and public parcel files, it will be possible in the future (and now on a limited basis) to provide even finer detail about the environment around each location in the region.  There is some reluctance among model builders because of the expense of assembling and maintaining files at this level of detail and the need for high-powered computers to run the model.  But the ability to evaluate the transit accessibility throughout the region has obvious interest.  This level of detail would also allow the models to go directly from the parcel level to the transportation network, bypassing the zone aggregation and averaging assumptions about median or mean travel times between the zone centroid and the network.

An even smaller unit of geography is that defined by the raster cell, a very small unit of geography located at a particular point and, in some cases, defined by the size of a pixel.  The assumed benefit from using these very small geographic units is the ability to minimize the equivalence problem caused by the different geographic bases used to assemble data.  In this way, if we know the location of a single traveler, we can collect all the geographic, demographic and system attributes.  It also obviates the need for dealing with averages, but it does not solve the problem of confidentiality.

The most disaggregate methodology is based on a GIS where the attributes of a place can be developed at the raster cell level, using each of the geographic layers at whatever level of aggregation is required for the data being presented by each layer.  The calculation of distance and accessibility to transit service can then be estimated for each traveler.  This last method for evaluating TOD or transit orientation of the geographic elements of a region may fall beyond the scope of assimilation into current modeling practice, but it has exciting potential.

### 4.1.2 Improving Land Use Models

It is important to recognize the interactive nature of the transportation and land use models even though the relationships may be difficult to represent in travel forecasting models. Most land use planning models do not address the factors related to MMTD land use patterns for current conditions much less attempt to forecast them for the future.  One of the problems in doing these types of land use projections is that long-term residential locations may be chosen as a function of short-run visions.  This is another way of saying that the choice we make may not

be applicable very far into the future.   Another impact of this process is that lifestyle changes that tend to take place slowly may mean that neighborhoods respond slowly to changes in urban design features.  Therefore, introducing good transit service and sidewalks may not show impressive benefits or changes in lifestyle for as much as a decade, principally because the residents have organized their lifestyle around different patterns (PBQD 2000).

MMTD land use patterns at the origin or production point determine the modes that are available for the first journey and whether or not autos are available for the rest of the tour. Likewise, they determine whether or not childcare facilities require a diversion from the typical path, and whether or not it is located near the home or workplace.  The mix of land uses – another MMTD feature – will also be important in setting up the sequence of trips within a tour or journey.  These types of MMTD features are typically not included in most land use models as input variables or factors that can be modeled.

Another factor in the choice of residential location appears to be the neighborhood and its visual and structural components, how close the houses are to each other, how walkable it is, how well the houses and surrounding grounds are tended, and the attractiveness of walkways. These may be appealing to individual family taste more than to economic decisions about transportation.  In examining decisions and models, it would appear that travel time or commuting distances are more of a constraint on the other choices than a real element in the residential-location decision.  Put another way, any location within a tolerable commuting distance is a candidate and is not significantly more attractive because it is closer rather than farther from the center of employment (PBQD 2000).

Most land use models do not include these types of variables nor do they provide projections to the geographic level required to evaluate these factors for MMTDs.  Land use models typically do not include detailed information about physical characteristics needed to support MMTD such as pedestrian and bicycle facilities, walkability factors, or specific interrelated land uses such as day-care centers and either residences or work locations.  The land use models are not sensitive to the characteristics of the people who live within them and how their travel differs depending upon their lifestyle or where they are in their lifecycle.  For example, three 2-person households living in a TND – a young unmarried couple both of whom are employed, one a single mother with a child under age 5, and a retired couple – are likely to have very different travel patterns.  Similarly, the same person living in a single-family home for forty years is likely to have different travel patterns first as a single, employed young adult, then as one of a married couple, then with children and a finally as one of a retired couple.  In summary, many of the same inherent problems and deficiencies related to travel demand models and MMTD are also the same problems for using most standard land use models for evaluating MMTDs.

### 4.1.3 Incorporating Non-Motorized Travel into the Florida Modeling System

For existing four-step models to be used in Florida for evaluating multimodal environments, the models must address non-motorized travel demand.  There are ways in which non-motorized travel can be incorporated into the existing travel modeling system in Florida.

While there are different ways of doing this, the following issues are generally common to all possible methods.

*Revise trip generation modeling.* – No matter where in the process motorized and non-motorized trips are separated, the trip generation stage must include both motorized and non-motorized trips. This will mean revision of the existing trip generation models (PBQD 2000).

*Mode choice model including non-motorized travel.* – The mode split models included in FSUTMS all focus on the choice among different motorized travel modes. To properly model the performance of the transportation system in a multimodal setting, it is essential to have the capability of modeling the choice among a more extensive set of travel modes, including motorized modes and non-motorized modes, such as walk or bicycle. To achieve that capability, the mode split model needs to be a nested logit so that the different modes can be properly grouped into different nests.

A critical issue in trying to model pedestrian and bicycle trips is defining what constitutes a trip by these modes. The data that are necessary to calibrate non-motorized mode choice models are usually not available because travel surveys typically do not ask about such trips. In addition, non-motorized trips, especially bicycle trips, are reported less frequently than auto trips, and they may not be numerous enough to estimate detailed models. Thus, household travel surveys should be worded carefully to obtain information on all non-motorized trips. Many respondents apparently do not consider short walk trips worth reporting, especially nonhome-based trips (PBQD 2000).

Bicycle trip generation is obtained by extracting these trips from the standard person trip tables by trip purpose using the travel times and posted speeds on the highway network. The result is a trip table specifically for bicycle trips for that trip purpose. Those trips are then assigned to the bicycle network, which is a combination of the standard highway network with additional links added for separate bicycle paths or other exclusive bicycle facilities (PBQD 2000). In attempting to apply this approach for multimodal districts, the same issue of the size of the traffic zone and the lack of a detailed street network limits the use of this application within the standard travel-forecasting model.

Furthermore, the type of model used to separate motorized and non-motorized trips will depend heavily on where in the process the separation occurs. For example, if trips are separated after trip generation, then the mode choice model is applied to trip ends, not trip tables, and variables that rely on knowing both ends of the trip, such as travel time or distance, cannot be used.

*Revise other models (e.g., trip distribution) as needed.* – If non-motorized trips are removed immediately after trip generation, then existing trip distribution and mode choice models are likely to be used (though they may need to be recalibrated). However, if trips are separated after trip distribution, then the distribution model will need to be revised to include non-motorized trips. A model based only on highway travel time would be particularly inappropriate for analyzing non-motorized trip distribution.

***Revalidate/calibrate entire model system*** – Because there will be changes at the very top of the modeling process, it will be necessary to revalidate the entire model, even components that were not changed directly when non-motorized travel was added to the process.

It is clear that there are viable methods for considering non-motorized travel in travel demand models.  It has been done in several urban area models in a variety of contexts.  The amount of non-motorized travel can be estimated at the zone or origin-destination level, and the effect of these trips on the amount of auto and transit travel can be considered.  It is difficult, however, to determine pedestrian network flows due to the lack of available data to calibrate assignment models.  Key considerations in modeling non-motorized travel include where to separate motorized and non-motorized trips in the model process and how to quantify the pedestrian environment, which can significantly affect travel behavior involving non-motorized trips.

It must be recognized that there are many difficulties associated with doing so.  Foremost is the difficulty in obtaining accurate data on non-motorized travel, especially for bicycle trips.  There is no substitute for a good local household travel/activity survey data set.  Another issue that must be dealt with is that of the level of detail required to accurately model non-motorized travel.  Nevertheless, there are tested methods whereby travel modelers can develop model systems that consider non-motorized travel, or incorporate non-motorized travel into existing conventional model systems.

## 4.2 Alternative Approaches to Modeling

Alternative approaches to the four-step modeling process offer some options for assessing multimodal environments.  In this section, three alternatives to the traditional four-step modeling process are discussed: (1) microsimulation; (2) TRANSIMS, an activity-based modeling system; and (3) dynamic traffic assignment.  These techniques can be used in combination with or in place of the four-step modeling process and they offer some additional options for multimodal analysis.  Microsimulation performs detailed stochastic analysis of traffic operations by simulating the movement of vehicles (in some models bicycles and pedestrians) second by second.  Activity-based modeling systems estimate activities for individuals and households to derive and simulate the travel associated with these and other activities in the regional economy.  Dynamic traffic assignment models the dynamic nature of the transportation system.  In this section, these three types of models are described and their applicability and limitations for multimodal analysis are discussed.

### 4.2.1 Microsimulation

Microsimulation is a type of computer modeling that performs detailed stochastic analysis of traffic operations on a series of roadway segments by simulating the movement of cars (bicycles, and pedestrians in some packages) second by second. In an integrated project selection process, output data from microsimulation can serve as input for engineering economic analysis, which in turn provides an objective basis for project selection.  There is a wide array of software products available on the market, and they are different in their requirements for input data, types of analyses they can perform, algorithms underlying the traffic simulation, and the

visual presentation of the input and output. To evaluate the implementation of microsimulation models in multimodal projects, the functionalities of three traffic simulation packages, CORSIM, PARAmics, and VISSIM, and their potential for use in multimodal analyses, are discussed in this section.

4.2.1.1 CORridor SIMulation (CORSIM)

*4.2.1.1.1 Overview*
         CORSIM is a mature traffic simulation software product that is probably the most widely used package for traffic operation evaluations. It was originated in the 1970s with two FORTRAN programs developed for the Federal Highway Administration; UTCS-1 (Urban Traffic Control System) for surface streets and INTRAS for freeways. These two models later were modified and enhanced and renamed as NETSIM and FRESIM, respectively. In the 1990s, NETSIM and FRESIM were integrated under a single user interface, TSIS, more popularly known as CORSIM (USDOT FHWA 2003a).

         CORSIM is a useful tool for the evaluation of traffic operations in small networks; however, its application in the evaluation of system-wide traffic operations is limited by some software issues as identified in a report by Shaw and Nam (2001). In the following, we discuss some of the issues that are potentially relevant to the software's application in multimodal analyses.

         The size of the network that can be accommodated in the modeling and simulation is very limited. In a microsimulation model, a link represents a segment of roadway with uniform characteristics, while a node represents a point where the characteristics change, thus a node is required at each intersection, each point where a lane is added or dropped, and each change in grade or curvature, consequently, the number of nodes and links that need to be represented in the simulation is typically quite large. Currently, CORSIM is limited to 500 nodes and 1000 links (Shaw and Nam 2001).

         Users cannot localize calibration parameters to account for different driving styles that occur in different parts of a network since only global calibration is available.  There is no control over fleet mix either, and users cannot localize the characteristics of the modeled vehicles to accurately reflect the appropriate mix of cars, transit vehicles, and/or trucks in the network (Shaw and Nam 2001).

         For larger projects, the area under evaluation is usually divided into smaller sub-areas to be prepared by different analysts and the sub-areas are then combined back together for the study of the entire network. In CORSIM, it is difficult to combine sub-area files prepared by different modelers, thus making it difficult to divide the network-building task among staff.

         There are also deficiencies related to the underlying algorithms in CORSIM. For instance, the vehicle routing algorithm is very simple and no vehicle diversion strategy can be developed under situations that cause capacity reduction (for example, incidents).

*4.2.1.1.2 Limitations and Applicability to Multimodal Analysis*

FHWA's NGSIM (Next Generation Simulation) team recognizes the limitation of CORSIM and made the following statement (from NGSIM website):

> *In spite of its widespread use, CORSIM does have its limitations. It is unable to model very large networks and provides limited capability to model various Intelligent Transportation System (ITS) technologies, such as dynamic message signs (DMS), wide-area surveillance, adaptive cruise control, or route navigation systems. There are limited multimodal capabilities for transit, pedestrians, or bicycles. With CORSIM's roots dating back to the 1970s, the software, written in FORTRAN, has become increasingly brittle and difficult to maintain. The source code is complex and difficult-to-read, with poorly documented software and modeling algorithms. The underlying traffic algorithms also reflect the state of knowledge of 1970s. These CORSIM limitations have directed FHWA to undertake some recent activities aimed at examining its future role in traffic simulation and traffic analysis tools* (Federal Highway Administration n.d).

Note that the above paragraph pointed out directly that CORSIM lacks the capability for modeling multimodal transportation systems that include transit, bicycles, and pedestrians. Furthermore, since there is no routing capability in CORSIM and the turning volumes need to be pre-specified at each intersection, the software cannot be used to evaluate operational and/or planning strategies that may have an impact on travelers' route choice behavior.

4.2.1.2 PARAllel MICroscopic Simulation (PARAmics)

*4.2.1.2.1 Overview*

The PARAmics development has its roots in a large number of research and development projects. Initially work was done in project IMAURO under the European Community DRIVE-I scheme, and later the Edinburgh Parallel Computing Center (EPCC) collaborated on a UK Department of Transport LINK-TIO project. This work provided the prototype system that was then transformed into the current commercial software via two UK Department of Trade and Industry (DTI) projects in 1993 and 1994 (Quadstone paramics V4.0 2003).

PARAmics has the following characteristics that result in more realistic simulation results from the software package. The software has been designed for a wide range of applications where traffic congestion is a predominant feature. Differentiation between behaviors in each lane of a road can also be modeled and modified by the user if required. PARAmics includes a sophisticated microscopic car following and lane-changing model, for roads of up to 32 lanes in width (Quadstone Paramics V4.0 2003).

As to the demand on the network, the software models a system where the origin-destination (O-D) matrix definition generates trips from zone to zone. For each trip, a unique vehicle is created that carries a conceptual driver and passengers, if appropriate. The vehicle carries a set of parameters (currently about 75) that define the physical and behavioral characteristics of that driver-vehicle unit. This detailed level of parameters allows the complexity of a real traffic system to be modeled far more accurately than with a flow model, which makes

little or no distinction between vehicle or driver types. Furthermore, a dynamic and intelligent routing algorithm is used in the model that provides more realistic vehicle routing strategies (Quadstone Paramics V4.0 2003).

### 4.2.1.2.2 Application

Leftwich Consulting Engineers, Inc. is using PARAmics in the Miami downtown transportation study.  With 380 zones, 481 junctions and 361 major intersections, the project is one of the software's largest ever applications. Modes included in the model are passenger vehicles, light trucks, heavy trucks, buses, light rail transit, and people mover. A two-layer approach is adopted where FSUTMS is used as a macro-simulation model for the large-scale travel patterns and PARAmics as a micro-simulation model for more detailed study of the traffic in the area.

### 4.2.1.2.3 Applicability for Non-motorized Projects

PARAmics is an appropriate simulation package for simulating traffic on networks with motorized trips as the dominant means of travel. Nonmotorized trips are modeled in the software mainly for the purpose of evaluating their impact on the performance of motor vehicle trips and the software does not provide the capability for appropriate modeling of their traffic flows. Thus, for networks with non-negligible amounts of non-motorized trips (such as bicycle trips), PARAmics cannot provide very good network performance measures for the non-motorized trips.

## 4.2.1.3 VISSIM

### 4.2.1.3.1 Overview

As a result of its comprehensive system analysis, VISSIM can model more detail than many other microscopic traffic simulators.  VISSIM has some advanced features such as expanded dynamic assignment capability to identify alternative path and provide route guidance; new analysis features such as additional macroscopic link evaluation and automatic generation of measures of effectiveness per intersections; comprehensive modeling of urban and regional traffic control strategies; and improved traffic flow models that not only simulate motorized traffic more realistically, but also have the capability of modeling bicycle traffic for both separate bicycle paths and on-street.  Furthermore, all motorized road users as well as crossing pedestrians are considered in VISSIM, thus making it suitable for both inner- and outer-urban traffic (VISSIM 2003).

The ability to model both motorized vehicles as well as bicycles and pedestrians is a feature that sets VISSIM apart from other simulation software packages and makes it a good candidate for analysis and evaluation of projects that include and/or promote non-motorized travel. Basically the behavior of different vehicle classes, including passenger cars, trucks, buses, bicycles and pedestrians are modeled and differentiated. Each of these classes is refined into vehicle types by specifying individual parameters, e.g. acceleration and deceleration values. For an individual vehicle such parameters are randomly chosen from distributions to form an individual parameter set describing one vehicle (VISSIM 2003).

VISSIM has been used widely for transportation projects across the US, including a lot of transit planning and/or operations projects.  For instance, in Portland, OR, VISSIM was used to assist the City of Portland and Tri-Met in the development of a "tool box" for bus transit improvement measures.

VISSIM's capability to model non-motorized trips was utilized in a simulation study for Ft. Myers. The objective of the project was to evaluate various strategies for improving traffic conditions and reducing congestion. The unique problem in this network is a signalized pedestrian crossing that creates a bottleneck for traffic, especially during the peak season when traffic can back up for miles in either direction.  In addition, there are numerous locations where pedestrians and bicyclists cross at uncontrolled intersections. Since VISSIM can accurately model the interaction of vehicle and pedestrian traffic through the use of priority rules, vehicle and pedestrian detection, vehicle and driver types, and pedestrian and bicycle speeds, VISSIM traffic simulation models were developed for the existing and proposed conditions to better simulate the interaction of pedestrians, bicycles and vehicles.  In addition, roadways and pedestrian facilities were modeled with grade separations to demonstrate realistic roadway bridges and pedestrian overpasses.

A more dramatic application of VISSIM's pedestrian capability is probably demonstrated in a proposal for a pedestrian lab (VISSIM 2003), where using VISSIM, a planned roundabout was modeled according to the CAD design drawings for the facility and using operational traffic data (including transit performance) actually collected at the site. The gap acceptance attributes of blind and sighted individuals (based on field data collected at roundabouts in Maryland and Florida) were included and used in the model. The performance measures of interest in this study include pedestrian delay and total pedestrian crossing time for the blind and sighted pedestrian groups.

*4.2.1.3.3 Applicability for Non-Motorized Projects*

As discussed in the Overview section, the VISSIM package has the capability of modeling non-motorized trips as well as some expanded capabilities of modeling motorized trips, which make it a package worth further study and evaluation as part of the toolbox for multimodal district analysis.

## 4.2.2 An Activity-based Model System -- TRANSIMS

In contrast to the traditional four-step travel demand models, TRANSIMS consists of six integrated modules: population synthesis, activity based travel demand generation, intermodal trip planning, traffic microsimulation, emissions/air quality analysis, and a feedback selector. Using these components, TRANSIMS estimates activities for individuals and households, plans trips satisfying those activities, assigns trips to routes, and creates a microsimulation of all vehicles, transportation systems, and resulting traffic in the corridor or region of interest. Emissions estimates are computed from traffic forecasts and used for air quality analysis (USDOT FHWA 2003b).

### 4.2.2.1 Overview

TRANSIMS also differs from previous models in its underlying concepts and structure. These differences include disaggregate models, simulation, an integrated model system, built-in feedback, highly detailed vehicle emissions estimates, and microsimulation as an operational tool. These advances are producing important changes in the travel forecasting process.

The usual practice in transportation modeling is to survey people about elements of their trips such as origins, destinations, routes, timing, and forms of transportation used, or modes. TRANSIMS starts with data about people's activities and the trips they take to carry out those activities, and builds a model of household and activity demand. The model forecasts how changes in transportation policy or infrastructure might affect those activities and trips. TRANSIMS tries to capture every important interaction between travel subsystems, such as an individual's activity plans and congestion on the transportation system. For instance, when a trip takes too long, people find other routes, change from car to bus or vice versa, leave at different times, or decide not to do a given activity at a given location. TRANSIMS then uses a microsimulator that simulates the movement of individuals across the transportation network based on a set of cellular automaton driving rules, including their use of vehicles such as cars or buses, on a second-by-second basis. This virtual world of travelers mimics the traveling and driving behavior of real people in the region. The simulator records individual vehicle times and locations, it also keeps summary data, such as link travel times, densities, etc (USDOT FHWA 2003b).

Also, because TRANSIMS tracks individual travelers — locations, routes, modes taken, and how well their travel plans are executed — it can evaluate transportation alternatives and reliability to determine who might benefit and who might be adversely affected by transportation changes. Also because of this feature, TRANSIMS may perform better than other models in a multimodal environment where a significant portion of trips are made using alternative modes of travel.

### 4.2.2.2  Limitations

Since TRANSIMS simulates and tracks individual traveler's movement on a second-by-second basis, the computational requirement can become prohibitive.

### 4.2.2.3 Application

Major studies of TRANSIMS have been carried out in Albuquerque, Dallas, and Portland. More specifically, the Portland study has a focus on forecasting activity demand and predicting trips that use multiple modes of transportation (USDOT FHWA 2003c). Since the goal of TRANSIMS is to develop technologies that can be used by transportation planners in any urban environment, however, there are no reports or studies currently available on the use of the model specifically for evaluating impacts of multimodal environments.

### 4.2.2.4 Applicability for Non-Motorized Projects

This type of model would be a desirable travel-forecasting tool for evaluating multimodal districts since it does not have the geographic limitations of traffic zones and uses a detailed street network that could represent the local non-motorized trips, which cannot be modeled with the current type of travel demand models.

Furthermore, there are significant benefits to modeling travel within an activity-based framework.  Tours, or trip chains, are explicitly modeled, and many non-motorized trips occur within the context of a more complex chain of trips. It would seem that tour or activity-based models would provide a more accurate basis for analyzing non-motorized travel.

**4.2.3 Dynamic Traffic Assignment**

The traditional four-step process for transportation planning assumes a static system, where both demand and supply (capacity of roadway) of the system keep constant throughout the analysis period. However, it has long been recognized that the assumption does not hold and that not accounting for the dynamic nature of a transportation system results in sub-optimal solutions to transportation problems.

Dynamic Traffic Assignment (DTA) is introduced in an effort to better understand, describe, and forecast system performance under time-dependent demand, roadway capacities that changes constantly with time, as well as traffic management and control measures that vary throughout the day. DTA can capture the dynamics of congestion formation and dissipation associated with traffic peak periods (USDOT FHWA 2003b).

In 1994, the FHWA R&D initiated a DTA research project to address complex traffic control and management issues in the information-based, dynamic Intelligent Transportation System (ITS) environment. A deployable, real-time Traffic Estimation and Prediction System (TrEPS) as well as an offline, planning version (TrEPS-P) is to be developed under this project. Two software systems, DYNASMART and DynaMIT, respectively, were developed under this contract at the University of Texas at Austin and the Massachusetts Institute of Technology, respectively (Mahmassani *et al*. 2003, Massachusetts Institute of Technology 2003).

4.2.3.1. Limitations
Modeling the time-dependent nature of the transportation network is a research field still under intensive development and there is not much experience as to the models' implementation, such as the data needs for implementation. However, it should be emphasized that dynamic models can provide more accurate evaluation of the system performance, and furthermore, traditional static models cannot provide reliable evaluation of some traffic or travel demand management measures, such as those that impact the temporal dimension of travelers' trip making behavior.

4.2.3.2 Applications
The applications of DTA models are mostly research oriented projects rather than real implementations of DTA. The two software packages developed under TrEPS program have been evaluated in Knoxville, TN and Irvine, CA.

4.2.3.3 Applicability for Non-Motorized Projects
As mentioned previously, modeling the time-dependent features of the transportation network is still a field under intensive research, and using it as a tool in multimodal analysis is a good topic for future research as the dynamic models mature.  However, due to their limited

applicability, such models will not be pursued in this project. For those interested in learning more about the DTA project, Appendix D contains more detailed descriptions about the two software packages developed at UT Austin and MIT, and a review of TRANSIMS, which is a model developed in Las Alamos National Lab and sponsored by the US DOT.

## 4.3 Other Tools for Multimodal Analysis

In addition to the tools for modeling of multimodal environments, a number of other analytical tools and processes for evaluating the coordination between land use and transportation are available. These include: (1) the Real Accessibility Index (RAI) which was developed by the University of Virginia (FHWA 2002); (2) the Smart Growth Index (USEPA 2002), which was designed as a GIS-based sketch tool; (3) Portland's Systems Development Charges (SDC), which are used to calculate one-time capital costs for new development; (4) various applications of multimodal concurrency in Florida communities; (5) variety of approaches to concurrency that are used by local governments in the State of Washington (Trohimovich 2001); (6) Montgomery County, Maryland's Local Area Transportation Review (M-NCPPC 2002); (7) fiscal impact assessment, which has been developed by Fishkind and Associates under contract with the Florida Department of Environmental Protection (Fishkind & Associates, 2002a,b); and (8) Florida's Efficient Transportation Decision Making Process (ETDM) (FDOT 1999). These tools represent a wide range of approaches and scope of analysis of various aspects of the multimodal environment. Some of these approaches are included in this discussion because they are used for related purposes in the State of Florida, while others are included because they represent approaches that others have considered for related issues in their own environment. Each of these approaches is described briefly and then the advantages and disadvantages of these approaches are identified.

### 4.3.1 Real Accessibility Index

The Real Accessibility Index (RAI) (FHWA 2002) was developed at the University of Virginia to be used as a real-world tool for measuring multimodal accessibility. Specific neighborhoods are chosen and then scored according to point scale (see Table 13). An individual, who visually evaluates the neighborhood according to the scoring criteria, gathers the data. Areas receive points based on the accessibility of various modes of travel as well as connections between services and residential areas. Higher scores represent a higher number of options available in an area.

The RAI is based on linkage points and interior accessibility points. Linkage points are awarded for each mode if residents of a neighborhood are able to effectively reach services using that particular mode. Interior accessibility is also scored by determining if a resident can travel easily within a particular area. Scores in the category reflect the existence of a right-of-way for each mode as well as the condition of the right-of-way. Pedestrian friendliness factors are also scored such as safety, cleanliness, convenience, lighting and weather protection. Listed in Table 13 are the scoring possibilities for the RAI.

| Table 13.  Scoring Possibilities using the Real Accessibility Index | | | |
|---|---|---|---|
| **Mode of travel** | | | **Points Available** |
| Automobile | Links | Frequent use links | 15 |
| | | Regular use links | 10 |
| | | Occasional use links | 5 |
| | | Total links | 30 |
| | Interior access | Parking | 4 |
| | | Number of access points | 2 |
| | | Pavement markings | 2 |
| | | Lighting | 2 |
| | | Signage | 2 |
| | | Speed controls | 2 |
| | | Lack of congestion | 2 |
| | | Road width | 1 |
| | | Road surface condition | 1 |
| | | Debris/litter | 1 |
| | | Snow removal | 1 |
| | | Total interior access | 20 |
| Pedestrian | Links | Frequent use links | 15 |
| | | Regular use links | 10 |
| | | Occasional use links | 5 |
| | | Total links | 30 |
| | Interior access | Provision of sidewalks | 1 per 10% coverage |
| | | Crosswalks | 3 |
| | | Clear walks (obstacle-free) | 2 |
| | | Handicapped access | 1 |
| | | Lighting | 1 |
| | | Calm traffic | 1 |
| | | Cleanliness | 1 |
| | | Weather protection | 1 |
| | | Total interior access | 20 |
| Bicycle | Links | Frequent use links | 15 |
| | | Regular use links | 8 |
| | | Occasional use links | 2 |
| | | Racks at destinations | 5 |
| | | Total links | 30 |
| | Interior access | Lanes on major streets | 10 |
| | | Calm traffic | 5 |
| | | Clear of debris/obstacles | 5 |
| | | Total interior access | 20 |

| Table 13 contd. Scoring Possibilities using the Real Accessibility Index | | | |
|---|---|---|---|
| Transit | Links | Service available | 10 |
| | | Time open | 8 |
| | | Days open | 3 |
| | | Buses per hour | 4 |
| | | # Of routes available | 3 |
| | | Provision of maps/info | 2 |
| | | Total links | 30 |
| | Interior access | Platforms | 5 |
| | | Benches | 5 |
| | | Shelters | 5 |
| | | Crosswalks | 2 |
| | | Handicapped access | 2 |
| | | Trash bin | 1 |
| | | Total interior access | 20 |
| | | | **Total Score = 200** |
| Source: Federal Highway Administration 2002. | | | |

The scores are tallied and then the total is divided by two. The score is then given a corresponding letter grade (see Table 14).

| Table 14. Letter Grade Scale | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Score** | 40 | 41 | 48 | 55 | 56 | 63 | 70 | 71 | 78 | 85 | 86 | 93 | 100 |
| **Letter Grade** | F | D- | D | D+ | C- | C | C+ | B- | B | B+ | A- | A | A+ |
| Source: Gensic and Namkung, n.d. | | | | | | | | | | | | |

4.3.1.1 Advantages of Real Accessibility Index

   The RAI closely resembles the FDOT Quality/Level of Service Handbook (FDOT 2002) in that it seeks to grade all modes of transportation instead of concentrating on only the automobile. The RAI is also scored using a letter grade in the same way as the Q/LOS Handbook. The RAI is beneficial because it utilizes a "real-life" approach to determining an LOS grade for each mode. It scores a neighborhood's infrastructure in much the same way that an average citizen would. The RAI employs a unique way to measure land-use mix by dividing establishments into categories of frequent use, regular use, and occasional use, and scoring them accordingly.

4.3.1.2 Disadvantages of Real Accessibility Index.

   The Q/LOS Handbook uses a much more technical approach to determine the score and subsequent LOS of each mode, especially with the bicycle and pedestrian LOS models, than the RAI. The Q/LOS models appear to offer a more complete analysis than the RAI. The problem with the RAI approach is that it is almost impossible to determine the RAI without going to the

neighborhood and scoring each of the parameters by hand.  The parameters are so unique to each location that the use of GIS or other modeling programs would be impractical.  The RAI does not take into consideration densities of a neighborhood – a very important urban form element of a multimodal transportation network.  Additionally, the pedestrian scores do not reflect width of the sidewalk or barriers from the roadway and automobile traffic (however, calm traffic is incorporated in the analysis).  While the RAI is a tool that could prove valuable for evaluating some aspects of a multimodal district, it fails to account for important parameters of each mode.  Data collection for the RAI could be time consuming and may not give a complete description of the overall LOS of an area.

### 4.3.2 Smart Growth INDEX

The Environmental Protection Agency (EPA) has designed a GIS-based sketch tool known as the Smart Growth INDEX in order to link land-use decisions with transportation planning (USEPA 2002).  The INDEX can simulate alternative land-use and transportation scenarios and evaluate their outcomes using environmental performance indicators.  Sketches can be prepared for

> - Regional growth management plans
> - Comprehensive land-use plans
> - Transportation plans
> - Neighborhood plans
> - Land development proposals
> - Environmental impact reports
> - Special projects

After the user enters certain parameters such as a land-use plan, transportation system, infrastructure service area, and population growth projections, the program uses the information to score various sketches with a set of 24 performance indicators that measure such outcomes as land consumption, housing and employment density, proximity to transit, pollution emissions, and travel costs.  The INDEX then displays graphical snapshots of the sketches.  Comparisons can then be made of various developments.  The INDEX is also able to estimate traffic changes without the use of the four-step modeling process by evaluating land use changes. However, the INDEX can also work with the four-step process if the user chooses to do so.

The INDEX can operate in two different modes, forecast and snapshot.  In forecast mode the user inputs a population forecast, transportation system, and infrastructure service area and also determines growth constraints and incentives in an area.  The INDEX then uses a travel-based gravity submodel with land-use and transportation interaction for each year interval.  Afterwards the result is scored and mapped.  In snapshot mode the user inputs a land-use plan and transportation system that is then scored for a single point in time by performance indicators.

The indicators used in the INDEX are divided into the categories of land-use, housing, employment, travel, and environment.  Listed in Table 15 are the indicators that could be used for multimodal trade-off analysis for both the forecast and snapshot mode of the INDEX.

| Table 15.  Indicators Used in Smart Growth INDEX | | | |
|---|---|---|---|
| ***Land Use Indicators*** | | | |
| Indicator | Forecast Mode | Snapshot Mode | Units |
| Growth compactness | X | | · persons/sq. mi. of developable area |
| Use mix | | X | · proportion of dissimilar land-uses among grid of one-acre cells |
| Population density | X | X | · persons/sq. mi. |
| Incentive area use for housing | X | | · % of total housing incentive area used |
| Incentive area for employment | X | | · % of employment incentive area used |
| Jobs/workers balance | X | X | · ratio of total jobs to total employed residents |
| Land· use diversity | | X | · comparison of sketch area pop/employment mix compared to regional pop/employment mix |
| ***Housing Indicators*** | | | |
| Indicator | Forecast Mode | Snapshot Mode | Units |
| Housing density | X | | · DU/acres |
| Residential density | | X | · DU/acre of residential land |
| Single-family housing share | | X | · total % of single-family DU |
| Multi-family housing share | | X | · total % of multi-family DU |
| Housing transit proximity | X | X | · % DU within .25 mi. of transit route |
| Housing recreation proximity | | X | · % DU within .25 mi. of parks |
| ***Employment Indicators*** | | | |
| Indicator | Forecast Mode | Snapshot Mode | Units |
| Employment density | X | X | · employees/acre |
| Employment transit proximity | X | X | · % employees within .25 mi. of transit route |

| Table 15 contd..  Indicators Used in Smart Growth INDEX | | | |
|---|---|---|---|
| **_Travel Indicators_** | | | |
| Indicator | Forecast Mode | Snapshot Mode | Units |
| Vehicle miles traveled | X | X | · VMT/day/capita |
| Vehicle trips | X | X | · VT/day/capita |
| Arterial vehicle hours traveled | X | | · VHT/day/capita |
| Freeway vehicle hours traveled | X | | · VHT/day/capita |
| Arterial vehicle hours of delay | X | | · VHD/day/capita |
| Freeway vehicle hours of delay | X | | · VHD/day/capita |
| Auto driver mode share | X | | · % trips by auto |
| Auto passenger mode share | X | | · % trips as passenger |
| Transit mode share | X | | · % trips by transit |
| Sidewalk completeness | | X | · % of total street frontage with sidewalks on both sides |
| Walk/bicycle mode share | X | | · % trips by walk or bike |
| Auto travel costs | X | X | · $/year/capita |
| Pedestrian route directness | | X | · ratio of shortest walkable route distance from outlying origin points to central node destination vs. straight line distance |
| Pedestrian design index | | X | · composite index of sidewalk completeness, street network density and pedestrian route directness indicator scores |
| Street network density | | X | · density of streets in centerline mi. per sq. mi. |
| Street connectivity | | X | · ratio of street intersections vs. intersections and cud-de-sacs |
| Source: USEPA 2003(adapted from pages 7-8) | | | |

4.3.2.1 Advantages of the Smart Growth Index

The INDEX is beneficial in that it allows planners to compare various alternative development proposals with a base model in order to evaluate the alternatives and determine whether they have the characteristics of a smart growth development.  Additionally, the INDEX produces maps that can be presented at forums and town meetings in order to show the public the

potential effects of proposed developments. The INDEX works at both the neighborhood and regional level, which could be beneficial to planners that are looking at the effects of larger developments such as DRIs.

<u>4.3.2.2 Disadvantages of the Smart Growth Index</u>

      The major drawback of the INDEX is that it is very data intensive. While many cities may already have existing GIS data layers, the data layers must be an exact match to the required inputs of the INDEX in order for the model to work properly. Employment data must also be collected, which could mean employing the use of surveys in order to develop the necessary data for the INDEX. Gathering this information could take a very long time and converting the data into GIS shape files to input into the INDEX could take even longer. While the actual INDEX interface is relatively easy to use, the data collection and preparation is much more difficult (Bojanowski 2001).

***4.3.3 Portland's SDC***

      In 1997, the City of Portland established rates for systems development charges (SDC) that are one time fees paid by new development to local governments for the capital costs associated with public facilities that are needed to serve the new development and the people who will occupy or use the new development. The SDCs were established in response to the *Dolan v. City of Tigard* (Oregon) [512 U.S. 374 (1994)] decision that exactions be "roughly proportional" to the impacts caused by the development and that a "rational nexus of benefit" be established between the SDC and the development. The SDC is calculated as a "reimbursement" fee, or an "improvement" fee, or a combination of both. Reimbursement fees are based on the costs, including carrying costs, associated with capital improvements that are already constructed or under construction provided that "excess" capacity is available to accommodate growth. "Improvement" fees are based on the costs of capital improvements that increase the capacity available for new development (Henderson, Young & Company, *et al.* 1997). The SDC is charged at the time the local government issues a permit or order allowing land to be developed. The SDC is calculated using the following steps:

(1) Based upon existing plans and lists of transportation improvements, identify the capital improvement projects that are needed to serve new development.
(2) Analyze each project to determine the portion of the cost for each of three modes of travel: motorized, transit, non-motorized (bicycle and pedestrian).
(3) Determine the portion of the cost of the project that serves new development and the portion that eliminates the existing deficiencies. The portion that serves new development becomes the basis for the SDC while the deficiency portion is excluded from SDCs and must be paid by other sources of revenue.
(4) Identify the portion of the project that serves traffic that begins and/or ends within the city and the portion that serves "through" traffic. Traffic that begins or ends within the city is included in the SDC. The traffic that travels through the city without stopping is excluded from SDCs and is paid by other sources of revenue.
(5) Use the Metro's traffic model to forecast the number of new trips that will be generated by each mode of travel.
(6) Calculate the costs per new trip (for each mode) by dividing the costs that are eligible for SDCs by the number of new trips.

(7) Quantify the impacts of various types of new development by calculating the number of new trips that are generated by various types of land use. The trip generation data is adjusted to account for (1) the number of trips that are a part of another trip (trip chaining); and (2) variations in the length of trips to/from different types of land use (i.e., trips to offices and industrial trips are usually longer than trips to supermarkets and restaurants).

(8) Calculate the SDC for each type of land use; multiply the cost per trip (from step 6) times the number of trips (for step 7).

(9) Combine the SDC for each mode to determine the total SDC for each type of land use. Steps 3 through 8 are performed separately for each mode of travel, producing an SDC for each mode for each land use. Then the SDC rate for each of the three modes is combined to produce a composite SDC for each type of development (Henderson, Young & Company, *et al.* 1997, p. 16-17).

To accomplish this analysis, a mode allocation of the capital cost of each project must also be accomplished in a series of four steps:

(1) The direct cost of each mode is separated from the costs that are common to all modes (e.g., the cost of mobilization, right-of-way, etc. are common to all modes of travel, whereas the cost of sidewalks are considered "direct" non-motorized costs).

(2) Direct costs of non-motorized facilities (bicycle and pedestrian) are identified, and subtracted from all other direct costs.

(3) The remaining direct costs for capital improvements are allocated between transit and motorized modes. The transit portion is determined by comparing the transit passengers along the project route to the total of all persons ("passengers") moving on the same route in all motor vehicles. The motorized portion of direct cost is the remainder (after subtracting non-motorized costs and costs for transit).

(4) The direct cost of each mode is divided by the total direct cost of all three modes to identify the relative distribution of project costs among modes. The resulting percentage for each mode's direct cost is used to allocate the common costs among the three modes (Henderson, Young & Company, *et al.* 1997, p.16-17).

The SDC can only apply to the growth portion of the cost of infrastructure and not to the portion that covers the existing deficiency. The amount that covers the deficiency is calculated for each project in the capital improvements plan (CIP) using a separate formula for each mode. For transit (rail and bus) the deficiency calculation takes 100 minus the average maximum load factor for Trimet bus route if it exceeds 100%. For example, if a route supporting new development operates at 120% of capacity, the existing deficiency would be 20% of capacity. For non-motorized facilities the deficiency is based upon the percent of the arterial without sidewalks based upon a 1994 sidewalk inventory. For motorized modes the deficiency calculation is made based on the following formula:

(current traffic count) minus (existing capacity)
(future capacity) minus (existing capacity)

4.3.3.1 Advantages of Portland's Systems Development Charge (SDC)

The advantage of this approach is that it is legally defensible in that it directly attaches the cost of development to each mode of travel. The system is built on a strong CIP and it allocates the portion of new development to the mode of travel with which it is associated. Because the calculation of trips is based upon the regional travel models, the trip generation and mode split are based upon the existing behavior of residents in the region. Portland has a strong reputation for its models and their ability to model all modes of travel including non-motorized modes. The SDC requires a strong understanding of travel behavior within different areas of the region and solid planning of transportation improvement plans and various master plans within the region.

4.3.3.2 Disadvantages of Portland's Systems Development Charge (SDC)

Many of the disadvantages of this approach are related to the state of practice in Florida. This system assumes that local governments have adequately planned and developed master plans of all transportation improvements for all modes of transportation and that they can determine which portion of new travel demand is associated with new development and which is associated with the existing backlog of development. The system uses a system-wide averaging of costs for all trips by a specific mode irrespective of the location within the region. While it may be more expensive to build facilities in neighborhoods that do not currently have good connectivity, the SDC is based on an average cost for various facilities. Ideally the system would account for the differences in the cost of each individual mode based upon the land use and transportation configuration, but for administrative simplicity and political reasons the charges are averaged across the region. The impact of this bias is partially minimized by the ability of the models to identify the mode split in various locations within the region and to allocate costs accordingly. This calculation also combines bicycle and pedestrian facilities; this may be appropriate in many, but not necessarily all, situations.

### 4.3.4 Applications of Multimodal Concurrency in Florida

Within the state of Florida, several jurisdictions have been exploring the development of concurrency management systems that attempt to accomplish the same goals as the MMTDs. As a part of the development of the MMTDs and Areawide Level of Service Handbook (FDOT 2003), case studies were developed in both Orlando and Gainesville. Neither of these communities is likely to adopt the approach taken in the multimodal Handbook because the case study locations are already located in areas with transportation concurrency exception areas. Currently, the Cities of DeLand and Destin have been working with the FDOT and Florida Department of Community Affairs (DCA) to analyze areas for the application of the MMTD. Other communities, such as Seminole County and Winter Park have taken other approaches to multimodal planning. In this section, these other approaches are discussed.

4.3.4.1 Seminole County's Multimodal Concurrency System

In 2000, the voters of Seminole County passed a ballot initiative called "Cents for Seminole" that included as a part of its rationale the improvement of multimodal transportation facilities throughout the county. The passage of this initiative appears to have unleashed a set of new efforts throughout the county for development of multimodal methods for concurrency management. Seminole County has completed a study on a countywide multimodal concurrency

system and is implementing a pilot study on the US 17-92 corridor (Glatting Jackson 2001). In their proposed comprehensive plan amendments, Altamonte Springs is proposing a system of multimodal transportation planning. They have yet to develop LOS standards compatible with a multimodal transportation system but they plan to do so by December 2003 (Altamonte Springs 2003: GOP4-7).

Seminole County is in the process of implementing a multimodal concurrency system. The County has decided to take this approach because traditional LOS methodologies leave no options for improving mobility once improvement measures have been used up and because transportation demand increases in response to added capacity. Glatting Jackson Kercher Lopez Rinehart, Inc. were hired as a consultant and in that role prepared a white paper, *Expanded Approaches to Transportation Concurrency* (Glatting Jackson 2001), which explored three options for doing so. The principles used to make the concurrency system work in Seminole County are similar to the those incorporated in the FDOT's MMTDs and associated LOS measures: (1) broaden the definition of transportation adequacy to include walking, bicycling, and public transit, in addition to vehicular travel; (2) devise a process that allows transportation concurrency to transition, as an area grows, from a simple traffic LOS measure for rural areas, to more sophisticated multimodal measures as the area becomes developed and simple LOS becomes inappropriate; (3) describe real, detailed, improvement actions, rather than abstractions; and (4) take a long-term view of transportation improvements to consider actions that may not have an immediate impact on traffic, but will have an accumulative effect of dealing powerfully with the problem over the longer run.

Based upon these principles, Glatting Jackson (2001) proposed three broad approaches to applying a multimodal transportation concurrency mandate: (1) multi-mode LOS with an LOS point system; (2) performance criteria; and (3) multi-mode sector plan. The multimode LOS with an LOS point system would involve developing a LOS measure for each mode of travel (walking, transit, etc. along with vehicle traffic) and combining the scores into an overall LOS score. This approach takes the same notion of LOS and applies it to more modes of travel, over greater areas. In establishing performance criteria, actions (e.g., frequency of bus service) that eventually produce more multimodal capacity are specified. This approach differs fundamentally from a LOS approach in that the goal is specified, and not the means of achieving the goal. For example there may be more than one way to achieve connectivity in a community; this method allows the flexibility for the community to decide how a goal is achieved. In the multimodal sector plan all elements of multimodal adequacy are identified as a part of a detailed site-specific plan. An applicant simply complying with the plan would, therefore, assure adequate public facilities and no further concurrency action would be required. The Seminole County Comprehensive Plan would establish the LOS Point System countywide with four distinct areas in the county: rural areas, development corridors, mixed-use centers, and neighborhoods. In rural and development corridors, the following priority of transportation modes would be established: (1) single-occupancy vehicle; (2) multiple-occupancy vehicle; (3) public transportation; (4) cyclist; and (5) pedestrian. In contrast, in mixed-use activity centers and neighborhoods, the priority would be: (1) pedestrians; (2) cyclists; (3) public transportation; (4) multiple-occupancy vehicle; and (5) single-occupancy vehicle. These approaches and their advantages and disadvantages are described in greater detail below.

The first option was to develop a LOS measure for each mode of transportation, and to combine scores into an overall composite LOS score. The strengths of this approach are that LOS measures are quantifiable, objective, and readily calculated. This approach has a long history in traffic engineering that is understood by transportation professionals. The disadvantage of this approach is that LOS measures are abstract, not directly comparable (see Winters *et al.* 2001) and can not be directly related to school grades despite the similar "A" to "F" grading system, are subjective in terms of where thresholds are set, not based upon an understanding of the preferences of users of the highway and transit systems, may be complex to calculate or require continually updated data, and tend to produce an adversarial process that emphasizes enforcement, restrictions, and denial of projects.

The second option was to specify performance criteria that eventually produce multimodal capacity; the criteria specify the physical items that are required, rather than the results. Criteria could also include number of local street connections in each direction from a subdivision, accessibility (e.g., percent of floor area within a certain walking distance of a transit stop), average wait time for a transit vehicle, pedestrian travel circuitry (actual distance vs. ideal distance), and percentage of trip attractions in a given radius reached by bicycle path, bicycle lane, sidewalk or local street. Performance criteria differ from LOS point systems in several important ways: (1) LOS factors measure attributes of facilities while performance measures consider human factors in design; (2) LOS factors apply to elements of the system (BikeLOS on a given block) while performance criteria embrace an entire system (bicycle routes to all travel attractors in a one-mile radius); (3) LOS measures are descriptive of what is in place and observed while performance criteria are prescriptive in guiding what ought to be. Strengths of a performance measure approach are that it generates design guidelines that express how a community would like to develop, it gives developers flexibility in choosing how to meet the guidelines, all parties more easily understand it, and it is more efficient than the other two options. For example, to meet a performance criterion that development connect in all directions, the applicant could design an internal network fronted by lots or parkways that incorporate open space and pedestrian/bicycle requirements, or even perimeter roads that surround a walled subdivision. Disadvantages of this approach are that the criteria are still abstract and not well understood by the public, and could potentially result in designs that meet the criteria but do not achieve the intended result.

The final option was a multimodal sector plan. Under this approach, an area plan would be developed showing, in graphic form, a conceptual plan for all of the modal elements, including sidewalks, crosswalks, transit stops, bicycle lanes and paths, and other elements of the transportation system. Some site design concepts would also be incorporated, such as internal street networks and building placement and massing. The strengths of this approach are that it helps engage the public through the use of graphics, it uncovers potential issues at earlier stages in the process, and is more easily explained than either LOS measures or performance criteria. Challenges with the approach are the amount of effort up front to develop the initial plan, the mismatch of skills of existing concurrency planners and the needs of a coordinator of area plans, and the unknown amount of effort required to update the plans (e.g., how often do they need to be updated).

Glatting Jackson (2001) recommended a two-pronged approach to concurrency. First, a multimodal LOS point system should be used county-wide, using the LOS measure developed by the FDOT, but with local weightings applying to the amount of priority given to each mode in different environments: rural areas, development corridors, mixed-use centers, and neighborhoods.  In areas where meeting the LOS standard can no longer be feasibly achieved, and that have been identified in the County comprehensive plan for redevelopment, a multimodal sector plan should be developed to guide how the redevelopment should occur.  The county is in the process of incorporating these recommendations into their Comprehensive Plan and Land Development Regulations.

4.3.4.2 Winter Park's Multimodal Concurrency System

Winter Park has developed a vision-based LOS standard that involves the use of a checklist for the segment of each community street.  The checklist, which is based upon the Principles for Community Streets, considers and measures all the design and facility elements, such as, traversable roadway, transit service, continuous sidewalk, planting strips, bicycle facilities, landscaping, lighting, and on-street parking.  In addition, the methodology also considers the following design elements, such as: vehicular travel lane widths, median provision, number of vehicular lane miles, median design, vehicular travel lanes pavement, median landscaping material, transit stop design, sidewalk width, planting strip width, sidewalk location, landscaping in planting strip, sidewalk pavement material, on-street parking, location of bicycle facilities, traffic calming measures, lighting design, and posted speed limit.  The City proposes six designations for vision-based levels of service and they range from "A" to "F".  Vision-based LOS "A" is built to the exact specifications of the Principles for Community Streets, while vision-based LOS "F" describes a segment that matches less than 20% of the appropriate Principles for Community Streets.  The rankings between a LOS of "A" and "F" are equally distributed with respect to the percentage of Principles for Community Streets that are met (Winter Park 2003).

The City of Winter Park is still working out the details of their comprehensive plan update that would implement the multimodal concurrency.  But the plan currently identifies the following potential sources of revenue: state and federal funds, gas tax, location and bridge ad valorem tax, local option gas tax, local option sales tax, special assessment districts, proportionate share impact fees and joint funding with Orange County.

4.3.4.3 Advantages of Multimodal Approaches in Seminole County and Winter Park

The approaches to multimodal concurrency taken by these two central Florida communities offer alternative methodologies from the capacity-based LOS methodologies being proposed by the Florida Department of Transportation.  Each of these methodologies represents an attempt to develop measures of the level and quality of service for roadways in a manner that is more easily understood by the general public.  Most of the details of these alternative methodologies have not been finalized so it is difficult to assess the approaches.

4.3.4.4 Disadvantages of Multimodal Approaches in Seminole County and Winter Park

The disadvantages of the approaches taken by Seminole County are associated with innovation. The measures that both communities are proposing are more qualitative and intuitive

than quantitative and replicable. They have not yet been tested in the field to determine the issues that might be associated with them.

### 4.3.5 Creative Concurrency in the State of Washington

The State of Washington is the only state other than Florida to require the implementation of concurrency for all jurisdictions participating in the State Growth Management program.[4] While the State of Florida developed the LOS Handbook (FDOT 2002) as guidance for local governments, the State of Washington has allowed local governments to establish their own measures to implement growth management. At the present time, the State of Washington is evaluating the success of various aspects of their growth management programs. As such, the Puget Sound Regional Council, Clark County (across the Columbia River from Portland Oregon), and four cities on the east side of the Puget Sound are completing evaluations of their concurrency programs. Because of these studies a wealth of information is available on various means of measurement that are used as a part of various local government concurrency management systems. The Puget Sound Regional Council conducted a survey of 82 cities in the four counties in its region and received 68 responses. About 27% of the responding jurisdictions address transit, 23% address nonmotorized and 33% address transportation demand management (TDM)/land use in their jurisdiction's concurrency ordinance. About 20% use some form of district or zonal areawide LOS methodology. The research team was not able to review the details of the measures used in any of these jurisdictions to determine if these methods would be applicable to the multimodal LOS. Furthermore, research by the University of Washington in four cities, three of which indicate that they use some form of district or zonal LOS measure and all four claim to use a multimodal approach to the level-of-service calculation, suggest that the "process may be considered 'multimodal' technically speaking, but functionally the determination of concurrency is based strictly on roadway conditions" (underline in the original: Hallenbeck *et al.* 2002, p. 30). Nonetheless, several innovative techniques are being used that could be applicable to MMTDs, which potentially represent a methodology to complete the multimodal tradeoff analysis.

Tim Trohimovich of 1000 Friends of Washington summarizes the "New Concurrency System" to include the following techniques that might be applicable in the Florida context: (1) travel delay system; (2) average vehicle operating speed; (3) LOS at a screen line rather than intersection or a link LOS; (4) arterials that serve a new development are required to meet certain construction standards; (5) person throughput or person carrying capacity; (6) certain transportation facilities (streets, intersections, or both) that are built out are not included in concurrency calculation, and (7) regional concurrency systems. (Trohimovich 2001)[5]

4.3.5.1 Travel Delay System
Under the travel delay system, which is being used in Vancouver, Washington and Clark County, the system works as follows: (1) uses travel time along selected arterial streets (links)

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[4] Rural counties in Washington are not required to participate in the Growth Management Act unless their population or rate of growth exceeds certain thresholds. They have the option of voluntarily entering the growth management program and once they choose to do so they must remain.
[5] The contents of this section are taken from Tim Trohimovich's document with additional analysis based on the experience of the authors.

with different classes of arterials having different standards; (2) measures delay at intersections at such selected arterial streets, and (3) calculates a mobility index that consists of the number or percentage of intersections operating under the average and limits this to a predetermined level. The advantage of this system is that the travel delay is comprehensible to the public. As a form of performance measure, it is easy to explain and understand. It measures something that the public cares about – the time it takes to drive through a corridor. The Western Washington Growth Management Hearings Board upheld both of these systems concluding that such approaches "discourage sprawl and encourage multimodal transportation by avoiding costly intersection improvements that promote single occupancy vehicle use and discourage walking and cycling" (*Progress Clark County v. Vancouver* 2002, and *Achen v. Clark County* 2000).

4.3.5.2 Average Vehicle Operating Speed

Average vehicle operating speed is commended by Reid Ewing as a "potentially better basis of area wide LOS" than volume to capacity based systems. It would use an average vehicle speed on arterial corridors. The advantage of such a system is that it is another measure of volume to capacity, but "is more consistent with the philosophy of the 1985 Highway Capacity Manual (which abandoned volume/capacity ratios in favor of more direct measures)" (Ewing as quoted by Trohimovich 2001, p. 3/C-15). It is easy to gather and measure something the public cares about and understands – delay. The disadvantage of this system is that it would require people to change systems of measure, it would require modeling to determine compliance, and as such it can be a complex system. Finally, the average vehicle operating speed equates to speed and if travel times are set too low, you may have to widen a street or intersection your community does not want to modify.

4.3.5.3 Screen Lines Rather than Intersection or Link LOS

The City of Seattle makes use of series of screen lines on selected arterial streets to measure travel times rather than using intersections or link LOS. The major advantage of the use of screen lines is that they requires fewer calculations because fewer locations are used to monitor compliance. It measures the LOS on an areawide basis (i.e., that operate as an exception area) that aligns with the location of screen lines. The disadvantages of such a system are that it requires modeling to determine compliance and could allow increased growth without much increase in transportation facilities. Depending upon the number of screen lines, the system may not be very sensitive to the differences in geographically diverse parts of the city.

4.3.5.4 Arterials that Service New Development Meet Construction Standards

This system requires that arterials that service development must meet certain construction standards. The advantages of such a system are that it is simple, easy and cheap to administer, does not require traffic modeling and is well suited to small, slow or moderate growth communities with few public facility limitations. The disadvantage of such a system is that it does not address intersections, which are the primary limitations on urban area capacity. The system could be modified to do so. Rapid growth or unforeseen facility needs could overwhelm the system because a set facility standard, such as a two-lane arterial, may not have enough capacity to be sufficient in high growth areas.

4.3.5.5 Person Throughput or Person Carrying Capacity

Person throughput or person carrying capacity is a system that would measure person transportation carrying capacity using all modes, including cars, buses, high capacity transit, walking and biking. The advantage of this system is that it gives local governments many options to meet transportation needs and encourages addition of capacity in all modes, not just roadway improvements. The community can choose where to spend its transportation money, not simply to add intersections and make roadways wider.

4.3.5.6 Exclude Built-out Transportation Facilities from Concurrency Calculations

Like Florida's Transportation Concurrency Exception Areas, this system provides that once certain facilities (streets, intersections, or both) are built out, they are not included in the concurrency calculation. Olympia is using such a system whereby certain streets will only be widened to a certain number of lanes. Investments would then be made in other transportation modes. It is not clear from the description if this exception applies on a street-by-street, link-by-link or areawide basis as is required in Florida's TCEAs. The advantage of this system is that it prevents transportation concurrency from requiring streets and intersections to be widened beyond the level desired by the community, encourages development where the community wants it even if automobile congestion exists, and it may help manage transportation facility costs. The key disadvantage to this system is that if sufficient alternatives are not present, automobile traffic could get extremely congested. This is not specifically authorized in Washington and it may be unpopular with people who want to be able to drive anywhere, anytime.

4.3.5.7 Regional Concurrency Systems

A regional organization, such as a Regional Planning Council, Metropolitan Transportation Organization, Rural Transportation Organization, county, or consortium of cities, could maintain a concurrency model and conduct the concurrency analysis. The key advantages of such a system are that it would do a better job of taking into account regional traffic, background traffic and all of the development within a region, smaller communities would be able to afford a more complex system than they would on their own, developers would have a uniform set of rules across jurisdictions, and the system could be structured to encourage forms of development preferred by the region. The disadvantages of such a system are that local governments would have less control over the concurrency system and they may have conflicts between local goals and regional goals.

### 4.3.6 Montgomery County, Maryland's Local Area Transportation Review

Montgomery County, Maryland's adequate public facilities ordinance is one of the oldest and most comprehensive concurrency programs in the country (Pelham 1992). Under their system, a subdivision application may be subject to one of two tests: (1) the Policy Area Transportation Review; or (2) the Local Area Transportation Review. The Policy Area Transportation Review divides the county into geographic areas for which the adequacy of public facilities is addressed on an area-wide basis. For transportation, a staging ceiling may be established that establishes a limit on the amount of land development, expressed as jobs ceiling and a housing ceiling, that can be accommodated by the existing and programmed public transportation facilities serving the area, at an assigned congestion standard. The assigned

congestion standard reflects a critical lane volume reflecting the number of vehicles per lane per hour and varies from 1,450 in rural areas to 1,800 in central business districts (CBDs) and Metro Station Policy areas, which are more urban. The intent of the Local Areas Transportation Review is to establish criteria for determining if development can proceed, whether the staging ceiling is or is not available (M-NCPPC 2002).

The developer will be required to prepare a traffic study to determine if there are adequate facilities to support their development. The transportation planning staff conducts a review to determine if the proposed development exceeds the congestion standard for that area and analyze the project and the potential solutions to address the local traffic impact. If a proposed project exceeds the local congestion standard, the developer works with local and state agencies to identify projects, such as additional traffic engineering or operations changes beyond those currently programmed, or non-programmed transit or ridesharing activities that would make the overall transportation system adequate. Transportation planning staff may also identify the degree to which transit (i.e., bus service, proximity to a Metrorail station, ridesharing or other TDM activities) can be considered to mitigate vehicle trips generated by the proposed development. As a part of the analysis, the local area transportation impact is established and the developer may be required to engage in a variety of activities to reduce the impact of the development. These mitigation strategies, which are subject to a maximum reduction, include: construction of sidewalks and bicycle paths, provision of bus shelters, provision of bicycle lockers, and provision of real-time transit information (M-NCPPC 2002).

4.3.6.1 Advantages of Montgomery County, Maryland's Local Area Transportation Review Process
Montgomery County, Maryland's local area transportation review is a comprehensive planning review that coordinates the review of proposed development with the availability of all modes of transportation facilities. Florida communities can learn from the long-term experience of Montgomery County in fashioning an adequate public facilities system to address various issues. The review process has several key features that may be applicable to the multimodal tradeoff. First, the CBDs and Station Policy areas are similar to MMTDs both in their construction and their scale. Second, the use of an assigned congestion standard ties the level of traffic allowed to the level of congestion and the level of urbanization. Third, the process addresses a wide range of transportation mitigations from major roadway or intersection improvements that are currently the capital improvements plan, to new unfunded transportation projects and TDM. It also addresses impact from residential development separately from non-residential development. Finally, the review process addresses the issue of local traffic congestion, due to specific developments, separately from background (i.e., regional) traffic.

4.3.6.2 Disadvantages of Montgomery County, Maryland's Local Area Transportation Review Process

Montgomery County's local area transportation review does not address the multimodal tradeoff as explicitly as Portland's Systems Development Charge. The link between planned improvements for each mode and the anticipated trip generation for each mode is not as explicit in this transportation review process as it is in Portland.

### 4.3.7 Florida's Fiscal Impact Assessment

The consulting firm of Fishkind & Associates is currently completing a study under contract with the Florida Department of Environmental Protection that seeks to develop a model for the implementation of FIAM throughout the state of Florida (Fishkind & Associates 2002a). The objectives of this model are several: (1) to quantify costs and revenues associated with all types of land uses made by communities, whether "macro" (decisions related to an entire comprehensive land use plan ("comp plan") or "micro" (decisions related to an individual project, rezoning, or plan amendment): (2) to address future capital and operating costs, and the backlog of infrastructure needs; and (3) to address both short-run impacts and long-term implications, with sensitivity to variations in development location and the cost-and-revenue differentials associated with different locations.

The advantage of the FIAM is that it may provide a framework for conducting the multimodal tradeoff analysis. Many of the considerations in the planning for the transportation network are incorporated into the FIAM framework. If the FIAM is developed in the manner of Portland's SDC, it could incorporate planning with the associated cost of alternative patterns of development.

The disadvantage of the use of the FIAM is that the tool was developed for a greater diversity of circumstances and without the active participation of FDOT staff so it may not be specific enough to address the particular circumstances that the multimodal tradeoff analysis is intended to address. The reports on this project have not yet been reviewed in enough detail to determine if they are applicable to multimodal tradeoff analysis. An initial review shows an analysis on a countywide and community-wide rather than an individual project basis. Also, the political acceptance of this technique has not yet been established. Recently, however, a study by the Cantanese Center suggests that FIAM has not generally been used for transportation applications (Anthony James Cantanese Center 2003).

### 4.3.8 Florida's Efficient Transportation Decision Making Process (ETDM)

The Florida Department of Transportation is working in conjunction with the Federal Highway Administration and other federal, state, and local agencies to develop a refined and improved methodology for effecting transportation decisions. This effort was initially called "streamlining" in response to Section 1309 of the Transportation Equity Act for the 21st Century (TEA-21). The FDOT process redefined how the State of Florida will accomplish transportation planning and project development by creating links between land use, transportation, and environmental resources planning initiatives through early, interactive agency and community involvement, which is expected to improve decisions and greatly reduce the time, effort, and cost to effect transportation decisions. Efficiency is gained by screening of planning and programming activities. An Environmental Technical Advisory Team (ETAT), which is comprised of planning, consultation, and resource protection agencies, performs these screenings. The FDOT or the MPOs will coordinate the response of the ETAT in both the planning screen, which is conducted in response to the development of mobility plans, and the

programming screening, which is conducted after the development of the long-range transportation plan and before the development of FDOT's Work Program.

The objective of Environmental Streamlining is to improve interagency coordination, more effectively address environmental concerns, and reduce costly delays in the environmental review process. The ETDM (FDOT 1999) process would provide a predictable and expedient timeframe within which resource agencies conduct their roles in the process. The result should be more meaningful and increased activity from federal resource agencies. The agencies' input would be provided earlier in the process and, thus, make environmental issues easier to resolve.

While the ETDM framework is not currently linked with multimodal planning, it offers a framework for meaningful review of proposed projects that have been developed as part of a multimodal transportation planning process.

# 5 ASSESSMENT OF OPPORTUNITIES FOR MULTIMODAL ANALYSIS IN FLORIDA

The State of Florida has several decisions to make about the incorporation of multimodal tradeoff analysis into its planning and regulatory framework. Over the past several years the state has developed a set of analysis tools that are the building blocks for multimodal analysis. These tools, which are a part of the concurrency management system, include, but are not limited to, the MMTDs and Areawide Level of Service Handbook (FDOT 2003), the Pedestrian Level of Service Model, the Bicycle Level of Service Model and the Model Municipal Land Development Regulation for MMTDs. The concept behind MMTDs and multimodal tradeoff analysis presumes that concurrency management in Florida will change from being seen as a set of regulatory tools to respond to development proposals to a proactive planning process that provides the right incentives for development that minimizes the impact on the surrounding roadways.

Fundamentally, some basic decisions will need to be made about how multimodal tradeoff analysis will be incorporated into existing transportation analysis tools in Florida. These basic decisions can be described with four broadly defined questions that should be considered by the Florida Department of Transportation as it continues its efforts to incorporate multimodal planning into its transportation processes: (1) Does the State of Florida, and specifically the Florida Department of Transportation (FDOT) and Florida Department of Community Affairs (FDCA), wish to continue using existing LOS methodologies to assess the priorities for transportation funding and concurrency, or do they wish to use other performance indicators and other measurements of effectiveness? (2) How will the multimodal tradeoff analysis be coordinated and integrated with existing assessment tools (e.g., environmental assessment, site impact assessment, regional travel demand forecasting, statewide travel demand modeling, etc.)? What is the impact on the methods of assessment of changing the statewide model to use the TransCAD system? (3) Will other concurrency tools (i.e., performance based measures, e.g., travel time, rather than LOS measures) be applied in the implementation of concurrency to accomplish multimodal tradeoff analysis? and (4) Will the multimodal tradeoff analysis be limited to MMTDs, or, will similar analysis tools be developed to consider the cumulative impact of smaller, yet significant projects? In section 4, a number of tools are described that provide a variety of frameworks for multimodal analysis. In the next section the connection between these tools and the multimodal tradeoff analysis will be summarized. Following this, the constraints to the use of these and other multimodal tradeoff analysis techniques will be considered.

## 5.1 Applicability of Tools for Multimodal Analysis

The tools for multimodal analysis, outlined in Section 4.3, provide several options for the Florida Department of Transportation. Portland's Systems Development Charges (SDCs) arguably provide the most comprehensive approach to multimodal tradeoff analysis while the other approaches may provide methodologies that can better address the needs of Florida.

Portland's SDC provides a comprehensive and coordinated system that integrates transportation and land use planning with transportation modeling and the charging of impact fees. This system incorporates modal master plans with long-range transportation plans for all

modes to develop an inventory and the associated costs of facilities. When a development project is proposed, the transportation analyst then uses information from the transportation models to identify the demand for various types of facilities in various locations and establish which of the costs are associated with a specific development and which costs are of general regional and statewide benefit to determine what can be charged to a specific development. The system is supported by Portland's commitment to strong planning. Portland has strong regional travel demand models that identify the level of activity of each mode by location, and incorporate monitoring of activity after development to validate the trip generation rates and mode splits used in the development plans. This could provide a long-term and comprehensive approach for the State of Florida. As will be discussed below, such an approach would require major improvements in regional transportation modeling and in the monitoring of results of coordinated land use-transportation planning.

The multimodal concurrency systems used in Seminole County and Winter Park represent alternative approaches to concurrency methods that are intended to be more easily understood by the public. Winter Park's system addresses an urban environment by establishing principles for community street design. Seminole County provides a range of ways to view multimodal tradeoff from extending the LOS measures from the automobile to non-automobile modes to the use of performance measures that extend beyond roadway LOS. This approach also suggests a way to phase the review used for development from areas the most rural, where performance standards are based primarily upon roadway LOS approaches to concurrency, to more heavily developed locations where multimodal areas are reviewed based upon more complex performance standards. The weakness of the methodology is that it may not allow the orderly growth from rural to urban if an interconnected roadway network is not developed as a part of this transition. Neither community has yet fully developed the methodologies to assess the LOS using these alternative methodologies.

Montgomery County, Maryland's approach to concurrency is based upon many years of experimentation in the development of multimodal environments. Their system applies a range of congestion measures that accommodate the variety of urban to rural conditions. The system offers a wide range of options to mitigate the transportation impacts of new development and it applies different standards for residential and non-residential development. Thus, many of the features of this approach appear to have applicability in Florida and they should be explored more fully.

The Smart Growth Index offers a methodology that compares alternative development scenarios and how these scenarios perform in comparison to a series of performance standards. The performance standards extend beyond simply considering the transportation and land use variables, but the methodology does not provide a means to directly compare these performance measures and the program itself is not transparent to users.

The Real Accessibility Index (RAI) provides a list of performance standards that could be applied to assess the multimodal environment, but these measures are data intensive and subjective in their development. Nonetheless, some of these variables could be incorporated into the LOS methodologies.

The examples of concurrency in Washington offer other alternatives to the LOS measures that are currently being used in Florida. While some of these alternatives incorporate ideas with which Florida has struggled for over a decade, others offer measures that might be more intuitively obvious to the users of the transportation system than the accepted methodologies of roadway LOS.

The FIAM and ETDM processes offer related frameworks for similar types of analysis that are being developed in Florida. ETDM offers a framework for evaluating proposed roadway projects that are included in long-range transportation plans or are in the conceptual design phase. The ETDM framework could be extended to incorporate the differences in land use-transportation configurations associated with proposed development. Like the environmental streamlining that ETDM seeks to address, an early review of the transportation impacts of major development projects could be conducted so that developers could address the concerns about connectivity, access, density, intensity and organization early in the planning of new development projects. At the present time the use of ETDM for multimodal analysis is not yet on the agenda but this framework for transportation decision-making could also accommodate multimodal planning.

Fiscal Impact Assessment offers an assessment of environmental impacts associated with development. Although in theory, a fiscal impact tool should be used to measure the transportation impacts of specific projects, the FIAM as currently proposed does not distinguish between alternative land use and transportation configurations. The current tool does not appear to have incorporated multimodal analysis into its framework because it does not consider alternative forms of land development. However, there would be many advantages of doing so in that the fiscal impact assessment would provide a framework for tying impact fees to the specific traffic impacts on associated roadways on both the State Highway System and local arterials.

The newer micro-simulation models offer a number of opportunities for application to the evaluation of multimodal districts. In the past, these models have been severely limited by the type of analysis that could be conducted, the size of the network that could be modeled, and the types of modes that could be analyzed. The newer micro-simulation models have expanded capabilities that allow for much larger networks and provide a better analysis of bicycle and pedestrian movements, which would be an important feature for multimodal analysis. As these micro-simulation models move towards larger geographic areas similar to the standard FSUTMS model, they will have many of the same capabilities as the standard four-step travel forecasting models without some of the more significant limitations to multimodal tradeoff analysis of those models. Two research projects currently underway in downtown Miami and Tampa to integrate the PARAmics model with the countywide FSUTMS model. The PARAmics model which is setup for the center city area of Miami (downtown Miami, Omni and the Brickell area) is being used with the countywide FSUTMS model to evaluate the travel patterns of a variety of modes including various types of transit, pedestrian movements, freight movements to the Port of Miami and the impact of opening and closing drawbridges (see projects under Quadstone paramics 2003). A similar study undertaken for downtown Tampa also used the PARAmics model and Tampa Bay Regional Planning Model. The integration of these two modeling

approaches in these types of sub-areas could help identify techniques that can be applied to multimodal districts (see projects under Quadstone paramics 2003).

Many of the newer travel demand models are moving towards providing the ability to evaluate more detailed networks that include bicycle and pedestrian facilities. The TransCAD package has some of the same capabilities as many of the micro-simulation models. It is not known if TransCAD is currently being used for non-motorized travel forecasting. In order for a multimodal tradeoff analysis to be implemented, the analysis of multimodal environments will need to be incorporated into regional travel demand modeling (Caliper Corporation 2003).

## 5.2 Constraints on the Implementation of Multimodal Analysis

The ability of the State of Florida to use multimodal tradeoff analysis will be limited by several factors in the current environment. These factors include: (1) the state of research on multimodal impacts; (2) the state of modeling in Florida; (3) the incorporation of MMTDs into the concurrency framework in Florida; (4) institutional arrangements for transportation and land development regulation in Florida; and (5) the measurement of multimodal LOS.

### 5.2.1 State of Research on Multimodal Impacts

At present, empirical research on the multimodal impact of alternative forms of development is not well established, especially with respect to its applicability in Florida. Many of the studies on high-density, mixed-use, and highly interconnected forms of development have been conducted in older, well-established neighborhoods in large, urban areas, in areas of so-called Old Urbanism, rather than in cities that developed about the same time as cities in Florida or the more recent greenfield developments. Few studies have been conducted in New Urbanist communities partly because the commercial and office centers have taken a long time to develop. The few studies that have been conducted in Florida (see, e.g. Ewing *et al.* 1994, Steiner *et al.* 2000) suggest that different patterns may be at work in Florida because of the differences in the organization of development within the region. Furthermore, studies on travel in Downtown Orlando suggest high rates of single-occupant auto usage for work trips even among residents who live and work in Downtown Orlando. However, among these same residents there are higher rates of walking and usage of modes other than the automobile for non-work trip purposes, which are largely ignored in regional travel models (Steiner *et al.* 2000).

The trip generation rates for New Urbanist communities are difficult to find with the same precision as the rates for conventional suburban development. Ewing and Cervero (2001), in their summary of previous studies on the connection between urban form and travel behavior, conclude that trip generation rates are determined by socioeconomic factors rather than urban form. Early in this project, a research team member listened with interest as an employee of the US Environmental Protection Agency discussed plans to fund a paired comparison study on trip generation in a conventional suburban development and a New Urbanist development, including internal capture, pass-by trips and trip generation by non-motorized modes of transportation. As of the Transportation Research Board Meeting in January 2002, this study has been cancelled.

### 5.2.2 The State of Modeling in Florida

The FSUTMS standard four-step modeling process has a number of basic deficiencies that limit its use for modeling the impacts of multimodal districts. While the ULAM provides an automated process to allocate future growth in the form of countywide population and employment totals (ULAM 2003), the projections are made at TAZ level within the FSUTMS format. However, the size of the traffic zones used in the standard models is too large and does not provide enough detail for evaluation of the impacts of multimodal districts. The only way to apply these models is to subdivide the traffic zones into individual city blocks or groups of blocks. The ULAM model is currently being updated to perform analysis at the parcel level, which may support analysis at the greater level of detail required for multimodal tradeoff analysis.

Another key problem is the level of detail in the highway network typically used by the standard four-step model. The standard model uses a highway network consisting of expressways, arterials, major and some minor collectors. For use in evaluating multimodal districts, more detailed highway networks are needed. In addition, the detailed network would need to include additional links for special facilities for bicycles and pedestrians. These types of detailed networks are more commonly found in micro-traffic simulation models and not in the standard four-step model typically used for county or regional modeling applications. Because of its lack of detail in the network and geographic level, the FSUTMS standard four-step model is not an adequate tool for evaluating the impacts of multimodal districts. Other analytical tools should be considered.

The FDOT has decided to move from the FSUTMS to TransCAD as the standard model for regional and statewide transportation modeling. As the conversion to the TransCAD modeling software is planned and implemented, multimodal modeling needs to be considered in the main software package, in micro-simulation models, or other additional modules that are used to supplement the basic modeling software.

### 5.2.3 The Incorporation of Multimodal Transportation Districts into the Broader Planning Framework

As MMTDs are implemented into the concurrency framework, the existing transportation planning framework will need to be coordinated with these districts. The MMTDs may overlap with other concurrency and land use/transportation assessment tools (e.g. transportation concurrency exception areas, transportation concurrency management areas, and long-term concurrency management systems) but the methodologies of assessment and the overall goals for these designations may be slightly different. Similarly, the level of detail required for analysis of multimodal districts differs from what is currently used in regional travel demand models. This may cause confusion in the analysis and the conclusions drawn from those analyses. For example, once an area is incorporated into a transportation concurrency exception area, with a specific set of tools, can a local government impose a multimodal transportation district, which

has a more stringent set of rules?  How will MMTDs be coordinated with adjacent developments just outside of their boundary?

### *5.2.4 Institutional Framework for Transportation and Land Development Regulation*

Another related issue is the current restructuring of state agencies.  The Florida Department of Community Affairs (DCA) is currently being proposed for reorganization under the Secretary of State.  As a part of this reorganization, the role that the Department of Community Affairs takes with respect to growth management may change.  Even under the previous Secretary of the Department of Community Affairs, the direction of DCA was to engage in less oversight of the actions of local governments and to provide more technical assistance and to get involved when the State had a clear interest at stake.  Given that the State DOT does <u>not</u> have an explicit role in local land development decisions, how can it maintain its interest in maintaining the LOS on state highways?  The state may still want to assure that roads on the FIHS do not become congested by local traffic.  Thus the FDOT may have an interest in local governments engaging in good access management practice and requiring developers to design their improvements in a manner, like the MMTDs, that increase connectivity and reduce the impact of those new developments on adjacent state roadways.

### *5.2.5 The Measurement of Multimodal Level of Service*

Finally, we need to ensure that the tools that have been established for multimodal analysis in Florida measure what they are purported to measure and achieve the desired results.  Two major issues surface with respect to these tools: (1) the comparability of LOS measures across modes; and (2) the failure of these measures to incorporate demand-side variables.  A study by the Center for Urban Transportation Research (CUTR) reviews a variety of approaches to LOS measures and concludes that they are not directly comparable in several ways.  Glatting Jackson *et al*. (2001) reach a similar conclusion when they recommend the use of performance measures for Seminole County.  One major source of this difference results from the construction of the LOS measures, the BikeLOS, BusLOS and PedLOS all focus on supply side variables while the vehicle LOS incorporates both supply and demand when it compares volume to capacity on a roadway.

# 6 FUTURE DIRECTIONS FOR MULTIMODAL RESEARCH

As this issue paper has shown, the State of Florida has made significant progress in developing tools for multimodal analysis, but there are still many additional opportunities for further development of these tools. As Section 4 illustrates, many approaches exist, both within the state and nationally, to enhance the multimodal analysis tools used in the State of Florida. These tools will need to be developed in a manner that is consistent with the opportunities and the constraints within the transportation-planning environment in Florida. In this section, several areas for further research are identified based upon the findings in the earlier sections of this report. First, a general approach to additional multimodal research is identified and then detailed research ideas are identified. In each section, additional data collection needs are identified where applicable.[6]

## 6.1 Proposed Research

In Section 5, the authors of this paper outline several questions that the Florida Department of Transportation need to consider in deciding on how to incorporate the multimodal tradeoff analysis into existing transportation analysis tools in Florida. The authors of this issue paper cannot anticipate how any of these questions will be answered, but we have built our recommendations based upon a recommended approach to multimodal tradeoff analysis. Additional data needs will be identified as the FDOT makes decisions related to the development of MMTDs, multimodal tradeoff and new approaches to modeling. The research proposed below addresses two aspects of the multimodal tradeoff analysis: (1) the scope of analysis; and (2) two approaches to analysis – a generalized approach and a detailed modeling approach. The first of these concerns addresses the details contained in the existing proposed MMTDs, while the second addresses approaches to multimodal tradeoff analysis. Throughout the identified research projects, the research team has also identified areas in which the Florida DOT can support the national research agenda on multimodal analysis. Support of the national research agenda would provide a benefit to the state in extending and leveraging the value of existing multimodal research that is specific to Florida.

## 6.2 Scope of Multimodal Analysis

As currently defined, the MMTD should have a minimum area of 2 square miles, a minimum residential population of 5,000, a ratio of population to jobs of 1:2, provide scheduled transit service and have pedestrian connectivity that includes 50 polygons per square mile. The appropriate mix of land uses should include three or more significant land uses, such as retail, office, residential, hotel/motel, entertainment, cultural, and recreational, that are mutually supporting and also include a physical and functional integration of project components, such as connected and continuous pedestrian facilities (FDOT 2003).

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[6] Some of the research team is involved in another project called, *Future Directions for Multimodal Areawide Level of Service Handbook Research and Development*. The purpose of that contract is to develop tools for the analysis of Multimodal Transportation Districts. As such, some of the research proposed here overlaps with that research and data requirements. To the extent that the data needs are being identified in that contract, they will not be discussed in the recommendations of this report.

The LOS measures used in the MMTD are also defined by the Highway Capacity Manual (Transportation Research Board 2000), Multimodal Transportation Districts and Areawide Level of Service Handbook (FDOT 2003), the Pedestrian Level of Service Model (FDOT 2003), the Bicycle Level of Service Model (FDOT 2002), and the Transit Capacity and Quality of Service Manual (Transportation Research Board 1999).

Because these LOS methodologies are relatively mature, the research should look to expand the scope of multimodal tradeoff analysis to incorporate other important types of developments and analysis tools that are not used for MMTD. In particular, the following areas of research are proposed to address the scope of multimodal tradeoff analysis: (1) assessment tools for Developments of Regional Impact (DRIs); (2) assessment of districts of less than 2 square miles in size; (3) development of standards for multimodal assessment near schools; (4) alternative approaches to multimodal LOS analysis; and (5) the incorporation of parking availability and pricing into the MMTDs and multimodal tradeoff analysis.

### 6.2.1 Assessment Tools for Developments of Regional Impact

The first proposed research area discussed would address the concern that the analysis of the MMTDs has been based upon an assessment of existing urbanized areas, and therefore yields misleading results for new developments. Thus far, areas in Gainesville, Orlando, and DeLand have been evaluated for their potential for MMTDs. The development pattern in these locations stands in contrast to the large-scale new development that is occurring on the suburban fringe throughout much of Florida. Yet, the MMTDs and Areawide Level of Service Handbook (FDOT 2003) indicates that MMTDs may be established both in areas that are already developed and in new proposed developments outside of traditional municipal areas. Because of the scale of these projects, the MMTDs would apply exclusively to Developments of Regional Impact (DRIs). Many DRIs have a lower density of development, less connectivity, and little or no transit service even if they have a good mix of land uses.

Thus this research project would consider a sampling of DRIs that meet the requirements of an MMTD: a minimum area of 2 square miles, a minimum residential population of 5,000, and a ratio of population to jobs of 1:2. Based upon an initial analysis, a much smaller number of DRIs would be selected for a complete analysis of the multimodal potential of these developments. This research will use existing empirical data that has been used for the site impact assessment and other tools for multimodal analysis. A part of this contract would be to understand the ways in which the data collection and analysis should differ for MMTDs when they are DRIs at the urban fringe compared to infill and redevelopment projects.

### 6.2.2 Development of Multimodal Analysis Tools for Projects of Less Than 2 Square Miles In Size

This proposed research would address the concern that the MMTD requires an area in excess of 2 square miles. While this scale of development is appropriate for planning for multimodalism, the vast majority of projects, and a significant source of new development in Florida, are in projects that do not meet the threshold for developments of regional impact (DRI) or the minimum 2 square miles required for a MMTD. The average size of existing DRIs is between 500 and 700 acres (Jackson 2003) and several of the existing TCEAs cover areas of less than 2 square miles.

Developers are increasingly seeking multimodal options to reduce or eliminate the anticipated impacts of projects of various sizes on the transportation network. Traffic impact analysis reviewers within the Department of Transportation, Department of Community Affairs and local governments are challenged to figure out how to implement multimodal solutions when no tools exist to carefully plan these smaller areas. The proposed research will develop alternate conceptual frameworks and tools for the analysis and planning of development projects that are of large enough scale to have a significant impact on the transportation network but are too small to qualify as MMTDs. A part of this project will be to understand and develop tools for data collection and analysis of these smaller projects and to establish thresholds for the applicability of these various tools (e.g., areas may need to meet a specific population or density threshold). It is anticipated that this analysis would use existing sources of data that are currently being used for the assessment of MMTDs.

### 6.2.3 Standards for Multimodal Assessment Near Schools

The current MMTDs and Areawide Level of Service Handbook recommends a higher standard of LOS for alternative modes of travel along corridors leading to schools that are located within MMTDs. The need for an even higher standard can be understood when the Handbook is considered in conjunction with safety programs of the FDOT, such as the Safe Ways to Schools (SWTS) program (FDOT n.d.). Under the SWTS program, schools are encouraged to develop a plan to improve the pedestrian and bicycle facilities along routes that lead to the school. The goal of the MMTD should be to provide a safe environment in which children can walk or bicycle to school by reducing the volume and speed of automobiles in these special zones within the MMTDs, and by providing walking facility networks.

This research project would assess the special requirements for zones around schools and make recommendations for specific standards to be applied based upon the need to provide a safer environment for young children. This project will use the materials and the data collections techniques developed by Dr. Linda Crider as a part of her Safe Ways to School project. Given the national interest in providing safe environments for children who walk and bicycle to school, the research team recommends that FDOT support ongoing national research efforts in this area.

### 6.2.4 Alternative Approaches to Multimodal Level Of Service Analysis

The LOS standards used in the assessment of automobile LOS in the MMTD are based upon the Highway Capacity Manual (Transportation Research Board 2000) and FDOT's 2002 Quality/Level of Service Handbook (FDOT 2002). Thus, in Florida communities, the roadway LOS is calculated in a similar manner even if local governments set different LOS standards or establish roadway segments in a different manner. In contrast, in Washington State, local governments have used a variety of approaches to measure the roadway LOS. As is discussed in Section 4.3.5, these approaches include: (1) travel delay; (2) average vehicle operating speed; (3) screen lines rather than intersection or link LOS; (4) requirement that arterials serving new development meet certain design standards; (5) person throughput or person carrying capacity; (6) transportation facilities (streets, intersections, or both) that are built out are not included in concurrency calculation; and (7) regional concurrency systems. Similarly, Winter Park and

Seminole County, Florida and Montgomery County, Maryland have developed alternative methodologies to assess the level and quality of service as a part of their concurrency system.

Some of these various methodologies have the advantage of being more easily understood by a lay audience, or they reflect a more intuitive approach to measurement of the LOS. This research proposal would analyze the applicability of these measures to the Florida context. The FDOT will need to provide direction that they want to pursue these alternative methods to capacity-based measures of automobile LOS. The FDOT is a national leader in the area of multimodal LOS measures, analysis techniques and software, and supports the national research effort in this area to develop and test, under the National Cooperative Highway Research Program Project 3-70, a framework of enhanced methods for determining levels of service for automobile, transit, bicycle and pedestrian modes (NCHRP 2003b). We recommend that FDOT continue to support national research that builds on the state research to develop methods of multimodal analysis.

### 6.2.5 Incorporating Parking Policies into Multimodal Analysis

Parking availability and pricing have long been considered an important factor in the decision to use alternative modes of transportation (Shoup 1995, Ewing and Cervero 2001, Wachs 2003). Constrained or highly priced parking has a strong influence on mode choice especially where alternatives are available. The purpose of MMTDs is to encourage the use of alternatives to the automobile. Yet, the MMTDs and Areawide Level of Service Handbook (FDOT 2003) does not explicitly incorporate policies on parking availability and pricing into its analysis and planning.

In this proposed project, prior research on parking and its connection to mode choice will be researched and recommendations for how parking policies would be incorporated into MMTDs and multimodal tradeoff analysis. Examples of successful parking strategies, such as shared parking, parking pricing, and alternatives to minimum standards, in support of multimodal planning will be identified and reviewed for their applicability for multimodal analysis in Florida.

### 6.3 Approaches to Multimodal Tradeoff Analysis

In addition to understanding the scope of the MMTDs, approaches to the tradeoff analysis itself need to be addressed in additional research. The research team recommends that the State of Florida work towards a system similar to Portland's SDC. Such an approach provides a comprehensive and coordinated methodology that integrates transportation and land use with transportation modeling and the charging of impact fees. While such an approach represents a long-term goal, it is recognized that such a system will be developed through a series of incremental steps that accommodate the diversity of situations in Florida communities and regions. The research team would propose two overlapping approaches, a simplified, or generalized approach, and a more detailed, elaborate approach. These two suggested approaches are somewhat parallel to the approach taken in the Highway Capacity Manual (Transportation Research Board 2000) and FDOT's 2002 Quality/Level of Service Handbook (FDOT 2002). The generalized approach would include sketch planning tools, spreadsheet applications, and

look-up tables to address the multimodal tradeoff.  The detailed modeling approach would incorporate the multimodal tradeoff analysis into existing and proposed analysis tools, such as the Site Impact Assessment, the FSUTMS modeling and other modeling approaches, and the Fiscal Impact Assessment.  In this section, research needs are identified for these two approaches.

### 6.3.1 Generalized Approach to Multimodal Tradeoff Analysis

The research team recommends that the Smart Growth INDEX, and other approaches currently in use by other local governments, be explored for their applicability as a generalized approach to multimodal tradeoff analysis.  Any such approach would need to be consistent with the detailed approach taken to provide multimodal tradeoff analyses.  In this project, several different approaches have been identified ranging from the smart growth INDEX to the multimodal planning approaches used in Ft. Collins, Colorado, Davis California, and Montgomery County Maryland.  The GIS-based Smart Growth INDEX (INDEX) provides a valuable tool for evaluating various aspects of multimodal districts.  This tool utilizes many indicators, such as population density, employment density, vehicle trip information, as well as pedestrian connectivity, which could potentially be modified to suit multimodal districts.  One of the main advantages of the INDEX is that it is fully automated.  Once all the data is collected it is simply entered into the application where it is then evaluated.  This eliminates the need to make calculations.  Additionally, because the application is GIS-based, it is possible to graphically view the results of the analysis.  Instead of inputting the data and then creating GIS maps after the fact, the user can integrate both steps into one, substantially cutting down on time.

In order to use the applications with multimodal districts, the INDEX must be modified for all of the specific parameters according to the multimodal handbook.  The developer, Criterion Planners/Engineers, has used the INDEX in a variety of applications in cities such as Palm Beach, Orlando, Tampa, and Atlanta, and could potentially modify the application to be used for multimodal districts.  According to Ewing and Cervero (2001), the INDEX program also has incorporated elasticities of demand to reflect the tradeoff between driving and other modes of travel.

This research project would analyze the applicability of the Smart Growth INDEX to the analysis of MMTDs and the multimodal tradeoff analysis.  In addition, the applicability of the INDEX program as a generalized tool would be considered.  Its basis in GIS technology may be an impediment to its general use, but this may be balanced by the appropriateness of the results to the multimodal tradeoff analysis.  The additional data needed to implement the approach if it were adopted, will be identified as a part of this proposed project.

In addition to the INDEX software, other methodologies that are used in a generalized approach should be documented and analyzed for their applicability to multimodal tradeoff analysis and their compatibility with the detailed approach to multimodal tradeoff analysis.  This report has referenced the programs undertaken by local governments in Fort Collins, Colorado, Davis, California and Montgomery County, Maryland that are seen as models for implementation of multimodal planning.  These three cases were not studied in sufficient detail

to determine if and how they conduct multimodal tradeoff analysis but they certainly are worthy of additional investigation.

### *6.3.2 Detailed Approach to Multimodal Tradeoff Analysis*

The detailed approach to multimodal tradeoff analysis will be used to incorporate the analysis into the existing tools used by the FDOT and local governments. Several research projects are proposed in this section that address the weaknesses in the existing site impact assessment and transportation modeling in Florida. These research proposals, which are described below, include: (1) incorporation of MMTDs into the site impact assessment process; (2) data collection for the evaluation of multimodal districts; (3) incorporating multimodal analysis into planning model structure; (4) use of microsimulation for multimodal tradeoff analysis; and (5) fiscal impact analysis for MMTDs.

#### 6.3.2.1 Incorporation of Multimodal Transportation Districts into the Site Impact Handbook

This proposed research will recommend implementation strategies for the integration of MMTDs into the site impact analysis handbook. The recommendation will subsequently form the basis for a training module that incorporates MMTDs into site impact analysis. Additionally, data collection needs will be addressed as a part of this project.

As is discussed in Section 3.1, the site impact assessment is important for a number of different reasons, the most important being that it will ensure that state transportation systems impacted by a proposed development will continue to operate at an acceptable LOS. This is especially important if the facility is part of the SHS and especially the FIHS. Additionally, site impact assessment allows local governments to ensure that proposed development is consistent with local government comprehensive plan goals and objectives including the future land-use map elements. The FDOT has explicitly addressed three situations in which a site impact analysis review is required: Development of Regional Impacts (DRIs), LGCP reviews, and other types of reviews such as campus master plans (CMPs), military base reuse plans or requests for access to roadways on the State Highway System.

The Site Impact Handbook addresses mandatory analysis and review requirements, offers guidance to agencies on when FDOT will be conducting these reviews and identifies how these reviews will be conducted. The handbook creates a framework of basic processes that should be followed for all site impact analyses. This framework consists of eleven steps including: methodology development, existing conditions analysis, background traffic, trip generation (including internal capture and pass-by rates), trip distribution, mode split, assignment, future conditions, mitigation analysis, site access and parking, review and permitting. The site impact training and the FDOT Site Impact Handbook do not currently incorporate consideration of the multimodal LOS and quality of service measures and the requirements for MMTDs. This proposed research would address this need.

6.3.2.2 Data Collection for the Evaluation of Multimodal Transportation Districts

A key problem in evaluating the impacts of MMTDs is the lack of data available about such developments. Additional information is needed about the travel patterns associated with those types of developments to facilitate the creation of analysis tools to better evaluate the impacts of those types of developments. In particular, mode choice coefficients and trip generation rates for non-motorized travel for different types of developments, different land use and transportation configurations, and different areas of the state are needed to accurately predict the impact of proposed developments.

As was discussed in Section 5.2, an ideal research design would begin to document the differences in travel behavior in conventional suburban development and New Urbanist communities. Such a study would make a paired comparison of trip generation and mode splits in a conventional suburban development and a New Urbanist development, including internal capture, pass-by trips and trip generation by non-motorized modes of transportation. However, while this study would provide a new set of information, it would not provide complete information on the impact of alternative land use and transportation configurations in a wide variety of circumstances. The Florida Department of Transportation should support efforts at the national level to conduct research that is consistent with the goals of better documenting the internal capture, pass-by trips, and trip generation associated with different patterns of land development.

The objective of the research proposed here would be to develop a database of information about travel characteristics associated with MMTDs through case studies of different socio-economic groups within a variety of existing multimodal environments in Florida. Many Metropolitan Planning Organizations (MPOs) and FDOT District Offices already collect travel data from travel surveys and other data collection techniques. The purpose of this study is not to create a new data collection effort by local agencies, but rather to create a standardized format for inclusion of data on multimodal travel and various multimodal environments into existing and on-going data collection efforts of these agencies. The research will recommend guidelines and standards for collecting and maintaining travel data and expand the knowledge base of information about internal capture and pass-by trips as they relate to various multimodal environments. This research would also make recommendations on the types of information to be collected and the methodologies to be used to collect data on the physical characteristics of various urban forms.

6.3.2.3 Incorporating Multimodal Analysis Into Planning Model Structure

Among the four steps in the typical transportation planning model structure, mode split is probably the most important step to review for multimodal analysis. Traditionally, mode split models focus on the choice among different motorized travel modes and the data collected for calibrating transportation planning models are usually in the form of trip diaries, where no specific efforts are made to record trips by non-motorized mode. Additionally, the land use data that is entered into the transportation models is not sensitive to differences in land use configurations.

To model properly the performance of a multimodal transportation system, it is essential to have the capability to explain and estimate the choice from a more extensive set of available

modes. Both motorized modes and non-motorized modes, such walking and bicycling should be included in the mode choice models.

A critical issue in trying to include these non-motorized modes in the models is defining what constitutes a trip by each mode. Households filling out traditional travel surveys do not usually count such trips in their trip diaries (because they are usually short trips and are not significant). Travel surveys in the form of activity diaries is a good alternative since people are asked about their daily activities and short walking/bicycle trips that are usually ignored in a travel survey can be expected to be recorded when people are asked to recall/record their trajectory through the day.

Similarly, the supply side characteristics have a significant impact on the choice of the mode. The typical information collected (such as origin and destination, start and end time, and mode of the trip) needs to be obtained about the surrounding environment for the non-motorized trips. Such information includes (but is certainly not limited to): existence of sidewalk/bicycle lanes, the traffic condition on the street (busy traffic vs. light traffic), size of a city block, comfort measure (for instance, shade trees along the sidewalk), presence of other pedestrians/bicycles.

Another research direction is to study their transferability to the Florida context. There have already been research activities to estimate mode choice models that include both motorized and non-motorized modes, and if the transferability of these models can be determined, much of duplication of effort can be eliminated.

The objective of this research would be to identify the issues associated with the incorporation of alternative mode choices in multimodal environments into the transportation-modeling framework. This research should identify the modeling needs for MMTDs and how multimodal tradeoff analysis can be incorporated into the modeling framework. As such, the project team also recommends that the Statewide Model Taskforce ensure that TransCAD is implemented in a manner such that the need for multimodal planning and analyses is accommodated. FDOT should request that the Statewide Model Taskforce establish a subcommittee to provide technical reviews and recommendations about the development of analytical tools and a process for evaluating multimodal districts. Furthermore, the FDOT should support efforts to incorporate multimodal analysis into the existing four-step modeling process.

6.3.2.4 Use of Microsimulation Models for Multimodal Tradeoff Analysis
As was discussed in Section 4.2.1, different traffic simulation models/packages have different capabilities and limitations. Different microsimulation software packages have been evaluated regarding their role in regional transportation planning. However, there has not been much effort in trying to understand how these software packages can be used for understanding the performance of multimodal transportation systems, especially those with heavy pedestrian and/or bicycle trips.

Since a microsimulation model simulates the movements of individual vehicles, it places high demands upon a computer's processor and memory. As a result, the size of the network the

model can accommodate is usually limited. Many software evaluations have focused on the size of the network a traffic simulation package can handle. Since a MMTD is typically of a small scale, a traffic study using microsimulation techniques can be carried out in two steps that can be built into a toolbox for multimodal analysis. In the first step, a larger area that encompasses the MMTD under evaluation is studied to get the movement volume to be used as the demand for the district. In the second step, traffic operations in the district are simulated with the microsimulation model to obtain detailed performance measures, such as travel times, link flows, levels of service for different modes.

Other criteria used in existing software package comparison studies include the software's capability to allow calibration with local data, the complexity associated with data file management, etc., which are all relevant concerns for multimodal analysis. However, one of the most important questions to be answered in multimodal analysis – if the software has the ability to model a multimodal network with non-motorized trips – has not been addressed in depth. As a direction for future research, a study should be completed that compares different simulation packages in the context of multimodal transportation system analysis and emphasizes the ability to model bus, bicycle, and pedestrian movements and their interactions.

To build a microscopic simulation model, detailed information about the supply and the demand needs to be collected. The required data vary with the simulation package for the analysis, but for most packages, the specific data needs to be collected. On the supply side, the data include information about the street network including the connectivity of roads and intersections, length of link segment, number of lanes, lane widths, existence of parking on the side of the street, existence of turning lanes, traffic control at intersections (stop sign vs. traffic signal), signal timing, and control of turning movements (prohibited left/right/U-turn). On the demand side, the amount of demand, categorized by vehicle type (car, bus, truck, etc), needs to be obtained. If the simulation package does not have routing capability, then the movement at intersections needs to be collected so that the appropriate percentage of traffic can be allocated to each movement.

6.3.2.5 Development of a Fiscal Impact Analysis Application for Multimodal Transportation Districts

The essential component of multimodal tradeoff analysis is the ability to compute the costs and revenues associated with various land development alternatives. As was discussed in Section 4.3.7, the framework for multimodal tradeoff analysis does not appear to have been incorporated into the Fiscal Impact Assessment Model that was developed for the Florida Department of Environmental Protection.

The purpose of this project will be to complete a detailed analysis of the existing Fiscal Impact Assessment Model and determine if multimodal tradeoff analysis can be completed with the existing tool, or, in the likely event that the project team's initial assessment is correct, determine another methodology to incorporate fiscal impact assessment of land development alternatives into the existing transportation modeling framework. One approach may be using the ULAM model, which is currently used to evaluate the transportation impacts of various alternative land development patterns and how changes in land use policies might impact the need and cost for additional transportation facilities. A comprehensive fiscal impact assessment

would also identify costs for other forms of infrastructure and public services, including transportation, water and sewer, schools, parks, police, fire and emergency medical services. The application would be used to identify possible funding sources for all forms of infrastructure, including capital and operating expenses. Potential funding sources might include impact fee revenues, special taxing districts, and potential increased property tax revenues around transit stations and other facilities.

The Fiscal Impact Assessment will need to incorporate a wider range of data than is currently available in the FSUTMS model. The current land use model techniques are based upon traffic zones and the six land use classifications used by the FSUTMS model. Once the variables needed to evaluate multimodal districts are identified, the land use modeling applications currently in use in Florida, such as ULAM, will need to be modified to provide the tools necessary to analyze the impact of a greater variety of land uses. Those tools also need to be modified to help evaluate where multimodal districts can be incorporated into potential redevelopment areas.

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## APPENDIX A – LIST OF ABBREVIATIONS

CBD        Central Business District
CIP         Capital Improvements Plan
DCA        Department of Community Affairs
DRIs       Development of Regional Impact
DTA        Dynamic Traffic Assignment
EPA        Environmental Protection Agency
ETAT      Environmental Technical Advisory Team
ETDM    Florida's Efficient Transportation Decision Process
FAC        Florida Administrative Code
FDOT      Florida Department of Transportation
FIAM     Fiscal Impact Analysis Model
FIHS      Florida Intrastate Highway System
FSA        Florida Statutes Annotated
FSUTMS  Florida Standard Urban Transportation Model Structure
GMA       Growth Management Act
HBO        Home-Based Other
HBW       Home-Based Work
ITE         Institute of Transportation Engineers
LDR        Land Development Regulations
LGCP      Local Government Comprehensive Plan
LOS        Level of Service
MMTA     Multimodal Trade-Off Analysis
MMTD    Multi Modal Transportation District
MPO        Metropolitan Planning Organization
NCHRP    National Cooperative Highway Research Program
NHB        Non-Home Based
PEF        Pedestrian Environment Factor
PMT        Person miles traveled
Q/LOS     Quality/Level of Service
RAI         Real Accessibility Index
SDC        System Development Charges
SHS        State Highway System
SWTS     Safe Ways to Schools
TAZs      Traffic Analysis Zones
TCEA     Transportation Concurrency Exception Area
TCMA    Transportation Concurrency Management Area
TDM       Transportation Demand Management

| | |
|---|---|
| TND | Traditional Neighborhood Development |
| ULAM | Urban Landuse Allocation Model |
| VHT | Vehicle hours traveled |
| VMT | Vehicle miles of travel |

**APPENDIX B - OVERVIEW OF THE FOUR-STEP TRANSPORTATION MODELING PROCESS**

The Florida travel forecasting package FSUTMS is based upon the traditional four-step modeling process. The four-step process includes trip generation, trip distribution, mode choice and travel assignment. A general overview of each of these four steps is explained below.[7]

**B.1 Trip Generation**

Trip generation may be defined as the study of the relationships between the number of trips made in an area and characteristics of the area such as land use, population, employment and other economic activity measures. Trip generation models predict urban trip making behavior by translating urban activity characteristics into numbers of trips. Trip generation provides the link between land use and travel, which is essential to the transportation planning process. Trip generation is the first, and in many respects, the most influential stage in simulating travel behavior. Because it attempts to predict human behavior on the basis of socioeconomic variables, themselves the products of uncertain forecasting techniques, trip generation can be prone to error.

The desired end product in trip generation analysis is an accurate identification and quantification of trip ends beginning and ending in each traffic analysis zone within a transportation study area. Thus, two sets of trip ends are identified: those produced by each zone and those attracted to each zone.

Trip generation modeling would be easier to grasp if the models were simply required to estimate the total number of trip ends. The Institute of Transportation Engineers (ITE) Trip Generation manual, for example, provides rates and equations to estimate total trip ends by land use category (ITE 1997). Trip generation in a modeling context, however, must estimate the number of trip ends within several trip purpose categories. This complication is necessary because trip purpose is critical to the accurate prediction of travel behavior in steps following trip generation.

UTPS and the earlier FHWA PLANPAC packages did not provide any specific trip generation programs; many of today's transportation modeling systems provide only limited trip generation capabilities without use of a user-provided supplemental program. TRANPLAN provides for only the most simplistic trip rate analysis. Most trip generation models can be categorized into one of three different types:

**Regression analysis,** which relates trip ends to the land use and socioeconomic characteristics of the traffic analysis zones in the study area. Regression analysis is usually based on data from origin-destination surveys that have been aggregated to traffic analysis zones.

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[7] The contents of this appendix are taken from the Florida Department of Transportation *Documentation and Procedural Updates to the Florida Standard Urban Transportation Model Structure (FSUTMS)* (FDOT 1997).

**Cross-classification**, which classifies trip ends by characteristics of the households or dwelling units in the study area. Cross-classification uses origin-destination data at the dwelling unit level and is referred to as a disaggregate technique.

**Trip rate analysis**, which relates trip ends to factors such as land use, floor area, or employment. The trip rate method is also a disaggregate technique.

## B.2 Trip Distribution

Once productions and attractions have been identified through the trip generation process, production and attraction trip ends are used to generate actual trips. A trip distribution model simulates the attraction zones for trips produced in a particular area. The result is a table showing trips among all possible production and attraction zones.

In deciding how many trips will go from one zone to another, the trip distribution model uses two factors: relative attractiveness of, and accessibility to, all possible attraction zones. The number of attraction trip ends in a zone measures attractiveness for each purpose analyzed. Accessibility is measured by highway travel times to zones. These variables assign the greatest proportion of trips from a zone to those nearby zones with many attraction trip ends.

Most trip distribution models can be categorized into one of three different types:

**Growth Factor** or **Fratar Models** are used to project existing travel patterns into the future based on an origin-destination survey. This technique is more commonly used to forecast external trip-making patterns.

**Intervening Opportunities Models** use a probability concept that, in essence, requires that a trip remain as short as possible, lengthening only as it fails to find an acceptable destination. This approach, originally developed as part of the Chicago Area Transportation Study, is not commonly used.

**Gravity Models** are based on the premise that trips produced in any given area will distribute themselves in accordance with the accessibility of other areas and the attractions they offer. The Gravity Model, is the most commonly used approach for trip distribution.

The gravity model formulation is based upon the hypothesis that the trips produced at an origin and attracted to a destination are directly proportional to the total trip productions at the origin, the total trip attractions at the destination, a calibrating term (friction factors), and possibly a socioeconomic adjustment factor (K-factor).

The spatial separation between zones can be measured by one of several parameters. These include travel time, friction factors, and socioeconomic adjustment factors. The total travel time between zones is the sum of the minimum path driving time between zones plus the terminal times at both ends of the trip. Intrazonal driving times must also be estimated. The minimum path driving time between each pair of zones is obtained by the path building process.

Friction factors ($F_{ij}$) express the effect that spatial separation exerts on trip interchange. Friction factors indicate the impedance to interzonal travel due to spatial separation between zones. In effect, these factors measure the probability of tripmaking at each one-minute increment of travel time.

The remaining input to the gravity model formula reflects the effect on travel patterns of social and economic characteristics of particular zones or portions of the study area. These are represented by the zone-to-zone socioeconomic adjustment factor ($K_{ij}$). These factors reflect the effects on travel patterns of social and economic characteristics, which are not otherwise accounted for in the use of the model. If found to be necessary, they should be quantitatively related to socioeconomic characteristics of the particular zones to which they apply. It is necessary to relate the adjustment factors to characteristics of the zones so that they may be forecast as a function of the socioeconomic conditions estimated for the future land use plan. Although the gravity model provides for these adjustments, K-factors are used somewhat infrequently.

## B.3 Mode Choice

"Mode choice" determinations specify which trips between zones use which modes (e.g., car, car pool, bus). Mode usage is also accomplished during trip generation in some models. At that point it is called pre-distribution mode usage. The split of trips among modes depends on three general categories of factors: characteristics of the trip maker, characteristics of the trip, and characteristics of the transportation system. Trip maker factors often considered are income and auto availability. Common characteristics affecting mode choice are time of day and trip purpose. Important characteristics of the transportation system are travel times for modes, quality of public transportation service, and the costs of parking, operating an auto, and riding transit. Following is a summary of two types of models, logit and probit, that are often used.

**Multinomial Logit Models**: Logit models are based on the assumptions that the different modes possess the independence of irrelevant alternatives (IIA) property. This type of model is easy to calibrate and to use, however, the problem with the IIA property is that the alternative modes included in the choice set are independent of each other, (i.e., they do not share any common characteristics). For traveler's mode choice modeling, this is a very strict assumption. For instance, the mode choice between bus and light rail – although they use different networks so their travel time/cost can be viewed as being independent of each other, however, they share some common characteristics since they are both public transit. Nested logit models have been proposed to solve this problem.

**Multinomial Nested Logit Models**: In nested logit models, different modes are grouped based on the characteristics they share in common and then put into different nests. In this structure, the modes in the same nest do not need to be absolutely independent of each other. For instance, if car, bus, and light rail are the three alternatives that a traveler has, then bus and light rail can be grouped together and put in a "public transit" nest, while car will be in a nest that is parallel to the "public transit" nest. There are other more advanced logit models, such as Paired Combinatorial Logit Models, but they are not commonly used.

**Multinomial Probit Models**: In a probit model, the error terms are assumed to follow multinomial normal distributions. The resulting models do not have an analytically closed form and thus their implementations are usually computationally expensive and hard to trace.

## B.4 Trip Assignment

Trip assignment is the process that assigns mode use between zones to paths in the highway and transit networks. Transit and highway trips are assigned separately using transit person and auto vehicle trip tables developed during mode choice analyses. The assignment process uses the shortest time paths between zones and assigns zone-to-zone transit or auto vehicle trips to all links occurring on that path. The results are the numbers of vehicles on each roadway link and of passengers on each transit link.

Traffic assignment models can be categorized into one of five different types, which are summarized in the following:

**All-or-Nothing** trip assignment is where trips are loaded onto the minimum cost paths of the network based on free-flow traffic condition. Since the minimum cost paths will most likely become congested with the assigned flow and this method does not take that into consideration, the assignment results it provides are typically not a good representation of the real flows on the network.

**All-or-Nothing Capacity Restraint** trip assignment is where the trips are loaded the same as the All-or-Nothing technique except that the time parameter is adjusted link by link according to user-specified volume/capacity time adjustment curve data or the standard Bureau of Public Roads (BPR) capacity restraint formula.

**Incremental** trip assignment is where, for each iteration of trip loading, a user-specified percentage of trips is loaded on the minimum paths during each iteration. As with the All-or-Nothing Capacity Restraint trip assignment method, link-by-link time adjustments are accomplished according to user-specified volume/capacity speed adjustment curve data or the standard BPR capacity restraint formula. For each iteration, the function has the capability of adjusting link times on the initial base network or on the network used for the previous iteration.

Using different assumptions on traveler behavior, traffic assignment produces different equilibrium flow patterns. **User equilibrium** is the most commonly used assumption where the theory is every traveler is seeking the best possible path for him/herself and will switch to another path if it is better than the current one. Thus at equilibrium, the used path(s) between a certain origin-destination (O-D) pair all have the same cost. Using the Frank-Wolfe decomposition algorithm typically solves the user equilibrium. It involves running several iterations of all-or-nothing capacity restraint assignment with an adjustment of travel time reflecting delays encountered in the previous iterations. The load from each assignment after the first iteration is combined with the previous load in such a way as to optimize the objective. This assignment is multi-path since the minimum cost path changes during the iterations because of the time adjustments after each iteration.

**Stochastic** trip assignment is an equilibrium assignment performed with the assumption that travelers choose their paths based on perceived travel costs rather than the actual costs. The equilibrium principle still holds, meaning that travelers will still try to use the minimum cost paths, although the costs now are considered with some randomly distributed error terms. Because of the random terms in the cost structure, the Frank-Wolfe algorithm used for user equilibrium assignment cannot be used for stochastic assignment. Typically, the method of successive averages (MSA) is used, where at each iteration, trips are loaded on to the perceived minimum cost paths using all-or-nothing assignment, and the result is then combined with the result from the previous iteration using a preset ratio.

In the context of modeling a regional network, equilibrium assignment produces acceptable results on highways and major arterials; however, when a small local network needs to be studied in detail, it is not enough to simply use a more detailed network representation that includes all the local streets with the user equilibrium assignment procedure, because doing so will probably generate link volumes that do not match the observed data on the network. The reason for the discrepancy is mostly due to the fact that travelers do not always take the shortest paths possible, especially when the cost differences among paths are small. Stochastic assignment could be a good alternative to the strict equilibrium assignment model since it can reflect some of the randomness in travelers' route choice behavior. The challenge is to find the appropriate representation for the error term for travelers' perception of link travel costs.

**APPENDIX C - THE FLORIDA TRANSPORTATION MODELING PROCESS**

The FSUTMS software used in Florida is based upon the traditional four-step modeling process. There are variations in the way these steps are applied in different areas of the state depending on the physical, economic and demographic characteristics in that particular urban area and the type of transportation facilities available.[8] The way in which the four-step model is applied in Florida and the special variations developed for specific urban areas in Florida is explained below.

**C.1 Florida Trip Generation Models**

The FSUTMS standard trip generation model uses a combination of cross-classification and trip rate analysis. The cross-classification technique is used to generate home-based trip productions for the following four trip purposes:

➢ Home-based Work
➢ Home-based Shopping
➢ Home-based Social/Recreation
➢ Home-based Other

The trip generation model requires trip rate analysis for generation of trip attractions for the home-based trip purposes listed above and for the remaining three FSUTMS trip purposes:

➢ Nonhome-based
➢ Truck-Taxi
➢ Internal-External

Some urban area and regional models such as Tampa Bay have been expanded to include additional trip purposes such as Light Truck, Heavy Truck, Airport Trips, and University Student Trips.

The model requires four socioeconomic data files as input. These are named as follows:

➢ ZDATA1 -- Trip Production Data
➢ ZDATA2 -- Trip Attraction Data
➢ ZDATA3 -- Special Generator Data
➢ ZDATA4 -- Internal-External Trip Productions

The standard ZDATA1 file contains socioeconomic data used to generate trip productions. As trips are generally produced at the home end of a trip, the ZDATA1 file is oriented toward housing and population data. The following data is contained in the ZDATA1 file: Single Family Dwelling Units (DUs), Percent Vacant & Non-Permanent DUs, Percent Vacant, Single Family Population, Percent 0 Autos per DU, Percent 1 Auto per DU, Percent 2+ Autos per DU, Multi-Family Dwelling Units (DUs), Percent Vacant & Non-Permanent DUs,

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[8] The contents of this appendix are taken from the Florida Department of Transportation *Documentation and Procedural Updates to the Florida Standard Urban Transportation Model Structure (FSUTMS)* (FDOT 1997).

Percent Vacant, Multi-Family Population, Percent 0 Autos per DU, Percent 1 Auto per DU, Percent 2+ Autos per DU, Number of Hotel Units, Percent Occupied Hotel/Motel Units, Total Hotel/Motel Occupants.

The standard ZDATA2 file contains socioeconomic data used to generate trip attractions. As trips are generally attracted at the activity end of a trip, the ZDATA2 file is oriented toward employment and school enrollment data. Employment data should reflect peak season conditions to be compatible with peak season dwelling unit estimates found in ZDATA1. The following data are contained in the ZDATA2 file: Industrial Employment, Commercial Employment, Service Employment, Total Employment, School Enrollment, Short Term Parking Cost, Long Term Parking Cost. Base year employment data used in the ZDATA2 file are often obtained through the Florida Department of Labor and Employment Security.

The ZDATA3 file contains special generator trips by traffic analysis zone. Special generators should be limited to traffic analysis zones (TAZs) with major or unique land use activities which generate trips at rates not reflected in the standard trip generation model equations. Provisions are made to accept either trip productions or attractions in ZDATA3. The following land use activities are considered appropriate for special generator applications:

- ➢ Colleges and Universities
- ➢ Large Regional Shopping Malls
- ➢ Regional Airports
- ➢ Military Bases
- ➢ Group Quarters (Dormitories, Barracks)
- ➢ Recreational Areas

The ZDATA4 file contains internal-external trip productions for each external traffic analysis zone. Internal-external trips are those trips with one trip end inside the study area and one trip end outside the study area.

### C.1.1 Life Style Trip Generation Models

The Florida Standard Urban Transportation Model Structure (FSUTMS) generates home-based trips using three cross-classifying variables -- household size, vehicle ownership, and dwelling type. Tampa Bay and Southeast Florida have selected an alternative "life style" model, which appears to better represent actual travel behavior than the FSUTMS model.

The concept of a *life cycle* is a simple one. Individuals and families pass through a series of distinct stages between birth and death. Rural sociologists were among the first to apply the concept; they found it useful in explaining changes in spending patterns and farming activities of rural families. Economists, marketing specialists, and demographers later adapted the concept to the modeling of labor markets, family expenditures, and population growth.

Application of the life cycle concept to travel forecasting dates back to the Detroit Transportation and Land Use Study of the 1960s, when life cycle stages were first distinguished in a set of trip generation models. From that time forward, life cycle models have been touted as

behaviorally oriented alternatives to conventional trip generation models.  Households at different stages in the life cycle have different activity patterns, auto ownership levels, and opportunities for trip trading and trip chaining among household members.  In theory, there should be a strong relationship between life cycle stages and the numbers and purposes of trips made.

Travel researchers have borrowed another concept from the social sciences, that of *life style*. Life style is a more inclusive term than life cycle.  A household's life style depends on its life cycle, but also on its social class, labor force participation, rural vs. urban residence, and many other factors.  The life style trip generation models that are used in the Tampa Bay Region and South East Florida are explained in the next two sections.

C.1.1.1 Tampa Bay Life Style Model
One of the major trip production enhancements in the Tampa Bay Regional Planning Model (TBRPM) is the "lifestyles" concept.  Users of the standard FSUTMS trip generation model had previously recognized that some of the characteristics of the Tampa Bay area, such as a large proportion of retired persons, were not distinguished in the model.  As a result, the standard trip generation model would often over-estimate the number of work trips for these households while under-estimating trips for other purposes.  This enhancement better reflects the demographic character of Tampa Bay.  All occupied dwelling units have been classified into four categories based upon lifestyle characteristics of their residents:

➢ Retired Households: Households that include at least one retired household member and no full-time employed household members.

➢ Working Households with No Children: Households, other than retired households, with no household members under the age of 16.

➢ Working Households with Children: Households, other than retired households, with at least one household member under the age of 16.

➢ Seasonal Households: Households whose residents live in the region more than one month, but less than 6 months per year.

The TBRPM trip generation model includes a refinement to the hotel/motel category.  Hotels are classified based on characteristics of occupants as well as available amenities. In an effort to reflect observed differences in hotel trip generation, hotel/motel room data included in the model were refined to include four categories, as follows:

➢ Resort hotels/motels: These cater primarily to tourists and vacationers.  They are generally located near the beaches or major tourist attractions.  The majority of guests at these hotels/motels stay for two or more nights.

➢ Business hotels/motels: These cater primarily to business travelers and convention delegates. They are usually located near major business centers.  The majority of guests at these hotels/motels stay for two or more nights.

➢ Economy hotels/motels: These cater primarily to "through" travelers looking for a place to spend the night, or to persons on a more limited budget.  They are generally lower priced than business and resort categories of hotels and motels.  While they may be located throughout the area, they are usually located along major travel routes, and are often clustered at freeway interchanges.  The majority of guests at these hotels and motels stay for only one night. As a result, these hotels and motels generally offer far fewer amenities than either resort or business hotels/motels.

➢ Resident hotels/motels: These hotels and motels generally serve permanent or seasonal residents.

As such, they function more like group quarters or retirement villages.  Generally, these hotels include efficiency kitchens and offer few, if any, on-site amenities, such as restaurants.

Tampa Bay's trip generation model is a simple life style model.  It captures one element of life cycle by distinguishing between households with and without children.  It also captures both householder age and employment status, albeit loosely, by distinguishing between retired and other adults.  On the negative side, Tampa Bay's model neglects three potentially significant life style determinants. It makes no distinction between family and non-family households, or between single parent and two-parent families, or between singles and childless couples.

## C.1.1.2 Southeast Florida Life Style Model

FDOT District 4, in association with the FAU/FIU Joint Center for Environmental and Urban Programs, completed a research project aimed at developing a trip production structure that can explain more in household trip rates than the existing FSUTMS trip production structure.  The research project concluded that a new structure, using the life style variables of Workers, Presence of Children, and Vehicle Availability, outperforms the existing FSUTMS trip production structure, which uses housing type, household size and auto ownership variables.  Based upon their research finding, the FAU/FIU team recommended the following household cross-classification structure to enhance the FSUTMS trip generation model:

➢ Workers: 0, 1, 2+ full time workers.
➢ Presence of Children: With or without children under age of 18.
➢ Vehicle Ownership: Defined as households with more cars than workers, or those with the same or fewer cars than workers.  Households in the first category always have an extra car available for home-based other trips, while those in the second category may not.

School trips have been divided in two broad categories in the South Florida Life Style model – public and private. Public schools are further divided into elementary, middle, and high school.  The initial set of school productions is calculated using the trip rates and socio-economic data.  Then the attractions at the school end are prorated to the home zones in proportion to the initial set of productions.  These prorated values become the public school productions for this school.  The differences between the initial set of school productions and the prorated public

school productions are considered as private school productions and are distributed by the gravity model.

## C.2 Florida Trip Distribution Model

Although various methodologies are available for trip distribution, Florida's urban areas use the gravity model. Gravity models vary between urban areas in the values of friction factors used in the distribution of trips. The gravity model formulation is based upon the hypothesis that the trips produced at an origin and attracted to a destination are directly proportional to the total trip productions at the origin, the total trip attractions at the destination, a calibrating term (friction factors), and possibly a socioeconomic adjustment factor (K-factor).

Finally, friction factors used in the Gravity Model are defined by minutes of travel time. Free-flow highway skims are revised to include intrazonal and terminal times prior to being input to the trip distribution model. Terminal time refers to the walk time required to travel from trip origin to auto and from auto to final destination. Intrazonal time is an estimate of the time required to travel across a given traffic analysis zone.

## C.3 Florida Mode Choice Models

FSUTMS mode usage (mode choice) models are post-distribution models. In FSUTMS, the function of the **MODE** module is related to the complexity of transit modeling in a given urban area. FSUTMS presently includes four alternative mode choice models: non-transit, single path transit, multi-path transit, and multi-period/multi-path transit processes. The mode choice alternative selected for application will determine which FSUTMS files and modules are required. Selection of the appropriate mode choice model is based on the extent of transit use in a particular area.

## C.4 Florida Trip Assignment Models

### C.4.1 Highway Assignment and Evaluation

The FSUTMS highway trip assignment model has used the equilibrium trip assignment technique both in its original mainframe (UTPS) and current microcomputer (TRANPLAN) configurations. The other types of trip assignment techniques are not considered standard FSUTMS processes.

In the context of modeling a regional network, equilibrium assignment produces acceptable results on highways and major arterials; however, when a small local network needs to be studied in detail, it is not enough to simply use a more detailed network representation that includes all the local streets with the user equilibrium assignment procedure, because doing so will probably generate link volumes that do not match the observed data on the network. The reason for the discrepancy is mostly due to the fact that travelers do not always take the shortest paths possible, especially when the cost differences among paths are small. Stochastic assignment could be a good alternative to the strict equilibrium assignment model since it can

reflect some of the randomness in travelers' route choice behavior.  The challenge is to find the appropriate representation for the error term for travelers' perception of link travel costs.

### *C.4.2 Transit Assignment and Evaluation*

Use of the single-path transit model would result in a single mode transit assignment for local bus service.  The multi-path transit assignment includes four separate transit loadings (peak local bus, peak line haul bus/walk access, peak line haul auto access, midday local bus).  Multi-period/multi-path transit assignments are performed for three peak and three midday modes (local bus, line haul bus/walk access, line haul auto access).  The model produces a series of tabular summaries on transit assignment results.  The FSUTMS TEVAL program calculates transit service ratios from coded headways and can be used to estimate the number of vehicles required to achieve coded headways. In addition to transit assignment evaluations, route structure summaries are also provided.

**APPENDIX D – DYNAMIC TRAFFIC ASSIGNMENT PACKAGES**

Dynamic Traffic Assignment (DTA) is introduced in an effort to better understand, describe, and forecast the system performance under time-dependent demand, roadway capacities that change constantly with time, as well as traffic management and control measures that vary throughout the day.  DTA can capture the dynamics of congestion formation and dissipation associated with traffic peak periods.  Numerous formulations and approaches have been introduced since the discrete non-linear programming formulation of DTA proposed by Merchant and Nemhauser (1978a,b).  The proposed approaches include simulation-based models and theoretical formulations in various mathematical forms, such as mathematical programming, variational inequality (VI), and control theory.  The theoretical methods (mathematical programming, VI, control theory) provide optimal solutions to the problem while for simulation-based models, there is no guarantee of convergence or optimality.  However, since simulation-based approaches have the advantage of being able to account for details in traffic control, network capacity and demand, they are being implemented in software packages for planning purposes.

In 1994, the FHWA R&D initiated a DTA research project to address complex traffic control and management issues in the information-based, dynamic Intelligent Transportation System (ITS) environment.  A deployable, real-time Traffic Estimation and Prediction System (TrEPS) as well as an offline, planning version (TrEPS-P) is developed under this project.  Two software systems, DYNASMART and DynaMIT, were developed under this contract at the University of Texas at Austin and the Massachusetts Institute of Technology, respectively (Mahmassani *et al*. 2003, Massachusetts Institute of Technology 2003).

TrEPS-P systems represent a new generation of tools to support transportation network planning and operations decisions in the ITS and non-ITS environments.  They combine dynamic network assignment models, used primarily in conjunction with demand forecasting processes for planning applications, and traffic simulation models, used primarily for traffic operational studies.  TrEPS-P describes the evolution of traffic flows that result from the travel decisions of individual trip-makers at different locations in a network over a given period of time.  TrEPS-P supports the evaluation of strategic and tactical planning decisions by identifying deficiencies in design and evaluating the impact of alternative courses of actions in the context of the broader set of policy objectives for the study area.  This enables the evaluation of a wide array of congestion relief measures, which could include both supply-side and demand-oriented measures.  Some typical applications of TrEPS-P include providing DTA as the tool at the traffic assignment stage of the four-step planning process, and assessing the impacts of traffic operations and control measures.

**D.1 Dynamic Network Assignment Simulation Model for Advanced Road Telematics (DYNASMART)**

DYNASMART-P is a state-of-the-art dynamic network analysis and evaluation tool conceived and developed at the University of Texas at Austin.  DYNASMART-P models the evolution of traffic flows in a traffic network, which result from the travel decisions of individual

travelers.  The model is also capable of representing travel decisions of travelers seeking to fulfill a chain of activities at different locations in a network over a given planning horizon.  Its applicability is primarily for urban and metropolitan networks that experience considerable congestion, especially during certain periods of the day.

An important feature of DYNASMART-P is its ability to represent the demand onto the network in the form of activity chains, and to specify the demand input in varying forms depending on the purpose of the application and local data availability.  There are two methods for preparing vehicle generation in DYNASMART-P.  The first method is to specify origin-destination (OD) matrices among origin-destination zones at different demand intervals. DYNASMART-P loads vehicles according to their departure intervals and simulates them until each vehicle reaches its destination.  The second method is to specify the characteristics of all vehicles and their corresponding travel plans, which might include visiting more than one destination (trip chaining).  DYNASMART-P loads and then moves the vehicles in the network until they reach the final destination in the travel plan.

Due to the micro-simulation of individual trip-maker decisions, detailed representation of the network and control elements, and efficient hybrid traffic simulation approach, DYNASMART-P allows for consideration of an expanded set of measures compared to both conventional static assignment models and traffic simulation tools, and thus it can be used to evaluate an array of strategic and operational network planning decisions.  However, although DYNASMART-P is able to consider multiple user classes in the simulation, the user classes here are defined as vehicles with different operational performance (for instance, buses vs. passenger cars), and it is still a system that is designed to evaluate the network performance under vehicular movements.

## D.2 DynaMIT

DynaMIT is the software package developed at MIT and has its root in the simulation-based DTA model proposed in Ben-Akiva *et al.* (1994).  It is a mesoscoptic traffic simulation model, where vehicles are moved in packets and links are divided into segments that include a moving part and a queuing part.  Traffic propagation is based on a link performance function where the speed of a packet of vehicles is assumed to be a function of the traffic density ahead of it on the moving part of the segment.  Demand simulation in DynaMIT uses a micro-simulator, which generates individual travelers and simulates their choices regarding whether to travel or not, departure time, mode, and route (pre-trip and en-route), in response to information provided by the ATIS.

DynaMIT-P, the planning version of DynaMIT, is designed to assist the evaluations of proposed changes to local and regional transportation networks.  Such changes could be infrastructural, operational, or informational in nature.  Through flexible modeling of demand-supply interactions including both equilibrium algorithms and day-to day learning behavior, DynaMIT-P can effectively predict the day-to-day evolutions of travel demand and network conditions and the within-day patterns of traffic flows and travel times.

Similar to DYNASMART, the applications supported by DynaMIT-P are mostly related to the performance evaluation of a transportation network loaded with vehicles of different types, where different traffic management and control measures are to be implemented.