FINAL REPORT

to

THE FLORIDA DEPARTMENT OF TRANSPORTATION
SYSTEMS PLANNING OFFICE

on Project

Expanded Transportation Performance Measures to Supplement Level of Service (LOS) for Growth Management and Transportation Impact Analysis

FDOT Contract BDK77 977-14

October 31, 2012

from

The University of Florida

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METRIC CONVERSION CHART

U.S. UNITS TO METRIC (SI) UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
in	Inches	25.4	Millimeters	mm
ft	Feet	0.305	Meters	m
yd	Yards	0.914	Meters	m
mi	Miles	1.61	Kilometers	km

METRIC (SI) UNITS TO U.S. UNITS

LENGTH

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
mm	Millimeters	0.039	Inches	in
m	Meters	3.28	Feet	ft
m	Meters	1.09	Yards	yd
km	Kilometers	0.621	Miles	mi

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Expanded Transportation Performance Measures to Supplement Level of Service (LOS) for Growth Management and Transportation Impact Analysis		5. Report Date October 2012 6. Performing Organization Code
7. Author(s) Lily Elefteriadou, Sivaramakrishnan Srinivasan, Ruth L. Steiner, Patricia C. Tice, Kwangkyun Lim		8. Performing Organization Report No.
9. Performing Organization Name and Address Transportation Research Center University of Florida 512 Weil Hall, PO Box 116580 Gainesville, FL 32611-6580		10. Work Unit No. (TRAIS) 11. Contract or Grant No. BDK77 977-14
12. Sponsoring Agency Name and Address Florida Department of Transportation 605 Suwannee Street, MS 30 Tallahassee, FL 32399		13. Type of Report and Period Covered Final Report (May 2011 to October 2012) 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract
Many jursidictions in Florida are moving toward multimodal transportation systems that provide users with viable travel options in an effort to minimize the economic, social, and enviornmental costs that have been associated with a purely vehicular system. To support this transition, a set of performance measures is needed that will supplement the vehicle-based Level of Service (LOS) that has been the primary tool within project impact analysis. This project developed a framework for assisting agencies in selecting a set of performance measures that are consistent with their overall goals and the quality of life that the community desires. An extensive list of performance measures was synthesized from the literature and categorized into groups according to several typical community and agency goals that they may support. Since there are numerous performance measures that can support each goal, several evaluation criteria were listed that can be used by a local agency to assess each measure in light of the agency's goals, policies, and resources. These criteria consider the type and quality of data available to the agency, the compatibility of the measures with other agency processes, as well as the degree to which a measure encourages multimodal transportation. The report provides an example of how an agency could apply these criteria in order to select performance measures consistent with its goals and capabilities. The review systems for four Florida communities that have implemented successful multimodal areas are described in terms of their comprehensive plan, land development code, and project impact review. Land use mix and pedestrian environment measures were strongly favored by the communities documented in these system-level case studies, with multimodal choice strongly prioritized over congestion management. Finally, two development scenarios are created and studied using several performance measures to compare how different land use form affects the calculation of performance measures. A comparison of the impact is made based on whether measures support congestion management or mobility choice. The two development scenarios yield similar results when using congestion management as the primary agency objective, but show significant differences in their ability to support multimodal systems.

17. Key Word	18. Distribution Statement No restrictions		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 203	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

EXECUTIVE SUMMARY

Growth management has attempted to manage the pace of development while providing or improving transportation services to its users. However, these efforts have largely focused on automobile travelers using as a primary evaluation tool for growth management the Level of Service (LOS) designations. Continuing this vehicular focus is no longer feasible due to increased right-of-way costs, limited public and private funding, and the shrinking returns associated with vehicle-oriented infrastructure improvements. Many jurisdictions in Florida are moving toward multimodal transportation systems that provide users with viable travel options in an effort to minimize the economic, social and environmental costs that have been associated with a purely vehicular system. To support this transition, a set of performance measures is needed that will supplement the vehicle-based LOS and will help agencies assess new development and land use changes from a multimodal perspective.

This project first identifies an extensive list of performance measures from the existing literature. These measures are categorized by type into 5 major categories: infrastructure and environment, system utilization, user perception, safety, and sustainability. Infrastructure and environment measures focus on the Four Ds of land use and the built environment: **d**ensity, **d**iversity, **d**esign, and **d**estination Accessibility. System Utilization measures focus on the extent to which the system is used as well as on its operational functioning. Measures are identified for all modes and for combinations of modes. User perception measures relate to the experience of the system users, while safety measures assess incident history and risk management characteristics. Sustainability measures assess the ability of the system to continue successful operations economically, ecologically, and socially.

Next, the project develops a framework for assisting agencies in selecting a set of performance measures that are consistent with their overall goals and the quality of life that the community desires. This framework can be implemented by agencies through the following three steps:

STEP 1: The agency or local government identifies or formulates goals for the transportation system of the region. Generally, the goals and objectives for the community are defined in the Comprehensive Plan and the associated Land Development Regulations. Goals may be selected from the following list:

- Minimize ecological impact

- Increase accessibility
- Increase non-SOV travel
- Reduce congestion
- Optimize freight movement
- Enhance safety
- Reduce air pollution

STEP 2: The agency lists an extensive set of measures that are appropriate for each goal. See Appendix B (Table B.2) of this report for a list of primary and additional performance measures related to each goal.

STEP 3: Since there are numerous performance measures that can support each goal, this report provides several evaluation criteria that can be used by a local agency to assess each measure in light of the agency's goals, policies, and resources. An agency may evaluate the set of performance measures identified in the previous step using the criteria of Table B.1. These criteria consider the type and quality of data available to the agency, the compatibility of the measures with other agency processes, as well as the degree to which a measure encourages multimodal transportation.

The report provides an example of how an agency could apply these criteria in order to select performance measures consistent with its goals and capabilities.

The last two chapters of the report focus on case studies to illustrate the application of the methodology developed. Four existing community systems are described to provide a context of how these performance measures can be used as part of comprehensive planning. Gainesville, Florida, has an **impact area** type of review system that focuses on a multimodal analysis of the portion of the surrounding area with significant project impacts. St. Petersburg, Florida, has a **prescriptive** type system that specifies the infrastructure characteristics of a project but requires no impact analysis. Alachua County, Florida, combines features of both systems prescribing multimodal infrastructure and land use requirements in urbanized areas with only minor operational reviews in the immediate vicinity of the project while requiring an impact area type of review in rural areas. Orlando, Florida, uses a **geographic-based** review system, where available vehicle trips are geographically allocated each year, based on the availability of infrastructure. All four of these systems include a substantial focus on pedestrian environment in areas that will support multimodal travel. In general, within multimodal areas, the focus of the design and review is shifted from congestion management to provision of safe, useful multimodal facilities.

To examine how various performance measures could be applied at a project level, a theoretical development project was created and arranged in two scenarios. The transit-oriented development (TOD) scenario includes compact mixed-use development laid out in a gridded roadway network with a complete network of sidewalk, transit, and bicycle facilities. The suburban scenario includes a conventional single-use zoning strategy that incorporates limited transit, bicycle, and pedestrian facilities. From a congestion management point of view, the impacts of the two projects are quite similar. They are projected to have similar roadway infrastructure needs, both internally and externally, and similar offsite impacts. From a multimodal choice point of view, the two scenarios show marked differences that are likely to synergistically interact with travel impacts beyond what can be shown based on typical suburban-based review processes. A comparison of the two scenarios shows that a jurisdiction that focuses on congestion management alone would miss the distinction between the way the two forms function, while a jurisdiction focusing on the provision of multimodal choice would be able to see significant differences between the two scenarios. Examining a broader set of measures provided a broader view of the project's potential outcome.

In summary, the research showed that even though projects can be evaluated using a variety of performance measures, it is important for local governments to set clear priorities and goals in the planning process and identify the most appropriate set of performance measures to achieve community goals. The systematic process used in this project can be used to guide local governments in using performance measures that match both the community's planning priorities and the agency's resources.

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Chapter 1: Introduction

Background

Growth management has attempted to manage the pace of development while providing or improving transportation services to the users of the transportation system. However, these efforts have largely focused on automobile travelers. The majority of the statutory rules, measurements, management strategies and accountability have been framed in terms of passenger vehicle trips. Furthermore, the primary evaluation tool for growth management has been the Level of Service (LOS) concept, which has traditionally assessed the quality of service for passenger vehicles. A handful of communities have attempted to rigorously integrate and support all modes of travel and the movement of people, not just vehicles, within the project review processes. However, the topic is often approached as an afterthought to a vehicular analysis rather than an integrated and coordinated evaluation of viable mobility options.

Continuing this vehicular focus is no longer feasible, for three main reasons. First, most local governments have limited funding to expand their roadway network consistent with projected growth. Second, many local governments depend on new growth as a revenue source, but most development companies are equally strapped for funds, and private financing is extremely limited. Third, vehicular congestion becomes an issue for most communities long before they build out fully. Ironically, it is the congestion itself that attracts commercial development because of the increased visibility that a congested road provides.

In the past, the immediate reaction to congestion was to increase vehicular capacity on the congested roadway. However, this approach has often proven counterproductive, primarily because this new capacity is often consumed by trips relocating from other routes, rescheduling from other times or shifting from other, less attractive, modes[1]. Although each capacity improvement serves proportionally fewer drivers (see Figure 1.1[2]), each improvement also becomes significantly more expensive than the last, both financially and socially. The increase in financial cost typically stems from right-of-way acquisition to support additional pavement and drainage, while social costs may relate to lost or injured businesses that have previously framed the identity of the community. The construction often results in corridors that have a vehicle-

1. Downs, Anthony. (2003) *Still Stuck in Traffic.* Brookings Institution, Washington, DC. pp. 82-83.
2. Kulash, Walter, unpublished papers.

oriented character and are unfriendly to pedestrians and bicyclists. This may permanently limit the corridor's ability to serve all modes and support a high quality of life.

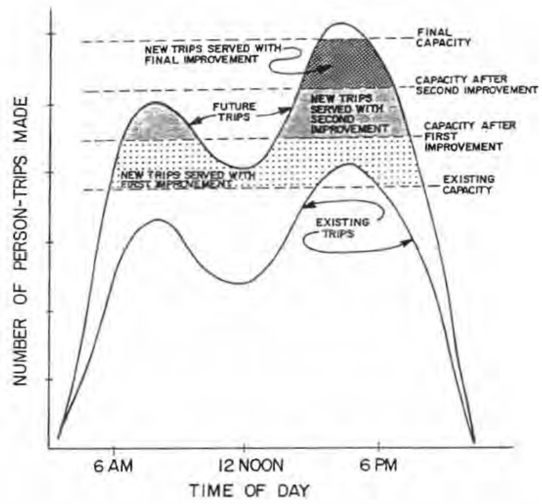

Figure 1.1 Decreasing Benefits of Roadway Capacity Improvements (Kulash)

The goal of a transportation system is to allow citizens to participate in the activities they desire. "Activity Participation" is the aim of all mobility strategies, even travel demand strategies that ultimately reduce travel, such as telecommuting. From the community's point of view, safety, livability, and economic development are key goals of the transportation system. The ability to participate in a wide range of desired activities that support a community's economic vitality is the essence of a high quality of life from a transportation perspective. Both the existing growth management legislation in Florida and federal transportation policy has explicitly refocused a community's role toward this end. The ability to choose from a wide range of travel modes is also fundamental to these goals. In a recent interview with AARP, U.S. Department of Transportation (DOT) Secretary Ray LaHood explicitly linked this freedom to choose with a high quality of life by defining a livable community in this manner: "It's a community where if people don't want an automobile, they don't have to have one." Florida's Community Planning Act (see Florida Statutes Section 163.3161 et seq.) gave the power to local governments to adopt and amend their comprehensive plans and to implement them with land development regulations. The comprehensive plan is the guiding document for the future development of the community consistent with the community's vision for its future.

The sections of the comprehensive plan containing the principles and strategies, generally provided as goals, objectives, and policies, shall describe how the local government's programs, activities, and land development regulations will be initiated, modified, or continued to implement the comprehensive plan in a consistent manner. The plan shall establish meaningful and predictable standards for the use and development of land and provide meaningful guidelines for the content of more detailed land development and use regulations. The comprehensive plan shall identify procedures for monitoring, evaluating, and appraising implementation of the plan. (FS Chapter 163.3177).

The comprehensive plan and the associated land development regulations provide the basis for the assessment of the impacts of proposed development projects. Performance measures, such as the ones described in this report, allow the local government to monitor, evaluate and appraise the success in implementing the plan and the impacts of individual development proposals. As such, the performance measures selected by a local government should be consistent with the goals, objectives, and policies of the jurisdiction's comprehensive plan.

To achieve the goals of vibrant and viable communities, the selection and application of performance measures must be framed in terms of the system's ability to facilitate activities within the community and support its economic and social vitality while providing the user with an appropriate range of mode choices. In essence, a local government's goals and objectives must move from facilitating auto-based movement to supporting the community's livability and quality of life within its limited resources. To move beyond vehicular focus, mobility analysis must assess the traveler's needs and the ability of the system to address them.

Objectives

The objectives of this research are to expand the local transportation practitioner's toolbox and thinking beyond vehicular-based LOS measures and recommend appropriate ones that could be used to support multimodal growth management, site design and site impact studies. This wider range of performance measures should address the needs of all travelers and support the development of multimodal mobility systems. These performance measures should also be useful to Florida Department of Transportation (FDOT) as they review projects of state interest that have multimodal implications.

Methodology and Report Organization

To accomplish the project objectives, an extensive literature review was first performed to identify as many performance measures as possible related to mobility, growth management, site design, and site impact. This review confirmed that there is a very wide range of possible measures, and narrowing the list to an appropriate group of measures applicable to all different types of communities would not be feasible. Therefore, the project developed a procedure for assisting agencies in selecting performance measures that match their goals and capabilities.

Chapter 2 of the report provides an overview of this procedure. It first lists potential agency objectives and categorizes the performance measures identified based on these objectives. Next, a set of evaluation criteria are proposed to further reduce the list of performance measures that are appropriate for an agency based on its capabilities and resources, as well as existing transportation planning framework. Examples of how these criteria can be applied to select a suitable list of measures are also provided. It is recommended that a list of primary and secondary performance measures be developed, to consider a broader set of mobility conditions and perspectives.

Since the final outcome of a project development process is shaped by the entire regulatory system, growth management practices in Florida and other states were reviewed considering all phases of growth management from comprehensive plan through land development code to the final individual project review. Chapters 3 and 4 use case studies to provide guidance on how the identified performance measures can be applied within the growth management framework in Florida. Chapter 3 documents how several Florida jurisdictions are applying a wide range of performance measures within their planning, review and design requirements to support a multimodal environment. In Chapter 4, a pair of theoretical development scenarios is reviewed using a wide range of performance measures, both to provide worked examples of how these measures are applied as well as show how different development forms may affect transportation impacts and outcomes. Chapter 5 provides a summary and conclusions from the project.

Chapter 2: Systematic Procedure for Developing a Set of Usable Performance Measures

The state of the practice involves the use of a limited set of measures to assess the overall performance of a transportation system. Changing the focus of transportation planning from purely congestion management to a broader spectrum of goals such as sustainability, livability, and safety, it is evident that the limited number of measures used in practice are inadequate to assess the attainment of the newer planning goals via alternate strategies. Therefore there is a need for an expanded set of measures that are appropriate for the current-day planning context.

Considering the wide range of community characteristics, there is a very broad set of agency priorities and capabilities. Not all agencies have the same set of goals (or the goals are not equally important to all agencies) and therefore a common set of performance measures to be used “across the board” does not seem appropriate. Further, the agencies also differ in terms of the available resources (such as data, computational capabilities, availability of computer models of the region, and staff) and the measures must be chosen considering these limitations as well. At the same time, on examining the literature on measuring the performance of transportation systems, we find that an extremely large number of measures have been identified that are appropriate under a wide variety of application contexts.

Therefore, it is important to provide guidance to agencies on how they could select an appropriate set of measures from the extensive list available while considering local needs, priorities, and constraints. This chapter outlines such a procedure. This chapter first outlines the three major steps of this procedure and then provides a detailed discussion of the individual steps.

In the selection of the performance measures, a local government must start with its own goals for the transportation system of the region (Step 1). Generally, the goals and objectives for the community will be defined in the Comprehensive Plan and the associated Land Development Regulations. Once the goals are described, an extensive set of measures that are appropriate for each goal can be identified (Step 2). As the list of potential measures is still very long, the measures are also further classified into a set of “primary” and “secondary” measures. Next, the set of performance measures associated with each goal are evaluated by the agency in terms of several criteria such as technical feasibility, usefulness and affordability (Step 3). The agency would assign a score for each measure considering all relevant criteria, and the measures that score the highest overall are selected as the appropriate performance measures. This step is illustrated with an example later on in this chapter. This process ensures that the selected measures are both relevant (from the standpoint of the agency's goals for the region) and usable (fits within the constraints of the agency). This exercise may also show that there is no usable measure to examine attainment of certain goals (because of current lack of data or models). In this situation, the agency may choose to invest in data collection or model building so that the additional measures could be generated in the future.

Step 1: Identification of Agency Goals and Objectives

The first step in the process of identifying performance measures is to list the agency's goals for the transportation system of the region. For example, the Florida Transportation Plan defines transportation goals, objectives, and strategies to make the state's economy more competitive, enhance quality of life, and ensure our environment provides quality places to live for future generations. Six goals are identified in this plan:

- Economic competitiveness
- Community livability
- Environmental stewardship
- Safety and security
- Maintenance and operations
- Mobility and connectivity

These are rather broad as they reflect the overall preferences for the entire state. Within this broad umbrella of goals, agencies within the state would have more focused objectives. As an example, we use a study from Texas to present seven mobility-related planning objectives (Ramani et al., 2009):

- ***Minimize ecological impact***: The ability of the land uses to complement each other, enabling a range of land uses including residential, commercial, and industrial uses in an integrated way that supports sustainable forms of transportation and a reduction in auto dependence and trip length
- ***Increase accessibility***: Capability of reaching the desired destination within an acceptable travel time, geographic area, mode or facility

- ***Increase non-SOV travel***: The ability to increase mode shift from single occupancy vehicle (SOV) travel to non-SOV travel
- ***Reduce congestion***: The extent to which the transportation system supports travelers' ability to move efficiently within a community
- ***Optimize freight movement***: The ability to increase freight movement efficiency
- ***Enhance safety***: The ability to enhance directly or indirectly identify the physical safety of the users by measuring safety related environments or systems.
- ***Reduce air pollution***: The ability to directly or indirectly improve air quality

The above seven objectives serve to illustrate a rather exhaustive set of objectives that an agency may wish to consider. Each agency should consider their goals and objectives in this process. Certain goals may map directly to a corresponding objective whereas other goals may be achieved by several objectives. For instance, the FTP goal of “Safety and Security” maps clearly to the objective “Enhance Safety” but the FTP goal, “Economic Competitiveness” is supported through several objectives, including “Increase Accessibility,” “Reduce Congestion,” and “Optimize Freight Movement.” Table 2.1 provides a matrix that maps the FTP goals with the list of mobility-related objectives presented previously:

Table 2.1 Relationship between the FTP Goals and Proposed Mobility Objectives

Objectives	FTP Goals	Economic Competitiveness	Community Livability	Environmental Stewardship	Safety and Security	Maintenance and Operations	Mobility and Connectivity
Minimize Ecological Impact			○	●			○
Increase Accessibility		●	●	○	●	○	●
Increase Non-SOV Travel			○	○	○	●	●
Reduce Congestion		●	●	○	●	●	●
Optimize Freight Movement		●		○	○	○	●
Enhance Safety		○	●		●	○	○
Reduce Air Pollution			○	●			○

● Direct ○ Indirect

For the purposes of this study we use the seven broad objectives identified in the study by Ramani et al. (2009) and listed above.

Step 2: Performance Measures by Objectives

A review of the literature resulted in the identification of over two hundred performance measures. This extensive set of measures is documented in Appendices to this report. Appendix A provides a comprehensive list of these measures and provides short definitions. Appendix B presents tables that link each of the measures to each of the seven mobility-related planning objectives previously identified. These tables also indicate how well each measure supports the seven objectives (strongly applicable, applicable, or not applicable). The data requirements for the measures are provided in Appendix C.

For illustration purposes, the entire list of performance measures has been classified into a set of "primary" measures and another set of "secondary" measures corresponding to each objective (Figure 2.1). Those that strongly support an objective (from Appendix B) are listed as primary performance measures for that objective, while those that provide limited support are listed as secondary performance measures. An agency could use these primary measures as the starting point for determining objective-specific performance measures that are associated with the community's Comprehensive Plan. Alternatively, they could choose to identify their own set of primary measures from the exhaustive lists provided in Appendix B.

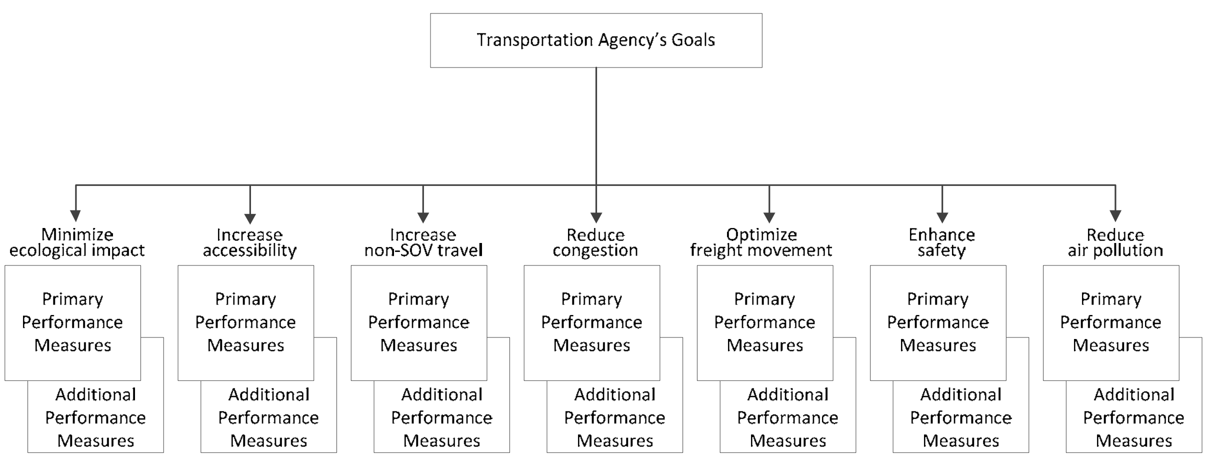

Figure 2.1 Procedures for Performance Measure Selection

The primary and secondary sets of performance measures identified by the research team are shown in Tables 2.2 to 2.8, grouped by mobility-related planning objectives.

Table 2.2 Measures for Minimizing Ecological Impact

Primary Performance Measures	Additional Performance Measures
Non-residential intensity	Average School Size
Residential density	Tree-lined/Shaded Streets
Percent in Proximity measurement	Internal Capture
Minimum thresholds of land use intensity	Commute Cost
Nearby Neighborhood Assets	Average trip length (ATL) per traveler
Sprawl Index (Ewing et al., 2002)	Mean daily trips per household
Consumption-Based Mobility Fee	Mean daily vehicle trips per household
Parking Footprint	Trip length by mode
Residence proximity	VMT (by mode)
Employment proximity	VMT per capita
Land Consumption	Additional Fuel Tax
Vehicle Hours Traveled (VHT)	TDM effectiveness based on TRIMMS model

Table 2.3 Measures for Increasing Accessibility

Primary Performance Measures	Additional Performance Measures
Cross Access between Adjacent Properties	Crosswalk Spacing
Street Continuity	Non-residential intensity
Number of safe crossings per mile	Residential Density
Connectivity to intermodal facilities	Tree-lined/shaded streets
Average School Size	On-vehicle bicycle-carrying facilities
Geographic Service Coverage	Parking Spaces per 1000 workers
Bike/pedestrian accessibility	Sidewalk shade
Pedestrian Scaled Lighting	Sidewalk quality
Bicycle parking requirements	Availability of on-site bicycle amenities
Intermodal Connections	Parking spaces designated for carpools or vanpools
Population Service Coverage	Percent of network that is "Effective"
Transit Accessibility	Percent in proximity measurement
Roadway Access management	Minimum thresholds of land use intensity
Residential Accessibility	Safe Routes to School Program (SRTS)
Land Use within Village Center	Bicycle and pedestrian LOS (FDOT)
Land Use within Transit Supportive Area	Speed Suitability
Lane miles per capita	Average transit headways
Bicycle path condition	Miles of express/fixed transit route/dedicated bus lanes
Bicycle/pedestrian connectivity	Connected and open community
Pedestrian/bicycle route directness	Transit convenience
Destination Accessibility	Spacing between Village Centers
Road density	Project Adjacency to transit
Block length	Smart Growth Index
Transit passes	Land use ratios/mix
Connected streets	Nearby neighborhood assets
Access requirements	Sprawl Index (Ewing et al., 2002)
Connectivity Index	Mode choice availability
Connectivity Index, Polygons	Capital funding for bike/pedestrian facilities
Number of key destinations accessible via a connected pedestrian system	Bicycle parking spaces at schools
Transit network coverage	Bicycle parking at stops and stations
Transit service to site	Park-and-rides with express service
Walking distance to transit	Average transit service frequency
Significant Land Uses	Land use balance
Transportation-Efficient Land Use Mapping Index (TELUMI) Model	

Table 2.4 Measures for Increasing Non-SOV Travel

Primary Performance Measures	Additional Performance Measures
Hours of service Crosswalk spacing Number of safe crossings per mile Bus pass program utilization Sidewalk width On-vehicle bicycle-carrying facilities Parking Spaces per 1000 workers Geographic Service Coverage Bike/pedestrian accessibility Roadway seat capacity Sidewalk shade Pedestrian scaled lighting Bicycle parking requirements Sidewalk quality Availability of on-site bicycle amenities Parking spaces designated for carpools or vanpools Intermodal Connections Population Service Coverage Transit Accessibility Parking Pricing Parking Supply Average transit headways Miles of express fixed-transit route/dedicated bus lanes Bicycle/pedestrian connectivity Transit convenience Pedestrian/bicycle route directness Project Adjacency to transit Mode choice availability Capital funding for bike/pedestrian facilities Transit passes Bus shelter locations Bicycle maintenance stations Traffic cells Posted information Bicycle parking at stops and stations Park-and-rides with express service Average transit service frequency Age of transit vehicle Number of key destinations accessible via a connected pedestrian system Transit network coverage Transit service to site Walking distance to transit Transportation-Efficient Land Use Mapping Index (TELUMI) Model HCM-based Bicycle LOS Fee charged for employee parking spaces TDM effectiveness based on TRIMMS model	Systematic Pedestrian and Cycling Environmental Scan Instrument (SPACES) Connectivity to intermodal facilities Ridership Non-residential intensity Residential density Tree-Lined/Shaded Streets Transit peak hour occupancy Percent in Proximity measurement Pedestrian scaled lighting Bicycle parking requirements Intermodal Connections Auto/Demand response transit (DRT) travel time ratio DRT trips not served Load Factor Transit Productivity Number of transfers Transit priority delay reductions Safe Routes to School Program (SRTS) effectiveness Bicycle and pedestrian LOS (FDOT) Bicycle path condition Percent of houses within 1 mile of an elementary school Block length Ratio of street width to building height Bicycle parking spaces at schools Land use balance Auto/transit travel time ratio Passengers per transit vehicle mile Response Time for DRT Transfer time Trip length by mode Transit condition of vehicles and facilities

Table 2.5 Measures for Reducing Congestion

Primary Performance Measures	Additional Performance Measures
LOS based on HCM 2010 Demand/capacity ratio Average School size Bus pass program utilization Parking spaces per 1,000 workers Transit peak hour occupancy Percent of lane-miles under traffic monitoring center (TMC) surveillance Parking spaces designated for carpools or vanpools Percent of network that is “effective” Vehicle Density Average clearance times for major incidents Parking Pricing Commute Cost Peak Hour LOS Percent of Capacity Consumed Vehicle speed/VHD by mode Posted information Park-and-rides with express service Connected streets Connectivity index Connectivity index, polygons Transportation-Efficient Land Use Mapping Index (TELUMI) Model Maximum Service Volume Districtwide Level of Service (LOS)/Quality of Service (QOS) Local traffic diversion Vehicle hours of delay (VHD) Control delay Variable fees based on LOS	Street Continuity Possible capacity addition within ROW Connectivity to intermodal facilities Ridership Non-residential intensity Residential density Sidewalk width On-vehicle bicycle-carrying facilities Geographic Service Coverage Internal Capture Vehicle accident rate Crash statistics/locations Total segment delay Improvements Based Mobility Fee Lane miles per capita Parking supply Miles of express/fixed-transit route/dedicated bus lanes Connected and open community Spacing between Village Centers Land use ratios/mix Nearby neighborhood assets ATL per traveler Mode choice availability Consumption-Based Mobility Fee Percent of houses within one mile of an elementary school Road density Travel delay Travel time Travel Time-based LOS Travel time index Vehicle hours traveled (VHT) Mean daily trips per household Mean daily vehicle trips per household VMT per capita Additional Fuel Tax Transportation Utility Fee (TUF) VMT-based Impact fee Fee charged for employee parking spaces TDM effectiveness based on TRIMMS model

Table 2.6 Optimize Freight Movement

Primary Performance Measures	Additional Performance Measures
Connectivity to intermodal facilities Truck miles traveled	Street continuity Roadway Access management Connected and open community

Table 2.7 Measures for Enhancing Safety

Primary Performance Measures	Additional Performance Measures
Bike/Pedestrian injuries/fatalities Traffic fatalities Vehicle accident rate Crash statistics/locations Annual severe crashes Pedestrian scaled lighting Safe Routes to School Program (SRTS) Bicycle path condition	Hours of transit service Crosswalk spacing Average school size Number of safe crossings per mile Percent of lane-miles under traffic monitoring center (TMC) surveillance Sidewalk quality Transit accessibility Roadway access management Average clearance times for major incidents Speed suitability Transit related Crime rate Capital funding for bike/pedestrian facilities Percent of houses within one mile of an elementary school Bus shelter locations Connected streets Connectivity index Connectivity index, polygons Number of key destinations accessible via a connected pedestrian system Walking distance to transit Transportation-Efficient Land Use Mapping Index (TELUMI) Model Cost recovery from alternate sources

Table 2.8 Measures for Reducing Air Pollution

Primary Performance Measures	Additional Performance Measures
Daily CO2 emissions Daily NOx, CO, and VOC emissions Vehicle hours of delay Vehicle hours traveled	Parking spaces per 1,000 workers Geographic service coverage Internal capture Transit accessibility Minimum thresholds of land use intensity Vehicle density Transit productivity Transit priority delay reductions Transit convenience Peak hour LOS Vehicle speed/VHD by mode Truck miles traveled Park-and-rides with express service Age of transit vehicle Transit network coverage Transportation-Efficient Land Use Mapping Index (TELUMI) Model Travel delay Travel time VMT by mode VMT per capita Attainment of ambient air quality standards Additional fuel tax Transportation utility fee VMT-based impact fee TDM effectiveness based on TRIMMS

Step 3: Criteria Assessment

While the previous step narrows down the measures by the objectives of the agency, there are still far too many measures to be all used in practice. Therefore, the next step in the process is to assess the overall usability and usefulness of the measures based on the agency's needs and constraints. A review of the literature resulted in the identification of several major criteria for performing this assessment. These criteria are: (1) Technical feasibility, (2) Agency feasibility, (3) Affordability, (4) Technical usefulness, (5) Agency acceptability, (6) Multimodal effectiveness, and (7) Robustness. A detailed description of these criteria is shown in Table 2.9.

Table 2.9 Criteria for Performance Measure Selection

Evaluation Criteria	Description
Technical feasibility	**Data availability and reliability**: The degree to which data to calculate, estimate, measure or model a specific measure is readily available or can be obtained at a reasonable cost **Methodology:** The degree to which tools or analysis methods are acceptable, measurable, and understandable, as well as interpretable **Predictability:** The degree to which an indicator produces outcomes that are predictable and consistent to infrastructure service providers, such as planners and developers
Technical usefulness	**Sensitive to changes that are significant to the system**: The degree to which an indicator is sensitive to the change of system such as new development **Measurable, target-oriented**: The degree to which a measure produces quantitative outcomes that can be compared with a target level or benchmark **Trendable and predictive**: The degree to which a measure show trends over time and is predictive for future conditions
Agency acceptability	**Intelligible and credible**: The degree to which the political decision makers, property owners and/or the development industry can easily understand and trust the process or believe that the outcome is fair enough to meet the goals of measurement **Political acceptability:** The degree to which an indicator is acceptable to various political constituencies such as local government officials, regional government officials, the development community, business owners and executives, environmental groups, community groups, and various transportation advocacy groups **Market signals:** The degree to which an indicator encourages private sector to build projects with desirable characteristics in desirable areas as identified by a jurisdiction and discourages undesirable project characteristics in areas that are inappropriate or not yet ready for development.

Table 2.9 Criteria for Performance Measure Selection (continued)

Evaluation Criteria	Description
Agency feasibility	**Compatibility:** The degree to which an indicator is compatible with existing planning processes, including the degree to which an indicator requires a revision of the governance and/or decision making structure of existing transportation and planning agencies; and/or the degree to which the data required to perform the required analytical tasks are already being produced by existing transportation planning efforts **Legal, financial and structural sustainability**: The degree to which an indicator is sustainable legally, financially, and structurally **Applicability to funding process**: The degree to which an indicator can be used to generate funds for multimodal transportation improvements
Multimodal effectiveness	**Encourages transportation options:** The degree to which an indicator successfully encourages the deployment and use of well-functioning transportation facilities that serve multiple modes of travel **Mode neutrality:** The degree to which an indicator encourages person mobility without prescribing one specific transportation mode over another **Appropriate detail to reflect scale of the mode**: The degree to which an indicator includes adequate detail to assess the performance of a system at an appropriate scale for the mode considered (i.e. smaller scale and finer resolution for pedestrian and bicycle modes, larger scale and less resolution for vehicular travel)
Robustness	**Scalability:** The degree to which an indicator can be applied across multiple scales (project, local, or region) within an analysis area **Context sensitivity:** The degree to which an indicator is sensitive to urban, suburban, or rural areas
Affordability	**Cost to implement and manage for public/private:** The degree to which an indicator increases the burden of doing business to the public and private sectors.

Based on the criteria described above, a few example ratings are provided in Table 2.10. A 5-point rating scale was used to represent the degree of satisfaction for each criterion: very poor (1), poor (2), average (3), good (4), very good (5). In this example, the first 10 measures are, in general, not feasible technically due to the difficulty of data availability, although they are useful in measuring project performance. The last six measures are rated higher.

Each agency is likely to rate each measure differently based on the availability of data, the significance of the transportation issue at hand and the resources available to implement the use of each measure. Therefore, the assessment procedures should be performed by the agency to select a set of usable performance measures that are consistent with the goals and objectives of their respective Comprehensive Plan.

Table 2.10 Example Performance Measure Rating

Indicators	Evaluation Criteria							Sum
	Technical feasibility	Technical usefulness	Agency acceptability	Agency feasibility	Multimodal effectiveness	Robustness	Affordability	
1. Noise pollution	2	5	2	2	1	2	1	15
2. Roadway network balance	3	4	3	3	3	3	2	21
3. Equitable distribution of accessibility	2	5	3	3	5	3	2	23
4. Pedestrian Friendliness	1	5	3	2	5	4	2	22
5. Transit ease of using the system	1	5	3	2	5	4	2	22
6. LOS based on traveler perception	1	5	3	2	2	3	2	18
7. Congestion Duration	2	5	5	3	2	3	3	23
8. Freight delay	1	5	2	2	2	5	3	20
9. Bicycle path condition	2	5	4	3	5	3	2	24
10. Perception of Transit safety	1	5	3	2	5	5	2	23
11. Land use balance	5	5	5	5	3	5	5	33
12. Transit-oriented residential density	5	5	5	5	5	5	5	35
13. Transit service density	5	5	5	5	5	5	5	35
14. % of network that is "effective"	5	5	5	5	4	5	5	34
15. Lane miles per Capita	5	5	5	5	3	5	5	33
16. Work accessibility	5	5	5	5	2	5	5	32

Although data availability is included as a part of the technical feasibility criteria, it is a significant enough component to merit its own discussion. If the data used to quantify a specific measure is unavailable, then the chance that the measure can be used decreases significantly. Historic data are difficult to recover or reconstruct if not previously collected. Some measures require significant amounts of data collection and the cost of that data collection must be weighed against the value of the measure to the agency. Table 2.11 summarizes the data requirements for each of the measures identified in Table 2.10. The data requirements for the all measures are included in Appendix C.

Table 2.11 Data Requirements for Example Performance Measures

Indicators	Data Requirement
1. Noise pollution	Roadway network, Vehicle volume by type and location, and On-site noise level
2. Roadway network balance	Roadway network inventory
3. Equitable distribution of accessibility	Land use map and Destination accessibility
4. Pedestrian Friendliness	Pedestrian survey data (walking environment)
5. Transit ease of using the system	Transit rider survey data (cleanliness, comfort, information, reliability, safety)
6. LOS based on traveler perception	LOS user perception survey and LOS based on HCM 2010
7. Congestion Duration	Average travel speed, Flow rate (pc/h/ln), and Travel time by time of day
8. Freight delay	Freight actual and scheduled arrival time
9. Bicycle path condition	Bicycle network inventory/Geometry/Parking
10. Perception of Transit safety	Transit rider survey data (cleanliness, comfort, information, reliability, safety)
11. Land use balance	Land use map by detailed type
12. Transit-oriented residential density	Number of residents (parcel) and Transit service network and route schedule
13. Transit service density	Transit service network and route schedule
14. % of network that is "effective"	Roadway network
15. Lane miles per Capita	Roadway network inventory and Population
16. Work accessibility	Pedestrian network inventory, Roadway Network Inventory, Land use map (detailed types), and Number of employees (parcel)

Chapter 3: System Level Case Studies

The use of mobility measures in a specific project, public or private, occurs within an overall context of the local government planning process. This process, with all of its intentions, assumptions, and users, dynamically shapes the final project and community outcome in many interrelated ways. To better understand how mobility-related performance measures are used in this context and how the selection can impact the success of multimodal mobility systems, this chapter discusses case studies that document the planning and review systems in three Florida communities that have had strong multimodal systems over an extended period of time. As such, this chapter focuses on the development of goals, objectives and policies and their implementation in the land development regulations to understand the use of performance measures as a part of the planning and regulatory environment for land development in a community. In the next chapter, the performance measures developed within a community planning process will be applied using a scenario of a specific development proposal. Each of these communities has a slightly different approach to managing the pace, characteristics and financial impacts of growth in varying contexts.

The objective of reviewing how performance measures are applied within the local government planning process is to ascertain how these measures support or detract from generating a context-sensitive multimodal environment. Additionally, it is hoped that by reviewing systems that have successfully planned and at least partially implemented multimodal transport patterns, principles and performance measures can be identified that will support other jurisdictions as they face similar challenges.

Case Study Selection

To understand the way that multimodal performance measures can support the development of a vibrant multimodal environment, three communities were selected for study. The criteria for selecting communities for case studies are:

- Plan, code or review elements that support a transition to a diverse multimodal system where users have a realistic choice regarding the mode used to access their desired activities.
- Public recognition for the community's current or planned provision of mode choice options

- Contrasting or innovative development review systems or codes
- Context sensitivity in specified design features and review processes that address the scope of the contexts that exist within the community

The literature review revealed many communities that had innovative development review procedures or systems. The initial literature review clearly showed that context and scale are critical issues in the design of these systems. Communities dominated by one type of context or a small scale focus on measures appropriate to only that context and scale. For instance, if the community is predominantly suburban, their review processes generally focus on a typical 4-step impact analysis[3] within a specified impact area. These systems are termed **Impact Area Review Systems**.

Some communities that are predominantly urban or close to build out frequently ignore typical roadway analyses, outside of safety analysis, within the immediate vicinity of the site. These communities generally focus on a project's urban design features, while the day-to-day vehicle operational issues are managed by the community's engineering staff. It appears on the surface that scant transportation review occurs within these systems. However, this is not the case. Within these systems, the site plan review provides prescriptive requirements regarding the project's future ability to support multimodal mobility. These systems are termed **Prescriptive Review Systems.** Many of these communities rely on Form-Based Codes or similar design-based review processes to implement these design features.

Larger communities or communities that contain a mixture of urban, suburban and rural contexts have found ways to apply measures at those varying scales and contexts in a geographic fashion. Specific geographic areas are required to apply specific design, analysis and/or mitigation criteria based on the context of the area. This generates a **Geographic Review System**, which is typically a hybrid of the other two systems.

Since this study is focused on identifying ways that performance measures can successfully support communities if they desire to transition to a more multimodal environment, the research team looked for communities that have received recognition for their bicycle or pedestrian systems despite being developed in a vehicle-oriented suburban pattern. Community Bicycle Friendly and Walk Friendly ratings published by the League of American Bicyclists and the University of North Carolina Highway Safety Research Center were used to identify

3. 4-Step Analysis: 1) Trip Generation, 2) Trip Distribution, 3) Trip Assignment/mode split, 4)Operational Evaluation

communities that have succeeded in providing a vibrant multimodal environment. A similar rating system for Transit Friendliness was not identified.

Very few communities in Florida met all 4 of the identified criteria. Several communities throughout Florida have geographic areas for which a wide range of mode choice is available, and context sensitivity is incorporated into their plan and codes. However, few have been recognized for their pedestrian or bicycle friendliness. Temple Terrace received an Honorable Mention on the 2011 Walk Friendly Communities rating with recognition for their Safe Routes To School program, their Multimodal Transportation District and Red Light Cameras. Funding reallocation from highway modes to pedestrian, bicycle and transit modes was also specifically cited. Gainesville received Silver recognition as a Bicycle Friendly Community and Boca Raton, Orlando, Sanibel, St. Petersburg and Tallahassee received a Bronze. Specific examples of each of the review types mentioned above were available within Florida and several of these communities have demonstrated success in providing a multimodal environment. Therefore, one of these communities representing each type of review process was selected for the case studies.

Methodology

Four areas are selected for study: Gainesville, Alachua County, Orlando and St. Petersburg. Gainesville utilizes a Site Impact System with strong geographic mitigation components and is contrasted with Alachua County, which uses a two-area Geographic-Based System consisting of a prescriptive analysis type for Activity Centers and areas within the Urban Growth boundary and an impact area type outside those areas. Although Alachua County's multimodal systems are less developed than other case study communities, it was felt that including both Gainesville and Alachua County would provide an opportunity to compare and contrast how multiple jurisdictions could plan and review projects within a similar geographic area and context.

A case study on Orlando further explores the ways a Geographic-Based System can be used to manage the timing of development within a large urban area containing multiple diverse contexts.

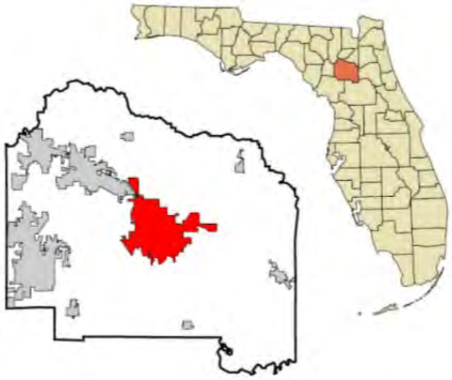

Figure 3.1 Gainesville and Alachua County

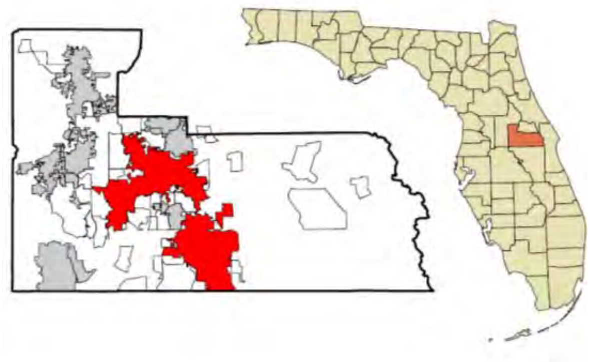

Figure 3.2 Orlando

The case study of St. Petersburg summarizes how their Prescriptive Review System addresses the needs of a historic community nearing build out. A summary of the common elements and performance measures identified within each case study is provided at the end of this chapter.

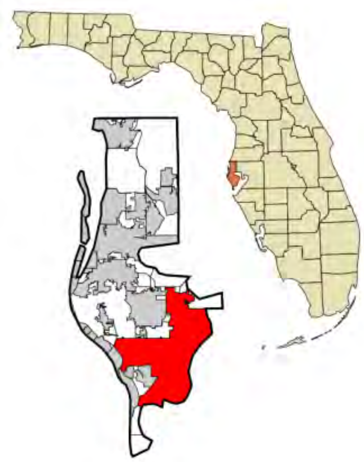

Figure 3.3 St. Petersburg

The applicable website for each community was referenced to gather their most recent comprehensive plan, land development code, vision plan (if any) and any documentation on their review procedures. These documents were reviewed and additional information was requested from the jurisdiction where clarifications or additional information was required. It should be understood that the administrative processes for each of these jurisdictions are constantly reviewed and modified. The documentation provided herein is based on published information available in early 2012. Alachua County has just recently updated their entire comprehensive plan and review procedures. The City of Gainesville is currently in the process of an overhaul of their Land Development Code and regulations. The City of Orlando had areas that were designated a transportation concurrency exception area (TCEA), but the recent legislative session has expanded that area to include the Orange County's Urban Service Boundary, which includes all of Orlando. The impacts of that change have not yet fully been incorporated into their review systems and its application is currently being addressed on a case-by-case basis.

The City of Gainesville−Impact Area Based Analysis

Because of Gainesville's student population, non-motorized travel has always been a major component of their overall mobility planning, particularly around the University of Florida (UF) campus. It would be easy to dismiss Gainesville as a "college town" whose results are not likely to be duplicated throughout Florida, but that would be short-sighted. UF and Shands Hospital represent a concentrated, regional employment center that has significant control over its facilities, including parking and internal circulation. Many Florida communities have similar employment centers.

One distinct aspect of their transportation planning environment that has been well utilized is the arrangement between the Regional Transit System (RTS) and the UF and Santa Fe College (SFC), whereby students pay through a per-credit fee for unlimited access to RTS routes. Each year, RTS negotiates with UF and SFC which transit routes will be served with funding from student fees. UF also uses funds from the Parking and Transportation Services to give unlimited access to transit to all faculty and staff. Parking on campus or at the hospital is

Table 3.1 Community Characteristics: Gainesville

Population

· 124,354 (preliminary 2010 census)

Student Population, 2010

· University of Florida, 50,116
· Santa Fe Community College, 3,326

Major Employers (2007)

· University of Florida, 12,633
· Shands Healthcare, 7,508
· Malcolm Randall VA Medical Center, 2,700
· The Oaks Mall, 2,500
· FL Department of Children and Families, 2,119
· Publix Supermarkets, 1,865

Size and Density

· 61.31 square miles
· 2,028 persons per square mile

Mean Travel Time to Work

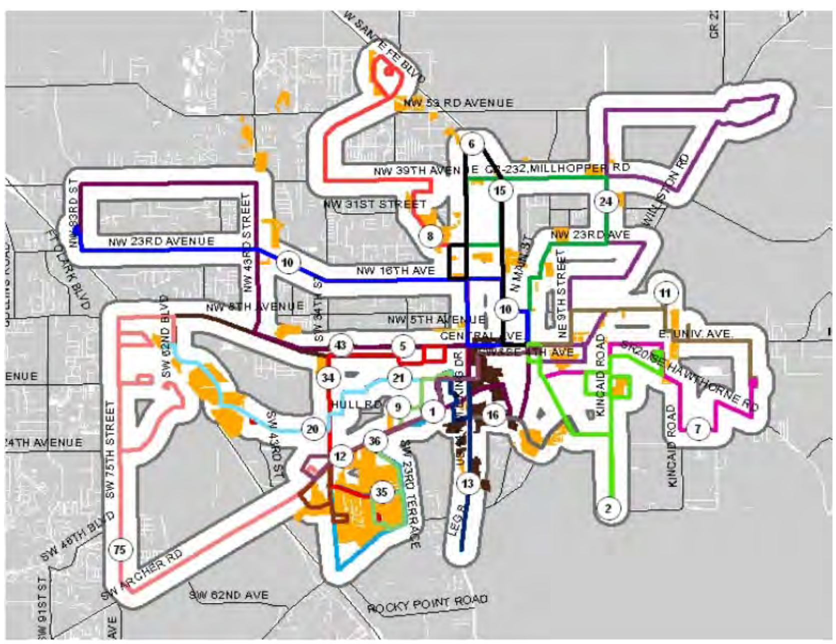

Figure 3.4 RTS Routes and ¼ Mile Service Buffer, (RTS TMP 2007)

both limited in supply and expensive, which allows for land to be used for buildings instead of parking[4].

Furthermore, Gainesville has maintained a relatively compact, dense built environment around campus within walking distance of UF which further supports transit use. Even in areas of lower density land use with a relatively suburban form, transit service is often available within a reasonable walking distance along major roadways. RTS had a ridership of just under 10 million passengers in 2011[5], with most routes located within the City of Gainesville.

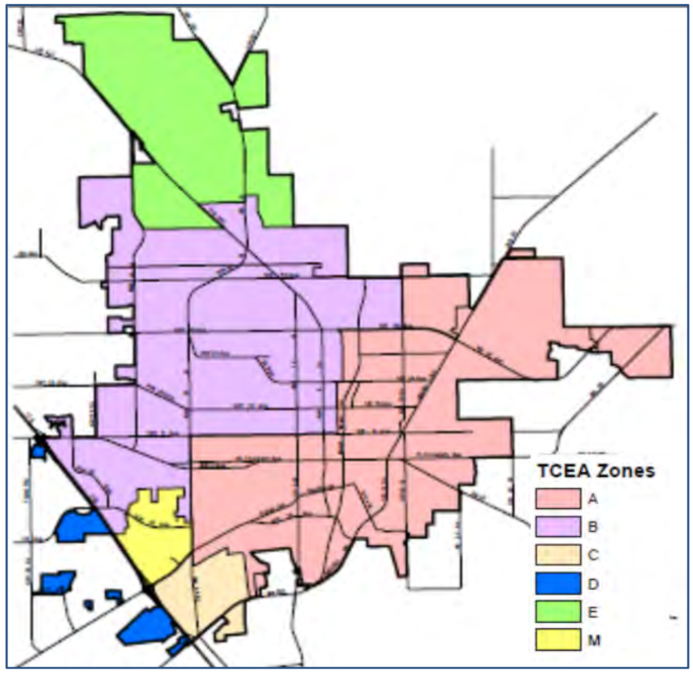

Figure 3.5 Gainesville TCEA Zones (Gainesville Land Development Code (LDC))

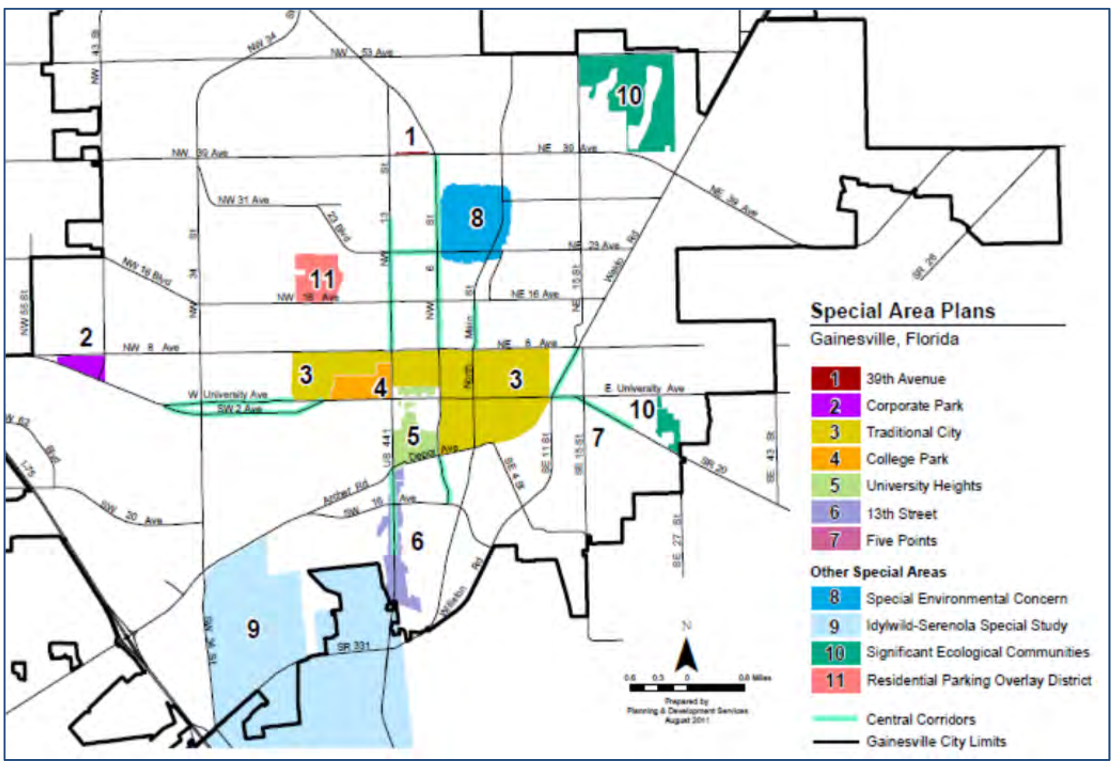

Figure 3.6 Gainesville Special Area Plans (Gainesville LDC)

4. Bond, Alex and Steiner, Ruth. "Sustainable Campus Transportation through Transit Partnership and Transportation Demand Management: A Case Study from the University of Florida" *Berkeley Planning Journal, Volume 19*. 2006

5. RTS. RTS Fiscal Year 2011 Ridership by Route.

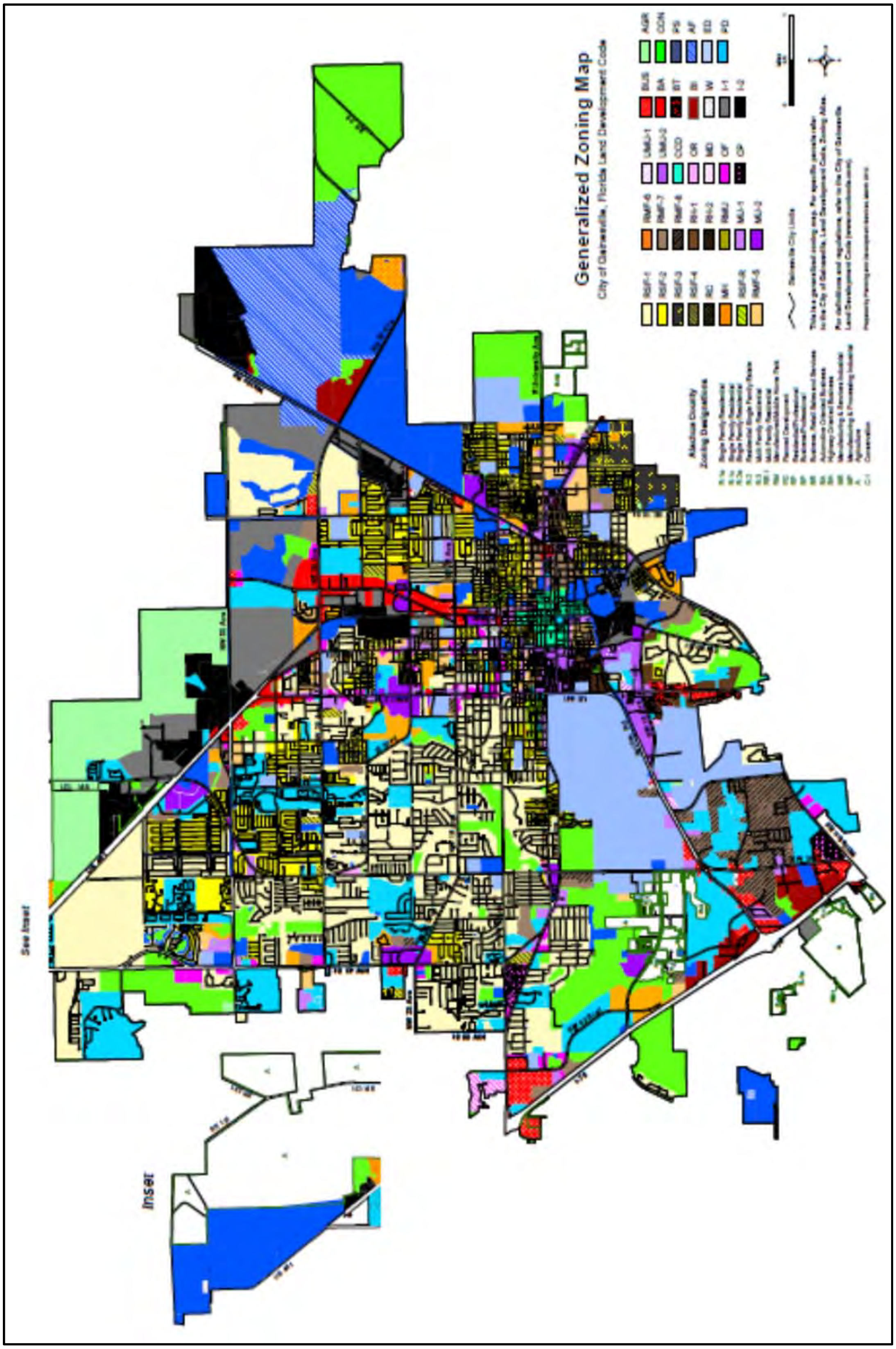

Figure 3.7 Gainesville Zoning Map (Gainesville LDC)

Growth Management History

Gainesville was one of the first jurisdictions in Florida to take advantage of statutory provisions for Transportation Concurrency Management Areas (TCMAs) and has converted the TCMAs to a Transportation Concurrency Exception Area (TCEA) since 2001 when their most recent comprehensive plan was adopted. Significant updates were approved by DCA in 2005/2006 to address areas that were annexed into the City[6]. This TCEA was expanded by state law in 2009 to include the entire city. Gainesville then drafted a new ordinance to address the TCEA approval procedures on an interim basis until new The City completed its Evaluation and Appraisal Report (EAR) in 2010 and finalized its Comprehensive Plan in January of 2012. They are currently holding public meetings about updating their Land Development Code (LDC) to a form-based code (FBC), consistent with the new requirements of their updated Comprehensive Plan. One of the reasons for the update is to streamline and consolidate their code. Even the published review procedures recognize that the current LDC is complex and difficult to administer and use because of the piecemeal way it has been adopted over time. It includes a wide range of land use categories, zones (Figure 3.5), special area plans (Figure 3.6) and overlay districts. The existing code anticipates this difficulty in its review procedures, requiring an initial pre-proposal ("First Steps") meeting before any formal plans can be prepared so that staff can brief the applicant on the specific requirements that are associated with their parcel. The conversion to a FBC is expected to consolidate many of the current requirements, providing the development community with a visually based code that is hoped to be easier to understand and implement. Provisions can be incorporated into their Comprehensive Plan[7]. Figure 3.7 shows the adopted LDC.

Long-Range Planning

The framework for Gainesville's last major comprehensive plan was published in 2001 but updates to nearly every element have been adopted and updated in January of 2012. The Data and Analysis[8] provided in support of their transportation mobility element describes "Transportation Choice" as a primary design motivation for all of their mobility planning. They further recognize that the character of the available transportation facilities often drive the nature

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6.http://www.cityofgainesville.org/GOVERNMENT/CityDepartmentsNZ/PlanningDepartment/ComprehensivePlanUpdate/tabid/504/Default.aspx 1/27/2011

7. City of Gainesville Ordinances, §30-38, STATE-MANDATED TRANSPORTATION CONCURRENCY EXCEPTION AREA

8. City of Gainesville, Data and Analysis Transportation Mobility Element, Jan 25, 2001.

of the land uses developed around them. Therefore they included a list of "*Important Components for Retaining and Creating Transportation Choices*" (Table 3.2). The remainder of the document summarizes specific ways the community intends to support these components, even requiring mode neutral language is used to describe modifications to the roadway network system. This is an extension of a Metropolitan Transportation Planning Organization (MTPO) policy adopted many years ago.

Appendix A lists the mobility related goals identified in each case study community's comprehensive plan. Gainesville's Comprehensive Plan includes many of the typical goals identified in Chapter 2. Notably absent is the desire to reduce congestion or address freight movement. Freight movement has been addressed at the MTPO level rather than the City level. Indeed, slow vehicle speeds are considered desirable to help balance the needs of all travelers within all modes. Gainesville includes an optional Comprehensive Plan Element addressing Urban Design that explicitly addresses the design of urban spaces in a manner that is conducive to multiple travel modes.

The current comprehensive plan includes or infers many of the performance measures identified in this study. Street and sidewalk width as well as block length are frequently mentioned. Connectivity measures are not directly mentioned, but limitations on culs-de-sac and dead ends, along with design for stub-outs to future development are required. Several characteristics of a walkable environment are mentioned, including pedestrian/bike short cuts, street trees, on street parking, proximity to daily complementary land uses, minimum densities and intensities, modest/minimal front yard setbacks, entrances facing the street, porches, and lighting scale. Nearly all of these inferences

Table 3.2 Important Components for Retaining and Creating Transportation Choices

Streets & Travel
- Modest street dimensions.
- Connected sidewalks of ample width on both sides of street, shaded with trees and awnings.
- Modest number of street travel lanes (no more than 4).
- Connected streets (rather than culs-de-sac or dead ends) with modest block sizes (no more than 500 feet long).
- Modest supply of parking for cars, and surface parking and storm basins at the side or rear of buildings.
- Pedestrian- and bicycle-friendly connections from neighborhoods to neighborhood centers.
- Pricing that encourages sustainable travel and discourages single -occupant vehicle travel.
- Frequent, clean, easy-to-use buses coupled with transit passes and bicycle racks.
- Alleys.
- Formally aligned street trees.
- On street parking.
- Pedestrian short-cuts (cross-access sidewalks, diagonal sidewalk alignment, no walled/gated subdivisions).
- A connected, citywide trail system.

Buildings & Land Use
- Mixed use (vertical, or horizontal within ¼ mile walking distance).
- Buildings at least 2 stories high.
- Mixed housing types.
- In-town development instead of development remote from downtown or neighborhood centers.
- Daily needs (residence, office, retail, recreation, civic) within ¼ mile walking distance, and less frequent needs within 3-mile bicycle/transit range.
- Residential density of at least 7 du/acre and commercial intensity of at least 1.00 FAR (floor area ratio).
- Modest front yard setbacks. For example, building facades aligned at streetside sidewalks.
- Building entrances facing the street.
- Front porches.
- Buildings, lighting, parking scaled for people instead of cars.
- Car-oriented uses designed to be scaled for, and compatible with, neighborhoods.

Source: Gainesville Comprehensive Plan, Transportation Element Data and Analysis have been incorporated into the requirements within the LDC. The care with which the multimodal environment has been crafted has paid big dividends. Gainesville has the shortest average commute time in Florida and is ranked 19th in the nation[9].

Overall Project Review Process

As mentioned previously, Gainesville has relied heavily on multiple overlay districts and special area plans (SAPs) to implement context sensitive features within specific geographic areas. This makes understanding the specific zoning and development requirements for an individual parcel complicated. Therefore their project review procedures begin with a “First Step” pre-application meeting that specifically identifies to the applicant the specific sections of the ordinances that are applicable to that land parcel. These overlay districts and special area plans frequently include specific design features that directly relate to pedestrian, bicycle or transit mobility.

Some of the mobility measures that directly impact the site plan review include setbacks and build-to lines, front porches/balconies, parking design, window glazing requirements, access/driveways, sidewalk dimensions, street trees, land use mix (horizontally and vertically), entrance orientation, street width to building height ratios, façade rhythm, corner radii, clear zones, parking screening, bicycle paths/trails, and bicycle parking (both quantity and location). All of these are directly related to the success of non-motorized travel.

TCEA Mobility Review

From 2001 to 2009, the majority of the City was part of a TCEA. All proposed projects would be required to prepare a traffic impact analysis for all modes available to the site. Those within the TCEA would be given a menu of specific amenities that assist with multimodal mobility that could be included in their site design. The number of amenities required would be based on the potential trip generation of the development. Outside the TCEA, the development would be required to mitigate any deficiencies identified by the impact analysis through network changes or proportionate share payments.

9. http://quickfacts.census.gov/qfd/states/12/1225175.htm 1/27/2011,
http://www.cityofgainesville.org/HOME/tabid/36/Default.aspx 1/20/2011

To address the statutory changes regarding Dense Urban Land Areas (DULAs) in 2009, they added a temporary TCEA review section that addresses concurrency through the use of 6 TCEA zones. These provisions have been incorporated into the comprehensive plan update.

Similar to the previous TCEA provisions, five of the six TCEA zones were given their own menu of improvements that could be provided by the development to meet their concurrency requirements (see Table 3.3). This is in contrast to strict concurrency where a project would be required to identify and mitigate for its own specific impacts either through improvements or proportionate share contributions. Four of these five TCEA zones include construction or contributions toward specific improvements as a potential menu choice for development approval. Nearly all of these menu choices relate specifically to performance measures identified in this study.

As part of the TCEA provisions, all projects that have an Institute of Transportation Engineers (ITE) trip generation that is estimated to be over 50 peak hour trips are required to provide a fairly significant transportation impact analysis for all modes with a minimum ½ mile radius impact area. Major projects (over 100 peak hour trips) are required to provide the same analysis until project impacts drop below 5% of the published Maximum Service Volume (MSV) for each roadway segment. All intersections within the impact area are to be analyzed for AM and PM peak hour LOS conditions, with signal warrant analysis provided if required. Mitigation for intersection improvements within the impact area is considered site-related impacts. There are some areas of Gainesville that are urbanized with small blocks where even this relatively small impact area can

Table 3.3 TCEA Minimum Requirements

All Zones

- Sidewalks across the development frontage
- Cross accesses and joint driveways
- Land dedication/easements across frontage for future planned mobility improvements
- Closure of excessive, duplicative or unsafe curb cuts
- On site pedestrian circulation
- Non-mobility related traffic safety/operational improvements

TCEA Menu Examples

- Intersection/signal modifications
- Funding a new or expanded bus maintenance/ operations facility
- Bus Shelters or solar lighting for shelters
- Bus turn out facilities
- Bus pass programs for the project's users
- Payments to RTS to increase service frequency or add service
- Construction of public sidewalks offsite*
- Sidewalk Widening
- Construction of bicycle lanes
- Ride sharing or van pooling programs
- Streetscaping coordinated with the City's streetscaping plans
- Business operations that have limited or no peak hour impact
- Pedestrian shading through awnings or canopies
- Additional bicycle parking beyond minimums
- No ground mounted signage
- Enhancements to the City's Greenway system
- TDM programs with annual reports
- Clustering for maximum density and open space preservation
- New road construction including bicycle and pedestrian facilities to reduce congestion*
- Addition of lanes on existing facilities *
- Lighting improvements*
- Design or construction studies/plans for mobility related projects
- Matching funds for mobility related grants or transit
- Innovative transportation related modifications
- Proportionate share contributions to projects listed as City prioritized improvements (Zone M only)

*Specific improvements are identified as priorities within specific TCEA zones.

Source: Gainesville LDC

require the analysis of numerous segments and intersections. In addition to the vehicular analysis, the following information is required:

- All significant land uses/activities within ½ mile of the site
- Regional Transit System (RTS) routes and shelters within ¼ mile of the site
- Sidewalk conditions and gaps within ¼ mile of the site
- Bicycle facilities and gaps within ¼ mile of the site
- Programmed, proposed or scheduled transportation system modifications
- Project impacts (measures unspecified, usually assumed to be Multimodal LOS) on the transit, pedestrian and bicycle system

The traffic analysis is required to identify any needed modifications to any of the mobility systems (roadway, transit, pedestrian or bicycle) as well as how the specific menu items that were selected for the TCEA-mandated improvements will be provided. A description of how the selected menu items will mitigate the projects transportation system impacts is also required.

Even though the required site impact area analysis does not strictly determine whether a project meets concurrency requirements, it does guide the applicant in selecting appropriate menu options for contribution, since those menu items must be justified in the analysis. It also provides timely information to Gainesville's growth management team allowing them to apply the full range of revenues available to them through project fees and taxes to the issues that are most pressing. Their intentional focus on assuring that all projects provide a walkable pedestrian realm is a significant key to the success of all of their multimodal systems.

Alachua County−Mixed Type Analysis

Alachua County is considered to have a mixed type of impact analysis because it addresses development roadway impacts based on a typical impact area analysis outside of the Urban Cluster, but requires at most only a long walk distance analysis (1/2-mile radius) within the Urban Cluster. The provision of mobility services within the Urban Cluster is intended to be multimodal and therefore the standards applied are more prescriptive in regard to form, arrangement and design than capacity related.

Table 3.4 Community Characteristics: Alachua County

Population
· 27, 336 (2010 census)

Major Employers (2007)
· Nationwide Insurance, 1,300
· WalMart Distribution Center, 736
· Dollar General Distribution Center, 624
· Tower Hill Insurance Group, 500

Size and Density
· 875.02 square miles
· 283 persons per square mile

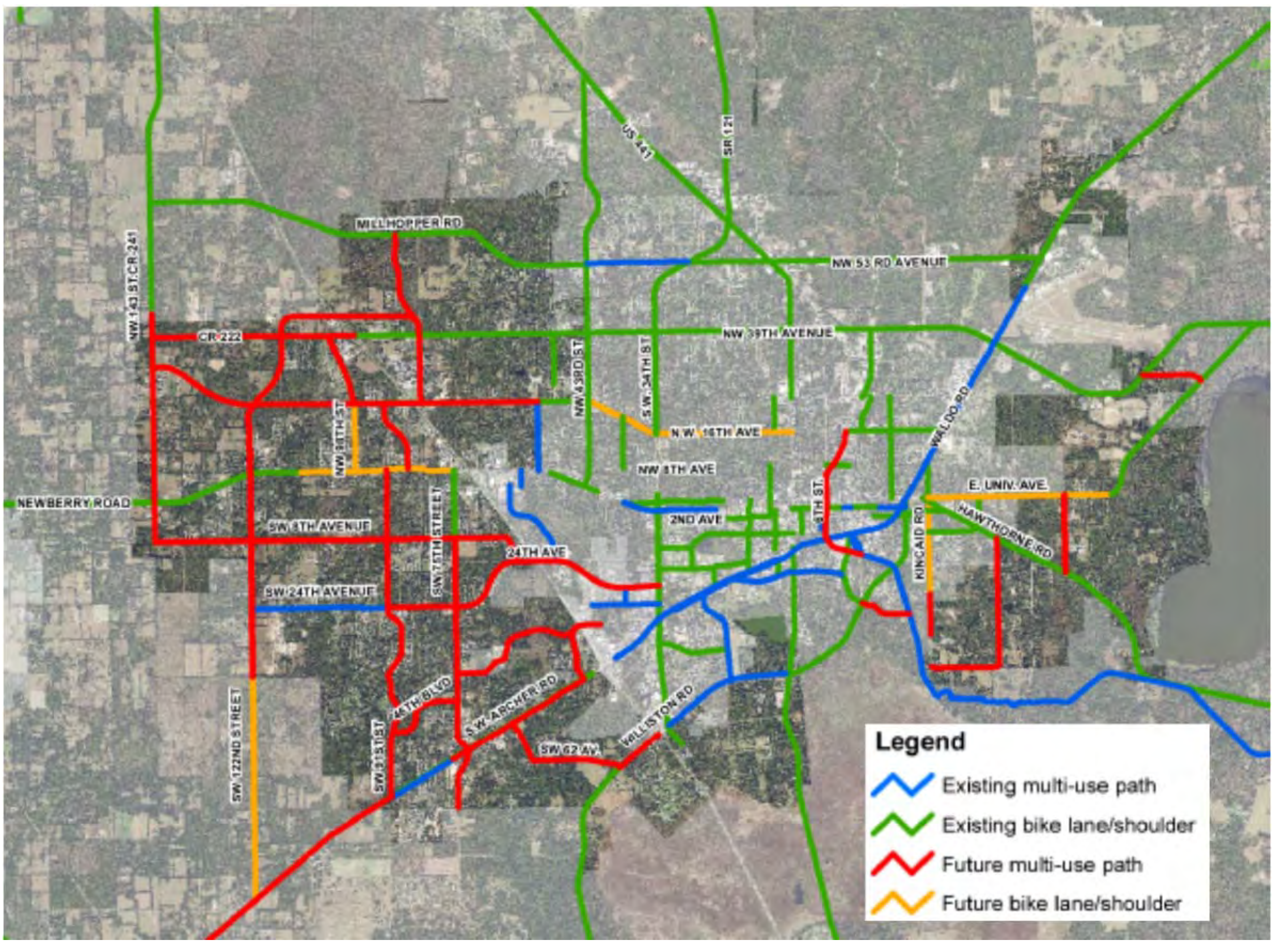

Figure 3.8 Existing and Future Bicycle and Pedestrian Network
(Alachua County Comprehensive Plan)

Planning Environment and History

Alachua County defines growth management as "[t]he creation and implementation of policies that influence the type, the amount, the timing and the location of new development in order to promote a sustainable, vibrant and equitable community[10]." Alachua County has shown strong support for non-vehicular travel within its urban areas for several decades, including substantial funding for non-vehicular transportation systems and cooperative agreements for limited transit service through Gainesville's RTS system. In 2001, they commissioned a comprehensive set of typical roadway cross-sections that include complete streets concepts in nearly every type of roadway along with context sensitive design features where appropriate[11]. Around the same time, The North Central Florida Regional Planning Council (NCFRPC) created the "Alachua Countywide Bicycle Master Plan" which was intended to not only map out future bicycle routes, but to document latent demand for those routes. This master plan has been used extensively by both the City of Gainesville and Alachua County to implement their non-vehicular system.

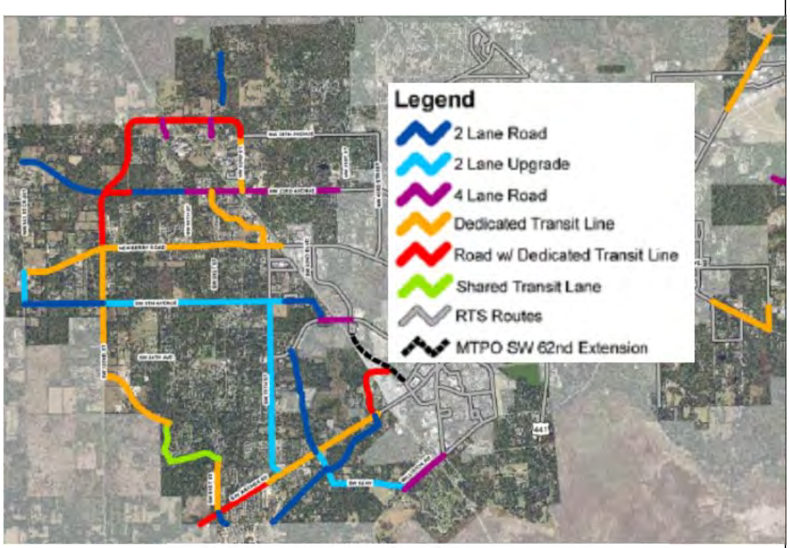

Figure 3.9 MMTM Planned Projects

Table 3.5 Multimodal Transportation Capital Improvements Summary, 2011-2030

Northwest

· 4.05 miles of dedicated transit lanes
· 4.8 miles of 2 lane reconstruction/extension
· 3.85 miles of new 2 lane construction
· 2.6 miles of widening to 4 lanes
· One bridge over I-75 with transit preemption
· 1 mile of sidewalks
· 11.2 miles of multiuse off-road facilities
· 19 miles of express transit service
· 7 new park and ride facilities
· $7.165 M for express bus purchases

Southwest

· 7.05 miles of dedicated transit lanes
· 4.95 miles of 2 lane reconstruction/extension
· 4.65 miles of new 2 lane construction
· 2.5 miles of widening to 4 lanes
· Two bridges over I-75
· 3 miles of upgrades in an existing multiuse facility
· 24.8 miles of multiuse off-road facilities
· 19 miles of express transit service
· 6 new park and ride facilities
· $7.165M for express bus purchases

East

· 2.6 miles of dedicated transit lanes
· 1.6 miles of widening to 4 lanes
· Intersection/median improvements
· 8.1 miles of multi-use off-road facilities
· 6 miles of express transit service
· 1 new park and ride facility
· $3.575M for express bus purchasesr

Source: Alachua County Comprehensive Plan

10. http://growth-management.alachuacounty.us/ 1/28/2012
11. Alachua County Corridor Design Manual, 2001.

While most jurisdictions were wrestling with how to address the state's DULA designations, Alachua County had a different set of problems. Their county-wide density was not sufficient for a DULA designation and therefore they were not only still subject to concurrency, but also required to address financial feasibility for their long-range improvement plan. With several communities experiencing pressure to expand as usual and inadequate public infrastructure funding to support that growth pattern, Alachua County developed a mobility plan that incorporated strategies for both land use and transportation. This plan created a mobility fee in the urban service area and urban cluster that was based on an aggressive transit scenario and highly dense land uses in either a Traditional Neighborhood Development (TND) or Transit-Oriented Development (TOD) form. Both forms required a highly walkable development pattern with high density land uses clustered within a ¼ mile of a designated village center, accessible to bus-based transit service within TND areas or premium transit within TOD areas.

RTS provides transit service for both the City of Gainesville and the surrounding unincorporated areas. As part of the mobility plan, express transit service for all urban cluster areas were planned beginning in 2015, funded by the county[12]. Bus Rapid Transit in dedicated lanes and roadway network grid completion round out the plan and are to be constructed as density and mobility fee revenues support it[13] (see Table 3.5). The amount of the mobility fee to be charged for each new development is tied directly to the list of specific mobility improvements designated in each district rather than a generalized impact fee based on a project's theoretical roadway trip length.

Impact fees, review procedures and concurrency requirements would remain as before outside the urban cluster, emphasizing maintaining the existing rural roadway network systems. This mobility plan was adopted by ordinance in 2009 and formally included in their 2011-2030 Comprehensive Plan. A corresponding update to their Land Development Code was adopted in September of 2011.

Funding for roadway maintenance and construction in the rural areas of Alachua County continue to pose difficulties. Approximately 15% of the County's 5 cent gas surtax is reserved for upgrading unimproved roads in the county[14]. The county is currently proposing a local option

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12. Mobility Plan Poster, http://growth-management.alachuacounty.us/transportation_planning/ 1/29/2012
13. Alachua County Comprehensive Plan: 2011-2030, Capital Improvements Element, Table 1, FY 2010-2030 Multimodal Transportation Capital Improvements Program.
15. Alachua County Public Works Website, http://www.alachuacounty.us/Depts/PW/engineering/roadProjects/Pages/UnimprovedRoadImprovement.aspx , 1/31/2012.

sales tax to support pavement management systems throughout the county which will go to referendum in 2012[15].

Long-Range Planning

Similar to Gainesville, Alachua County's Comprehensive Plan also views congestion as an acceptable tradeoff in urban areas as long as viable alternative modes are provided to serve the travel demand. Issues like ecological impact, reducing air pollution, safety, and accessibility are addressed directly, while increasing non-SOV travel is addressed indirectly as a part of greenhouse gas provisions. The Comprehensive Plan goals do not directly address freight movement, but the Economic Element includes objectives and policies that support distribution centers in rural areas.

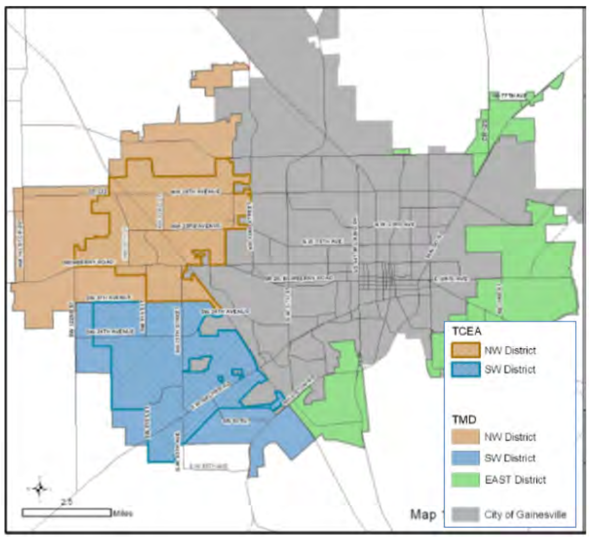

Figure 3.10 Alachua County Urbanized Areas

Source: Alachua County Comprehensive Plan

Based on the adopted Mobility Plan, areas outside the Urban Cluster will continue to collect traditional impact fees. However, backlogs in maintenance, and existing capacity needs within the rural areas of the county currently preclude the possibility of general revenue or gas tax funding for construction of any significant new capacity without new revenue streams.

15. http://www.alachuacounty.us/Depts/PW/engineering/TSS/Pages/TransportationSystemSurtax.aspx 1/29/2012

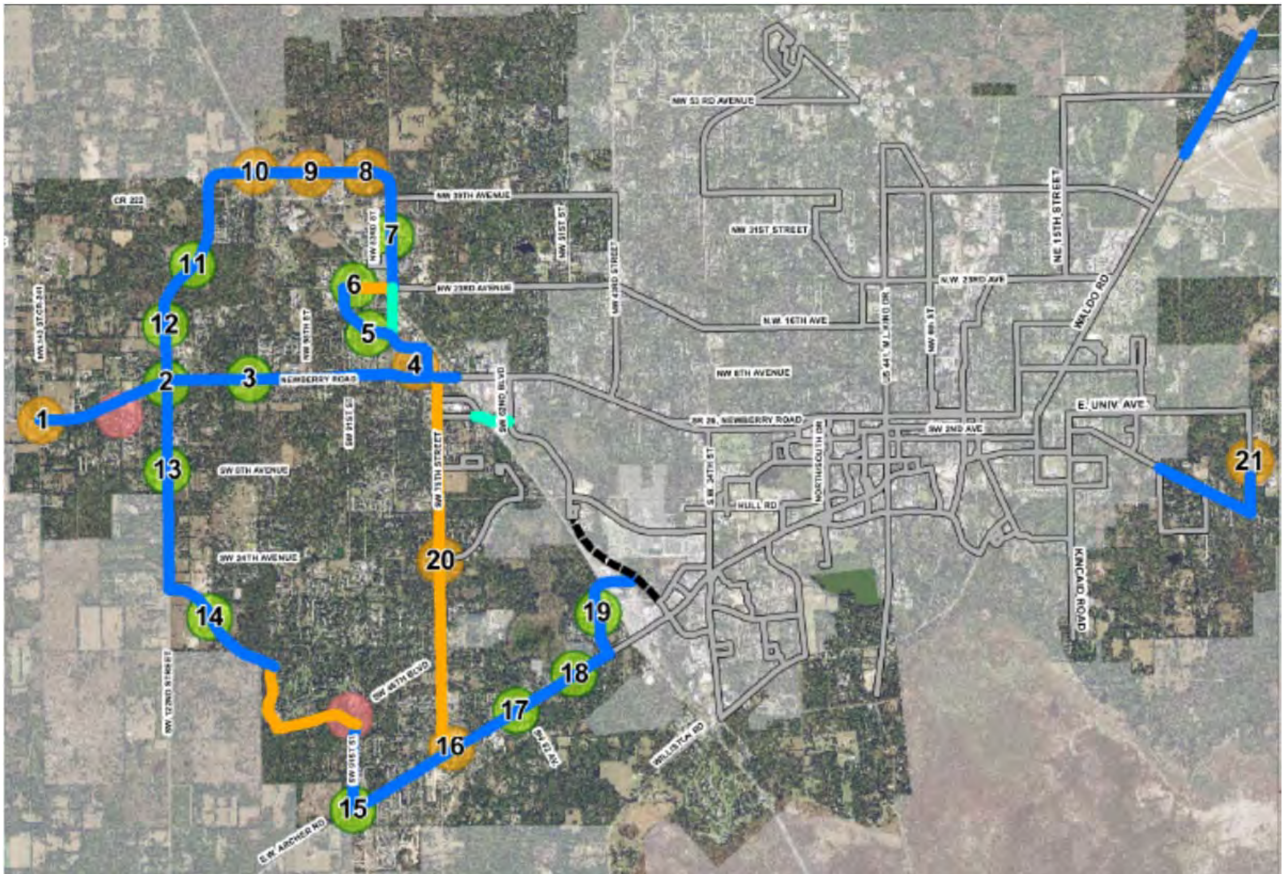

Figure 3.11 Potential TOD/TND Locations[14]

Within the Urban Cluster, three Transportation Mobility Districts were created[16]. These districts anticipate an interconnected network of route choices for all modes, as well as rapid and express transit corridors. The Mobility Element's multimodal planning is designed to work in conjunction with the Future Land Use Element's policies requiring TND or TOD development forms. These TOD/TND policies require a specific arrangement of minimum densities, intensities and land use mix that support acceptable walking distances from the center of each village as well as minimum spacing between village centers. Specific policies within the Future Land Use Element and corresponding Land Development Code also specify design architectural and geometric design features for TND and TOD villages[17]. Transfer of Development Rights (TDR) and density bonuses allow projects to build at densities that are supportive of transit service. Within the Urban Cluster, the plan specifically aims to "Avoid large areas of single-use, similar densities, and similar types of units.[18]"

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16. Alachua County Comprehensive Plan: 2011-2030, Transportation Mobility Element, Policy 1.1.1
17. "General Strategy 2," ibid.
18. "General Strategy 3," ibid.

Activity Centers with urban densities and TOD/TND layout are allowed outside the Urban Cluster and require a specified master plan, but for the most part, densities in the rural areas are intended to remain low (generally 1 dwelling unit per 5 acres). Even within these areas, variable lot sizes and conservation subdivisions allow for residential development to be clustered at higher densities with density transfers allowed for land placed in agricultural use or conservation[19]. Special Area Plans (SAPs) have been used within Alachua County as well. Although these plans must include land use and multimodal circulation, SAPs are specified more to assure that the particular environmental resource is protected rather than to address a specific transportation need.[20]

Project Review

County ordinance requires a pre-application conference at which time it is determined whether the project is of sufficient size to require a neighborhood workshop. Projects then proceed through a Preliminary Development Plan (PDP), an Initial Design Plan (IDP) and a Final Development Plan (FDP).[21] Each stage of the project review has a detailed plan checklist. The checklist for the PDP includes an initial narrative that instructs the applicant to analyze land suitability in the following sequence:

- Identify conservation, natural areas and tree canopy
- Identify open space
- Identify general location of access and connection to adjacent properties

The PDP documents must include all of the transportation related features listed to the right. In addition, a Traffic Analysis and Concurrency Report[22] is also required for the PDP (see right). This report is required to provide a review of roadway segment impacts for ½ mile around the site for projects within the Urban Cluster or projects outside the Urban Cluster that generate up to 1,000 trips per day. Projects outside the Urban Cluster that generate over 1,000 trips per day are required to analyze impacts until they drop below 5% of the published maximum allowable daily volume on a segment. Since this analysis is a concurrency-based

19. "General Strategy 1," ibid.
20. Chapter 402, Article 16, Special Area Plans, *Alachua County Unified Land Development Code*. Adopted 4/24/2007.
21. Chapter 402, Article 10, Development Plan Review, *Alachua County Unified Land Development Code*. Adopted 9/8/2009.
22. Chapter 407, Article 12, "Concurrency Management," *Alachua County Unified Land Development Code*. Adopted 4/12/2011.

analysis, segments approaching or exceeding their published capacities are likely to be reanalyzed using arterial strategies that address the signal operations on the failing segment and specific signal improvements would be addressed on a proportionate share basis. Projects within the Urban Cluster are only required to perform this segment analysis for planning purposes and their mitigation is addressed by paying the Multimodal Transportation Mitigation (MMTM) fee. Projects outside the Urban Cluster use the report to identify the mitigation required for the project. The future year analysis includes existing volume plus vested volumes plus project volumes on each segment.

Intersection analysis is also required within this study, but it is considered an access management consideration rather than a concurrency assessment[23]. The side bar to the right shows the radius used for determining impacted intersections based on the project's trip generation. Any required improvements to these intersections are considered safety related rather than capacity related.

The scope of the transportation review process used outside the Urban Cluster is fairly typical across Florida. No mention is made in the traffic analysis requirements of any multimodal performance evaluation. Even within the Urban Cluster, the analysis is fairly ordinary, with the exception of the limited impact area. Outside of the Urban Cluster, the performance of non-motorized modes may be addressed as part of an Activity Center Master Plan, but

Table 3.6 Preliminary Development Plan Required Mobility Features

- Section and half section lines including ROW/and setbacks (preservation of future corridors)
- Roadway ROW to be dedicated or preserved
- Adjacent streets and driveways within 150 feet of the site
- External vehicle access (two connections minimum)
- Proposed vehicular and pedestrian connections to adjacent sites
- Internal pedestrian and bicycle network
- Bus shelter and mass transit facility locations
- Parking, delivery and drop-off areas
- Proposed roadway cross-section(s)

Traffic Analysis & Concurrency Report Checklist

Trip Generation Data

Impacted Roadways

- Percentage of traffic distribution
- Project trips
- Annual Average Daily Traffic (AADT)
- LOS standard
- Roadway Segment Capacity (include source)
- Vested trips
- Available capacity
- Percentage of Available Capacity Consumed
- Does roadway meet LOS standards?
- Proposed mitigation

Intersection LOS Analysis (HCM)

Signal Warrant Analysis

Access Connection

Methodology Approval

Roadway Segment Impact Area Required

Trip Generation	Radius
Within Urban Cluster	½ mile
<1,000 trips per day	½ mile
>1,000 trips	5% of MAV

*MAV: Maximum Allowable Daily Volume, Minimum of ½ mile

Intersection Analysis Requirements

Trip Generation	**Radius**
<1,000 daily trips	n/a
1,000-5,000 trips	Site Access
5,000-10,000 trips	¼ mile*
>10,000 trips	½ mile*

*A minimum of one intersection analysis required.

Source: Alachua County LDC

23. Chapter 407, Article 13, "Access Management and Street Network Standards," *Alachua County Unified Land Development Code*. Adopted 8/10/2010.

no other specific requirements are indicated. It is within the urban design standards that Alachua County distinguishes itself from a multimodal standpoint.

TOD/TND Design Standards (Site Plan Review)[24]

Through the remaining plan review steps, the site plan is refined to meet the requirements of the comprehensive plan. One of the major innovations within this plan was the incorporation of form-based code elements in their specifications for TOD and TND projects within the urban cluster which are translated into the Land Development Code (LDC). It specifies the arrangement and components of the urban environment that will support multimodal travel rather than requirements for the performance of that multimodal environment. The measures used to prescribe the details of the TOD/TND environment are no less rigorous than those employed within American Association of State and Highway Transportation Officials (AASHTO) for roadway design, and many of them have significant empirical support. They aim to address the user's comfort within the environment for multiple modes rather than just the automobile.

TOD standards are used in areas that are contiguous to a rapid transit or express transit corridor. They are geared toward higher residential and commercial densities and will be served with express transit. TND standards are intended to generate walkable, bikeable villages that are also supported by

Table 3.7 Major TOD/TND Land Development Code Requirements

Minimum ½ mile spacing between Village Centers	Uninterrupted walls or roof planes to be avoided; Windowless walls prohibited
At least half of the non-residential uses must be in the Village Center	Minimum façade glazing percentages
At least ¼ of the non-residential square footage must be in mixed use multistory buildings.	Rear or side access residential garages
15-20 foot non-residential build-to lines (up to 40 feet for Civic uses)	Ground floor liner uses for all parking structures
6-8 Story maximum height	Off-street surface parking not required; Interior lots must be lined with buildings
Minimal residential setbacks (generally 10-20 feet)	Maximum number of driveways per block
70-80% maximum residential lot coverage	Clearly delineated pedestrian and bicycle routes through parking areas
Single tenant building footprints limited to 50,000 square feet	Off-street parking to provide mature canopy shading 50% of the paved area within 20 years
1,300-1,600 foot maximum block perimeters; can be extended through liner buildings, interior parking or continuous multi-use paths internal to the block	Street trees required in Transit Supportive Area; Encouraged in bulb-outs in Village Center
Buildings oriented toward the street with pedestrian access and shade along the frontage	Minimum clear sidewalk width on both sides of the street
Shade along the frontage; Canopy trees required for separate pedestrian paths	Trip based roadway design standards; generally 10' lanes
Architectural features that clearly identify the first story and primary entrances	Median separated drive aisles for angled parking on higher volume streets
	Stub-outs to adjacent projects required

24. Chapter 407, Article 7, "Traditional Neighborhood Development and Transit Oriented Developments," *Alachua County Unified Land Development Code*. Adopted 4/22/2008.

transit service, but not necessarily express service. The sidebar summarizes the major design concepts that characterize a TOD/TND project.

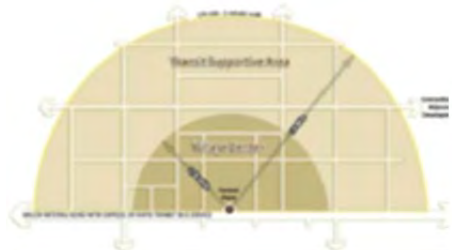
TNDs/TODs have minimum density requirements and land use mixes for the village center and transit supportive area. Additional non-residential intensity bonuses can be gained where higher residential densities are employed or where there is access to rapid or express transit. TOD projects must also have minimum and maximum retail percentages for their non-residential uses. Phased projects must incorporate residential and non-residential uses proportionately as they proceed through their phases.

The bulk of the LDC requirements for TNDs and TODs are included in Chapter 407, Article 7.   A summary of the major elements is included in Table 3.8.

Transit standards require that developments include previously planned dedicated transit lanes, turn out facilities or park and ride facilities. A principal transit station is required within the Village Center where the village is contiguous to a Rapid Transit Corridor. Smaller transit stations are also encouraged along the corridor and are required if there are locations within the project that are more than ¼ mile to the principal transit station.

No internal land use buffers are required within TNDs or TODs. Roadway buffers are required to meet FDOT sight triangle requirements and protect pedestrians from clear-zone intrusions along arterials. I-75 is provided a 25 foot medium density buffer.

Table 3.8 TOD/TND Development Concepts[23]



Central Point

· A plaza, square or open space with an architectural feature

Village Center

· Highest density/intensity area
· Mixed use
· Approximately 1/8th mile radius around the defined Central Point
· Pedestrian scale

Transit Supportive Area

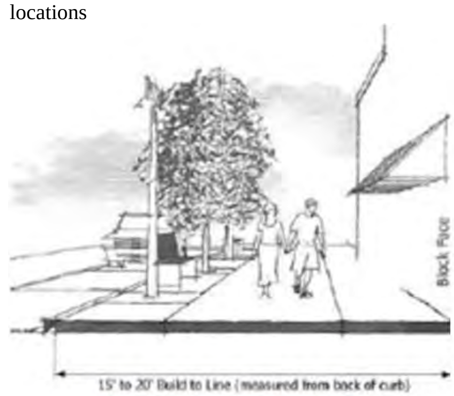
· Area extending ¼ mile around the Central Point
· Transitions densities/intensities to surrounding land uses

Common Areas

· Other plazas, squares, parks or open areas
· Can be used to satisfy open space requirements

Transportation Network

· Designed to support transit vehicles, automobiles, bicycles and pedestrians
· Must provide multiple points of ingress and egress
· Must connect to adjacent developments in a redundant fashion
· Must allow for multiple route choices between locations



Non-Residential Build-to Line

25. Alachua County LDC

Figure 3.12 shows a sample block layout that meets Alachua County's TOD/TND requirements

Each of these design features are intended to make the pedestrian, bicyclist and transit user feel comfortable, safe and welcome in the area while vehicular traffic is slowed to keep operational conditions safe. Providing narrow lanes also limits the street width that a pedestrian must cross. Even glazing minimums are intended to maintain visual surveillance of the pedestrian realm, making it safer for pedestrians.

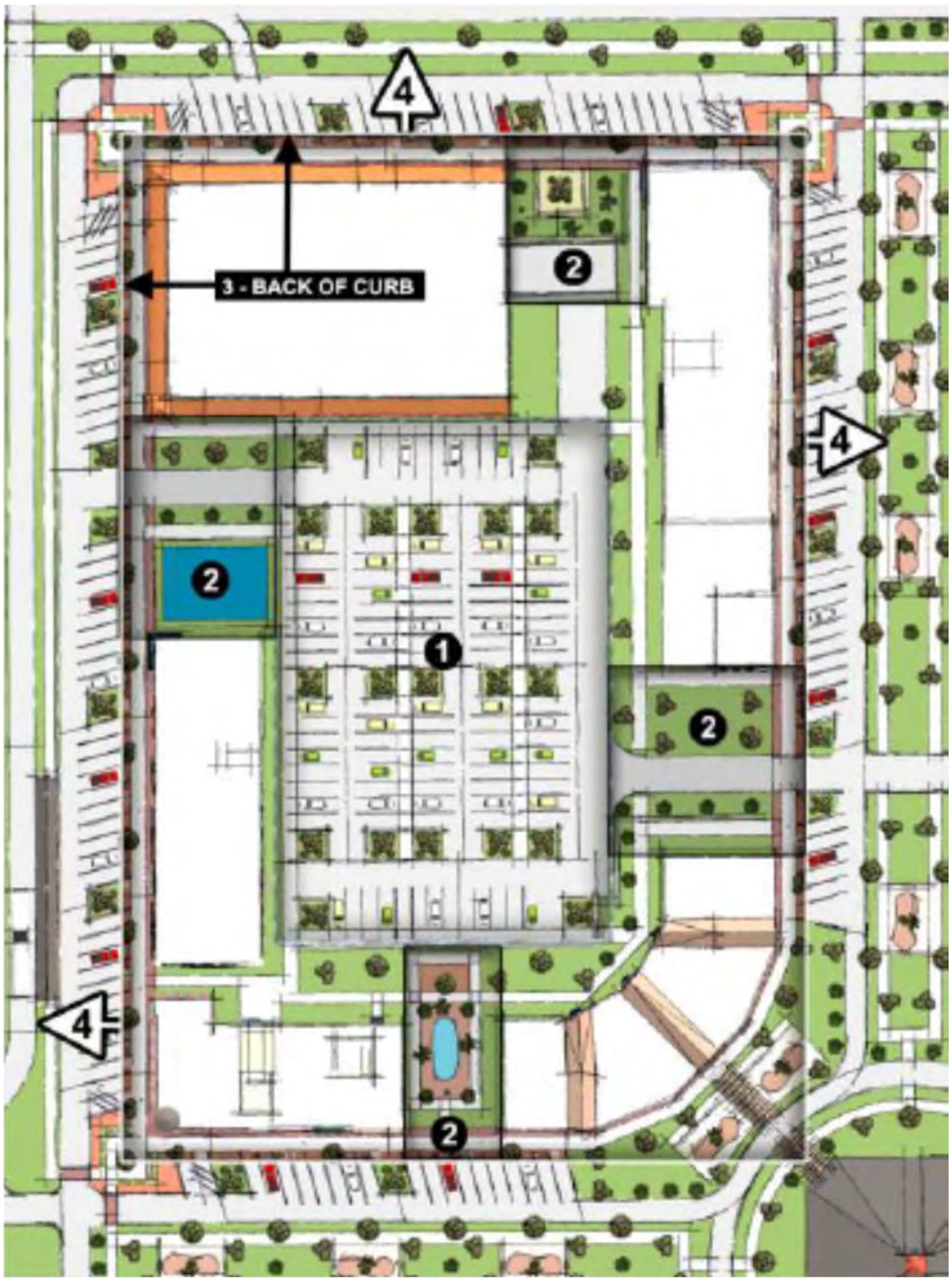


Figure 3.12 Sample Block (Alachua County LDC)

The City of Orlando−Geographic Analysis

The City of Orlando has become a large metropolitan area with a wide range of land uses and contexts. Although it is internationally known for its entertainment venues, the community has had a large, stable employment base since the 1920s when Martin Marietta first located its plant on the south side of town. This is likely to continue with the recent addition of the new "medical city" complex in southeast Orlando. Growth in the region since the 1970s has been rapid and sprawling, with the Metro Orlando area covering parts of at least 6 counties. Despite this growth, most locations throughout the region can be reached within a ½-hour drive. The primary north/south arterial, I-4, experiences chronic delays in the peak hours, but the remainder of the major, long-distance arterials are toll facilities and experience mild to moderate delays. Lynx, the local transit provider, coordinates a Road Rangers program which is funded by State Farm and provides roadside assistance on the major highways throughout the area, including I-4, SR 408, SR 528, SR 417 and the turnpike.

Table 3.9 Community Characteristics: Orlando

Population

· City: 238,300 (2010 census)
· Metropolitan Statistical Areas (MSA): 2,171,360 (2011 est)

Student Population, 2010

· University of Central Florida, 58,698
· Valencia Community College, 35,351
· Full Sail University, 12,400
· Rollins College, 2,715

Major Employers

· Walt Disney Co., 62,000
· Florida Hospital, 16,200
· Publix, 15,606
· Universal Orlando, 13,000
· Orlando Health, 10,000
· Busch Entertainment (Sea World), 7,800
· Lockheed Martin, 7,200
· Mariott, 6,312
· Darden Restaurants, 5,950

Size and Density

· 110.7 square miles
· 2,327 persons per square mile

Mean Travel Time to Work

· 24.3 minutes

Even though the majority of the travel through Central Florida occurs via private automobile, Central Florida has also been working toward multimodalism since the 1970s. Lynx was originally formed in 1972, under the name Tri-County Transit, and currently has a ridership of over 28 million passenger trips per year. A commuter rail line, Sunrail, will be added in 2014 that will ultimately span 61 miles from Deland to Poinciana. A second transit agency, I-Ride, provides transit service throughout the International Drive tourist corridor. Additionally, private transit service throughout the tourist area is extensive. Nearly every hotel has shuttle service to the major theme parks included as a part of their room rates. Within the major employment centers, Disney and Universal Studios, private parking is expensive, but high quality transit service is available to and from all hotels and entertainment venues. A regional multiuse trail now spans 25 miles from the western edge of the region in Clermont to the city of Apopka, northwest of Orlando. Other, shorter trails are also scattered throughout the region.

The City of Orlando has been known for several decades for its willingness to apply innovative approaches to transportation and land use issues. Their City Planning department consists of four planning studios. The Architecture and Design studio is responsible for urban design standards that include architectural concerns but have a strong focus on creating vibrant pedestrian environments that support the vitality of their urban spaces. This group is responsible for the strong visual orientation of their zoning ordinances. Although their standard zoning classifications are not a Form-Based Code, each zoning category includes a visual representation of the development form that is expected for that category. Their Community Planning Studio creates vision and special area plans and recommends changes to the LDC. Several of their more recent plans have been Form-Based Codes, with significant details specified regarding roadway cross-sections, and other pedestrian/transit environment issues. The Comprehensive Planning Studio attends to the City's Growth Management Plan (GMP), which completed its last EAR in 2007. The Land Development Studio reviews applications in light of the regulations of the LDC and the priorities of the GMP.

Comprehensive Plan Goals

Orlando has an extensive Growth Management Plan (GMP) that was started in 1991 and has been updated regularly. Appendix B lists the goals identified in their GMP. Major updates have occurred in conjunction with the 7 year EAR cycles, but interim updates are also included as statutes change or issues arise.

Orlando's GMP begins with a vision plan that is immediately followed by an urban design element that specifically encourages many mobility related features based on the pattern of the pre-WWII traditional city. These features include mixed land use/economic/architectural/density, gridded streets, narrow roads, sidewalks, trees, street orientation, and on street parking. These features have been preferred within the GMP since 1981. The remainder of Orlando's goals is extensions of the vision statement and the Urban Design element and refers back to them frequently. Within the Future Land Use Element, the themes of traditional neighborhood development, land use mix, and sustainable, effective provision of services are developed further and applied in context specific ways to activity centers, subareas (established neighborhoods), the airport, the Medical City, and the downtown. The Transportation Element goals focus on intermodal travel and travel choice and lay out the concept of transportation mobility areas as the primary geographic unit for which multimodal mobility is considered for new development. Financial feasibility and intergovernmental coordination are also cited as specific transportation goals. The Conservation Element includes efficient urban form and transportation system design in addition to resource protection and energy efficiency as primary strategies to address environmental and conservation concerns. The Capital Improvements Element embraces the concept of concurrency but requires that the provision of public facilities be consistent with the desired urban form.

Project Review

Orlando has recently reframed many of their design regulations in an initiative called "Get Active Orlando" so that projects are reviewed for ease of bicycling and walking. A one-page handout is given to the developer at the pre-application meeting that lists 15 different issues to be considered in the project design. A narrative must be submitted with the plan that documents how each item was considered. A copy of the handout is shown in Figure 3.13.

Several atypical performance measures are included within the Land Development Code to help assure that a wide range of mobility systems remain effective with the addition of new development. A connectivity index of 1.4 must be maintained for all projects.[26] This index is calculated as the number of links divided by the number of nodes where all streets and cul-de-sacs are counted as a link and each intersection and end of a cul-de-sac is counted as one node. Additionally, all culs-de-sac are required to have an improved, 15-foot wide pedestrian and bicycle access. Although this requirement can be waived, it is an effective way to complete existing pedestrian and bicycle routes and create access.

26. §61. 221(e), Code of Ordinances, Orlando, FL

get active orlando

Project Name ____________________ Date ____________
Your Name ____________________ Email ____________________

A Walkable & Bikable Orlando Project Design Checklist

Get Active Orlando recommends that planners, architects, landscape architects, engineers, citizens and developers review their projects for ease of walking and biking. Small details in a project's design can make a big difference in leading to a healthier lifestyle.

Please consider each item below as you design your project. Submit this form with your plans when applying for development approval from the City of Orlando. City Staff will examine how your project adheres to these principles and will include recommendations in the staff report.

Connectivity and Crossing

1. Are direct, short, clear, well lighted pedestrian routes provided to building(s)' entrances, adjacent uses and surrounding neighborhoods?
2. Are connections provided to nearby public sidewalks and bikeways?
3. Are safe, direct crossings provided for walkers and transit users on site and in transition areas, including nearby intersections? (These could include "bulb-outs" at corners, median refuge islands, mid-block crossings, speed tables, high emphasis striping, and pedestrian count-down signals.)

Entrances and Stairways

1. Are entrances to the building(s) visible and convenient from the street for all bicyclists, pedestrians and transit users?
2. Are wide central stairs provided in a prominent location to encourage walking rather than using elevators?

Bicycle Parking and Support Facilities

1. Does the project provide conspicuous short term and/or longer term parking for bicyclists?
2. Is weather-protected bicycle parking conveniently located near primary entrances of the building (i.e.: within 100 ft.)?
3. Are bike racks readily visible and identified with a City approved design? (City-approved designs depict either an upside down "u" or a "hitch").
4. Are showers and lockers provided for office and commercial employees?

Sidewalks, Walkways and Eliminating Barriers

1. Are sidewalks sufficiently wide to accommodate the anticipated number of walkers? (Provide a 5 ft. minimum clear width without obstructions; i.e. café tables, newspaper boxes, electrical poles, etc.)
2. Is shade and/or rain protection provided over the sidewalks by canopy trees, awnings, or buildings?
3. Is sufficient sidewalk width provided for a bus stop and bus shelter?
4. Are there adequate walkways through parking areas to building entrances?
5. Are utility poles, traffic mast arms, and equipment boxes located outside the sidewalk and walkway areas? (These items should be located in the planter strip between the sidewalk and the street.)
6. Is there an opportunity to remove obstacles from the sidewalks?

***Get Active Orlando** reminds all that we can be physically active every day by making choices such as walking to lunch instead of driving and taking the stairs instead of the elevator. **Get Active Orlando** seeks to provide the public with opportunities to being active and to remove barriers to physical activity.*

City of Orlando—City Planning Division March 2012

Figure 3.13 Get Active Orlando Handout

An access management classification system is used that designates the spacing and types of access points available along each roadway along with a series of standard cross-sections that address the entire[27] range of typical street types. Street widths are generally narrow, but this is particularly true in the case of alley ways, which have a typical 16’ ROW width and a 12’ pavement width. A second set of cross-sections are included that are intended to be used in conjunction with a series of land use and community design ordinances for a “Design Community.[28]” The Design Community ordinance is similar to the Alachua County TOD/TND ordinance, requiring a walkable environment within a 1/3 mile radius of an intense mixed use Village Center[29]. The transportation requirements for a Design Community indicate that streets shall be designed so that the required posted speed limit is equivalent to the design speed. This speaks to the issue that the performance measure speed suitability addresses—the mismatch between posted speed and the design speed of the roadway.

Sidewalks are required on both sides of all public streets within Orlando with only one exception. A bikeway can be traded within an attached dwelling unit project if it is part of an overall bikeway system that connects to the City’s open space network[30]. The pedestrian network in the downtown area is classed in a hierarchical manner, similar to how roadways are classed. Each classification has a designated cross-section and design standards that are managed by the Downtown Development Board[31].

City staff has been proactive in commissioning studies that identify the specific variables that are critical to the pedestrian environment. One such study will be released in late November 2012 that focused on pedestrian attitudes and desires on International Drive, their major tourist corridor. This study identified variables such as shade, lighting, sidewalk width, sidewalk buffering and connectivity as having significant influence on pedestrian attitudes and behavior. They have actively supported Lynx, the local transit provider, as they begin to incorporate art and shade into their stop locations in the corridor (see Figure 3.14).

Figure 3.14 Decorative Bus Shelter

27. §61.211-214, ibid.
28. §61.270-271, ibid.
29. §62.636-637, ibid.
30. §61.225, ibid.
31. §61.251-253, ibid.

As with both Alachua County and the City of Gainesville, parking requirements in Orlando are stringent in urban areas and specific bicycle parking requirements are listed in the LDRs along with design specifications for bicycle racks[32]. Parking can be provided onsite or within the Orlando Downtown Parking Program, by paying into the Parking System Revenue Fund. If a project developer desires additional parking beyond the maximum allowed, a premium of $1,500 per space can be paid to allow for bonus parking. Principal use parking facilities (stand-alone private garages) are not allowed within the downtown parking area unless the City has some form of ownership interest in the property.

Each commercial site (including multifamily sites) is required to have a loading berth and specific design dimensions are specified within the LDC[33].

Concurrency Management

A separate department, Transportation Planning maintains a geographic review system, called the "Traffic Allocation Program" (TAP), to regulate both adequate facilities requirements and the timing of development. The city is divided into 15 Traffic Performance Districts (TPDs). Within each district are multiple traffic analysis zones that are part of a travel demand model that is updated biannually with data from development and projects from the City's five-year Capital Improvements Element (CIE). Ongoing traffic count monitoring is used to regularly calibrate the model. Each zone is allocated the amount of trips that can be consumed by new development within that year while maintaining the LOS standards on the roadway network. Development applications consume the allocated trips within each of the zones until they are gone for that year. If the trips have been consumed within that Traffic Analysis Zone (TAZ) and the adjacent TAZs for that year, then development can be delayed until trips become available in the next year. If a developer wants to proceed before the trips become available, the location of the projected deficiencies that limit the available trips is identified. The developer has the option to fund improvement(s) to correct the identified deficiencies or provide a proportionate share payment toward them. Developers can provide a proportionate share contribution under several conditions. The contribution must be sufficient to allow the proposed improvement to be accelerated into the 5-year Capital Improvements Element (CIE). If multiple improvements are needed and the contribution is sufficient to construct one of the identified needs, then the

32. §61.320-345, ibid.
33. §61.350-352, ibid.

development can proceed by paying to construct that improvement, at the City council's discretion. Three of the TPDs near the City center have been designated Transportation Management Areas. These areas have significant multimodal support from transit, bicycle and pedestrian amenities. Within these areas, only 85% of the lane miles must meet their LOS standards within the TAP monitoring and modeling system for trips to continue to be allocated.

Transit LOS must also be maintained for all developments. All transit stops within ¼ mile of any proposed project must have headways of 1 hour or less. This is typically the case for nearly all areas within the City. If this standard cannot be met, then the applicant must provide the funding needed to increase service frequency for those lines.

A concurrency review is prepared internally by City staff. However, an access and near site operational analysis is required to document any operational deficiencies that could cause safety concerns at nearby intersections. Any needed improvements that can be identified in the study may become required if it is established that the deficiency is predominantly due to the addition of the proposed project. This is often a negotiated concern. Within the downtown area, this analysis is also required to include documentation of the pedestrian environment within ¼ mile of the site, including presence or absence of sidewalks, shade and cover.

This system allows development to occur at the pace at which the City can maintain and update the capacity issues within their system. If a developer desires to proceed at a faster pace than the City can manage, then it is his responsibility to provide for the deficiencies that will be needed and impact fee credits can be given for any improvements on City owned roadways. It also allows for an acceptable level of roadway congestion to occur in areas where alternatives are available.

The City of St. Petersburg−Prescriptive System

St. Petersburg is largely built out both from a land use and transportation standpoint. Less than 3.3% of the vacant land area can still be developed, and residential density is 7.7 dwelling units per acre[34]. Its overall density is nearly twice that of both Gainesville and Orlando and it includes a significant number of seniors. The land uses within the City are predominantly residential (72.9%) with a scattering of moderate size employers.

Table 3.10 Community Characteristics: St. Petersburg

Population

· City: 244,769 (2010 census)

Student Population, 2010

· Eckerd College, 1,832
· St. Petersburg College, 1,707

Major Employers

· Home Shopping Club, 4,000
· Times Publishing, 3,187

Size and Density

· 59.6 square miles
· 3,964 persons per square mile

Mean Travel Time to Work

· 22.0 minutes

Source: Wikipedia

The city is laid out in a grid system, which provides numerous redundant travel routes. Because the majority of the streets are two-lane streets with sidewalks, pedestrian movement is much easier than in most suburban locations. The City is also actively funding and constructing bicycle paths and trails throughout the community and has a Bicycle Master Plan that documents their goals and design preferences. Their bicycling site includes a google map that shows the location of all their existing and planned bicycle facilities and canoe trails.

St. Petersburg has had transit services since 1919; by 1928 it had a ridership of 4 million annual trips. Today, the Pinellas Suncoast Transit Authority (PSTA) provides extensive transit service throughout St. Petersburg and has a ridership of 13 million trips annually, with over 360,000 of those trips including bikes on buses. A $35 summer youth pass is available to students 18 and younger that is valid on all regular routes. Premium service via motor coach is available to Tampa with 30-minute headways in the peak hours. PSTA’s website includes a transit trip planner using Google maps and they are beta-testing a real-time bus location application that provides estimated arrival times at specific stops and a map that shows the actual location of the closest bus. This type of application is also available in Gainesville and improves the traveler’s perception of the quality of service.

34. Transportation Element, St. Petersburg Comprehensive Plan

Long-Range Planning

St. Petersburg's Comprehensive Plan has a distinctive format that includes significantly more narrative than most Florida comprehensive plans. Although the goals included are short and general in nature, specific local issues are highlighted under each goal to provide direction and rationale for the objectives and policies that follow. Similar to the other communities reviewed, congestion is addressed in terms of balancing level of service with urban infill and the needs of alternate modes. SOV travel and freight movement is not directly addressed, though a port master plan is recognized and supported. Ecological issues including stormwater runoff treatment, impervious surfaces, and air quality all have specific issues identified for which objectives are created.

Transportation Review

In contrast to the other three areas, St. Petersburg has had a TCEA since 2000 and no transportation analysis is required for new development within St. Petersburg. If the adjacent roadway is operating below LOS "D", the proposed project must demonstrate compliance with a list of site related design features (Table 3.11). A fee is collected based on the trip generation of the development. That fee, along with the City's tax revenues, are managed by the City staff and applied as needed to deficiencies as they occur.

Table 3.11 St. Petersburg TCEA Required Design Features

1. On-site or offsite road capacity enhancements shall be incorporated into the proposed development, such as, but not limited to:
   - a. acceleration/deceleration lanes,
   - b. reduction of curb cuts,
   - c. shared curb cuts/cross access easements, and
   - d. intersection capacity improvements, such as, but not limited to, signal timing and turn lane storage capacity.

2. Provision of transit accommodations developed in coordination with the PSTA, such as, but not limited to:
   - a. new or enhanced transit stop(s) or shelter(s)
   - b. walkways connecting transit stops to the principle building(s)
   - c. bus pull-off area(s), and
   - d. dedication of park and ride parking spaces.

3. Provision of pedestrian accommodations, such as, but not limited to:
   - a. sidewalks along all street frontages and
   - b. other sidewalks connecting to adjacent neighborhoods.

4. Provision of bicycle accommodations, such as, but not limited to:
   - a. bicycle rack(s) and
   - b. bicycle lanes.

5. Implementation of transportation demand management strategies, such as, but not limited to:
   - a. ridesharing programs
   - b. flexible work hours, and
   - c. telecommuting.

6. Provision of traditional design features, such as, but not limited to:
   - a. locate building adjacently to street sidewalk
   - b. building entry on street and
   - c. pedestrian protection devices such as, but not limited to, awnings over sidewalks and other outdoor walkways.

7. Site design minimizes cut-through traffic on neighborhood streets by encouraging vehicular traffic to utilize the major road network to travel to or from the site, utilizing local roads only for immediate site access.

Source: St. Petersburg LDC

Project Review

St. Petersburg utilizes a Form-Based Code that includes the following paragraph at the beginning of the section detailing the allowable site layout and orientation:

> *The City is committed to creating and preserving a network of linkages for pedestrians. Consequently, pedestrian and vehicle connections between public rights-of-way and private property are subject to a hierarchy of transportation, which begins with the pedestrian.*

Each zoning district includes a graphic that shows typical architectural styles and lot layouts as shown in Figure 3.15. Multiple performance measures are specified related to the quality of the pedestrian environment. These measures include densities, sidewalk widths and location, parking location and quantity, front porches, and window requirements (glazing percentage). In the downtown, buildings are to be constructed up to the right of way line.

Parking in residential areas is frequently required to sit behind the main structure. In the downtown, parking availability is limited by the land use, but not necessarily by the code itself. All parking is also required to be underneath or behind the building, on the interior of the block. Carpool/vanpool parking spaces are required for all non-residential buildings over a certain size. Minimum bicycle parking is also designated along with minimum numbers of loading berths for industrial or commercial projects.

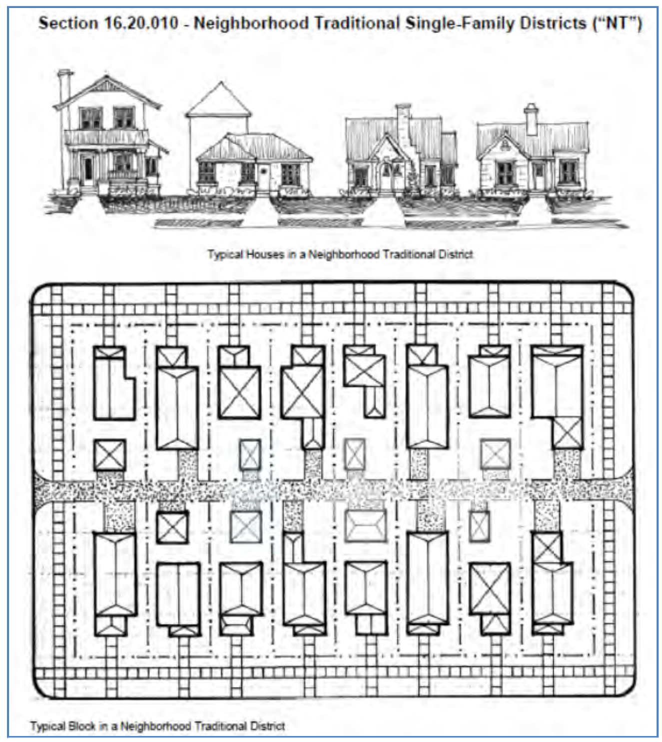


Figure 3.15 Typical Neighborhood Diagram from the St. Petersburg LDC

Comparison of Performance Measure Use across Jurisdictions

The measures that were used in each community were documented in a comparative spreadsheet as shown in Tables 3.12 through 3.20. The tables are organized based on the categories identified in Chapter 2.

Residential density (Table 3.12) is a fairly common measure used in nearly every jurisdiction, particularly with regard to maximum allowable density. Minimum development densities and intensities are less common but have been tagged frequently by new urbanists as desirable to assure that transit can be supported. The minimum density requirements used in Orlando around the airport are directly supported by extensive transit plans and interconnectivity with a major international airport. In Alachua County's urbanized areas, where TOD/TND development is desired, building coverage minimums help keep parking areas from interfering with the pedestrian and transit-oriented environment. In St. Petersburg, where undeveloped area is nearly non-existent and redevelopment is likely to increase intensity, measures like building coverage and minimum density or intensity are unnecessary because the economic pressures are sufficient to assure that development maximizes the potential of each parcel. On the other hand, this also means that St. Petersburg can optimize the relative proximity of schools and housing, particularly since their form-based code doesn't explicitly dictate where housing will be within the city.

Table 3.12 Performance Measure Application, Density

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Infrastructure-Density	Residential density (gross and/or net)	○	○	○	○
	Percent of houses within 1 mile of an elementary school				○
	Density of development (airport supportive district)			○	
	Population and employment centrality	○			
	Building coverage ratio		○		
	Non-residential intensity			○	

Many of the design-oriented measures are commonly used throughout the jurisdictions in this comparison (Table 3.13). All 4 communities use the ratio of street width to building height, tree-lined streets, parking footprints, sidewalk/path connectivity/width, connected streets, cross access, parking location/supply, bus shelter location and walking environment variables to assure that pedestrian or transit-oriented areas have the characteristics that make for a good walking environment. Three out of four jurisdictions include parking screening, sidewalk shade, block length, and connectivity to intermodal facilities. Bicycle requirements within the LDC are favored by Gainesville and Orlando while bicycle and pedestrian features are addressed regionally in St. Petersburg and Alachua County. Gainesville has experienced issues in the past with lawsuits regarding the safety of bicycle and pedestrian facilities that have not been adequately maintained and has explicit requirements for the quality of those facilities. Although 3 out of 4 jurisdictions have qualitative requirements for vehicle and pedestrian connectivity, only Orlando has a quantitative measurement for connectivity. Also, both Gainesville and Orlando operate their own transit systems and therefore have requirements directly related to transit service provisions.

Table 3.13 Performance Measure Application, Design

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Infrastructure-Design-point	Ratio of street width to building height	○	○	○	○
	Tree-Lined/Shaded Streets (Street tree spacing and planting area)	○	○	○	○
	Availability of on-site bicycle amenities			○	○
	Parking screening	○	○	○	
	Sidewalk quality	○			○
	Sidewalk shade	○	○	○	
	Sidewalk width	○	○	○	○
	Bus pass program utilization	○	○		
	Pedestrian scaled lighting	○	○		○
	Walkable Streets (Pedestrian/bike path height)		○		○
Infrastructure-Design-neighborhood	Parking footprint (On- & off-street parking)	○	○	○	○
	Connected sidewalks/paths	○	○	○	○
	Walking environment (Percent with porches and balconies, street-facing facades, window glazing percentages, building setbacks, build-to-lines)	○	○	○	○
	Block length	○	○	○	
	Connected streets	○	○	○	○
	Connectivity Index			○	○
	Cross access	○	○	○	○
	Parking location	○	○	○	○
	Pedestrian/bicycle route directness			○	
	Bicycle path condition	○			○
Infrastructure-Design-community	Connectivity to intermodal facilities	○	○		○
	Parking supply	○	○	○	○
	Bus shelter locations	○	○	○	○
	Bicycle parking requirements (location, design)	○		○	○
Infrastructure-Design-corridor	Bus turnout facilities	○			○
Infrastructure-Design-regional	Transit service density	○		○	○
	Road density	○	○		
	Parking spaces designated for carpools or vanpools (for shared parking, park and ride)			○	○

Destination-based measures (Table 3.14) are used in 3 out of the 4 jurisdictions studied. Orlando and St. Petersburg are working toward a more complete system throughout their urbanized areas while Gainesville has many more facilities and can begin to work toward assuring that the facilities they already have connect complementary uses.

Table 3.14 Performance Measure Utilization, Destination

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Infrastructure-Destination-network	Bike/pedestrian accessibility			○	○
Infrastructure-Destination-area based	Number of key destinations accessible via a connected pedestrian system	○			

Three of four jurisdictions require some assessment of land use balance (Table 3.15). These same jurisdictions also require some additional detail regarding the nature of the diversity of those land uses in and around proposed projects. Orlando requires land use mix within activity centers but has few limitations on how that land use mix is balanced.

Table 3.15 Performance Measure Application, Diversity

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Infrastructure-Diversity	Land use balance	○	○		○
	Jobs/housing balance				○
	Land Use within Village Center & within Transit Supportive Area		○		
	Significant Land Uses	○			

Most of the jurisdictions considered have some requirements for access management (Table 3.16). All state roadways are governed by FDOT's access management guidelines. Because St. Petersburg is working toward slower speeds, limitations on access that would increase speed is considered counterproductive, however, cross access between parcels is encouraged. Orlando and Alachua County both consider the distance between activity centers to assure that the increased densities associated with the center do not spread unchecked into strip commercial development that is harder to serve with transit.

Table 3.16 Performance Measure Application, Infrastructure Access

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Infrastructure-Access-network	Access requirements/Roadway access management	○	○	○	
	Spacing between Village Centers		○	○	
	Multiple Route Choices		○		

Standard LOS for segments and intersections are used for 3 of the 4 jurisdictions (Table 3.17). As St. Petersburg doesn't require a LOS-based analysis, these are not included in their requirements. However, their internal staff uses typical LOS measures to evaluate the functioning of their roadways and arterials and optimize their operations. Average commute time is only used by Gainesville because the impacts to local commute time from an individual development are difficult to assess within large areas like Alachua County or Orlando. St. Petersburg has chosen to focus more on alternatives to the automobile and accept some congestion, therefore auto-based measures are less relevant to their objectives.

Table 3.17 Performance Measure Application, Auto Utilization

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Utilization-Auto-quantity	Percent of Capacity Consumed		○		
	Maximum Service Volume	○	○		
	Peak Hour LOS	○	○	○	
Utilization-Auto-time	Congestion Duration				○
	Control delay (intersection LOS, HCM-based)	○	○	○	
	Average commute time	○			

Gainesville has a significantly more robust project assessment procedure and includes far more transit related measures than the other jurisdictions (Table 3.18). Orlando also applies transit requirements to individual projects. Again, both jurisdictions have direct control over the transit services provided throughout the area. St. Petersburg has chosen to focus on non-motorized mobility services so their measures are directly associated with these non-motorized trips.

Table 3.18 Performance Measure Application, Alternate Mode Utilization

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Utilization-Auto-multimodal	Multimodal LOS	○			
Utilization-Demand-mode share	Mode Split				○
	Average Vehicle Occupancy				○
Utilization-Demand-trip generation	Mean daily trips per household (bicycle and pedestrian trips)	○	○		○
Utilization-Transit-service	Off-peak transit availability	○			
	Average headways	○	○	○	
Utilization-Transit-occupancy	Ridership	○		○	

User perception measures are typically difficult to apply to development projects (Table 3.19), however, Gainesville and Alachua County require assessments that review the conditions of existing services around a development as a part of their project review procedures. The reviews included in project assessments are used by staff to strategize where investments and improvements are needed.

Table 3.19 Performance Measure Application, User Perception/Safety

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
User Perception	Transit condition of vehicles and facilities (cleanliness and ease of use)	○			
Safety-risk management	Speed suitability		○		

From the list of measures used, sustainability measures are considered important for both Orlando and St. Petersburg (Table 3.20). The Tampa Bay region has had criteria gas levels that approach non-attainment and therefore St. Petersburg has included air quality issues as a direct part of their evaluation procedures. Both Gainesville and Orlando have issues with multiple waterbodies in close proximity to development and roadways so runoff is a critical issue.

Table 3.20 Performance Measure Application, Sustainability

Dimension	Existing name (from chap. 2)	**Gainesville**	**Alachua**	**Orlando**	**St.Pt.**
Sustainability-Ecological	Attainment of ambient air quality standards			○	○
	Daily CO2 emissions (greenhouse gas emissions)				○
	Water runoff (floodplains)	○		○	
Sustainability-Social	Equitable distribution of accessibility (transit-based)				○
Sustainability-Fiscal	Parking pricing/availability	○		○	
	VMT-based Impact fee			○	

Concluding Observations

Despite the dramatic differences between each of the four communities in terms of scale and administrative procedures, these case studies have several characteristics in common:

- All have a unifying **Comprehensive Plan** created through rigorous community input that supports the inclusion of non-vehicular modes as a part of an overall mobility system. Congestion management is balanced with the needs for alternate travel modes. The comprehensive plan concepts are directly integrated within the Land Development Code.

- Nearly all of these communities have a **Multimodal Master Plan** for a complete non-vehicular system, with regular, consistent funding for system construction as well as provisions that require new or redeveloping projects to conform and support the community's vision and master-plan.

- A **Complementary Land Use Mix** at the scale of the pedestrian is preferred wherever possible. **Activity centers** are clustered within residential areas with good pedestrian and bicycle connectivity.

- **Roadway Optimization, Connectivity and Redundancy** rather than the addition of new lanes or facilities are the focus of the transportation analysis, construction and design. The focus of the transportation system analysis moves from typical peak hour concurrency review (i.e. "Is there adequate roadway capacity at a specified LOS?") to a **Mobility Choice-Based Review** (i.e. "Can safe and useful facilities for all travelers in all modes be maintained to in a way that provides viable mobility options despite some roadway delays?").

- **Context Sensitive Design Details** that support non-vehicular travel are an accepted and enforced part of their land development code as well as their public project design. Just as AASHTO optimized and standardized the roadway environment in the 1950s and 60s, a similar design consistency must be generated for the pedestrian, bicycle and transit environments. AASHTO developed design criteria and parameters employed in roadway design today, most of which have to do with the horizontal design features within the roadway cross-section. Similar design criteria have to be selected and applied for non-vehicular modes that include measures associated with the vertical aspects of the built environment with critical user comfort issues identified clearly for each mode.

- **A vibrant pedestrian realm is crucial to the success of a vibrant transit system.** All transit and riders are at some point a pedestrian and therefore investment in the details of the pedestrian realm around transit stops and stations supports a whole range of multimodal opportunities.

Several of the communities studied included Form-Based Codes or elements of FBCs. FBCs are helpful in two ways. First, they shift the focus from land use type to the appearance of the built environment. This change in focus can support enhanced land use mix, allowed by right (i.e., without the need to apply for time-consuming exceptions), and can simplify layers of special provisions that have been applied through years of community planning. Also, they explicitly specify the features that support a walkable pedestrian environment, which is the cornerstone to implementing multimodal transportation systems. The following is a summary of some features that are commonly specified within FBCs that support walking and transit.

- Build-to lines
- Sidewalk widths
- Maximum/minimum block lengths
- Maximum block perimeter length
- Minimum glazing percentages
- Maximum uninterrupted façade length
- Ratio of building height to street width
- Crosswalk dimensions, elevation and contrast
- Mid-block pedestrian crossings
- Street tree spacing and planting area
- On street parking requirements
- Liner buildings or screened parking
- Roads that terminate in vistas or open space
- Roundabout preference
- Transit shelters, pull-outs
- Architectural features that supply shade
- Pedestrian scale lighting
- Multiuse paths adjacent to buildings with a maximum distance to parallel roadways
- Designated, contrasting or raised non-vehicular paths through parking areas

Chapter 4: Project Level Case Studies

In the previous chapter, the use of performance measures as a part of the implementation, monitoring and evaluation of the Comprehensive Plan was explored; however, to fully understand how these measures are implemented, it is also important to examine how they work within the context of evaluating an individual project. The objective of this chapter is to apply some of the performance measures identified in the previous chapter to an illustrative project. This will provide an avenue to describe both the computational procedures associated with each measure, as well as highlight how the context, form and design features of a project can change the outcome of each measure, particularly as it relates to multimodal mobility. Also, the analyses can help identify where measures have the capacity to demonstrate the differences generated by these contexts as well as agency goals, and where they cannot.

A project level case study has been prepared to highlight some of the major development and redevelopment scenarios that could support increased mode choice. The case study is a Development of Regional Impact (DRI) scale project. DRIs are large scale projects that are likely to have impacts beyond a single jurisdiction. Due to the risks of the analysis impacting real property rights for the owner or local jurisdiction, the selected site was originally agricultural land that was later purchased for conservation use and therefore cannot be developed in the future. This case study includes two development design scenarios. The first scenario is designed consistent with the Alachua County TOD/TND regulations, which require dense, walkable mixed use development patterns that are supportive of premium transit service. The second scenario includes the same land uses developed in a more suburban form.

The case study is conducted using several of the corresponding measures identified in the previous chapters. The analysis provides sample calculations or describes the analysis procedure used to generate the results shown. The last section of this chapter discusses the impact of performance measures selection as a function of agency goals using the method of Chapter 2.

Case Study Development Profile

The case study documented in this chapter simulates a DRI scale project and is intended to replicate the scale of a small new town with a mix of residential, office, retail, civic and industrial land uses. However, the land uses have been arranged into two configurations on the same land parcel. This is intended to contrast the typical suburban patterns seen within much of

Florida with a land use form that is intended to strongly support multimodal travel. This type of analysis will allow for an evaluation of the use of the same performance measures under different contexts.

The site is located on land purchased for the reclamation of Lake Apopka in Orange County, Florida, just north of the City of Apopka. The portion of the parcel to be used is approximately 9,365 acres and is located along the northeast shore of Lake Apopka, near the Orange County/Lake County line. Figure 4.1 shows the roadway network and rail lines in the vicinity of the proposed site. By 2020, commuter rail service is planned to connect the City of Tavares with downtown Orlando and the rail line to be used for this service is immediately to the north of the case study site with a right of way spur off the rail line that terminates only a few hundred feet north of the site. Adding a stop in the vicinity of this location would provide premium transit service to support the project but it also provides a logical location for a park and ride to support the land uses along the north/south section of US 441 in Lake County. Figure 4.2 compares the two scenarios at the same scale.

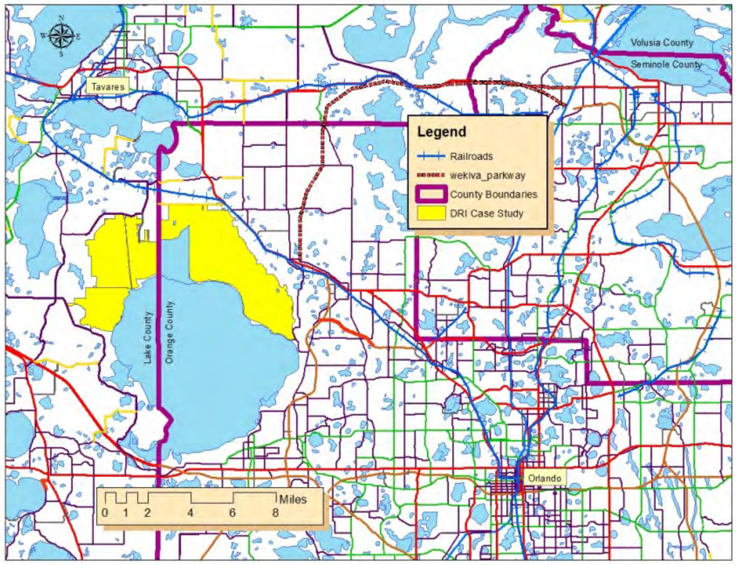


Figure 4.1 DRI Case Study Regional Context

The first configuration uses a transit-oriented, traditional neighborhood development (TOD/TND) pattern. Regional-scale office and retail uses are clustered in their own ¼ mile radius, walkable districts on the northwest side of the project. The remainder of the development configuration consists of four, ¼ mile radius villages. As much as possible the design for these villages is based on the land development code standards identified within the Alachua County TOD/TND Land Development Code requirements, because they are consistent with the typical TOD/TND design principles espoused within the new urbanist movement. The center of each of 6-7 clusters are connected using a Bus Rapid Transit system that operates within dedicated lanes with 5 minute headways during the peak hours and 12 minute headways off-peak. This system also connects to a commuter rail station located on the north side of the project.

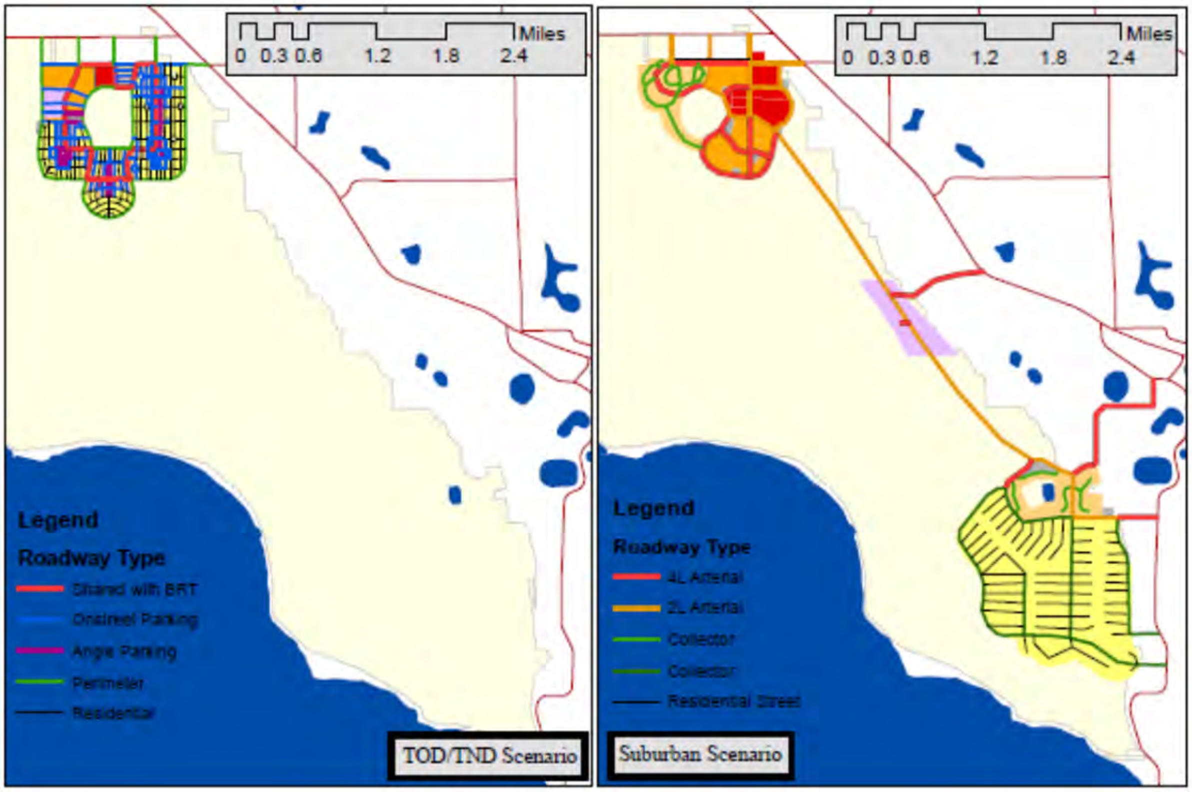


Figure 4.2 Scenario Comparison

The second configuration uses the same land uses in a fairly suburban pattern typical of current development patterns throughout Florida. In the north of the parcel is a cluster of retail, office and multifamily uses adjacent to the major roadway system. This area is connected to a regional commuter rail station and has bus service with 20-minute headways. Near the center of the parcel is an industrial/office cluster supporting an adjacent local airport. A third cluster to the south contains residential uses and a Kindergarten-6th grade school. This cluster is in the vicinity of several other residential subdivisions and the regional tolled highway system and would be considered a compatible continuation of the existing land use patterns. Transit service is not provided for either the center or southern clusters.

The following summarizes the development used in both scenarios:

- 3,647 Single Family Dwelling Units
- 1,353 Multifamily Dwelling Units
- 1,000,000 square feet of Retail Commercial Space
- 2,000,000 square feet of Office Commercial Space
- 500,000 square feet of Light Industrial Space
- 400,000 square feet of Civic Uses
- 750 student Elementary School (K-6th grade)

Conceptual Design

A layout consistent with a preliminary conceptual design was created for both scenarios. This design layout included locations of the roadway network, preliminary roadway cross-sections and the configuration of land uses. This design layout was then translated into a travel demand model zonal structure and added to the FDOT District 5 Central Florida Regional Planning Model (CFRPM) 5.2 Florida Standard Urban Transportation Model Structure (FSUTMS) model. Both models use 66 zones with identical socioeconomic data characteristics, although the zones were arranged and connected differently.

As recommended in the Alachua County Comprehensive Plan, the first step in designing a site is to outline the environmental features that must be preserved. The site is relatively flat and has less than 5 feet of elevation difference throughout. Because the land has been previously farmed, significant modifications to the wetland structures have already been made in the past, and the approvals for development related modifications would not add any significant difficulty to the environmental permitting process. Therefore, the land and water forms could be reshaped in any way the developer desired. It was assumed that a single large water feature would be located in the center of the TOD/TND design. This location was chosen based on the aerial photography and the soil type mapping. Other wet areas were similarly identified that would impact the land used for the suburban plan.

The fact that the land has been substantially disturbed in an ecological sense allows for an assumption that the single family units in the southern part of the suburban plan could be dredged and filled so that all lots would have waterfront or canal access. This means that the lot sizes and potential property values for the residential units within the suburban plan could be assumed to be comparable to the smaller, higher value units provided in the TOD/TND plan. Although variables like property value and lot size are not used within the CFRPM model, they directly impact the user's demographics and therefore their travel patterns. Adding amenities to the suburban plan that would provide a market justification for a smaller lot size and increased value further allows for an equivalent comparison to the TOD/TND plan.

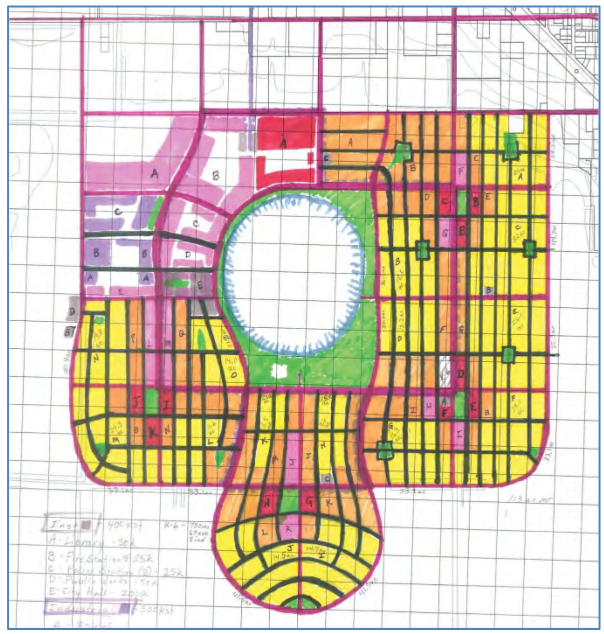


Figure 4.3 TND Project Design

TOD/TND Plan

The roadway network for the TOD/TND plan was laid out in a grid pattern with four residential villages that have commercial amenities located at the center of each village. Three additional commercial villages are also created that have a single land use type within walking distance of a bus rapid transit (BRT) stop. BRT service is provided with 5 minute headways throughout the full day. The design was completed with a park and ride lot, also within a walk distance of the regional rail station and BRT. Figure 4.3 shows the preliminary roadway and land use design sketches, consistent with the Alachua County TOD/TND design parameters, including roadway cross-section width, block perimeter and land use arrangement. Figure 4.4 shows how this design is translated to a FSUTMS zonal structure.

Although Alachua County's design parameters intend for land use mix to occur vertically as well as horizontally, each zone is limited to one land use type. This is a simplifying assumption that is not likely to directly impact the results. The neighborhood village office and retail land uses occur in immediate proximity of each other, well within a reasonable walk distance. The elementary school would be located immediately adjacent to one of the village centers and therefore nearly all of the students within that village could comfortably walk to school and an arrangement for student passes could be negotiated with Lynx for discounted access for the remainder. School bus service could not be provided for any of the students who live within the project because they are within the state mandated 2 mile radius.

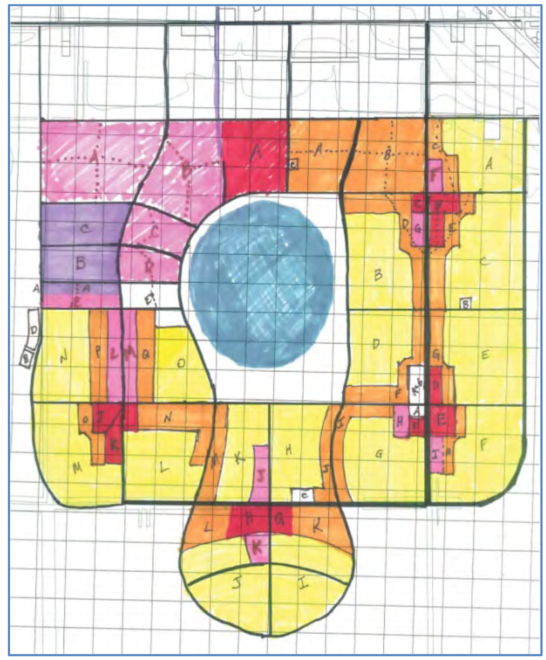


Figure 4.4 TOD Zone Structure

A series of typical roadway cross-sections were generated that are consistent with a complete streets implementation of current TOD/TND design patterns (Figures 4.5-4.9). Each roadway within the project was assigned to one of the 5 cross-sections. These cross-sections will be used to calculate both pedestrian environment variables and provide a rough estimate of project construction needs.

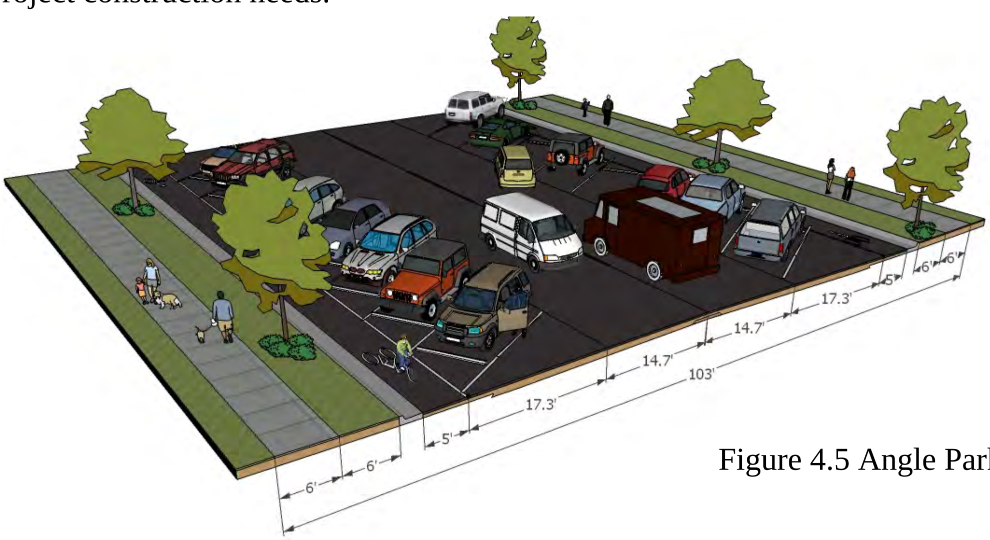


Figure 4.5 Angle Parking

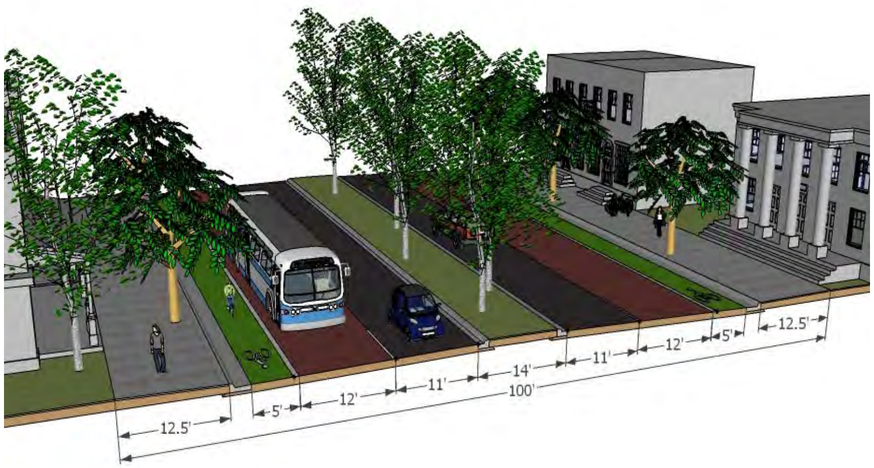


Figure 4.6 BRT Section

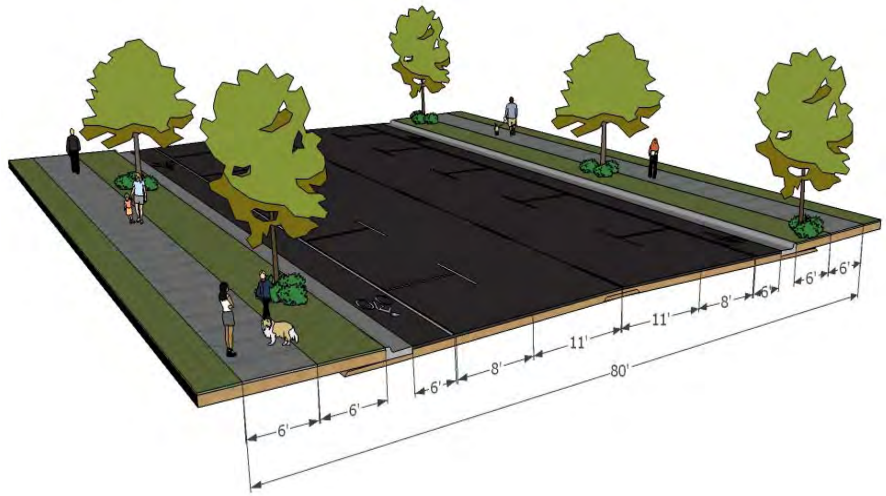


Figure 4.7 On Street Parking

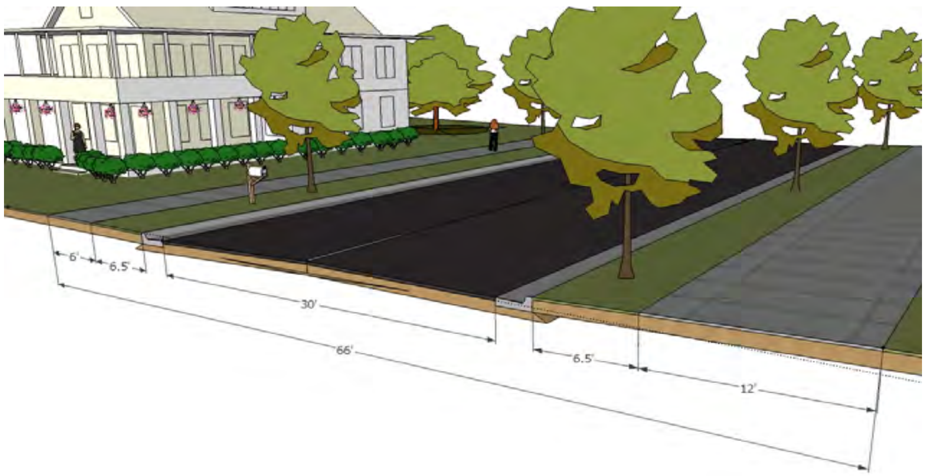


Figure 4.8 Perimeter Road

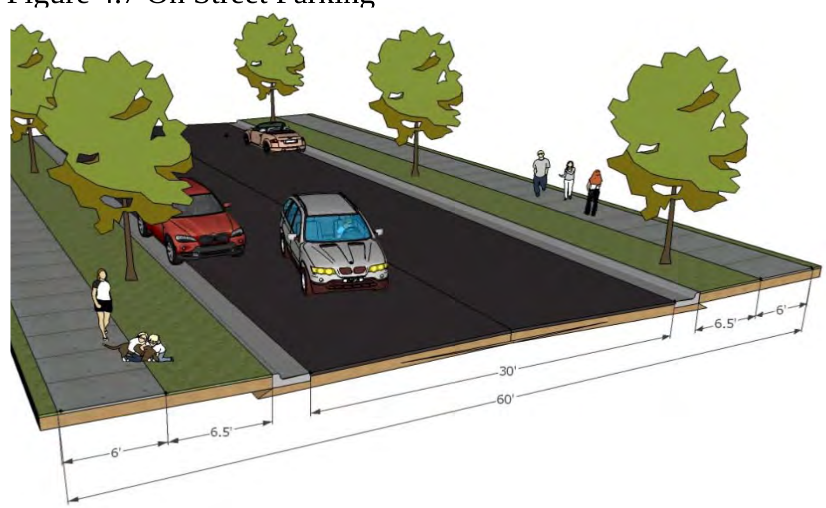


Figure 4.9 Neighborhood Street

Suburban Plan

The suburban plan is assumed to have roadway cross-section features that are typical in Central Florida, and is laid out in three large clusters. Rather than mixing land uses, each land use has a specific geographic concentration and is relatively consistent with the land uses adjacent to it in the surrounding area. Figure 4.10 shows a sketch of the initial overall project plan for the suburban scenario. Figure 4.10 provides a sketch of how this is translated to a corresponding zonal structure on the north and south.

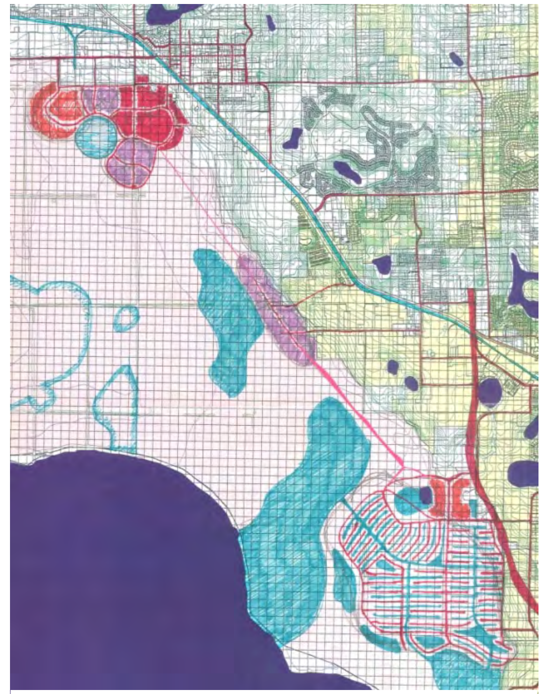


Figure 4.10 Suburban Plan

The northern cluster is located near the historic town of Zellwood. From a developer's point of view, a commercial center would be an appropriate use adjacent to the intersection of Jones Road and US 441, although it would be a better site if it were actually in the corner of the intersection itself, rather than buffered by other property owners. The intersection has several commercial properties consistent with a future retail expansion. The closest full service grocery stores are approximately 5 miles to the south and 7.7 miles to the north). The office and multifamily cluster would also be considered good land uses to place in proximity to a commuter rail station. They are laid out in typical suburban fashion with a strong vehicle orientation and little clustering. A circulating transit line connects to the rail service but with 30 minute headways in the peak hours and 60 minute headways in the off peak periods. In many areas of Florida, even suburban development forms are required to provide at least some transit service, particularly if a regional transit station is included as a part of the plan. These headways are consistent with the transit service provided in most suburban areas within the Lynx system. Figure 4.11 shows the northern section roadway network and how the land uses are translated into a TAZ structure.

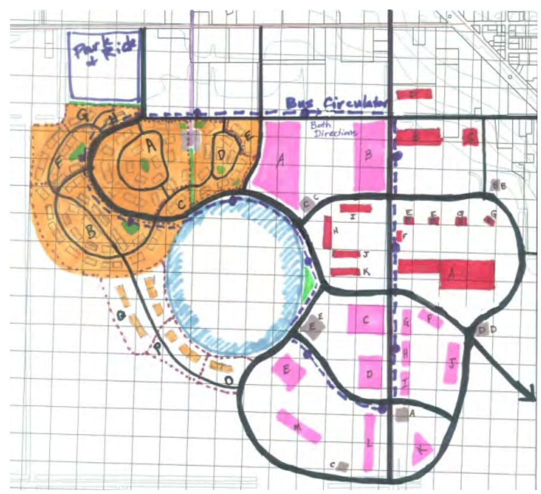


Figure 4.11 Northern Cluster, Suburban

Near the center of the suburban scenario is a cluster of industrial uses. This cluster would include all three industrial parcels and would access US 441 via the existing driveway for the local airport. This airport has recently undergone significant expansion and can provide limited service for small scale jet traffic. The industrial parcels would be an asset to the airport, which has sufficient length to support limited cargo deliveries. The zonal structure for this area was relatively simple and consisted of just 3 zones connected to the supporting through road.

The southern cluster includes some of the multifamily and all of the single family dwelling units as well as the elementary school. Potential access to the beltway and the surrounding land use pattern would make a suburban residential cluster a common development scheme in this area. It would be designed to have access, if possible, to the John Land Parkway, a component of the western beltway which includes SR 429 and the proposed Wekiva Parkway. Figure 4.12 shows how the southern cluster is translated into a corresponding TAZ structure.

Figure 4.12 Southern Cluster Zone

Based on the City of Orlando school concurrency regulations, the project's residential development program would be expected to generate approximately 750 students in Kindergarten through 6th grade. The location of the elementary school would mean that a handful of the single family units and many of the multifamily units would be within walking distance. However, the majority of the units within the southern cluster of the project would not be provided bus access because they are within the 2-mile radius dictated by the State of Florida. Therefore, as in many areas in the state, the majority of the students would arrive by car because they are beyond a comfortable ½ mile walk distance but under the 2-mile bus radius.

The four cross-sections assumed for this scenario reflect fairly typical suburban widths and the larger cross-sections include "complete streets" characteristics as they are typically applied (Figures 4.13 through 4.16).

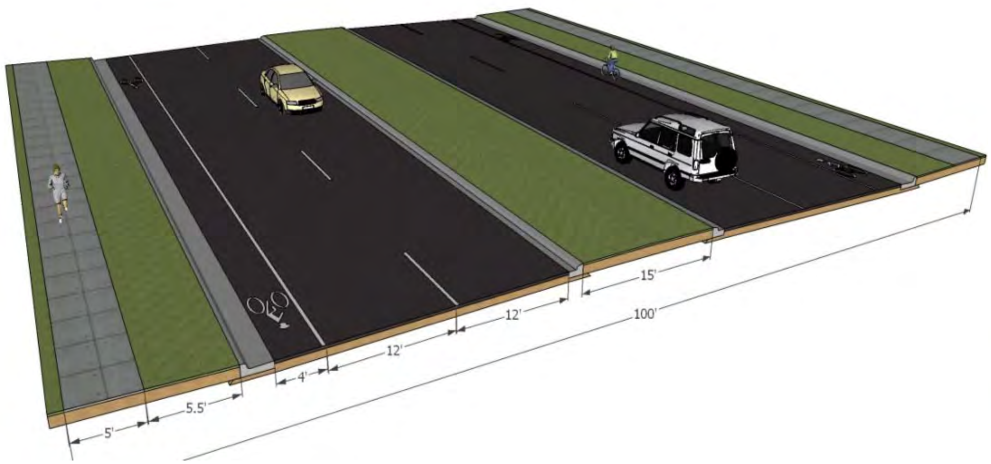


Figure 4.13 4 Lane Divided Section

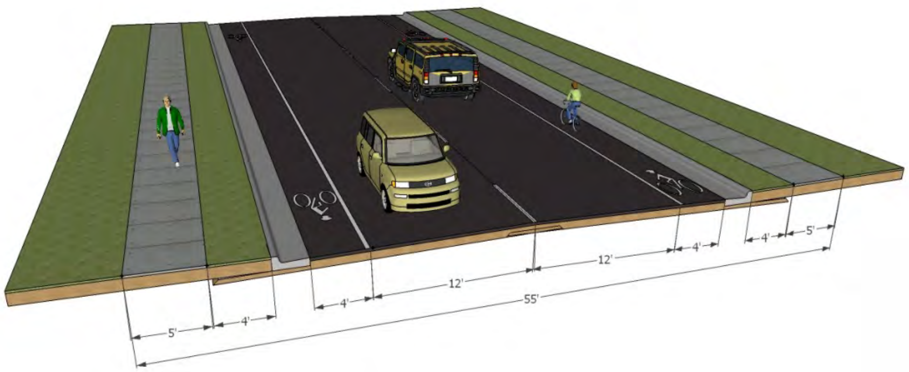


Figure 4.14 2 Lane Bikeable Section

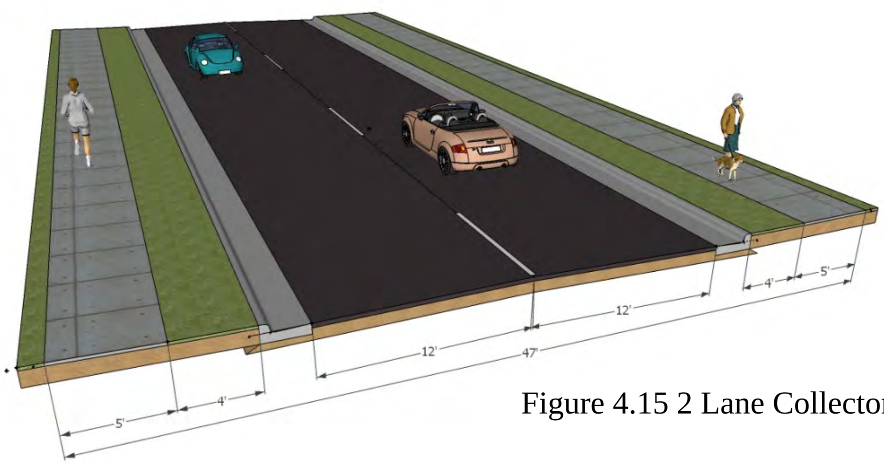


Figure 4.15 2 Lane Collector

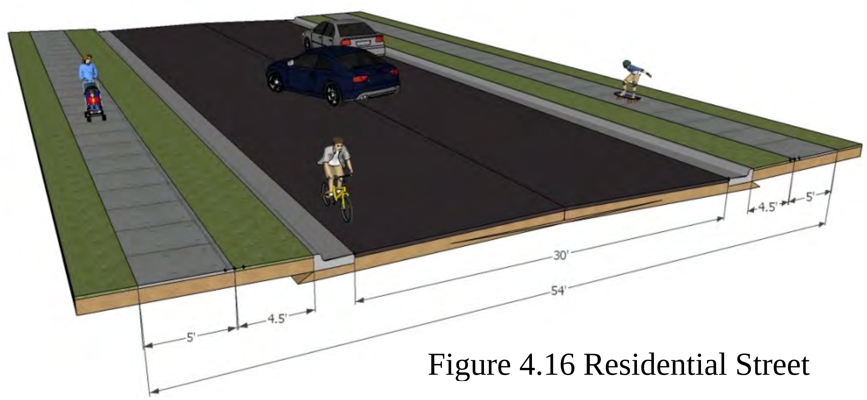


Figure 4.16 Residential Street

Typical Traffic Impact Analysis Procedures

Within any suburban transportation DRI impact analysis, the initial analysis step would be to estimate the project's trip generation and internal capture. The *ITE Trip Generation Report* (8th Ed., 2009) is the most common source for estimating trip generation, but it explicitly assumes a suburban development pattern, which can be a problem for projects that have a multimodal focus. The total trip generation that would be predicted for this project before any internalization or alternate mode split is assumed would be calculated as shown in Table 4.1.

Table 4.1 Total Trip Generation

Land Use	ITE Code	Intensity		Daily Trip Ends	PM Peak-Hour Trip Ends					AM Peak-Hour Trip Ends				
					Total	In %	Trips	Out %	Trips	Total	In %	Trips	Out %	Trips
Light Industrial	110	500	KSF	3,633	558	12%	67	88%	491	501	88%	441	12%	60
Police/Fire Stations	*	100	KSF	200										
Single Family	210	3,647	DU	28,439	2,674	63%	1,685	37%	990	2,563	25%	641	75%	1,922
Multi-Family	220	1,353	DU	8,323	839	65%	545	35%	294	667	20%	133	80%	533
Elem School	520	750	Stu	968	113	49%	55	51%	57	338	55%	186	45%	152
Library	590	50	KSF	2,320	365	48%	175	52%	190	60	71%	43	29%	17
General Office Building	710	2,000	KSF	13,396	2,319	17%	394	83%	1,925	2,061	88%	1,813	12%	247
Single Tenant Office Bldg	715	250	KSF	2,893	433	15%	65	85%	368	450	89%	401	11%	50
Retail Commerc. <570	820	1,000	KSF	42,940	2,976	49%	1,458	51%	1,518	1,000	61%	610	39%	390
Total	*DAILY*	*PM*		*103,111*	*10,275*		*4,445*		*5,831*	*8,825*		*4,267*		*3,372*
Internal Capture (ITE)	24.13%	19.95%		24,881	2,050		1,025		1,025					
Pass-By	40.00%	40.00%		17,176	1,190		595		595					
Net External				**61,054**	**7,035**		**2,824**		**4,211**					

Source: Trip Generation, 8th Edition (ITE, 2008)
KSF=thousand square foot, DU=dwelling unit, Stu=student

Trip generation rates for fire and police stations are not available, so they will be estimated to make approximately 50 trips per day each. Some internalization is assumed in the ITE Trip Generation Equations, based on the observation that larger land uses tend to have a lower trip generation per unit. A travel demand model is typically used to project the future traffic volumes as well as future transit usage. Theoretical centers of activity, called centroids, are used to estimate the level of activity in each geographic subarea, called Traffic Analysis Zones (TAZs). Socioeconomic variables like dwelling units, vehicle ownership, population, employment and school enrollment are estimated for each TAZ in the base year. The model is then calibrated by the local region to reflect the traffic volumes observed in that year. The model is generally calibrated using overall volumes throughout the model and each segment may vary significantly from its actual base year volume. This is due to both the uncertainties in the model and in human behavior. Socioeconomic (SE) data for future years are also projected so that future travel demand can be estimated, however the accuracy of the projection is only intended to discern whether new roadway lanes are needed in the future year.

To analyze a specific project for a future year, the proposed development would be represented within a set of new TAZs using estimated SE data or productions and attractions that reflect the number of person trips anticipated within each project TAZ. Traffic from the project zones would be tabulated separately within the model so that its impacts can be tracked for trip generation and/or distribution.

Future travel demand is estimated using the following assumptions:

1. SE data for the project are estimated using the anticipated population and employment for the project areas; the resulting distribution of project trips generated by the model is applied to the ITE trip generation rates to estimate the project traffic to be assigned to each segment. A distribution only analysis assumes that the traffic volumes in the area are not shifting substantially and can be estimated in the future based on past growth trends.
2. The SE data within the project zones is iteratively adjusted to reflect the trip generation estimates produced by ITE within a certain error tolerance (usually around 5%). This procedure is usually applied if new facilities are to be added prior to the analysis year or development patterns are changing. In those situations, the past growth trends may not accurately project the background traffic volumes and model projected roadway volumes are generally used.

Furthermore, since the ITE trip generation report explicitly states that its models are developed based on data from suburban conditions with little or no transit availability, a separate model run was created that eliminated the possibility of transit access for the project zones. It can be assumed that the SE data for the two scenarios will be similar. Therefore, the SE data used for the suburban plan was adjusted to reflect ITE trip generation estimates and then applied to both scenarios. Table 4.2 shows the model-generated total trip generation for each scenario without transit access after the land use is calibrated to match ITE. As can be seen from the table the trip generation from the model is not a perfect match for the two scenarios, but is within 5% of the ITE generated volumes for both the TOD/TND and the suburban scenario. The inconsistency in the trip generation between scenarios is partly because of the way the model balances productions and attractions but is also related to the relative availability of productions and attractions.

After the total trip generation was estimated and matched within the model, a portion of those trips are assumed to occur within the development. This proportion could be determined using the model itself or one of several internal capture methodologies. The most common methodology is the one documented in the ITE Trip Generation Handbook. The results of this calculation are shown in Table 4.2. Figure 4.17 compares the internal capture percentages generated by the model to those predicted by the ITE methodology.

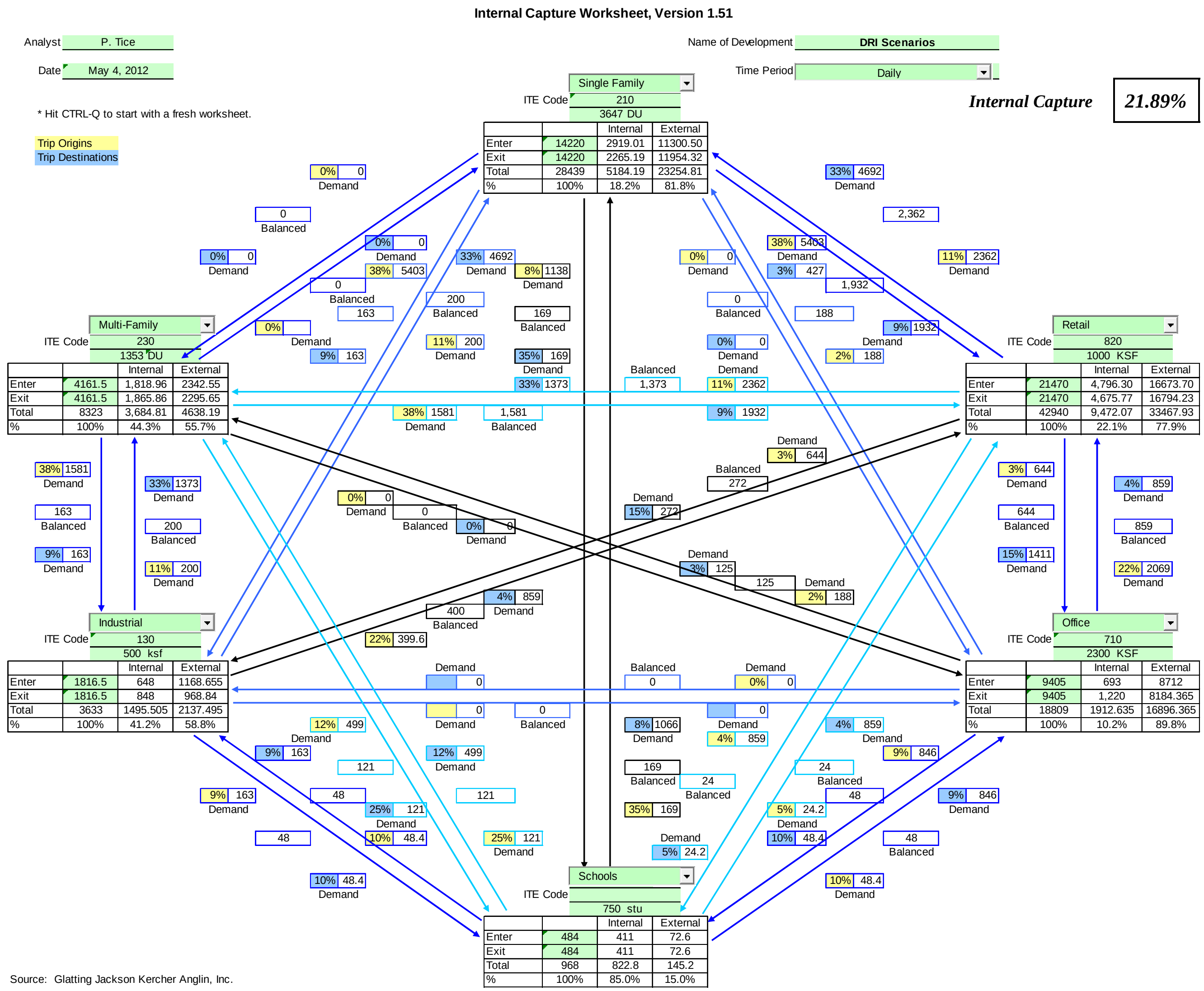
Table 4.2 Internal capture comparison

		TOD/TND scenario	Suburban scenario
ITE Methodology	Total Trips	103,111	
	Internal Trips	22,572	
	% Internal	22.0%	
Model Generated (No transit)	Total Trips	104,147	102,962
	Deviation from ITE	1.00%	-0.15%
	External Trips	61,503	78,538
	Internal Trip Ends	42,644	24,424
	% Internal	40.9%	23.7%
Model Generated (with Transit)	Total Roadway Trips	103,549	102,565
	External Roadway Trips	61,276	78,235
	Internal Roadway Trip Ends	42,273	22,570
	% of Total, Internal Roadways	40.8%	22.4%
	Trips shifted to transit	598 trips (0.57%)	397 trips (0.39%)

In both of our model scenarios, the land uses are well balanced and connected, well within the model's overall average trip length of 10.26 miles for passenger vehicles[35]. The location is relatively remote from any major non-residential land uses and the scale of the project is large. All of these factors tend to increase a project's internal capture potential so it is not surprising that the model projects a higher internal capture for both scenarios than the ITE procedure. However, it is clear that the density and proximity of the TOD/TND scenario lends itself to internalization, which should also be expected since it was designed explicitly to do so.

35. Not including truck, taxi, or IE trips.

Figure 4.17 ITE Internal Capture



Source: Glatting Jackson Kercher Anglin, Inc.

The external roadway trip impacts would also be reduced based on the development's projected mode split. Transit trips are generated in terms of person trips rather than vehicle trips, so their impacts on the roadway volume can only be measured indirectly by comparing the roadway trips generated with and without transit service. The TOD/TND plan has nearly 99% transit service coverage within ¼ mile of a transit stop. The line is coded as having no fare and the headways are specified as 6 minutes throughout the day. This is a very high level of transit service provided within a mixed use development that has transit supportive densities. Therefore, it would normally be anticipated that a significant amount of the internal trips should be shifted to transit. However, Table 4.2 shows that adding the internal circulator shifts only a small percentage of the total trips to transit service. The small scale of the trips shifted to transit can be explained by several factors. The model results indicate that nearly all of the trips using the BRT line are destined for a transfer to the regional commuter line where the time and cost savings for the longer commuter rail trip make the wait times for the BRT less significant in relation to the overall trip. The main reason that the BRT line has such minimal usage is that the average wait time assumed by the model is half of the headway time (3 minutes). Wait times are weighted double in the transit cost equations, and this additional time factor is significantly higher than the terminal time for a vehicle trip (4 minutes). Therefore, the model will consider the vehicle trip to be shorter in time and thus lower in cost than the transit trip in nearly every case. However, in reality, there is reason to believe that the BRT may garner more usage than the model anticipates, particularly if the geographic location of the BRT vehicles can be provided to users in real-time via some type of smart-phone or online application, which would reduce the wait time experienced by the user to less than a minute. Similar factors impact the suburban scenario as well, though not to the same degree. The ridership for the suburban scenario is dominated by transfers from the Lynx 406 line that runs on US 441 from Zellwood to Apopka. Parking cost is a variable that is used by the FSUTMS Cube model, but for most regions, parking availability other than park and ride lots is not considered. If parking availability is limited within the TOD/TND design, as it would be if the project was designed in accordance with the Alachua County design standards, then a substantially higher transit mode split may be possible. This mode split is not likely to exceed the 40% internal capture that was produced by the model for the roadway trips, since the primary transit service provided is an internal circulator. It would, however, minimize or eliminate the need for multilane roadways internal to the project and reduce vehicle volumes on the internal network which further encourages pedestrian interaction. In practice, the roadways along the BRT line would be initially designed to support vehicle traffic, but may not ultimately be needed for that purpose. In some areas of the project, vehicular traffic could be routed to the parallel roadways with parking access provided from those streets and the roadway sections adjacent to the BRT line could be converted to bicycle lanes and/or wider sidewalks.

It should be noted that few, if any, of the adopted 4 step models within Florida include a travel mode within the model for centroid to centroid bike or walk trips. All of the walk trips coded in the model are assumed to walk to another mode like a bus or rail system, use that system and then walk to the final destination. This is because most of the centroids within the FSUTMS structure have historically been larger than a typical walk distance would encompass and at this time, few jurisdictions have sufficient information to calibrate walk trips at a smaller geographic scale[36].

Level of Service (LOS) is then assessed on a segment by segment basis and necessary improvements are documented. When it appears that a segment may exceed the capacities shown in the FDOT Generalized LOS Tables, a more detailed arterial analysis and optimization are attempted in order to determine whether the facility can, in fact, support the projected volumes. The FDOT Generalized LOS Tables provide rough approximations of capacity using default values for a variety of important variables such as cycle length and g/C. A detailed operational analysis can reveal that the capacity of a particular facility is much higher.

For long-range term of a DRI analysis (greater than 5 years) the roadway volumes could be projected in one of two ways. The existing volumes could be increased in a manner consistent with each segment's historical growth trend and then the project's external vehicular trip

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36. Since the major concern within travel demand models has been roadway and transit volumes, walk only and bike only trips would be considered movements that are internal to the centroid that wouldn't affect the model's roadway network. The travel diaries used to calibrate the model rarely include or document vehicle trips in the range of a short or long walk (1/4-1/2 mile—i.e. parking in a shopping center to visit one store then re-parking within same center to visit a different store). Some jurisdictions are beginning to document these short vehicle, pedestrian and bicycle trips, but for the most part these trips are neglected. That means that dense urban areas where the typical zone size is significantly smaller than a short or long walk (1/4-1/2 mile radius) may not adequately represent the interplay between zones, particularly for pedestrian or bicycle trips. Forecasting volumes for pedestrian and bicycle trips is an area of ongoing research both in Florida and throughout the country.

For many DRI scale projects, this is a non-issue because the internal trips are handled by an internal roadway network to be provided by the development. The roadway geometry to be provided will be scaled and monitored based on the internal demand within the project. However, when the public roadway volumes could be significantly impacted by non-vehicular "internal" trips, the fraction of those short trips that use alternate modes may become a significant consideration.

For example, in the TOD scenario, nearly 40% of the project trips are internal to the project and many of these internal trips are short enough for a user to consider walking. Although it might be difficult, the congested skims matrix could be used to identify internal origin and destination pairs for which trips would be better completed by walking and have those trips or a fraction of them removed from the final origin-destination (OD) matrix so they are not assigned to the internal roadways. For instance, if it took someone longer to get to their vehicle and get out of their vehicle than it would take to walk to the destination, then the walking trip would be preferable. Therefore, trips that had an equivalent walk time at 3.5 mph that was less than the terminal times for the trip could be uniformly converted to walk only trips. Slightly longer trips could have a percentage of their trips converted to walk only trips. This could be done internally within the model structure or as a post-processing operation but clearly this type of adjustment to the model structure would have to be negotiated with the reviewing agencies.

distribution would be used to assign project traffic volumes to those segments. This procedure reduces the need to match the project's trip generation as closely, since the total project trips are always assigned to the external network. However, this procedure fails to take into account any redistribution of background traffic due to congestion or new facilities.

With the current decline in historic roadway volumes being attributed to economic conditions and gas prices, a straight line projection of roadway volumes is often dismissed by the local agency as unrealistically low and a minimum annual growth rate is required (usually 1-2% per year). Local jurisdictions usually require safeguards to assure that future volumes on individual roadways or corridors are not under-reported even though this can substantially increase the projected need for new roadway capacity.

It is beyond the scope of this project to produce roadway by roadway LOS projections for both scenarios based on the actual volumes and capacities that might be employed based on the FDOT Generalized LOS tables or a detailed arterial analysis. However, the 2010 Highway Capacity Manual utilizes a new procedure for assessing LOS that is based on the congested speed as a percentage of the free-flow speed for urban streets/facilities. This ratio should provide an estimate of the results that might be produced should detailed arterial analysis be performed on each segment. The LOS breakpoints for Travel Time Index can be generalized as follows to provide an indication of the projected LOS within the model:

LOS A	85%
LOS B	67%
LOS C	50%
LOS D	40%
LOS E	30%

Figure 4.18 compares the 2020 estimated LOS for the roadways within a 5 mile radius of the project for the Suburban and TOD/TND plans, respectively. Based on these figures, it appears that the only deficiencies within a 5 mile radius are in downtown Mt. Dora or within specific interchanges. One segment of US 441 shows LOS "E" conditions. It would be expected that a more detailed analysis would identify intersection deficiencies in several locations.

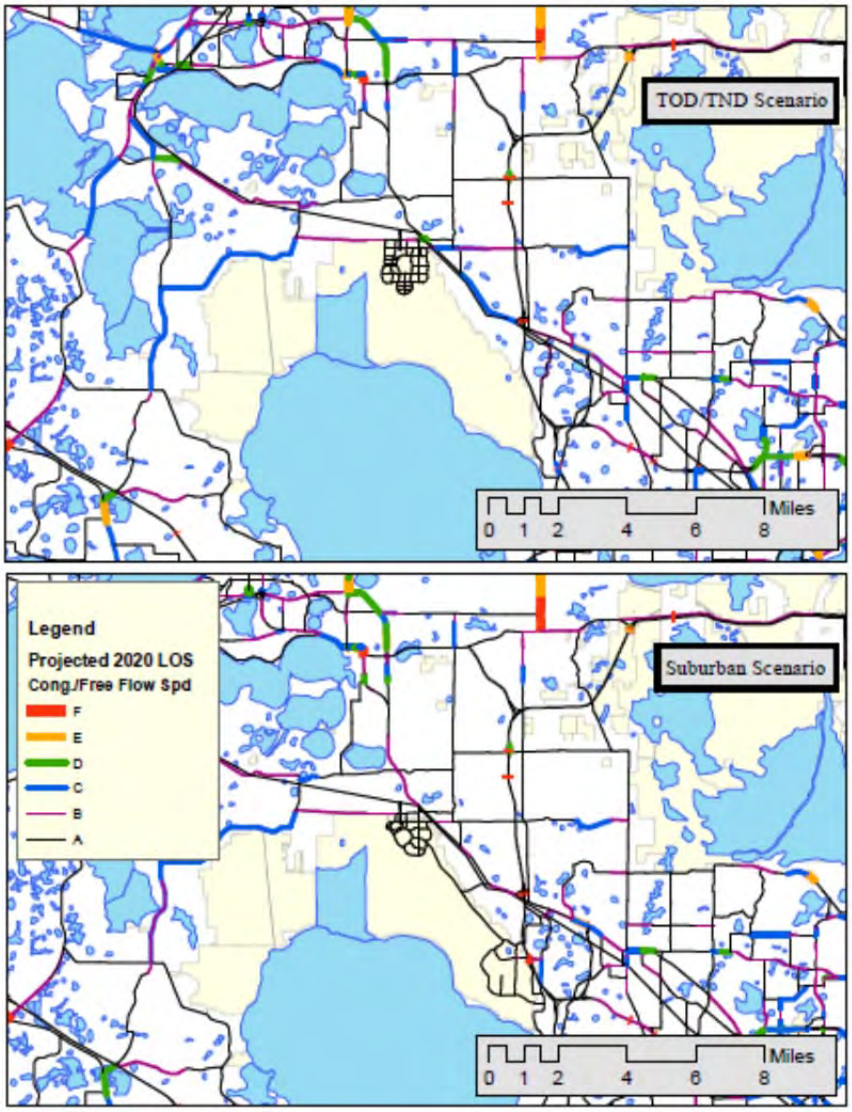

Figure 4.18 Estimated LOS

Performance Measures Estimation and Evaluation

The purpose of this analysis is to look beyond the typical performance measurement framework and identify additional measures that would support multimodal transportation solutions. This section provides a description of many of the performance measures identified within this study and a comparison of the outcomes for each of the two scenarios. As was mentioned earlier, intersection level analysis is beyond the scope of this study. However GIS analysis or model outputs can be used to provide a wealth of other information on the characteristics of the two development scenarios.

Some of the differences between the values of performance measures are a direct result of the assumptions made within the scenario. For instance, where a set of cross-sections were assumed, the resulting square footage of sidewalks will be a direct outcome of that assumption. As was seen in the St. Petersburg case study, some jurisdictions have chosen to dictate the design features of the constructed environment rather than, or in addition to, the transportation outcome. Many of these include quantitative assessments that can be applied to each of the proposed scenarios. The design of the site can be controlled through either the site plan design review or the minimum quantitative design standards.

Some results are outcomes of the form and design of the scenarios, such as transit ridership or projected roadway volumes. The measures within this category are more frequently used within standard transportation planning practice. Several of these measures such as trip generation, internal capture and LOS, have already been discussed in the section that documents the typical DRI transportation analysis.

The measures that are most applicable to our comparison are described in the following paragraphs.

Density/Intensity of Development

Density can be defined as the number of persons per acre or the number of dwelling units per acre. Table 4.3 summarizes several density calculations for the two scenarios.

Table 4.3 Density of Development

	TOD/TND scenario	Suburban scenario
Development area (acres)	737.47	1994.90
Residential area (acres)	514.31	1421.90
Population (person)	12,760	12,760
Density (person/acres)	17.3	6.4
Dwelling Units	5,000	5,000
DU/acre, project	6.8	2.5
DU/acre, residential	9.7	3.5

The densities identified for the suburban scenario are relatively common densities for Central Florida.

Development Intensity is the equivalent measure for non-residential development. It is usually measured in terms of either employees per acre or Floor Area Ratio (FAR), which is the ratio of the building square footage to the square footage in the development. For instance, a FAR of 1.0 means that there are 43,560 square feet of building space within each acre. Because of typical stormwater and surface parking requirements, single story retail development in Florida rarely exceeds a FAR of 0.25. Table 4.4 summarizes the development intensities for the two scenarios using the model employment as an estimate for the actual employment.

Table 4.4 Intensity of Development

	TOD/TND scenario	Suburban scenario
Development area (acres)	737.47	1994.90
Non-Residential area (acres)	223.16	573.00
Employment (persons)	7,492	7,492
Density (employees/acre)	33.5	13.1
Non-residential size (ksf)	4,000	4,000
FAR	0.411	0.160

KSF=thousand square foot

Note that the development form for the majority of the employment even within the TOD/TND scenario still includes large single use areas for regional employment with a significant area of those sites set aside for parking (either surface parking or structured parking).

The FAR for the non-residential development incorporated within the neighborhoods in the TOD/TND scenario are much higher (around 0.66).

FDOT has generated a draft Design Guideline that outlines the density, intensity, diversity, parking availability, connectivity and accessibility for Transit-Oriented Development (TOD). The initial guidelines for BRT or a local bus hub indicates that transit supportive densities range from 5 to 30 DU/acre and FAR of 2.0 to 3.0 with a jobs to housing ratio of 1:1.

Land Use Balance

A land use balance identifies the diversity of land use for a zone by segregating into different land-use categories. Developing Sustainable Transportation Performance Measures for TXDOT's Strategic Plan (2009) developed a formula for measuring land use balance as:

$$Land\ use\ balance = \frac{\sum |P_i \times lnP_i|}{lnN}$$

Where,

P_i = the proportion of total land area allocated to each land-use classification; and

N = total number of land-use categories considered (residential, commercial, industrial, and institutional)

The balance value ranges between zero (worst, a single-land use) and one (best, equal-land use). Figure 4.2 (earlier) compares how the two different land use development scenarios appear in GIS. The values of land use balance for the entire development area are 0.60 for both the TOD/TND and suburban scenarios. This means that the percentage of land allocated to each of the land uses is nearly identical between the two scenarios. However, a visual inspection of the two projects makes it clear that they will have very different internal interaction. Part of the motivation to use this measure is to establish whether the land use mix has a good balance of uses that will facilitate non-SOV travel through alternate modes and reduction of vehicular trip lengths through proximity. However, within the suburban plan, the segregated land uses and the lack of transit in the central and southern clusters mean that the overall land balance is less meaningful. Dividing the suburban scenario into the major three development clusters, the lack of land use mix becomes obvious. The mix in the northern cluster appears to be best of any of the scenarios. However, the balance of land consumed does not take into account the balance of population and employment, which is strongly tilted toward employment in the northern cluster.

Table 4.5 Land Use Balance Calculations

<table>
<tr><th>Acres by land use types</th><th>TOD/TND scenario</th><th colspan="2">Suburban scenario</th></tr>
<tr><td rowspan="3">Institutional</td><td rowspan="3">20.70</td><td>Northern</td><td>21.72</td></tr>
<tr><td>Southern</td><td>17.92</td></tr>
<tr><td>Total</td><td>39.64</td></tr>
<tr><td>Industrial</td><td>32.97</td><td>Central</td><td>181.86</td></tr>
<tr><td>Retail</td><td>47.36</td><td>Northern</td><td>148.94</td></tr>
<tr><td>Office</td><td>122.13</td><td>Northern</td><td>202.01</td></tr>
<tr><td rowspan="3">Residential</td><td rowspan="3">514.31</td><td>Northern</td><td>176.46</td></tr>
<tr><td>Southern</td><td>1245.44</td></tr>
<tr><td>Total</td><td>1421.90</td></tr>
<tr><td>Total</td><td>737.47</td><td colspan="2">1994.90</td></tr>
<tr><td rowspan="4">Land use balance</td><td rowspan="4">0.60</td><td>Northern</td><td>0.88</td></tr>
<tr><td>Central</td><td>0</td></tr>
<tr><td>Southern</td><td>0.11</td></tr>
<tr><td>Entire</td><td>0.60</td></tr>
</table>

Jobs/Housing Balance

The balance of jobs and housing is one of the performance measures identified in Chapters 2. It represents how the development potentially reduces VMT by increasing internal trips within an area. The value is defined as the number of employees divided by number of residences. Using the model inputs for employees, the Jobs/Housing balance is 3.62 for both development scenarios with approximately 18,075 jobs and 5,000 residences. This may be somewhat misleading, since the number of employees used in the model is usually inflated in project analyses so that the model generates trip counts that are roughly equivalent to the predicted ITE trip generation, but it provides a reasonable starting estimate that indicates that this project provides more employment than housing to the overall community. Since the predominant land use in the area is residential, a project that will supply employment within close proximity is likely to be seen as a benefit to the community.

Transit-Oriented Residential/Employment Density

To calculate this variable, a ¼ mile buffer was created around all transit stops, and the population within that buffer was estimated. Figure 4.19 compares these buffer areas. As table 4.6 shows, nearly all of the housing and employment within the TOD/TND development is considered transit supported while less than 15% of the housing within the suburban plan has access to transit. The TOD/TND scenario has double the residential and employment density of the suburban scenario. Because most of the employment in the suburban plan is in the northern cluster, the percent employment with access to transit is fairly similar for the two scenarios.

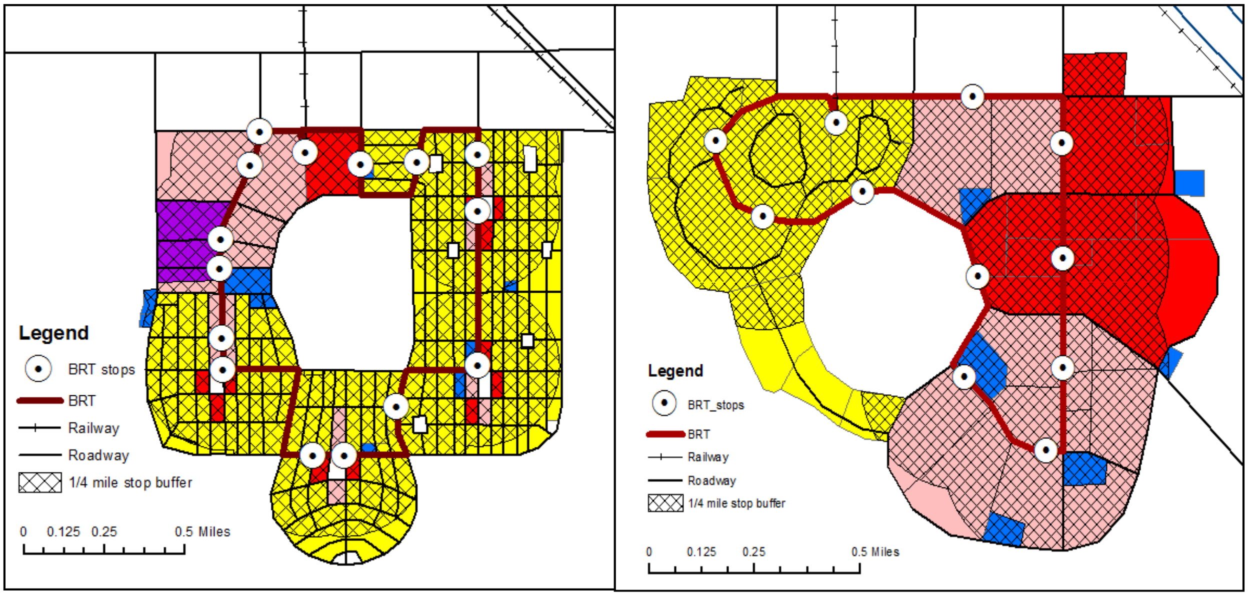

Figure 4.19 ¼ Mile Walk Distances from Transit Stops

Table 4.6 Transit-Oriented Residential/Employment Density/Intensity

		TOD/TND scenario	Suburban scenario
Residences	Dwelling units within ¼ mile buffer (5,000 total)	4,362	751
	Acres within ¼ mile buffer	456.3	152.21
	Residential density (DU/acres)	9.56	4.93
	% of DU within ¼ mile buffer	87.3%	15%
Employment	Employees within ¼ mile buffer (7,492 total)	7,492	5,471
	Acres within ¼ mile buffer	216.9	336.74
	Employment density (jobs/acres)	34.54	16.24
	% of employees within ¼ mile buffer	100%	73%
	Employment square footage within ¼ mile buffer	4,000	3,156
	FAR[37] within ¼ mile buffer	0.412	0.215

37. FAR=Floor Area Ratio=floor area/development acres/(43.56 ksf/ac)

As the table shows, there is a significant increase in the potential for transit to be useful to a resident or employee in the TOD/TND project. The residential and employment densities within the ¼ mile buffer are significantly higher as well. The higher densities are more likely to support significant ridership for the transit service.

Transit Service Density

Transit service density is used to identify transit system service intensity, and is defined as:

$$Transit\ service\ density = \frac{\sum(D_i \times N_i)}{A}$$

Where,

D_i = miles of transit route i,

N_i = number of times the route i is traveled in a day, and

A = a quarter mile buffer area of a stop in acres.

N_i can be calculated by considering headway and the time needed to run a route once. For instance, the time needed to run the BRT route once is 13.87 minutes during peak hours in the TOD/TND scenario (13.24 minutes off-peak). At least 5 vehicles are required during the peak hour with 6 minute headway. The number of routes run during a 29.34 minute circuit route will be:

Bus 1: 13.87 min	1 full route
Bus 2: 13.87 min – 6 min = 7.87 min	0.56 routes
Bus 3: 13.87 min – 12 min = 1.87 min	0.13 routes
Full route equivalents:	1.69 routes run/circuit

So, for the 4 peak hours of the day, the route is traveled:

$$\frac{60\ min/hrs}{13.87\ min/circut} \times\ 1.69 \frac{routes\ run}{circut} \times 4 hours\ \times 2\ directions =\ 58.5\ routes, pk$$

A similar calculation can be performed for the off peak hours:

$$\frac{60\ min/hrs}{13.24\ min/circuit} \times 1.64\ \frac{routes}{circuit} \times 12\ hours\ \times 2\ directions =\ 178.4\ routes, off\ peak$$

Adding them up gives the number of route runs per day (N_i):

$$N_i = 58.5\ pk\ routes + 178.4\ op\ routes = 237\ routes/day$$

The TOD/TND plan has one BRT route, 4.07 miles in length covering 689.5 acres (a quarter mile buffer distance). Therefore:

$$Transit\ Service\ Density\ (TOD) = \frac{4.07\ miles\ \times 237\ \ routes/day}{689.5\ acres}$$
$$= 1.388\ route\ miles/acre$$

The suburban plan has one route, 4.49 miles in length, covering 446.9 acres. Other transit operating characteristics used to estimate transit service density are shown in Table 4.7. The numbers of times traveling in a day are calculated by considering headway, time for running the route, and operating times. Due to the high frequency of transit service in TOD/TND project, transit service density is much greater than in the Suburban project.

Table 4.7 Transit Operating Characteristics

		TOD/TND scenario	Suburban scenario
Route distance in miles (A)		4.07	4.14
Operating time in minutes (B)	Peak hour	240	240
	Off-peak	720	720
Headway (C)	Peak hour	6	30
	Off-peak	6	60
Time needed to run a route once (taken from Cube) (E)	Peak hour	29.34	5.33
	Off-peak	29.19	5.29
Number of times running the route during one circulation (F)	Peak hour	1.465	1
	Off-peak	1.446	1
Number of times running the route in a day G=(B/C*F)	Peak hour	38.4	8
	Off-peak	116.2	24
	Total	155	32
Transit covered areas in acres (H)		689.5	446.9
Transit service density (G/H)		1.388	0.296
Buses needed to provide service		5	1

Based on the travel time results, the route for the suburban plan could become a part of the existing route 406 that runs from Zellwood to Apopka on US 441. The transit service density for the TOD/TND scenario is approximately 5 times that of the Suburban scenario.

Percent of Residential Areas within 1 Mile of an Elementary School

Figure 4.20 compares the 1 mile buffer around the elementary school site in each scenario.

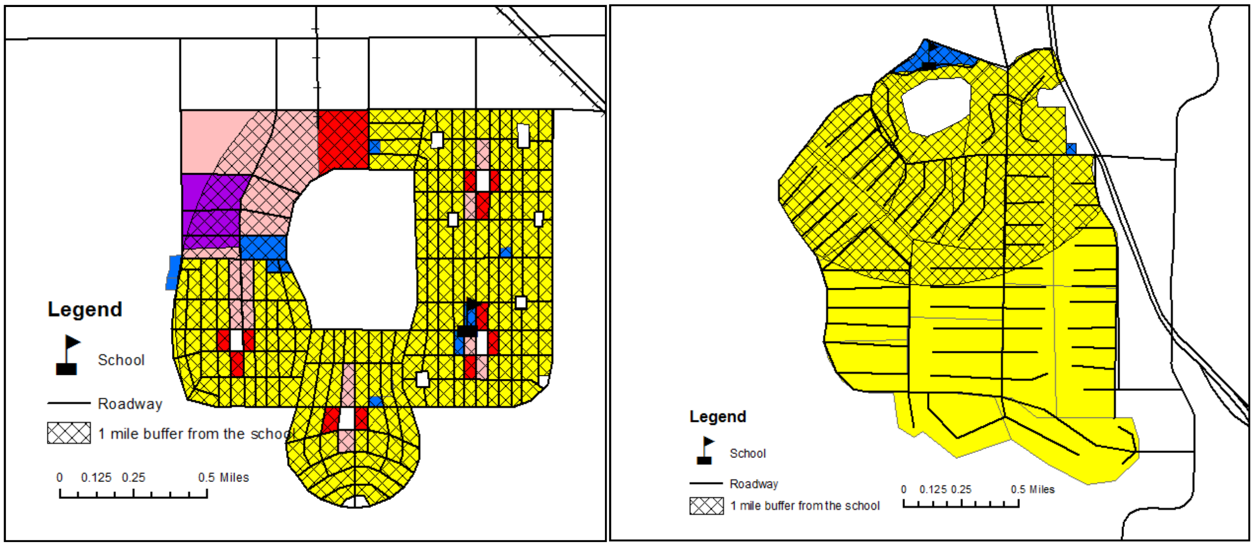

Figure 4.20 Residential Areas within 1 Mile of an Elementary School

Table 4.8 Percent of Residential Areas within 1 Mile of an Elementary School

	TOD/TND scenario	Suburban scenario
Residential areas (acres)	514.31	1421.90
Residential areas within 1 mile buffer (acres)	512.49	619.58
Percent of residence	99.6	43.6

The TOD/TND plan has 99.6% of its residential areas within 1 mile, while the suburban plan has 43.6% of its residential areas within 1 mile. One mile is a long distance for students to walk to school, but is half of the state mandated 2 mile bus service exclusion area and a reasonable distance for bicycle travel. All of the roadway facilities within the TOD/TND scenario are walk and bicycle-friendly. As can be seen from the figure, nearly all of the students in the suburban single family development will not be within a reasonable walking or bicycling distance from school and over half of the students in the multifamily portions of the project are not within the 1 mile radius.

Connectivity Index

Connectivity index can be defined in several ways. One simple way is to identify the number of intersections per acres, where intersections that only end in culs-de-sac are not counted. Using this measure, the TOD/TND development provides better connectivity than the suburban development as shown in Table 4.9. Figure 4.21 shows the intersections identified for each of the two scenarios as well as the nodes, which are identified in the next connectivity index calculation.

Table 4.9 Connectivity Index: Intersections per Acre

	TOD/TND scenario	Suburban scenario
Development areas (acres)	737.47	1994.90
Number of intersections	265	54
Connectivity (intersection per acres)	0.359	0.027

A second way to calculate connectivity index is to calculate the ratio of links to nodes. Links are defined as a segment between nodes and nodes are defined as the ends of the segments. All intersections are considered nodes and a cul-de-sac end is considered a node. Table 4.10 shows the calculation of the ratio of links and nodes for the two plans.

Table 4.10 Connectivity Index: Links/Nodes

	TOD/TND scenario	Suburban scenario
Links	466	155
Nodes	266	140
Links/Nodes	1.75	1.071

A third way to calculate connectivity index is to identify the number of closed polygons per square mile. Table 4.11 shows this calculation:

Table 4.11 Connectivity Index: Polygons per Square Mile

	TOD/TND scenario	Suburban scenario
Development areas (square miles)	1.152	3.117
Number of polygons	211	29
Polygons per mile	183	9.3

Each of these calculations is relatively simple, though the polygon per square mile is probably the easiest to calculate. The FDOT draft TOD guidelines indicate a minimum of 50 polygons per square mile. Most jurisdictions that employ these measures have specific rules regarding whether intersections/nodes/links at the edges of a project are included or excluded.

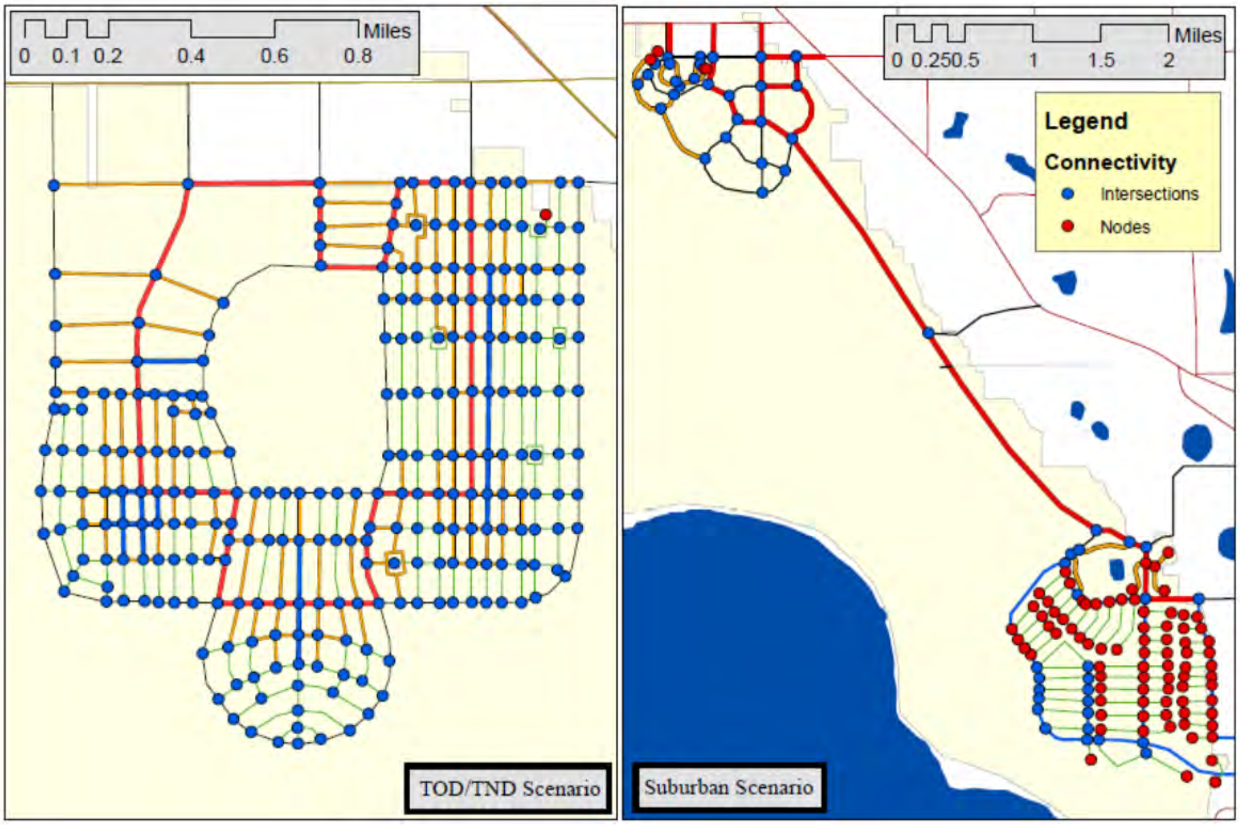

Figure 4.21 Intersections and Nodes for Connectivity Calculation

One simplification that is recommended concerns "Vista Parks." These are neighborhood scale parks that are located at the center of an intersection with a surrounding local street system and are intended to provide a pleasant vista and divert through traffic. It is recommended that this be treated as a single intersection rather than a set of four intersections with multiple links. In Figure 4.21, the east side of the TOD/TND scenario has several of these neighborhood scale parks and shows how the intersection identification can be simplified.

Percent of Network that is "Effective"

"Effective" roadways are defined as the paths that are not culs-de-sac. In other words, it is the roadway network that can be used to effectively transport you from one area of a community to another. GIS mapping is used to identify the number of roadway miles within an area. The ratio of effective road miles to total road miles gives a measure of the effectiveness and connectivity of the roadway network system. Table 4.12 shows 72.6 % of the network that is effective on suburban development, while there are no ineffective roadways on the TOD/TND development because of the grid structure.

Table 4.12 Percent of Network that is "Effective"

	TOD/TND scenario	Suburban scenario
Total roadway miles in one direction	37.72	39.85
Ineffective roadway miles	0	10.93
Percent of Network that is "Effective"	100	72.6

Lane Miles per Capita

The suburban plan has approximately 96.7 lane miles of new roadway provided by the project (both within the project and as improvements to the surrounding area) while the TOD/TND project provides only 75.44 lane miles of new roadway. This corresponds to 6.66 lane miles per 1,000 population in the suburban plan and 6.07 lane miles per 1,000 population in the TOD/TND plan (Table 4.13)

Table 4.13 Lane Miles per Capita

	TOD/TND scenario	Suburban scenario
Total roadway lane-miles	77.44	96.7
Populations (person)	12,760	12,760
Lane Miles per 1,000 population	6.07	7.58

This is an interesting result in that the roadway construction needs are fairly similar. However the earthwork for each of the two projects will be substantially different since the TOD/TND scenario uses only 37% of the land used in the Suburban scenario.

Square Feet of Pathways/Sidewalks, Bike Lanes, Roadways

Designing Sidewalks and Trails for Access (FHWA, 2006) provides the definition and the widths of sidewalk. Design width is defined as the width specification the sidewalk was intended to meet; it extends from the curb or planting strip to any buildings or landscaping that form the opposite borders of the sidewalk. Sidewalk design widths are required to be at least 60 in (5 foot). Based on this information, within the suburban plan, all sidewalk widths were designed to be 5 feet wide.

However, the TOD/TND plan is intended to have increased sidewalk widths in all of the cross-sections and lane widths that are directly tied to the street type. Table 4.14 shows the geometric parameters for each of the different specified cross-sections for both the TOD/TND plan and the Suburban Plan. Most communities are moving toward complete streets implementation, therefore bike lanes are included on most arterial streets and most local residential streets are bikeable. However, collectors often create a missing link in this system because they aren't as bikeable as typical residential streets, but don't have explicit bicycle support amenities.

Within the TOD/TND plan, much of the parking is shifted on street, though not all of it. A detailed parking calculation is beyond the scope of this analysis, but it is interesting to note how much of the parking needs for the TOD/TND plan have been met with the available on street parking. In contrast, the Suburban Plan assumes wide swaths of parking fields that can be a barrier to pedestrians and bicyclists.

Table 4.14 Square Feet of Roadways/Pathways/Sidewalks

	Total (mile)	ROW (ft)	Road width (ft)	Bike width (ft)	Sidewalk width (ft)	Road (ksf)	Sidewalk (ksf)	Parking (ksf)	Parking spaces
TOD/TND	**37.72**	**–**	**–**	**–**	**–**	**4,194**	**2,454**	**2,267**	**7,754**
BRT	3.94	100	42	10	25	874	520	–	–
Angle parking	1.85	103	29	10	12	287	117	377	1,332
On street parking	12.81	80	12	12	12	812	812	1,082	4,058
Perimeter street	6.53	66	22	12	6	759	207	276	1,034
Residential street	12.59	60	22	–	12	1,462	798	532	1,330
Suburban Plan	**39.82**	**–**	**–**	**–**	**–**	**5,989**	**2,102**	**551**	**1,378**
4 lane divided	8.53	100	48	8	10	2,162	450	–	–
2 lane arterial	7.29	55	24	8	10	924	385	–	–
SF/MF collector	10.95	47	24	–	10	1,388	578	–	–
Residential street	13.05	54	22	–	10	1,516	689	551	1,378

SF=single family, MF=multifamily, KSF=thousand square foot

Percent Miles Bicycle Accommodation

Percent miles bicycle accommodation is defined as the percent of the roadways that have bicycle path. GIS mapping is used to identify the length of bicycle miles within an area. Figure 4.22 compares the bicycle path maps for both developments. Note how the unbikeable roadways in the Suburban Plan become barriers between the residential areas and other land uses in the plan.

Within the TOD/TND development, the entire network provides bicycle accommodations of some kind while only 72% of the network on the suburban plan is bikeable as presented in Table 4.15.

Table 4.15 Percent Miles Bicycle Accommodation

	TOD/TND scenario	Suburban scenario
Total roadway miles in one direction	37.72	39.82
On street Bicycle Lanes	14.66	15.82
Separate Multiuse Paths	6.53	0
Bikeable Residential Streets	12.59	13.05
Percent miles bicycle accommodation	100%	72%

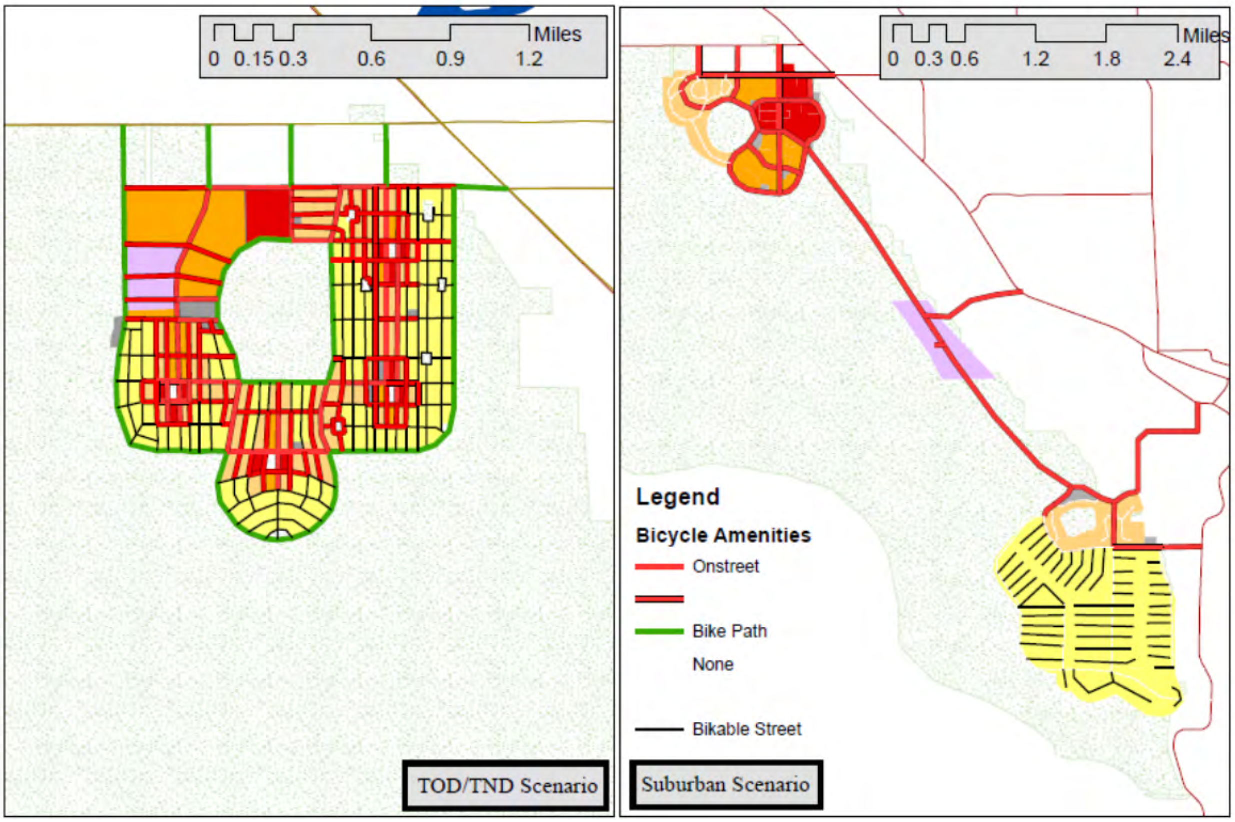

Figure 4.22 Bicycle Capabilities

Even this value is likely higher than most suburban projects and reflects the trend toward incorporating complete streets in most communities. However, both the quality and connectivity of the bicycle accommodations in the suburban plan may hinder the potential for these facilities to be used.

Work Accessibility

Destination accessibility can be influenced by the land-use type around the residential areas. Work accessibility is measured as one of destination accessibility types. The gravity-based measure discussed by Hansen (1959) is still the most widely used method for measuring accessibility, which is defined as:

$$A_{im} = \sum_{j} O_j C_{ijm}^{-2}$$

Where,

A_{im} = Accessibility at centroid i to potential work centroid j using mode m

O_j = Number of jobs at centroid j, and

C_{ijm} = Cost function to travel between i and j using mode m

This function is relatively easy to calculate with an output script from the FSUTMS model runs and is included as a part of the script provided in Appendix D. We assume the cost is equal to the vehicular travel time between *i* and *j* by automobile. Figure 4.23 compares different levels of work accessibility at every residential zone. Overall, the TOD scenario has roughly double the work accessibility as the Suburban Scenario (679,088 vs. 377,631).

Projected transit ridership

The FSUTMS model produces an estimate of the projected ridership within the transit systems that have been programmed within the model. Table 4.16 summarizes the number of person trips and the number of person miles anticipated to be served on the transit systems available within each scenario.

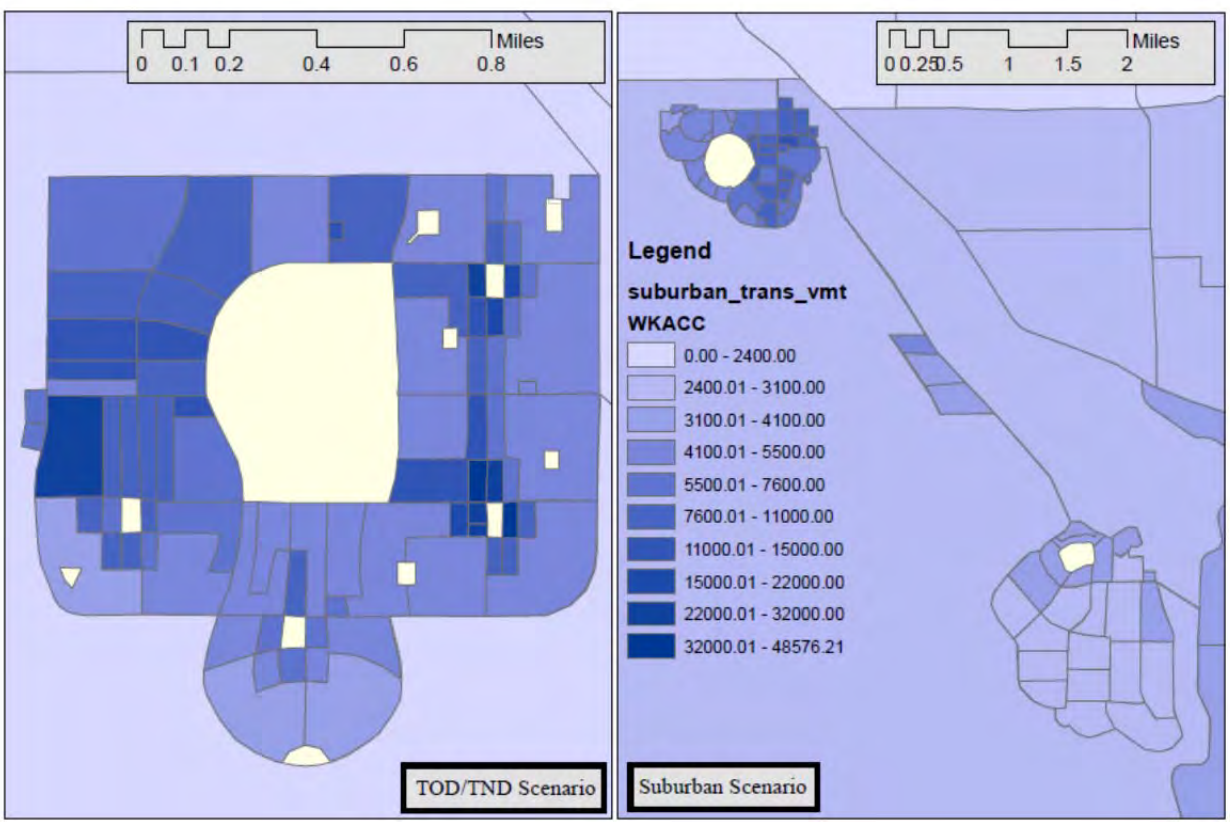

Figure 4.23 Work Accessibility

Table 4.16 Transit Ridership Projections

	TOD/TND scenario	Suburban scenario
Local Transit (BRT or bus—whole line)		
Peak ridership	275.2	273.6
Off-peak ridership	31.4	187.8
Peak person-miles	541.02	565.9
Off-peak person miles	72.47	388.2
Rail Transit (project only)		
Peak ridership	154.2	28.9
Off-peak ridership	29.2	8.8
Peak person-miles	3154.93	591.29
Off-peak person miles	597.43	180.04

Seat Capacity

US 441 has one location that is likely to have a deficiency between Errol Parkway and SR 429. One way to address those issues would be to see if the additional demand could be served using the transit service already provided along that route. The total two-way vehicle capacity on US 441 is 3,560 vehicles per hour during the peak period based on the FDOT generalized tables. Assuming the passenger vehicle occupancy for the high occupancy vehicle (HOV) trips on the corridor is 2 (which is conservative), and knowing that the model indicates the fraction of HOV trips is 29% of the roadway volume, the total passenger vehicle seat capacity on the link is approximately 4,600 persons per hour. During the peak period, two bus lines use the corridor in each direction and have headways of 30 minutes and 60 minutes. Assuming each bus has 50 seats and the rail line can carry 200 passengers, the available seat capacity from transit is 700 seats during the peak hour. Therefore, the total corridor capacity is 5,300 seats. The demand within the corridor shows the following (estimated for the peak hour using k=0.091 and transit peak period is 4 hours):

Table 4.17 Seat Capacity Demand Calculation

	TOD/TND scenario	Suburban scenario
SOV, Daily	23,368	24,005
HOV 2+, Daily	9,714	9,584
SOV, Peak Hour	2,126 seats	2,184
HOV, 2+, Peak Hour	884 (1,768 seats)	872 (1,744 seats)
Local Transit (pk hrs)	63 seats	91 seats
Rail Transit (pk hrs)	45 seats	22 seats
Total Demand	4,002 seats	4,041 seats

Using the concept of seat capacity, both scenarios are projected to have significant additional capacity. If bicycle facilities were available along the corridor and destinations were within biking distance, additional seat capacity could be added to reflect bicycle capacity as well.

Travel Time Ratio

The travel time ratio is the ratio of time it takes to travel from an origin to a destination via transit, compared to the time it takes via passenger vehicle. For a typical work trip, one of the multifamily zones (zone 1054) that is served by the local transit circulator system is used as the origin and the zone for Orlando City Hall is used for the destination (zone 720). Table 4.18 summarizes the comparison:

Table 4.18 Peak (Work) Travel Time Ratio

	TOD/TND scenario	Suburban scenario
Transit trip (commuter rail, 2 transfers)	55.47	53.38
Transit Fare	$2.00	$2.00
Roadway Trip (27.88 miles)	39.72	36.37
Gas Cost [38]	$8.67	$8.67
Travel Time Ratio	1.40	1.47
Out of pocket cost ratio	0.23	0.23

The suburban plan makes up for the difference in transit accessibility through increased roadway accessibility, lowered congestion on US 441 and auto-access park and ride at locations closer to downtown.

A similar comparison could be made for a retail trip internal to the project using zone 1056 (a multifamily zone) and zone 1023, the largest retail cluster. Assuming this is an off-peak trip, Table 4.19 summarizes the travel time and out of pocket cost comparison:

38. Assuming 22.5 mpg (2009 National Avg) and $3.50 per gallon.

Table 4.19 Off-Peak (Home-Based Other) Travel Time Ratio

	TOD/TND scenario	Suburban scenario
Transit trip	15.91	39.73 min
Transit Fare	$0	$1.50
Roadway Trip Time	2.59 min	5.77 min
Roadway Trip Distance	1.04 mile	4.76 mile
Gas Cost [39]	$0.16	$0.74
Travel Time Ratio	6.14	6.89
Out of pocket cost ratio	**	2.02

Interestingly enough, the transit travel time for the Suburban scenario includes over 26 minutes of time in an auto driving to a park and ride lot so the transit trip for the suburban scenario is not feasible unless the user owns a vehicle. Even for the TOD scenario, the travel time ratio indicates that unless you are transit dependent or parking is substantially limited, it is not a good value to use the internal transit services that have been provided which is reflected in the low internal ridership. However, in the TOD/TND scenario, substantial bicycle facilities are also available. At 15 mph, it would be a 4 minute bicycle ride between the zones we selected. A similar bicycle trip within the suburban plan (with incomplete bicycle amenities) would take approximately 19 minutes.

Local Traffic Diversion

The internal roadway within the suburban plan, parallel to US 441 may divert some traffic from US 441, particularly any traffic using both the beltway and Jones Road. Based on the model results, the total roadway volume on US 441 without the parallel facility is 29,769 while with the parallel facility, the volume is 26,622. Therefore the parallel facility diverts approximately 3,147 daily trips from US 441.

Land Consumption

Out of the total land parcel considered, each development scenario consumes a significantly different quantity of land. It is assumed that the remainder of the land will go into some type of conservation. Table 4.20 compares the amount of land consumed by each scenario and the remaining land that can be placed into conservation.

39. Assuming 22.5 mpg (2009 National Avg) and $3.50 per gallon.

Table 4.20 Land Consumption

	TOD/TND scenario	Suburban scenario
Land Consumed	737 acres	1,995 acres
Land Conserved	8,628 acres	7,370 acres
Percent of land Consumed	7.9%	21%

VMT, VHT, ATL

One of the most powerful tools that the travel demand model provides is the ability to estimate travel distance and time between the TAZ's within the model. This information can be tabulated by zone within a relatively simple model script to generate the Vehicle Miles Traveled (VMT), Vehicle Hours Traveled (VHT) and the Average Trip Length (ATL) within each zone. VMT and VHT are calculated by multiplying the congested skims (either distance or time, respectively) with the output trip table (the HTTAB table). The average trip length can then be computed by dividing by the VMT by the number of trips produced by the zone. Furthermore, each zone has estimates for residential population and employment. Dividing the vehicle miles traveled by the population in the zone gives the miles traveled per capita in each zone. A sample script is included in Appendix D. Table 4.21 compares the average VMT, VHT and ATL for the project zones.

Table 4.21 Scenario Summaries for VMT, VHT, ATL

	TOD/TND scenario		Suburban scenario	
	No Transit	With Transit	No Transit	With Transit
VMT	534,682 miles	544,901 miles	601,527 miles	608,237 miles
VHT	252.95 hrs	264.80 hrs	279.38 hrs	279.18 hrs
ATL[40]	10.25 miles	9.79 miles	11.45 miles	11.18 miles

Although the internal circulator doesn't make a significant difference in the VMT or VHT for either of the two scenarios, the development form does. The TOD/TND scenario is has saves roughly 11% to in VMT and 8% in VHT. GIS mapping for these variables indicates that there are some near-site differences due to the parallel facility provided by the suburban plan but no significant offsite impacts for these three variables (see Figures 4.24 to 4.26).

40. Averaged over all the project zones (i.e. not weighted)

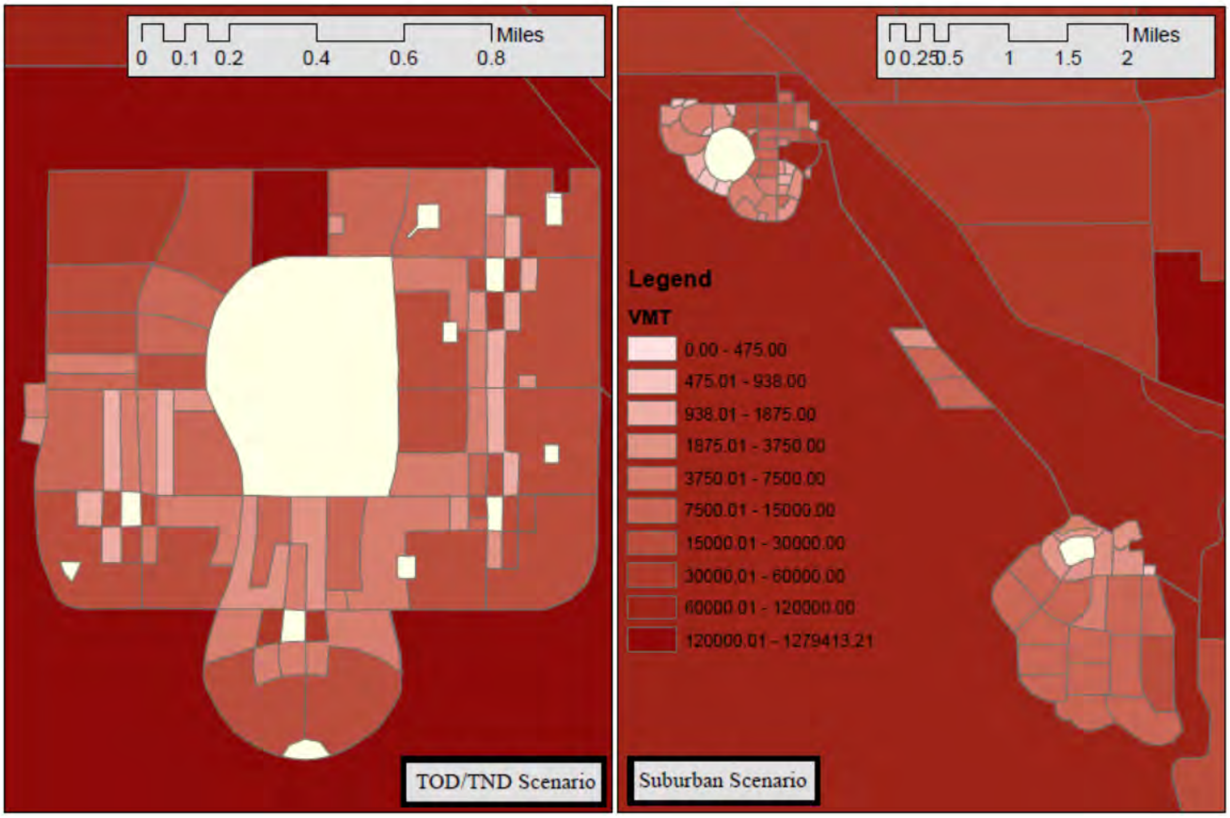

Figure 4.24 VMT by Zone

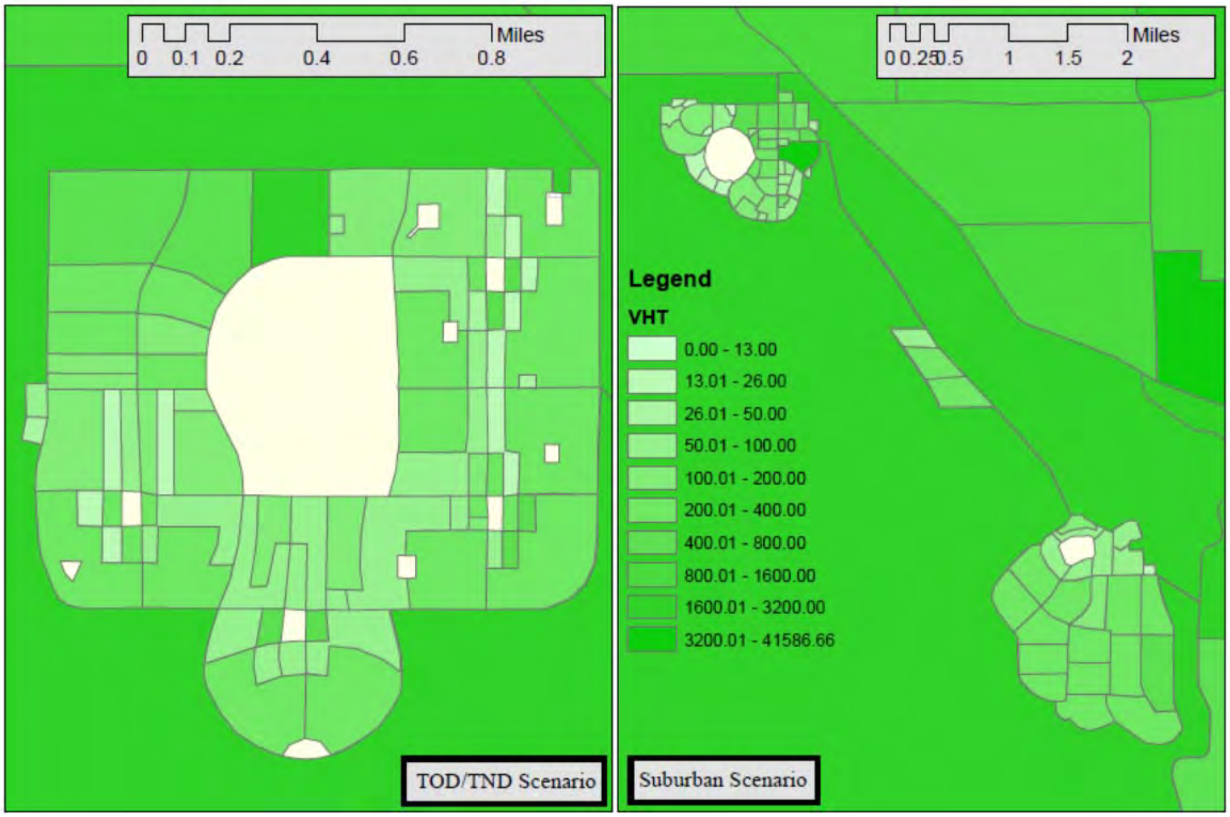

Figure 4.25 VHT by Zone

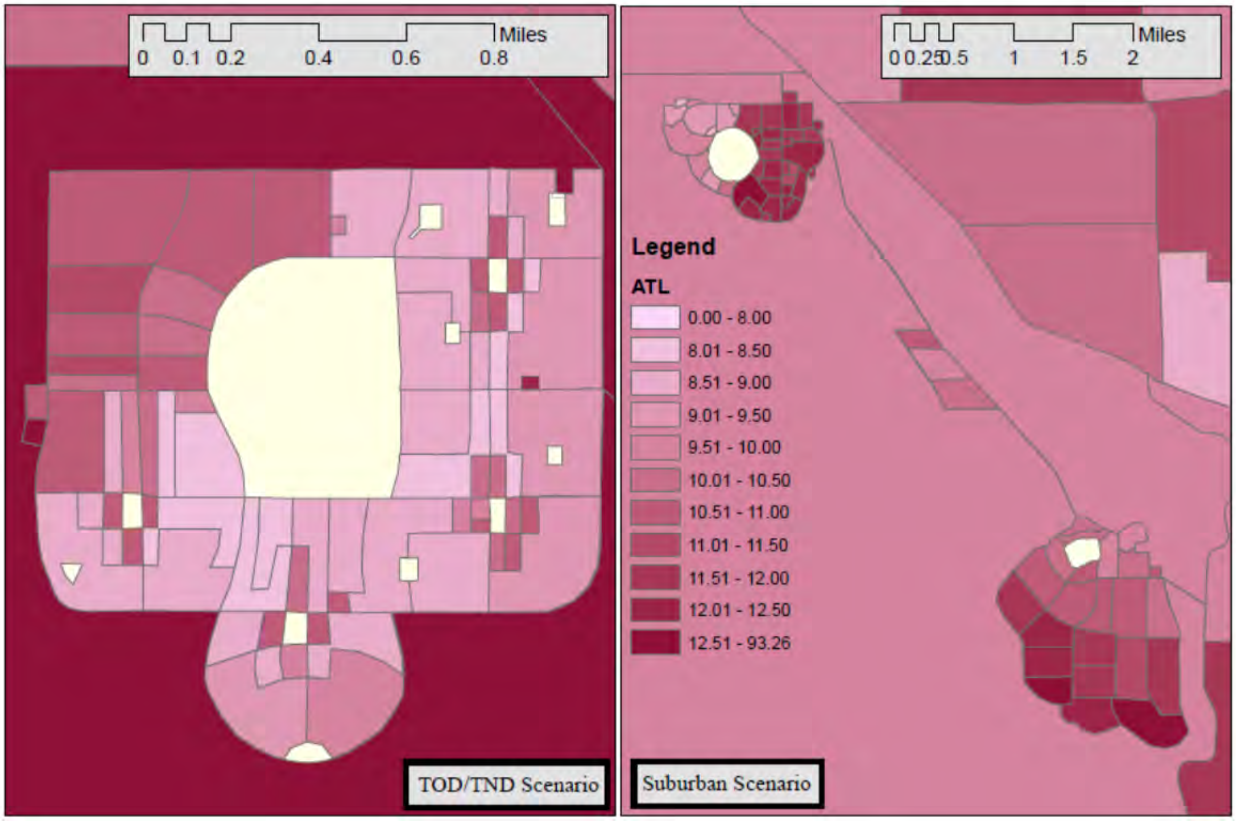

Figure 4.26 ATL by Zone

Sensitivity of Performance Measures to Land Use

The most immediate observation that can be made from this case study is that some measures appear more sensitive to the land use variations between the two scenarios than others. In some cases the measure itself isn't sensitive to land use; in other cases the process used to arrive at the outcome is not adequately sensitive to the land use and transit variations.

Of all the measures included in this chapter, only the ITE Trip Generation, the ITE internal capture rates and the jobs/housing balance are calculated in a manner that is inherently insensitive to land use arrangement. Table 4.22 summarizes the outcomes for these measures. In reality, internal capture, and to a lesser degree trip generation, are both very sensitive to land use arrangement and transit availability. Research on this topic is ongoing around the country.

Table 4.22 Performance Measures that are Insensitive to Land Use and Its Arrangement

Performance Measure	TOD	Suburban
ITE Trip Generation/Internal Capture		
Daily	103,111	Trips
Daily Internal Capture	24,881	Trips
PM Peak	10,275	Trips
PM Peak Internal Capture	2,050	Trips
Jobs/Housing Balance	3.62	employees/du

Jobs/housing balance is a measure that is usually considered in terms of an entire community, though it can be considered within TOD design. Jobs/housing balance can be used in comparison to the remainder of the community to establish whether the project helps balance the needs of the community as a whole. This measure can be expanded to address whether the jobs and housing provided are economically compatible internally and within the community at large.

Table 4.23 summarizes the measures that showed minimal sensitivity to the land use and arrangement within this case study. As was discussed earlier, the land use balance between the two scenarios was identical, but when clusters within walking distance were considered, the land use balance was dramatically different between the two scenarios.

Table 4.23 Performance Measures with Low Sensitivity to Land Use and Its Arrangement

Performance Measure	TOD		Suburban	
Land Use Balance	0.6		0.6	
Transit Ridership				
Peak	429	Riders	303	riders
Off-peak	60	Riders	197	riders
Total	489	Riders	500	riders
US 441 Seat Capacity utilized	4,002	Seats	4,041	Seats
Travel Time Ratio				
Work Trips	1.40		1.47	
Non-work trips	6.14		6.89	
Travel Cost Ratio				
Work Trips	0.23		0.23	
Non-work trips	**		2.02	
Vehicle Miles Traveled				
No Transit	534,682	VMT	601,527	VMT
Transit	544,901	VMT	608,237	VMT
Vehicle Hours Traveled				
No Transit	252.95	Hrs	279.38	Hrs
Transit	264.80	Hrs	279.18	Hrs
Average Trip Length				
No Transit	10.25	Miles	11.45	miles
Transit	9.79	Miles	11.18	miles

The remaining performance measures in this table are products of the travel demand model and are subject to the strengths and weaknesses of the model. The travel demand models were originally intended to project roadway travel demand so that future roadway needs could be identified. Therefore, their accuracy has always been assumed to be plus or minus a roadway lane. They are obviously used for far more than just roadway projections and there has been some effort to increase the accuracy of their projections. Three observations about their weaknesses can be made:

1. **Some elements are not measured in the model at all.** For instance, most of the standard FSUTMS models in Florida do not include a "walk only" or "bicycle" travel mode. Walk trips are generated, but only in support of a transit trip. The scale of these trips (less than ½ mile) is nearly always within the scale of a single zone. In urban core areas or where a subarea model is created (such as the model used for the TOD scenario), each zone is much smaller, and zone-to-zone walk or bicycle trips are

likely. Creating this type of travel mode within the model would require substantial modifications to the transit algorithms. There are limited data on pedestrian and bicycle flows that could be used to calibrate such a model. Furthermore, although we understand the qualitative factors that would influence those trips (for example, the pedestrian environment variables), we have almost no data correlating these variables with resulting walk or bicycle flows.

2. **Some elements cannot be measured well by the model.** The standard 4-step model does not address trip chaining or pass-by trips well. This directly impacts VMT, VHT, and ATL, particularly when land use mix is optimized so that shopping or recreational uses are within close proximity to residential areas. Rather than showing that trip as a part of the overall work trip, the 4-step model sees those trips as either a home-based shopping or recreational trip or a nonhome-based trip. Florida is moving toward an activity-based model structure, but this transition is likely to take well over a decade in many areas.
3. **Calibration of models is based on past experience and does not account for changes in traveler behavior.** All models (not only mode choice) are estimated using data from "current" year and hence inherently capture current-day biases. Therefore, the projected ridership will reflect the historic regional tendencies, rather than the specific traveler behavior as it evolves from year to year. There is a suite of methods available to address this issue: adjusting the constants using "engineering judgment"; borrowing parameters/data from other regions; using stated-preference methods to deal with currently non-existing conditions (these span the spectrum of cheap to costly and simple to sophisticated).

Table 4.24 summarizes the measures that were strongly impacted by the differences in the land use arrangement between the two scenarios. Although the total trip generation was not significantly different between the two scenarios, the trips that would impact the external roadway network showed a difference of more than 20%. Within a DRI analysis, this type of difference in external trips would make a significant difference in the project's overall impacts. The development density and intensities are also significantly different between the two scenarios, particularly the transit-oriented densities and intensities. Since density and intensity are a major factor associated with mode shift away from the single passenger automobile, these measures highlight a substantive difference between the scenarios. Transit service density is also very sensitive to the differences between the projects, particularly the differences in the headways provided. School accessibility, work accessibility and connectivity index also clearly highlight the differences between the two projects.

Differences in the built environment variables (for example, percent of network that is effective, or bikeable) demonstrate the extent of the built environment that is usable for the general public in each of the scenarios. The square footages to be built document the shift from asphalt to sidewalks, which are cheaper to build and maintain while serving a wider range of mode choices. The suburban scenario provides a parallel facility to a regional roadway, but the relief provided is small in comparison to the capacity provided. The amount of land used is also a significant difference.

Table 4.24 Performance Measures Strongly Sensitive to Land Use and Its Arrangement

Performance Measure	TOD		Suburban	
Trip Generation, Model Generated (no transit)				
Daily Total	104,147	Trips	102,962	Trips
External	61,503	Trips	78,538	Trips
Internal	42,644	Trips	24,424	Trips
% Internal	40.9	%	23.7	%
Trip Generation, Model Generated (transit)				
Daily Total	103,549	Trips	102,565	Trips
Internal	61,276	Trips	78,235	Trips
External	42,273	Trips	22,570	Trips
% Internal	40.8	%	22.4	%
Transit Trip Reduction	598	Trips	397	Trips
Development Density				
Overall Project	6.8	du/acre	2.5	du/acre
Residential Areas	9.7	du/acre	3.5	du/acre
Development Intensity	0.411	FAR	0.160	FAR
Transit-Oriented Residential Density	9.56	du/acre	4.93	du/acre
Transit-Oriented Employment Density	34.54	employee/acre	16.24	employee/acre
Transit Service Density	1.388	route-mile/acre	0.296	route-mile/acre
Percent of Res. Areas within 1 mile of a school	99.6	%	43.6	%
Connectivity Index				
Intersections per acre	0.359	intersection/acre	0.027	intersection/acre
Links/Nodes	1.75		1.07	
Polygons per square mile	183	/sq mi	9.3	/sq mi
Percent of Network that is effective	100	%	72.6	%
Lane miles per capita	6.07	mi/1,000	7.58	mi/1,000
Square feet of facilities				
Roadway	4,194	Ksf	5,989	Ksf
Bike facilities	1,531	Ksf	668	Ksf
Sidewalks	2,454	Ksf	2,102	Ksf
Percent of Roadway Network that is Bikeable	100	%	72	%
Work Accessibility	679,088		377,631	
Local Traffic Diversion (from US 441)	0	Trips	3,147	Trips
Land Consumption	737	Ac	1,995	Ac
Land Conservation	8,628	Ac	7,370	Ac
% Conserved	92.1	%	79	%

FAR= floor area ratio, KSF=thousand square foot, DU=dwelling unit

Agency Goals and Performance Measures

An agency's goals will directly impact the performance measures that are selected and therefore provide a significantly different evaluation of the outcomes for a specific project design. Appendix A provides a framework for identifying specific performance measures based on the community's goals. In Chapter 2, several of the jurisdictions studied had intentionally refocused their goals from congestion management to mobility choice. This shift in goals also shifted their evaluation methods from the demand and system utilization measures identified in Appendix A to infrastructure and environment measures.

Reviewing the case study land use scenarios from that perspective, if an agency's goals are focused on congestion management, the two scenarios result in similar performance. The performance measures chosen would include measures such as trip generation, internal capture, LOS (segment and intersection level, which are based on trip generation), local traffic diversion, VMT and ATL. As Figure 4.18 shows, the addition of the new parallel facility in the suburban plan offsets the additional capacity needs that could have resulted from the lower internal capture rate. Indeed, the offsite LOS impacts are nearly identical between the two scenarios. Even though the capacity relief to US 441 is minimal, a small relief can provide big changes in LOS and the connectivity to the western beltway would be seen as a plus, removing traffic from the interchanges on US 441. The majority of the mitigation required of the project would come in terms of turn lanes at intersections and interchanges within the study area. The small decreases in VMT in the surrounding community shown by both scenarios would be seen as a positive outcome, but would not significantly favor either project because the differences between them are so small. If transit ridership were considered, the low ridership levels indicated by the model results would seem to say that transit would not be a significant factor in mitigating any local congestion. Indeed, the expansion of bus service would be likely to increase congestion with minimal compensating mode shift. Land use balance might be considered in an effort to minimize vehicle trip lengths. However, the land use balance and ratio of employment to dwelling units are identical across the entire project regardless of the scenario, so these metrics would not favor either scenario as well.

On the other hand, an agency with goals related to mobility options is likely to choose an entirely different set of metrics and view the two scenarios as dramatically different. The measures they would be likely to consider would be many of the measures of Table 4.24 that showed significant differences between the two scenarios. These include transit-oriented densities and intensities, connectivity, roadway network effectiveness and bikeability, and percent of residences within 1 mile of a school. Land use balance would be considered important, but since mobility options are their goal, land use balance would be calculated based on the balance available within a walk distance or transit trip from the residences. This modification would highlight the segregated nature of the land uses in the suburban plan, showing where the segregation would inhibit pedestrian or transit interaction.

The transit ridership projections from the model would be examined critically to assess whether they are realistic in light of the services proposed and to determine if minor modifications to the service outside of the model parameters would make a significant difference in its use. At a minimum, the trip cost ratio tends to support the idea that transit would be more strongly utilized than shown in the model projections performed for this study.

One of the major impediments to use of the local circulators in the model was the anticipated wait time added to each trip. These wait times assume random passenger arrivals so the average wait time is usually set at half the headway time. However, the time spent waiting is weighted double within the model because the user perceives this time as more onerous than travel time. Therefore, the final wait time is usually mathematically equivalent to the full headway time of the service (6 minutes at best). If every transit trip in the model has a minimum of 6 minutes added to the trip, a low ridership predicted by the model is no surprise. The transit trip cannot compete with the equivalent vehicle trip which generally only has a two-minute terminal time added to account for an equivalent wait period. Many jurisdictions have started publishing real time GIS locations for their buses, which could allow the modeler to reduce the perceived wait time in the model to less than a minute based on the two wait time factors included in the model. First, the user can arrive at the stop based on when he knows the bus is there, making the arrivals non-random. Second, the perception of the wait time will be less onerous because the uncertainty associated with the wait is eliminated. This makes the transit trip competitive with a vehicle trip both within the model and in real-world behavior. Parking quantity limitations and pricing could further encourage the use of the transit system. Regardless, the internal circulators and connection with the regional rail system would be seen as valuable components supporting their goal of mode choice.

The shift within roadway construction from drive lanes to bicycle and sidewalk construction would also be seen as supporting the goal of mobility choice. The on-street parking provided in many of the cross-sections would allow for land uses to be clustered at walkable distances rather than buffered by large parking fields that are unfriendly to pedestrians.

Chapter 5: Summary and Conclusions

This report identifies and discusses a wide range of multimodal measurement tools available to planners, transportation engineers and government officials. Although transportation professionals will continue to build roads and bridges, the scale at which we can do so is limited both by the immediate construction costs and the long-term maintenance costs generated by these facilities. Expanding our metrics to support a wider range of mobility options increases our ability to respond to travel demand in a more resilient and cost-effective manner.

This project developed a procedure for assisting agencies in selecting performance measures that match their goals and capabilities. Chapter 2 of the report provides an overview of this procedure. It first lists potential agency objectives and categorizes the performance measures identified based on these objectives. Next, a set of evaluation criteria are proposed to further reduce the list of performance measures that are appropriate for an agency based on its capabilities and resources, as well as existing transportation planning framework. Examples of how these criteria can be applied to select a suitable list of measures are also provided. It is recommended that a list of primary and secondary performance measures be developed, to consider a broader set of mobility conditions and perspectives.

Chapter 3 summarizes the experiences of several jurisdictions within Florida, documenting their goals, codes, review procedures, and the metrics they have used to implement their multimodal systems. Review systems fall into 4 major categories. The City of Gainesville uses a multimodal impact area analysis system that analyzes project impacts until those impacts fall below a specific threshold. St. Petersburg uses a system that prescribes the characteristics of the infrastructure that must support each project but does not require analysis of the system utilization. Alachua County uses a mixed system that has characteristics of both an impact area system and a prescriptive system. Within urbanized areas, utilization is measured at intersections within a ½ mile, but the majority of the requirements for a project are prescriptive in nature. Outside the urbanized area, an impact area system is employed. The City of Orlando uses a geographic-based review system in which trips are metered to each TAZ throughout the city based on the availability of transportation facilities to serve those trips. This is done through an annual monitoring and modeling program that estimates the amount of growth that can occur in each TAZ without exceeding the capacity of the facilities that will be available within the next 5 years. This growth is used to meter out a specific quantity of available trips to each TAZ each year. These trips can be reserved by development in that year and the City is assured that its facilities will remain within an acceptable LOS for the next 5 years. To some extent trips can be shared across adjacent zones, but once those metered trips are reserved by development proposals within a year, the available capacity has been consumed and typical reservations must stop for that year. Once this occurs there are two options. Development projects can wait for more trips to be metered out in the next year or a more detailed analysis must be performed to determine what deficiencies limit additional capacity to that zone that deficiency can be remedied so that additional trips can be metered to that zone. Several of the jurisdictions have intentionally refocused their community goals toward multimodal choice and away from congestion management. In effect, they are prioritizing the safety of users and availability of service across all modes over the quality of service provided in the area's primary mode (the passenger vehicle). Part of this refocusing involves expanding the use of urban design parameters, often using form-based codes within multimodal areas to create pleasant and safe pedestrian environments that support walking, biking and transit.

Chapter 4 describes a case study with two different land use scenarios. The case study demonstrates the use of several of these measures in Florida development and provides the range of values that could be expected. Some measures are very sensitive to the change in land use arrangement, while others do not show significant differences. Although the two scenarios had dramatically different design characteristics, their capacity utilization performance is quite similar. However, the density and connectivity of the TOD form lends itself to a larger mode split, though the travel demand models in Florida do not always have the capacity to fully demonstrate that shift. The last part of the chapter discusses the selection of performance measures as a function of the agency goals and priorities, using the process outlined in Chapter 2. The case study showed that a jurisdiction that focuses on congestion management alone would miss the distinction between the way the two forms function, while a jurisdiction focusing on the provision of multimodal choice would be able to see significant differences between the two scenarios. Examining a broader set of measures provided a broader view of the project's potential outcome.

As can be seen from the case studies documented in Chapters 3 and 4, there are many ways to evaluate a project using a variety of performance measures. It is important for an agency to set clear priorities and goals and through those identify the most appropriate set of performance measures. The systematic process provided in Chapter 2 can be used to arrive at those considering the agency's resources and preferences.

Transportation and mobility are often addressed as an individual component of a project, independent from the overall project's ecological, economic and social costs. Additional research should be done to place the mobility-related impacts in context with these broader, long-term concerns.

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APPENDIX A: Performance Measures and Their Classification

This appendix presents an overview of the over 200 performance measures identified from the literature (see Table A.22 for details). The literature reviewed is identified in the Bibliography section. To facilitate a systematic discussion, the measures have been identified into five major groups:

- **Measures of Infrastructure and Environment.** These measures describe the characteristics of the physical environment that support mobility. They include the Four Ds of land use: density, diversity, design (facilities and system), and destination accessibility (area-based and network-based). These measures help characterize the supply of mobility features and the usability of the system.
- **Measures of Demand and System Utilization.** The measures of system utilization include auto-oriented, transit-oriented, non-motorized mode, freight-oriented and multimodal measures. These measures are generally constructed incorporating both demand and supply data in relationship to the system. Measures of travel demand include trip generation rates and mode shares.
- **Measures of User Perception**. Measures in this category assess user perceptions regarding various aspects of the system. These are directly elicited from the users or system stakeholders through surveys and are directly or indirectly related to other quantitative measures such as physical environment characteristics and utilization.
- **Measures of Safety.** These measures (such as crash rates & injury severity) assess the potential safety risks experienced by the users of the system. These measures generally document historical data regarding safety incidents, but could be expanded to include risk management and assessment of proposed systems.
- **Measures of Sustainability.** These measures assess the ability of a system to sustain itself ecologically, economically and socially over the long-term. Measures within this category are subdivided among those three domains. Ecological impacts include air quality, greenhouse gas emissions and energy consumption. Fiscal impacts include economic impacts both to the local agency as well as to private organizations and the community. Social impacts include equity considerations and impacts on the culture as well as social connectivity among individuals within the community.

Since the number of measures within each of these groups are still too numerous, the groups are further sub-divided into sub groups as shown in Figure A.1.

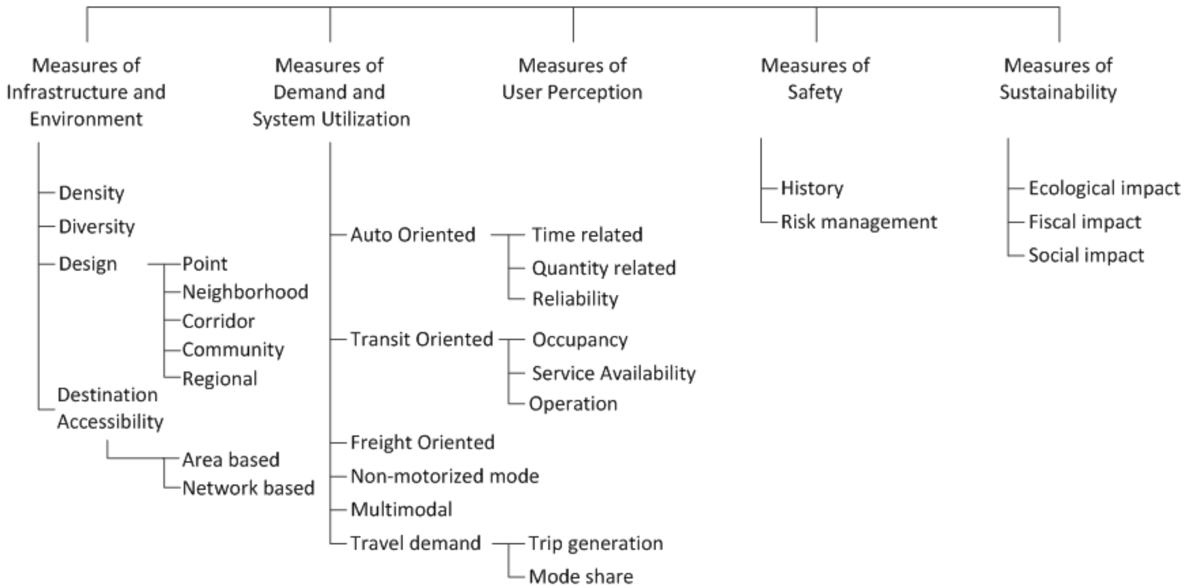

Figure A.1 Classification of Performance Measures by Mobility Dimension

Measures within each group and sub-group are discussed in detail in the following sections. The Appendix ends with a list of all the performance measures and their definitions in a tabular form.

Measures of Infrastructure and Environment

The physical environment provides the supporting infrastructure for all trips within a community. The characteristics of the physical environment are often described in the literature using the Four Ds: density, diversity, design, and destination accessibility. Regardless of the context, these characteristics directly impact the ability of a traveler to participate in activities in an efficient and satisfying way. Each of those subcategories and the respective performance measures are discussed below.

Density

The density of land uses plays a strong role in the mode users choose to function in that environment. Where activities are spread out, reliance on the automobile increases. If there are limited origins and destinations along a route, the efficiency of grouping trips on transit modes or in carpooling is lost.

Similarly, dense environments have a significant advantage in supporting transit, bicycle and pedestrian travel. Dense environments are more likely to have origins and destinations within distances that are acceptable to a pedestrian or bicycle user. Most Americans will not use these modes for discretionary trips if they are longer than 5 minutes (approximately ¼ mile). Longer trips may be acceptable for occupational or recreational uses. In other countries, longer trips are acceptable for a wider range of activities, which supports the notion that under the right circumstances those trip lengths could become acceptable in the US, and may already be acceptable within certain segments of the population. Table A.1 lists the density-related measures identified in the literature.

Table A.1 Density Measures of Infrastructure and Environment

Density	Transit-oriented employment density Transit-oriented residential density Development Scale Density Gradient Population and employment centrality Population density gradient Density at median distance Density of development Percent of houses within 1 mile of an elementary school Percentage increase in residential density Residential density (gross and/or net) Building coverage ratio Average School Size Non-residential intensity

Diversity

Diversity measures assess the quality of the land use mix, both developed and undeveloped. A diversity of land uses facilitates walking and bicycling by providing access to a variety of destinations together in a single location, allowing the user to park once and travel using other modes throughout the project. Coupling transit-oriented development with a mix of land uses doubles the benefits of diversity because it allows for transit use to and from work in conjunction with non-motorized travel for local convenience-based services, whether the convenience services are located close to home or employment. This is borne out by research conducted by Robert Cervero in the 1980s that showed greater transit usage among employees who work in suburban employment centers with a greater diversity of land uses. Table A.2 provides a list of these types of measures identified in the literature. As shown, they include several indices that attempt to provide a broad assessment of multiple measures within the Four Ds as well as measures that attempt to quantify the diversity of amenities that are available to the user within the service area of each mode. For instance, measures such as the Transportation-Efficient Land Use Mapping (TELUMI) index and Nearby Neighborhood Assets can identify whether a project's residents can get to schools, restaurants, a grocery store or other needs within a bicycle trip or whether that trip can be accomplished on transit or will require a vehicle. TELUMI also provides guidance to local officials about optimal locations for better transit service.

Table A.2 Diversity Measures of Infrastructure and Environment

Diversity	Smart Growth Index Significant Land Uses Land use ratios/mix Land use balance Variation of agricultural of green fields Land Consumption Core Land Use Land use separation Transportation-Efficient Land Use Mapping Index (TELUMI) Model Minimum thresholds of land use intensity Nearby Neighborhood Assets Sprawl Index (Ewing et al., 2002) Sprawl Index (Galster et al., 2001) Land Use within Village Center Land Use within Transit Supportive Area Jobs/housing balance

Design

Design features are the physical characteristics of an environment that are intentionally shaped through application of various performance measures to enhance the experience of the transportation user whether that user is a pedestrian, bicyclist, transit user or driver. These design related performance measures are applied at all scales, from the width of the sidewalk to the layout of the transportation network for a state or regional long-range plan. Both context and scale are critical guiding variables with regard to design. Therefore, the measures will be ordered based on the scale at which each measure is most commonly applied and include categories for Point, Neighborhood, Corridor, Community and Regional measures.

Point measures can generally be experienced by a single user in one location, though they may be applied throughout a neighborhood. The design of the last 100 feet around both origins and destinations are a significant factor in the traveler's mode choice. If the immediate environment around a person's home, work and shopping are all conducive to walking, it is much more likely that a person will make the effort to walk or use transit service when it is available. Sidewalk width or wayfinding systems are two important point level measures. Careful reconsideration of the existing geometric design features and the standards specified in the Land Development Code can make a significant difference in the community's ability to support several modes concurrently. Walking and biking environments must be designed to encourage a slower travel speed, which translates to narrow vehicular lanes, wide paths and buildings or trees close to the street. Wayfinding at a pedestrian scale rather than a vehicular scale is also critical.

Table A.3 Point Design Measures of Infrastructure and Environment

Point	Wayfinding information Sidewalk quality Sidewalk width Sidewalk shade Tree-Lined/Shaded Streets Walkable Streets Systematic Pedestrian and Cycling Environmental Scan Instrument Commercial on-site amenities to support alternative modes Availability of on-site bicycle amenities Pedestrian scaled lighting Ratio of street width to building height Parking screening Bus pass program utilization Parking shading

Neighborhood measures have impacts at the walking scale of the pedestrian (approximately as far as a pedestrian can comfortably walk—around ¼ - ½ mile). For instance, block length directly impacts the character of the neighborhood and the comfort of its walking environment. When parking design is considered as a part of site review, bicycle parking is often a neglected component. This includes the potential to "park" a bike during a transit trip and continue to use the bicycle at the end of the trip. This can be an important design factor in the transit system implementation. Bicycle parking may also require the inclusion of shower spaces as a part of building designs to allow for bicyclists to be adequately prepared for their day after a sweaty commute.

Another important measure at the neighborhood scale is connectivity. Connectivity has been used successfully in many jurisdictions to support multimodal mobility and can be directly enforced as a part of the development review process. Similarly, ensuring the continuation of a good street network and the proximity of a project's development to the existing network limits both sprawl and its negative effects.

Measures such as route directness also provide the ability to require site plan modifications when pedestrian or bicycle amenities have been added haphazardly as an afterthought rather than as part of a comprehensive system. Route directness could also be applied as a specification for the roadway network design within a project, both internally and as a potential incentive to improve overall community connectivity.

Table A.4 Neighborhood Design Measures of Infrastructure and Environment

Neighborhood	Square feet of pathways/sidewalks Crosswalk spacing Number of safe crossings per mile Bicycle parking at stops and stations Parking footprint Block length Parking location Bicycle path condition Pedestrian/bicycle route directness Land use buffers Walking environment Bicycle maintenance stations Bicycle/ped connectivity Connectivity Index Connectivity Index, Polygons Project Adjacency to existing network Connected and open community Connected sidewalks/paths Connected streets Cross access

Corridor measures impact along the length of a corridor, often penetrating through multiple neighborhoods and impact the function of transit users, bicyclists and drivers. These measures often relate to the physical geometry of the roadway cross-section, like typical lane width.

Table A.5 Corridor Design Measures of Infrastructure and Environment

Corridor	Possible capacity addition within Right-of-way (ROW) Bus turnout facilities Street continuity Bicycle Compatibility Index Access requirements/ Roadway Access management

Community measures have impacts at the scale of a single local jurisdiction or subarea. Many of these measures take advantage of Geographic Information System (GIS) analysis to gain an overall sense of a community's prevailing features. For instance, a GIS-based analysis of parking supply and transit service coverage can clearly identify the preferred mode for each area of the entire community. Parking design addresses the availability of vehicle storage either at the ends of the trips or, in some cases, during the trip itself. Parking availability has been shown as one of the chief indicators of the success of alternate mode choices. Areas that have parking limited or priced often have stronger demand for alternate travel modes, especially where transit is provided. Some urban areas like Los Angeles are including parking supply signage as part of its urban wayfinding system to reduce the congestion that occurs as drivers circle around the system looking for parking spaces (SCAG, 2012).

Table A.6 Community Design Measures of Infrastructure and Environment

Community	Bicycle network density Parking supply Parking Spaces per 1000 workers Age of transit vehicle/fleet Bus shelter locations Bicycle parking requirements Bicycle parking spaces at schools Intermodal Connections Transit service index Transit network coverage Transit service to site Walking distance to transit Project Adjacency to transit Connectivity to intermodal facilities

Regional design measures impact multiple jurisdictions across a large geographic area. Critical regional measures often communicate the completeness of regional transportation systems.

Table A.7 Regional Design Measures of Infrastructure and Environment

Regional	On-vehicle bicycle-carrying facilities Park-and-rides with express service Parking spaces designated for carpools or vanpools Transit passes Traffic cells Percent miles bicycle accommodations Percent miles pedestrian accommodations Miles of express fixed-transit route/dedicated bus lanes Road density Lane miles per capita Percent of network that is "Effective" Roadway network balance

Destination Accessibility

Destination accessibility measures the distance between a single point and the desired destinations in the area, usually at a regional scale. These measures fall into two categories: those that measure an area-wide tendency for land uses to be located in geographic proximity to each other and those that measure the proximity of uses in terms of the network of mobility services that are available to a user. For instance, complementary land uses located on either side of a river may show a good accessibility from the standpoint of physical proximity but may have significant travel distance between them.

Area-based measures are appropriate for long-range visioning and comprehensive planning purposes. They are valuable tools for assuring that future land uses are generally sited in a way that minimizes travel. At an individual site level, they can also be used to identify the scale of a project's impact area by identifying how geographically distant complementary uses are.

Network-based accessibility is tied to the availability of activities or travel options along a specific route for a given mode of transportation. These measures are effective tools for determining the potential for alternate mode use based on the availability of goods or services along the routes provided by that mode. Table A.8 provides the list of destination measures identified in the literature.

Table A.8 Destination Accessibility Measures of Infrastructure and Environment

Area-based	Residence proximity Employment proximity Work accessibility Number of key destinations accessible via a connected pedestrian system Industrial/warehouse proximity Transit convenience/Stop Accessibility Geographic Service Coverage Population Service Coverage Percent in Proximity Transit Accessibility
Network-based	Bike/ped accessibility Destination Accessibility Residential Accessibility Average walking distance between land use pairs Spacing between Village Centers Multiple Route Choices

Measures of Demand and System Utilization

Measures of demand and supply utilization are the measures most commonly thought of as mobility performance measures. The auto-related measures have a long history, and transportation professionals have a good understanding of the meaning of each measure, its application and common outcomes. As other modes have become more common, correlates to the traditional auto-oriented system utilization measures have been developed and are increasingly accepted and used.

Auto-Oriented

The auto-oriented measures of system utilization are those that have been traditionally been used as highway performance measures, but several of these can also be extended to person trips and to other modes. They can be divided into several subcategories: time-related measures, quantity-related measures, and reliability measures.

Time related measures are associated with travel time. Travel time related measures have two main advantages. First, there is evidence to suggest that some travelers have a daily travel time budget that governs their travel choices. This makes travel time a crucial variable for user satisfaction. Second, increases in travel time (regardless of the speed) are related to increased greenhouse gas emissions and fuel consumption. Therefore, strategies that show a significant drop in the amount of time spent in a vehicle directly impact the ecological sustainability within the community. Generally travel time is difficult and expensive to measure in the field. Travel time and delay studies using specially equipped probe vehicles and trained drivers are expensive and time consuming. It had been hoped that Bluetooth and transponder technology would make tracking vehicle speeds along corridors easier and more consistent, but the high frequency of pass-by, chained trips and destination trips within corridors means a high percentage of the data collected does not accurately reflect the corridor’s travel speed. Because the data is of such critical import in calibrating regional travel demand models, a significant amount of data loss may be acceptable despite the difficulty involved in its collection and processing. At the level of an individual project, travel time and delay can be estimated for an intersection, corridor or small area using Highway Capacity Software (HCS; University of Florida, McTrans) or other commercially available simulation programs, intersection turning movement counts and signal timings.

Table A.9 Time-Based Auto-Oriented Measures of Demand and System Utilization

Time related	Average Speed Average speed weighted by person miles of travel (PMT) Congestion Duration Control delay Highway Reliability Percent work trips within specific travel time Total segment delay Travel delay Travel time Travel Time-based LOS, Travel time index Vehicle hours traveled (VHT) Average commute time Time by trip purpose Vehicle hours of delay (VHD) Vehicle speed/VHD by mode Travel distance index

Quantity related measures are associated with either the volume or length of the trip and are directly related to the congestion on the roadway network. These measures are generally easy to measure consistently and are equally easy to communicate to the public. They are, by far, the most common variables used in transportation analysis and development review.

Table A.10 Quantity-Related Auto-Oriented Measures of Demand and System Utilization

Quantity related	Vehicle occupancy by land use District wide Level of Service (LOS)/Quality of Service (QOS) Local traffic diversion LOS (Highway Capacity Manual (HCM) 2010) Percent of system heavily congested v/C ratio Vehicle Density Demand/capacity ratio Maximum Service Volume Peak Hour LOS Percent of Capacity Consumed

Reliability measures are gaining in significance at the national level. They are less commonly used within the development review process, but are similar in both application and measurement to the Quantity Related Measures. They have the advantage of estimating the variability, as well as the upper and lower ranges of trip travel time. However, they come with high data collection and reduction costs which have limited their implementation.

Table A.11 Reliability-Based Auto-Oriented Measures of Demand and System Utilization

Reliability	% of trips 'on time' 90th- or 95th percentile travel time Buffer index Planning time index (PTI)

Transit-Oriented

Although transit service in Florida occasionally experiences ridership that approaches its capacity, the majority of the measures that are commonly applied to transit service are related to the desirability of the service rather than its utilization. The literature yielded a host of transit measures well beyond what is included in Table A.12. Each transit agency attempts to quantitatively capture many aspects of their service that have a bearing on their service, in an effort to increase ridership. Transit Measures fall into three major categories:

Occupancy measures focus on the number of riders using the system or its components.
Service availability measures detail the provision of services to riders.
Operation measures address the speed, efficiency and productivity of the system.

Unlike roadways, where the initial capital construction cost is the lion's share of the total facility life-cycle costs, transit costs are shared between both initial capital expenditures and ongoing operations and maintenance expenses. In the past, the mitigation required of development has been limited to only the initial capital construction costs and any long-term maintenance costs have been assumed to be the burden of the jurisdiction to be paid for through increased tax revenues. Therefore, mitigation for transit impacts has been comparatively rare, and most commonly involved construction of stops or stations or the purchase of new vehicles. However, funding of operational expenses has become increasingly more common as a mitigation strategy as transit gains a higher mode share throughout the state. In areas that are transit-rich, it is reasonable to allow higher intensity development because the roadway impacts can be significantly less. From a development review standpoint, the thoughtful provision of transit amenities within even a small proposed site can be a strong supports for the use of transit within their project. Requesting site plan comments from the local transit agency can provide valuable insight into how those required amenities can provide the most benefit to the transit rider.

Table A.12 Transit-Oriented Measures of Demand and System Utilization

Occupancy	Load Factor Passengers per transit vehicle mile Ridership Transit peak hour occupancy Percent person-minutes served
Service Availability	Average frequency Average headways Hours of service Off-peak transit availability Transit service density Transit type availability Fixed route missed trips On time performance Demand-response transit (DRT) trips not served Response Time for DRT
Operations	Number of fare media sales outlets Transit Productivity Number of transfers Transfer time Transfer time between modes Transit priority delay reductions Transit Reliability (Quantitative) Fleet spare ratio Road Calls Average life of vehicle components Average Age of vehicle components

Freight-Oriented

To make overall travel productive, freight must be thoroughly considered both from a regional standpoint and from a local standpoint. Congested urban areas have unique needs for freight delivery, but they are also some of the most challenging environments for the delivery of freight. As urban environments are fine-tuned to better support non-vehicular modes, regional corridors and local delivery routes must be clearly identified and fine-tuned for the delivery of goods. Similarly, as businesses and communities push toward increasing the diversity of commercial access which decreases auto trip lengths, accommodations for freight must be addressed with the utmost of care, both at the site plan level and at the regional level. A wide range of performance measures have been identified related to freight movement but are largely beyond the scope of this analysis. Where the site incorporates multiple modes including rail and port connections, specific analysis of intermodal travel may be desired, but this is not a common issue for a typical project review. Table A.13 provides a list of freight-oriented measures identified in the literature that could be important in most projects.

Table A.13 Freight-Oriented Measures of Demand and System Utilization

Freight-Oriented	Truck miles traveled Truck throughput efficiency Freight delay Number of violation of weight restrictions Overweight permits

Non-Motorized Modes

As modes other the vehicles become better utilized, the analysis of all trips must shift from a vehicular point of view to a more generalized person trip perspective. This type of analysis provides the ability to compare the mode options and set goals toward shifting travel from the single occupancy vehicle (SOV) to more resource efficient travel. Additionally, as these modes become congested, it will be important to evaluate their operational characteristics in relationship to their capacity. Table A.14 provides a list of the non-motorized mode measures identified.

Table A.14 Nonmotorized Mode Measures of Demand and System Utilization

Non-motorized mode	Average Trip Length per traveler Delay per traveler Door to door travel time HCM-based Bicycle LOS Proportion of total PMT for non-SOVs

Multimodal

Table A.15 provides a list of multimodal measures. Several of these measures provide innovative ways to approach total corridor capacity. An example of such a measure is Seat Capacity/Person Capacity, which assesses the person capacity of an entire corridor in terms of all viable modes in the corridor. Although capacity may be limited from a vehicular standpoint, this measure more accurately assesses the available capacity in terms of all modes, including transit or other modes.

Table A.15 Multimodal Measures of Demand and System Utilization

Multimodal Measures of Demand and System Utilization	
Multimodal	Auto/Demand response transit (DRT) travel time ratio auto/transit travel time ratio Multimodal LOS Seat capacity/Person capacity

Travel Demand Measures

The measurement or estimation of travel demand, both under existing conditions and in the future, is one of the most critical processes in project analysis. Travel demand can be measured or estimated in many ways, from simple historical statistical data to complex travel demand modeling. An understanding of the activities that are desired is the key to designing measurements, studies and estimates of travel demand, including latent demand, which is the potential demand if expanded capacity were available. Table A.16 lists the travel demand measures identified in the literature.

Table A.16 Travel Demand Measures of System Utilization

Trip Generation	Average Vehicle Occupancy Bicycle and Pedestrian activity Community Capture Internal Capture Mean daily trips per household Mean daily vehicle trips per household Person miles traveled (PMT) Person trips Trip length by mode Vehicle miles of travel (VMT) (by mode) VMT per capita
Mode Share	Bicycle and Pedestrian mode share Mode choice availability Mode Split Safe Routes to School Program (SRTS) effectiveness SOV mode split

Measures of User Perception

User perception measures are typically obtained through surveys. They correlate with design and system utilization measures, but also incorporate other intangible traveler needs and priorities. Within the transit field, measures of user perception are commonly used because those perceptions directly impact the utilization of the system. Although this is at least equally true of pedestrian and bicycle systems, measurements of user (and non-user) perceptions within those systems are rarely measured. If a multimodal system is to be a part of a long-range mobility plan, then the perceptions of the potential users regarding the existing and planned system must be considered and community attitudes toward those alternate modes must be considered. Ongoing measurement of community attitudes and user perceptions are critical to measuring the impacts of programs and projects that support alternate modes. Table A.17 provides a list of user perception measures.

Table A.17 User Perception Measures

User Perception	Bicycle LOS (FDOT) Pedestrian LOS (FDOT) LOS-based on traveler perception Perception of Transit safety Transit comfort Transit condition of vehicles and facilities Transit ease of using the system Transit Reliability/ Performance (Perceived) Transit Complaint Rate Transit Customer loyalty Pedestrian Friendliness

User perception and the identification of driver choices can also be a strong resource as communities optimize the traditional roadway system as well. Although many drivers complain about congestion or commute times, the rate at which those discomforts modify a driver's behavior is rarely analyzed. The acceptability of congestion in relationship to the costs of mitigation should also be considered as public projects are reviewed.

Measures of Safety

Safety relates to both crash history and risk management. Table A.18 lists the performance measures identified under each of these categories. In a project review, past histories of high incident locations in the vicinity of a proposed project are generally identified and an effort is made to mitigate them. Many jurisdictions have become proactive in managing the risks to which a community is exposed. These risks can significantly affect the perception and utilization of specific modes (such as walking and biking). Communities in Europe have been successful in adding contextual cues to the environment that signal to the driver that the environment includes more than just vehicles.

Proactive safety management has benefited from technological advancement. Several Intelligent Transportation System (ITS) approaches have been used to reduce delays and prevent additional incidents via Transportation Management Centers (TMC's) or Rapid Response Vehicles. Metrics that assess clearance time and monitored roadways document how well these projects achieve their goals. Furthermore, both transit and personal vehicles are increasingly equipped with advanced safety devices and this progress can be correlated with reductions in certain types of accidents.

Table A.18 Safety/Security Measures

Safety/Security Measures	
History	Bike/Pedestrian injuries/fatalities Traffic fatalities Transit accident rate Transit vandalism incidents Transit related Crime rate Vehicle accident rate Crash statistics/locations Annual severe crashes
Risk Management	Percent of lane-miles under traffic management center (TMC) surveillance Average clearance times for major incidents Speed suitability % vehicles with safety devices Ratio of police officers to transit vehicles

Measures of Sustainability

The essential concept of sustainability is that our built environment should support a high quality of life into the foreseeable future. To adequately support a sustainable infrastructure, measures that assess long-term impacts and potential are needed in the three main dimensions of sustainability: ecological, economic and social (Tables A.19 to A.21).

Ecological Impact

Such measures primarily focus on air quality and energy consumption. Within a broader perspective one can consider the impacts of proposed projects on ecological systems such as wetlands and habitats for protected species. Addressing these impacts from the initial visioning process through project implementation can yield significant ecological benefits. Table A.19 lists the Ecological Sustainability measures.

Table A.19 Ecological Sustainability Measures

Ecological Impact	Attainment of ambient air quality standards Daily CO_2 emissions Daily NOx, CO, and Volatile organic compound (VOC) emissions Noise pollution Impact on wildlife habitat Water runoff

Fiscal Impact

As communities plan their future mobility infrastructure, the fiscal sustainability of the local agency[41] and the development community are critical components that can be measured and mandated, similarly to volume/capacity relationships that have been used to mandate adopted Levels of Service. The codification of impact fees, mobility fees or mitigation identified by the local agency are intended to defray the fiscal impacts that are expected for a specific project. In essence, many of these fees reflect projections of the project's impacts measured in terms of dollars rather than miles or vehicles, and the relationship is not necessarily linear. This is a crucial step in the implementation process of a community vision as the fee structure and prioritization of long-term investments will determine the potential success of the multimodal system no less than the specific design features.

Although reimbursement fees (such as impact fees), user fees/fares or mobility fees are not generally considered measures of mobility, they are derived from mobility forecasts and impact both the applicant's and local agency's economic stability due to investments in mobility. Furthermore, a careful recognition of the fiscal differences of specific development forms within the review process is a strong economic motivator for forms that require less economic support in terms of infrastructure construction and maintenance. Taking the time to estimate or measure the economic impacts of leapfrog development in comparison to redevelopment within the existing urban area is one of the best ways to reduce a local agency's long-term infrastructure costs as they support a more multimodal environment (TCRP, 2003).

For projects that are considered by local agencies, benefit cost analysis is typically performed to assess the project's economic sustainability and impacts. Often, the availability of alternate funding sources for local agency projects or public private partnerships can significantly impact the ability for projects to move forward.

One noted absence from these measures is an assessment of private development's fiscal impacts on the general revenue streams that relates additional tax revenue generated by a project (public or private) to the maintenance costs of the infrastructure added or reduction in trip lengths. This type of economic measure could provide a better understanding of the long-term costs of sprawl and redevelopment using complementary land uses.

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41. Although general governmental fiscal performance measures will have indirect impacts on the development review process, these measures are beyond the scope of this project.

Table A.20 Fiscal Sustainability Measures

Fiscal Impact	Additional Fuel Tax Transportation Utility Fee (TUF) VMT- Based Impact fee Consumption-Based Mobility Fee Improvements-Based Mobility Fee Cost recovery from alternate sources Variable fees based on LOS Benefit cost ratio Parking pricing Capita funding for bike/Ped

Social Impact

The measurement of a mobility system's impacts on the social sustainability of a community has rarely been considered in any rigorous fashion at the community level. However, if our intent is to support activity participation and quality of life, measures of social impact cannot be ignored.

Social equity issues in particular are crucial to the success of a multimodal system. Assuring that safe access to all modes is available to all groups in ways that support the community's culture is very important. For example, one of the issues that fuels the pedestrian safety issues in Florida is the mismatch between environments designed exclusively for the automobile and populations that do not to drive for economic or cultural reasons. The relative lack of transit service in outlying suburban areas adds to the congestion and conflict. Further complicating matters, strong pedestrian and bicycle amenities and connections are frequently missing in low income rural and suburban neighborhoods where they are most needed.

Another facet of social sustainability is the evaluation of travel demand management strategies and local trip-making as described earlier. Communities that support and enforce strategies that reduce both the quantity and length of the trips, fundamentally impact the social ties that generate a cohesive community. Again, the concept of the last 100 feet around both origins and destinations has a strong impact on the types of trips and mode choices made.

Table A.21 Social Sustainability Measures

Social Impact	Distribution of benefit by income group Transportation Affordability Equitable distribution of accessibility Commute Cost Transit values Fee charged for employee parking spaces Travel demand management (TDM) effectiveness based on TRIMMS model Travel costs by income group, Travel costs by race VMT by income group, VMT by race Mode share by income group, Mode share by race Walk to transit by income group, Walk to transit by race

Table A.22 Details of Performance Measures

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Density	Transit-oriented employment density	(average) number of employees per net non-residential acre that is within a ¼-mile walk distance of a transit stop	employees/ acre	Identifies the potential work trip customer base for transit service in a specific area. May be applicable to large projects and could be used to plan future transit service within a new project.
Measure of Infrastructure and Environment	Density	Transit-oriented residential density	number of residences within a ¼-mile walk distance of a transit stop	du/acre	Identifies the potential residential customer base for transit service within a specific area. May be applicable to large projects and could be used to plan future transit service within a new project.
Measure of Infrastructure and Environment	Density	Development Scale	a minimum number of residents and employees within a district along with a minimum ratio of employees to residents and the provision of transit service	-	The minimum scale of mixed used development that is necessary to accommodate a robust transit service; This minimum may be dependent on the types of services provided. Large projects can be required to meet these requirements.
Measure of Infrastructure and Environment	Density	Density Gradient	Ln(D) = a+ b ln (u) +e; where u is the distance from the city center, e is an error term and the variables a and b characterize the urban form. D(u)=d*exp(-yu); where D(u) is the population density at distance u from the center, d is the density from the center, and y is the density gradient	-	A quantitative measure of urban sprawl. As "b" decreases, sprawl increases. This variable is called the density decay parameter. The variable "a" indicates the estimated central density and is a measure representing average density at increasing distances from the center which can be called "centrality"; Large projects can be assessed to determine whether they decrease "b" (and thus increase the area's overall tendency toward sprawl) or increase "a," which increases an area's central density.
Measure of Infrastructure and Environment	Density	Population and employment centrality	proportion of population and employment within x miles of the center	%	These are generally mapped within GIS showing bands of population and employment intensity. Large projects that significantly shift these bands may increase the impacts of sprawl and could be required to mitigate those impacts.
Measure of Infrastructure and Environment	Density	Population density gradient	D(x)=d*exp(-yx); where D(x) is the population density at distance x from the center, d is the density from the center, and y is the density gradient	A measure representing average density at increasing distances from the center	measures the population density by increasing distance from the center. Can be called "centrality"; Large projects can be evaluated based on their impacts to the community's centrality.
Measure of Infrastructure and Environment	Density	Density at median distance	density at the median distance (from center to edge)	persons (residents or employees) per acre	Provides an indication of the overall density of the city. Large projects at remote locations may impact the density at a median distance and could be identified as sprawl

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Density	Density of development	identify the density by urbanized and unurbanized acres	person per urbanized acre/ unurbanized acre	identifies the density of an area; Projects are often required to meet maximum density requirements; Projects that are intended to utilize multiple travel modes have been encouraged to meet minimum density requirements.
Measure of Infrastructure and Environment	Density	Percent of houses within 1 mile of an elementary school	% of residential units within an area or jurisdiction within 1 mile of an elementary school	%	This variable can be readily quantified using GIS analysis of the local property appraiser database. Projects that would improve this variable could be encouraged with slight reductions in school impact fees due to reductions in transportation costs to the school.
Measure of Infrastructure and Environment	Density	Percentage increase in residential density	variation of residential density over years	%	measures the change of residential density during specific time period
Measure of Infrastructure and Environment	Density	Residential density (gross and/or net)	residential density (dwelling units/acre) or non-residential density (floor-area ratio); weighted density used for mixed use projects	du/acre; FAR	The quantity of land use developed per acre. Projects that meet the minimum density criteria in Leadeship in Energy and Environmental Design (LEED) for neighborhood development have a high likelihood that they can support an urban sustainable environment
Measure of Infrastructure and Environment	Density	Building coverage ratio	areas occupied by buildings/parcel area	%	Measures the compactness of land use; Projects can be encouraged to cluster their land uses so that they operate in a compact way, despite environmental requirements.
Measure of Infrastructure and Environment	Density	Average School Size	Average number of students in the schools within an area or school district	# students per school	Average school size is usually established based on the policy decisions of the local school board. Large projects often provide school sites to local school boards based on minimum site sizes set by the local school board.
Measure of Infrastructure and Environment	Density	Non-residential intensity	floor area ratio to land area	0-1.0	

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Design-Community	Bicycle network density	minimum continuous length of bicycle network within a ¼-mile bicycling distance of the project boundary or provides access to a minimum number of diverse uses within a 3 mile bike distance	miles of bicycle network accessible within ¼-mile or number of diverse uses accessible within 3 miles	Identifies the ability to provide for daily needs within bicycle distance. Diverse uses include: supermarket, food store with produce, clothing store, convenience store, farmer's market, hardware store, pharmacy, other retail, bank, gym/health club, hair care, laundry/dry cleaner, restaurant/cafe/diner, licensed adult or senior care, child care, community/recreation center, cultural arts facility, educational facility, family entertainment venue (theater, sports), government office, place of worship, medical clinic/office, police/fire station, post office, public library, public park, social services center; Projects that meet the conditions of this metric within areas that have good quality bicycle accomodations could be provided with significant impact reductions due to mode shift.
Measure of Infrastructure and Environment	Design-Community	Transit service index	number of stops within a distance	number of stops	function of buses stopping within 1⁄4 mile of site, number of rail or bus rapid stops within 1⁄2 mile of site, number of dedicated daily shuttle trips; Can be used to evaluate project impacts pre and post construction.
Measure of Infrastructure and Environment	Design-Community	Parking supply	rate of parking provided/ITE parking generation rate	%	Identify whether parking spaces are provided in accordance with the ITE parking generation rates or if parking is managed to reduce parking needs. Minimized parking could be used by a site to justify lower vehicular trip generation rates, particularly in conjunction with other strategies intended to shift travel to other modes.
Measure of Infrastructure and Environment	Design-Community	Parking Spaces per 1000 workers	number of parking spaces provided by a development per 1000 employees	spaces per 1000 workers	quantity of parking provided for an employer in an urban area
Measure of Infrastructure and Environment	Design-Community	Age of transit vehicle/fleet	Average age of vehicle manufactured	years	Provides the ages of vehicle
Measure of Infrastructure and Environment	Design-Community	Bus shelter locations	Whether a bus shelter is appropriately and safely located not by conflicting with pedestrian movement and provide appropriate information		
Measure of Infrastructure and Environment	Design-Community	Bicycle parking requirements	Existence of bicycle parking requirements as an policy		A lack of safe places to park a bicycle is a barrier to increasing bicycling. Can overcome this barrier by requiring businesses and new developments, parking garages, and public events to include bicycle parking
Measure of Infrastructure and Environment	Design-Community	Bicycle parking spaces at schools	Bicycle parking spaces at schools per 1000 students	spaces/1000 students	indicate available bicycle parking spots at public schools

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Design-Community	Intermodal Connections	number and location of connections between modes within a specific area	mapped, quantity identified	Identifies locations where mode transfers or choices may be made. Large projects could be required to provide a minimum number of transfer locations within a specific area.
Measure of Infrastructure and Environment	Design-Community	Connectivity to intermodal facilities	% of a geographic area that is within 5 miles of an intermodal facility (1 mile for a metropolitan area)	% of land	Shows the land cover that has proximate access to a mode transfer. May be applicable to large projects.
Measure of Infrastructure and Environment	Design-Community	Transit network coverage	% of a geographic area accessible within a certain distance of transit by walk	%	Identifies which properties have access to transit service. A transit network coverage map is typically generated through a GIS analysis of the property database and the transit lines. Proposed developments can be required to assure that a minimum percentage of their developed areas have access to existing or new transit stops.
Measure of Infrastructure and Environment	Design-Community	Transit service to site	Bus service stops within a ¼-mile air distance (BRT, Rail or ferry stops within ½-mile air distance)	stops per day	Identifies if a minimum number of transit stops are available to serve residents or employees of an existing or finanacially planned development
Measure of Infrastructure and Environment	Design-Community	Walking distance to transit	Walking distance between the trip start and the transit stop	miles	measures transit accessibility; Projects can be required to design their site plans to minimize walking distance.
Measure of Infrastructure and Environment	Design-Community	Project Adjacency to transit	distance between a development and transit	distance	Is the project sufficiently close to transit for it to be a viable mode choice?
Measure of Infrastructure and Environment	Design-Corridor	Possible capacity addition within ROW	possible number of lanes within available ROW	number of lanes	The ratio of additional capacity that can be accomodated within the existing ROW. Can be affected by ROW dedications from proposed development and may impact the ability for projects to meet adequate facilities requirements.
Measure of Infrastructure and Environment	Design-Corridor	Bus turnout facilities	percent of facilities (such as bus stops, or terminal) with bus turnout	%	The purpose of the bus turnout is avoid blocking a lane of traffic and to improve passenger safety during boarding and deboarding
Measure of Infrastructure and Environment	Design-Corridor	Street continuity	number of dead ends or offset intersections	identification of network discontinuities	Identifies network inefficiencies due to discontinuities. Projects with an internal roadway network or that connect to an existing roadway network can be required not to create any new discontinuities within their effective street system or can be required to remediate any existing discontinuities that are under their control.
Measure of Infrastructure and Environment	Design-Corridor	Bicycle Compatibility Index	the capability of accommodating bicycle travel using roadway geometric and operational characteristics	0-~6	provides an indication of the potential bicyclist's comfort and compatibility within an existing roadway environment. Pedestrian acceptabililty can be used as a variable for project approval.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Design-Corridor	Access requirements/Roadway access management	Number of access points		For developments containing 25+ lots or generating 250+ daily trips need to provide at least two functional access points located on different sides
Measure of Infrastructure and Environment	Design-Neighborhood	Square feet of pathways/sidewalks	Quantity of bicycle or pedestrian paths available in an area	square feet per square mile	Provides a rough measure of the pedestrian and bicycle amenities provided in an urban environment. Very general measure that could be applied in TCEA's or MMTD's to assess adequate facilities.
Measure of Infrastructure and Environment	Design-Neighborhood	Crosswalk spacing	average crosswalk spacing at signal supported	feet	Connectivity measure for pedestrians. Minimum standards can be established for all transportation facilities, including pedestrian and bicycle facilities.
Measure of Infrastructure and Environment	Design-Neighborhood	Number of safe crossings per mile	Number of crosswalks or mid-block crossings per mile	crossings per mile	Identifies the number of pedestrian and bicycle crosswalks in an urban environment; Can be a minimum requirement in site plan review.
Measure of Infrastructure and Environment	Design-Neighborhood	Bicycle parking at stops and stations	Number of stops with bike parking available/total number of stops	%	Availability of bike parking at stops and stations. Sites with transit service should be evaluated to determine if bicycle parking is available or should be augmented by the project.
Measure of Infrastructure and Environment	Design-Neighborhood	Parking footprint	maximum development footprint devoted to parking	% of site	A LEED credit point that limits the parking to a maximum percentage of a site.
Measure of Infrastructure and Environment	Design-Neighborhood	Block length	block length	ft	
Measure of Infrastructure and Environment	Design-Neighborhood	Parking location	Parking location		Indicates how the parking locations easily accessible, and should be designed to minimize conflicts with flows of pedestrians and vehicles
Measure of Infrastructure and Environment	Design-Neighborhood	Bicycle path condition	quality of bicycle path using multiple measures like width, driveway spacing, surface, etc	-	
Measure of Infrastructure and Environment	Design-Neighborhood	Land use buffers	minimum buffer distances vary between incompatible land uses. For instance for the development of 20K square feet near the existing 20K square feet, minimum 110 ft is required as butter distance	ft	reduce a risk of land use conflicts and separate between incompatible land uses
Measure of Infrastructure and Environment	Design-Neighborhood	Walking environment	Quality of walking environment at the points of architectural design criteria for good walkable streets	-	Good walkable streets should have no obstacles and wide width of street by considering the architectural design critera such as setbacks, build to line, % with porches & balconies, window glazing percentage, and facade rhythm
Measure of Infrastructure and Environment	Design-Neighborhood	Bicycle maintenance stations	number of bicycle maintenance stations	numbers	identifies the number of bicycle maintenance stations with air and tools along the routes. This makes bicyclists more convenient and attractive away from auto denpendence.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Design-Neighborhood	Bicycle/pedestrian connectivity	number of dead ends or offset intersections	more likely to be measured as a ratio of the straight line distance to the path distance	The ratio of the walk or bicycle distance within a system to the straight line distance between the same points. Minimum connectivity could be required for all modes as a condition of project approval.
Measure of Infrastructure and Environment	Design-Neighborhood	Connectivity Index	May be defined at least 4 ways: Links/nodes, intersections/(intersections +dead ends) (0-1.0), Intersection density per square mile, straight line distance/travel distance (0-1.0)	usually either a ratio or intersection density per square mile	Encourages network design that supports alternative modes and redundant vehicular paths. Projects can be required to meet minimum connectivity standards as part of their site plan review processes.
Measure of Infrastructure and Environment	Design-Neighborhood	Connectivity Index, Polygons	Number of closed loop blocks (polygons) within a square mile.	polygons per square mile	
Measure of Infrastructure and Environment	Design-Neighborhood	Project Adjacency to existing network	intersection density on the adjacent side	intersection density within a specific distance	Identifies sites that are adjacent to well connected areas (areas with a minimum intersection density), with the intention of extending that type of connectivity through the site. The adjacent area is measured within ½-mile of the project border along at least 1/4 of the site border.
Measure of Infrastructure and Environment	Design-Neighborhood	Connected and open community	minimum number of internal intersections per square mile with maximum connection spacing; or if no internal streets minimum intersection density within ¼-mile of the project boundary	intersections per square mile	A site plan that provides a minimum of 140 internal intersection per square mile with an connection spacing of no more than 800 feet. If there is no internal project network, the intersection density within a ¼-mile of the project boundary must be no less than 90 intersections per square mile.
Measure of Infrastructure and Environment	Design-Neighborhood	Connected sidewalks/paths	number of connections between sidewalks/paths within a specific area	number	
Measure of Infrastructure and Environment	Design-Neighborhood	Connected streets	number of connections between streets within a specific area	number	
Measure of Infrastructure and Environment	Design-Neighborhood	Cross access	traffic moves between adjacent properties without re-entering the roadway	%	Cross access supports developments and businesses by encouraging customers to stay on-site and visit mutiple businesses
Measure of Infrastructure and Environment	Design-Neighborhood	Pedestrian/bicycle route directness	ratio of the shortest walkable route distance to the straight-line distance between two points.	ratio	Measures the functionality and directness of the pedestrian and bicycle route system; Improvements to route directness could be a viable mitigation strategy for new development or redevelopment.
Measure of Infrastructure and Environment	Design-Point	Wayfinding information	Presence of sign that help to find a destination	-	
Measure of Infrastructure and Environment	Design-Point	Sidewalk quality	quality rating of sidewalk using multiple measures like width, driveway spacing, surface, etc	-	sidewalk environment quality remains a significant variable for pedestrian facilities. May be assessed during a walking audit and documented with photos and sketches. Projects could volunteer or be required to assess and/or improve the conditions within their impact area.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Design-Point	Sidewalk width	(average) width of sidewalks	feet	The width of the sidewalk system indicates potential for multiple users or user types to travel concurrently. Developments projected to have high volumes of pedestrian or bicycle usage or a combination of multiple alternative modes should be required to assess and, if necessary, accommodate the alternate volumes anticipated.
Measure of Infrastructure and Environment	Design-Point	Sidewalk shade	length of shaded sidewalk/length of sidewalks	%	sidewalk environment quality
Measure of Infrastructure and Environment	Design-Point	Tree-Lined/Shaded Streets	Provide a minimum % of the future street front with shade from either trees	% of street front shaded	Provide for trees that produce shade adjacent to and potentially over the roadway. Applicable to site plan review.
Measure of Infrastructure and Environment	Design-Point	Walkable Streets	set of minimum criteria for open space in front of façade/entry, height to street width ratio, continuous sidewalks with minimum driveways, and maximum percentage of garage or service bay openings	-	This is an assemblage of metrics that directly relate to the character of the pedestrian realm. The measures can be assessed during a walking audit and an evaluation of the street geometry and building architecture. Site plan improvements can be identified based on the specific metrics included in this analysis.
Measure of Infrastructure and Environment	Design-Point	Systematic Pedestrian and Cycling Environmental Scan Instrument (SPACES)	An environmental audit instrument developed to measure features of the built environment associated with physical activity	-	This is an automated scan that systemizes a walking audit. Can be used as an assessment tool in impact analysis
Measure of Infrastructure and Environment	Design-Point	Commercial on-site amenities to support alternative modes	Are there Land Development Regulations that require transit/bike/ped consideration in site design? Are transit agencies included in site review?	%	Measures availability of transit vehicles to carry bicycles. Projects with strong bicycle amenities as well as comprehensive transit service may need to finance bicycle racks for buses.
Measure of Infrastructure and Environment	Design-Point	Availability of on-site bicycle amenities	Are there bicycle amenities available on-site?	% of roadway miles	Identifies availability of bicycle faciliities. Parallel facilities that are not included on the street itself could also be used to provide credit to specific roadway segments. Identifies the completeness of the alternate mode accomodations. Once an alternate mode system is substantially complete, new projects could be provided with an appropriate mode split for their anticipated project trips.
Measure of Infrastructure and Environment	Design-Point	Pedestrian scaled lighting	ratio of walkpath with pedestrian scaled lighting	0-1.0	Provide pedestrian-scale lighting for safety, pedestrian access, wayfinding, and sense of place
Measure of Infrastructure and Environment	Design-Point	Ratio of street width to building height	Ratio of average building height to the street width	ratio	Good walkable street have a sense of enclosure. Too low building height makes pedestrians monotonous. The ideal ratio of building height to street width is 1 to 2
Measure of Infrastructure and Environment	Design-Point	Parking screening	percent of parking spaces screened by trees, fences, or others	%	

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Design-Point	Bus pass program utilization	percent of customers using bus pass as a payment	%	
Measure of Infrastructure and Environment	Design-Point	Parking shading	percent of parking spaces shaded	%	provide superior protection from solar radiation
Measure of Infrastructure and Environment	Design-Regional	Road density	centerline miles of road network per square mile	miles per sq mile	Provides an aggregated way to measure compactness, connectedness and accessibiliity within one measure. Applicable to large projects and projects with internal roadway network.
Measure of Infrastructure and Environment	Design-Regional	Lane miles per capita	roadway mileage divided by population	miles/person	Intended as a rough indicator of sprawl. This metric could be applied to large projects to assure that their designs are consistent with the community's goals.
Measure of Infrastructure and Environment	Design-Regional	On-vehicle bicycle-carrying facilities	Number of vehicle available for bike carry on vehicle/total number of vehicle	Yes/no	Identifies whether bicycle parking, storage or shower facilities are available to serve bicyclists. Could be required of projects that estimate bicycling reductions in travel demand.
Measure of Infrastructure and Environment	Design-Regional	Park-and-rides with express service	park-and-ride facilities with express service for commuters	Number of facilities, areas served by those facilities	Identifies locations where park and ride express service has been provided. Trip length reductions could be provided for projects that can take advantage of a park and ride facility with express service.
Measure of Infrastructure and Environment	Design-Regional	Parking spaces designated for carpools or vanpools	parking spaces for carpools or vanpools/total parking space	%	Percentage of spaces reserved for carpool/vanpools; Could be a requirement for new site plans
Measure of Infrastructure and Environment	Design-Regional	Transit passes	Availability of transit pass to the users	-	
Measure of Infrastructure and Environment	Design-Regional	Traffic cells	number of zones restricted by auto access	numbers	Traffic cells are auto-free or reduced auto zones to encourage people to access to centers through bicycling, walking or public transit
Measure of Infrastructure and Environment	Design-Regional	Percent miles bicycle accommodations	% of total roadway miles with bike lane/shoulder accomodations	% of roadway miles	Identifies availability of bicycle faciliities. Parallel facilities that are not included on the street itself could also be used to provide credit to specific roadway segments. Identifies the completeness of the alternate mode accomodations. Once an alternate mode system is substantially complete, new projects could be provided with an appropriate mode split for their anticipated project trips.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Design-Regional	Percent miles pedestrian accommodations	% of total roadway miles with sidewalk coverage	% of roadway miles	Identifies availability of bicycle facilities. Parallel facilities that are not included on the street itself could also be used to provide credit to specific roadway segments. Identifies the completeness of the alternate mode accomodations. Once an alternate mode system is substantially complete, new projects could be provided with an appropriate mode split for their anticipated project trips.
Measure of Infrastructure and Environment	Design-Regional	Miles of express fixed-transit route/dedicated bus lanes	Miles of exclusive bus lanes	Miles	Lane miles of dedicated bus lanes and fixed route express transit. Large projects may plan for exclusive bus lanes in their densest areas.
Measure of Infrastructure and Environment	Design-Regional	Percent of network that is "Effective"	% of a community or area's roadway network that provides an effective through path for travel	%	GIS mapping is used to identify the number of roadway miles within an area and the number of miles of roadways that offer through paths (not culs-de-sac or subdivision roadways that do not pass through). A ratio of effective road miles to total road miles gives a measure of the effectiveness and connectivity of the roadway network system. Large projects could be required to assure that a minimum percentage of their roadway network is effective. All projects could be encouraged to provide connections that will increase the area's effective network.
Measure of Infrastructure and Environment	Design-Regional	Roadway network balance	Balance of arterial, collector, streets, and networks for transit and bicycle	fractional miles	Identifies whether the existing/future roadway network has adequate facilities for regional, subarea and local travel types. Applicable to large projects. Could also be used to justify and improve an area's planned roadway network vision that can later be enforced as future devevlopment occurs.
Measure of Infrastructure and Environment	Destination-Area based	Residence proximity	% of an area's residence accessible to non-auto modes within a specified distance	% of residences within x distance of transit service	Indicates the number of residential units that have potential walk, bicycle or transit access to alternate modes of travel; Projects can be assessed to determine whether a sufficient percent of their residential components are in proximity to transit service.
Measure of Infrastructure and Environment	Destination-Area based	Employment proximity	% of an area's employments accessible to non-auto modes within a specified distance	% of employees within x distance of transit or alternate mode service	Indicates the number of employees that have potential walk, bicycle or transit access to alternate modes of travel Commercial projects can be assessed to determine whether they assist or deter a community from meeting their proximity goals.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Destination-Area based	Work accessibility	An aggregated indication of the ability for people who access workwithin an environment.	varies	Some indicies include digital accessibility as well as multimodal accessibility; can also be used indirectly to identify vulnerabilities and network priorities. Used to map changes in accessibility over a region; can also be used to identify critical links or unserved areas in a vulnerability analysis. Could be used to identify areas where development is encouraged without needing accessibility improvements and areas that may need accessibility improvements.
Measure of Infrastructure and Environment	Destination-Area based	Number of key destinations accessible via a connected pedestrian system	number of accessible destinations	-	Provides a direct measure of the utility of the pedestrian and bicycle system. Project impacts could be modified based on the number of destinations that are available within a specified distance.
Measure of Infrastructure and Environment	Destination-Area based	Industrial/warehouse proximity	% of an area's industrial/warehouse accessible within a certain distance of an alternate mode	% of industrial/ warehouse within x distance of alternate mode facilities	identifies potential freight impact areas as well as industrial employment areas that could be served by an alternate mode. This can be an important variable in considering the employee impacts for freight distribution centers.
Measure of Infrastructure and Environment	Destination-Area based	Transit convenience/Stop accessibility	Availability of transit within ½-mile (or ¼-mile) air distance at an origin and destination	-	Measures transit convenience from the user perspective: Availability of stations/bus stops close to home/work/shopping, Availability of parking at stations/bus stops; Convenience features can be required as a part of the project site review process;
Measure of Infrastructure and Environment	Destination-Area based	Geographic Service Coverage	(Σ1/4-mile buffer areas of bus stops+Σ1/2-mile buffer areas of busways or rail stations)/area	% areas	Identification of sufficiently high residential density and employment density for scheduled transit service need to be feasible. Some areas have minimized project contribution requirements when they are located within geographic service coverage areas.
Measure of Infrastructure and Environment	Destination-Area based	Population Service Coverage	(Σpopulation in ¼-mile buffer areas of bus stops+Σpopulation in ½-mile buffer areas of busways or rail stations)/population	% population	Provides a measure to assess the transit accessibilty in both space and time for areas that have sufficient potential demand to support transit service with reasonable ridership rates. Projects can be designed to maintain a specific minimum percent of their residential population or employment within a transit supportive area.
Measure of Infrastructure and Environment	Destination-Area based	Percent in Proximity measurements	% of persons who are in within a certain distance of an intermodal facility	% of persons	Indicates the percentage of persons who are in reachable distance to access alternative modes. Large projects could be required to locate their land uses to assure that a minimum percentage of the users within the site have access to alternative modes.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Destination-Area based	Transit Accessibility	% of residents accessible within a certain distance of transit by walk (1/4-mile or ½-mile)	%	Indicates the number of people that have access to transit service throughout an area. Proposed developments can be required to assure that a minimum percentage of their residents or employees have access to existing or new transit routes.
Measure of Infrastructure and Environment	Destination-Network based	Bike/pedestrian accessibility	percentage of ideal system complete (distance between path and land uses)	%, feet	Identifies the relative availability of the bicycle or pedestrian system in relationship to the final planned system. Once a minimum threshold of system completeness is achieved, projects could take advantage of vehicle impact reductions due to the provision of alternate mode facilities.
Measure of Infrastructure and Environment	Destination-Network based	Destination Accessibility	Proximity of activities to work activities in a mixed use project	distance	Distance between various employment and residential support uses. Distance between activities within a mixed use project can be regulated to assure strong land use interaction.
Measure of Infrastructure and Environment	Destination-Network based	Residential Accessibility	Proximity of activities to a residence or set of residences	distance	Distance between residential land use and employment or supporting land uses. For a mixed use development this can be estimated using the center of a residential project or averaged using GIS analysis
Measure of Infrastructure and Environment	Destination-Network based	Average walking distance between land use pairs	Average walking distance between land use pairs	miles	Considers the distance between potential land use pairs in terms of their potential for walking or bicycling interaction; Can be used as an alternate process for determining a project's impact area.
Measure of Infrastructure and Environment	Destination-Network based	Spacing between Village Centers	distance between a pair of village centers	mile	
Measure of Infrastructure and Environment	Destination-Network based	Multiple Route Choices	Number of possible routes between origin and destination	numbers	
Measure of Infrastructure and Environment	Diversity	Smart Growth Index	GIS Sketch planning tool to identify and rank projects or community scenarios according to 56 transportation and environmental measures	Overall scenarios are scored on a 0-100 scale using stakeholder weighting	Compares alternative land-use and transportation scenarios by evaluating their outcomes using indicators of community and environmental performance
Measure of Infrastructure and Environment	Diversity	Significant Land Uses	identification of specific major land use clusters or categories	employees, dwelling units, visitors, customers, patients	identifies major person trip generators, usually on a map; Proximity to the significant land uses in an area can provide a rough estimation of the transportation impacts of a project.
Measure of Infrastructure and Environment	Diversity	Land use ratios/mix	various ratios of land uses, often within a specific area	retail/residential; office/retail; office/residential; recreation/residential, etc.	measures land use mix; commonly used in large project or mixed use project evaluations.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Diversity	Land use balance	Σ(Pi*lnPi)/lnN, Pi: proportion of specific land use area (N=3 categories), range between 0 (a single land-use, worst) to 1 (equal land-uses, best)	unitless	Measures diversity of land use in a half-mile zone along a specific line by segregating uses into three categories. Can be applied to a project to determine whether it improves or degrades an area's land use balance.
Measure of Infrastructure and Environment	Diversity	Variation of agricultural of green fields	Percentage reduction in acres of agricultural or green fields developed over years	%	measures how many acres of agricultural or green fields are consumed due to urban sprawl; Projects are often criticised based on their consumption of agricultural or green-field land.
Measure of Infrastructure and Environment	Diversity	Land Consumption	The ratio of land consumption to population growth during a given period	acres per capita	measures the efficient growth of land use. Identifies whether new development is occuring at a lower density than older development.
Measure of Infrastructure and Environment	Diversity	Core Land Use	The percentage of land within specific use types within 1/4 and ½-mile of the central downtown core intersection to those within a MMTD	%	Establishes the ratio of land uses concentrated at the core of a MMTD or similar project; Projects can be assessed to determine whether they assist or deter from MMTD land use goals.
Measure of Infrastructure and Environment	Diversity	Land use separation	distance between land uses, either specific parcel-based land uses or land use types	feet (for transit, ped, bike) or miles (roadway)	a maximum distance between land use pairs, usually 1/4 or ½-mile; Can be used to estimate the potential for non-motorized travel.
Measure of Infrastructure and Environment	Diversity	Transportation-Efficient Land Use Mapping Index (TELUMI) Model	various land use variables, affecting travel behaviors, statistically create composite index representing relationship between the land-use variables and bus ridership. 3-class zone; high, latent, low transportation efficiency (TE)	areas are rated High, Latent and Low on a TE scale	Used to identify which areas have adequate accessibility to support development without mitigation, which areas require mitigation and which areas will not support additional development.
Measure of Infrastructure and Environment	Diversity	Minimum thresholds of land use intensity	areas defined where transit and alternate modes will be preferrentially supported. Minimum land use intensities required in those areas regardless of network performance	minimum development intensity	Identifies areas that will be required to develop at transit supportive densities regardless of the roadway network performance in that area

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Infrastructure and Environment	Diversity	Nearby Neighborhood Assets	number of "diverse uses" within a ¼-mile or ½-mile walk distance from the proposed site	number of uses	Identifies the ability to provide for daily needs within walk distance. Diverse uses include: supermarket, food store with produce, clothing store, convenience store, farmer's market, hardware store, pharmacy, other retail, bank, gym/health club, hair care, laundry/dry cleaner, restaurant/cafe/diner, licensed adult or senior care, child care, community/recreation center, cultural arts facility, educaational facility, family entertainment venue (theater, sports), government office, place of worship, medical clinic/office, police/fire station, post office, public library, public park, social services center; Projects that meet the conditions of this metric within areas that have good quality pedestrian environments could be provided with significant impact reductions due to mode shift.
Measure of Infrastructure and Environment	Diversity	Sprawl Index (Ewing et al., 2002)	Composite index composed of 4 sub-indices: density, mix, centrality, and streets		Sprawl measurement in terms of density, mix centrality and street network; Specifically applicable to new projects and redevelopment.
Measure of Infrastructure and Environment	Diversity	Sprawl Index (Galster et al., 2001)	sum of an urban area's Z scores for 8 dimensions: Development density, Continuity, Concentration, Clustering, Centrality, Nuclearity, Mixed Use, and Proximity		indication of sprawl, the higher the Z-score, the less sprawl. Large projects can impact this variable and could be evaluated generally on this basis.
Measure of Infrastructure and Environment	Diversity	Land Use within Village Center	various ratio of land use within village center	retail/residential; office/retail; office/residential; recreation/residential, etc.	
Measure of Infrastructure and Environment	Diversity	Land Use within Transit Supportive Area	various ratio of land use within transit supportive area	retail/residential; office/retail; office/residential; recreation/residential, etc.	
Measure of Infrastructure and Environment	Diversity	Jobs/housing balance	number of jobs/residences		The more number of jobs within a residential area reduces VMT and increases internal trips
Measure of Demand and System Utilization	Auto-Time related	Average commute time	Travel time for work trip	hour (minutes)	The commute time can be measured using travel time calculation during peak hours, which is estimated using simulation software or measured directly with a travel time and delay study.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Auto-Quantity related	Vehicle occupancy by land use	Average number of people per vehicle by land use type (count inbound/outbound vehicle occupancy to/from specific land type)	person/vehicle	vehicle occupancy by different land use type (office, retail, restaurant, residential, cinema, and hotel) can be used to determine the sensitivity of occupancy as a function of land types. Can be applied to specific projects to estimate impacts.
Measure of Demand and System Utilization	Auto-Quantity related	District wide Level of Service (LOS)/Quality of Service (QOS)	LOS/QOS by mode estimated over an area. Weighting of the LOS/QOS is performed based both on the the length of a facility serving a mode and by the number of residents or employees in the service area for a facility	A-F	Each segment within an area is rated for both LOS and QOS (depending on the mode). A facility LOS/QOS is then determined based on a weighted average along each segment. The impact area for each facility is determined and the number of residents or employees within that area are tabulated. An areawide LOS/QOS is determined based on the average of the LOS/QOS for all of the facilities in an area weighted by the number of persons in the impact area of each facility. As long as detailed tabulations of the initial calculations are performed or GIS shapefiles are maintained, changes to those calculations due to the addition of a new site or the redevelopment of an existing site are comparatively simple.
Measure of Demand and System Utilization	Auto-Quantity related	Local traffic diversion	percentage of travel previously on regional facilities that has been transferred to supporting local roadway network	volume per hour	Indicates the amount of travel demand that has been diverted from a regional roadway to the local roadway network. This can be projected using a local travel demand model or identified after the fact through annual vehicle volume counts. LOS waivers have been used in the past to allow continued development despite strategic intermodal system LOSstandards. Projects can contribute ROW or roadway construction to assist with parallel facilities that assist in this diversion potential.
Measure of Demand and System Utilization	Auto-Quantity related	LOS based on HCM 2010	Level of Service; a quantitative/qualitative measure of facility performance	A-F; roadway based on either corridor speed or ratio of congested speed to free-flow speed	Provides a measurable "grading" of service quality. LOS has been the primary method of assessing project impacts.
Measure of Demand and System Utilization	Auto-Quantity related	Percent of system heavily congested	Σ Congested segment lengths/total lengths (% miles at LOS E/F during the peak period)	% of roadway miles	Metric used to identify roadway systems that are operating at or above capacity during the peak hour that may need remediation; Directly applicable to site impact analysis;
Measure of Demand and System Utilization	Auto-Quantity related	v/C ratio	Ratio of volume to published or theoretical capacity (usually roadway)	0-1	Compares the volume on a facility to the carrying capacity of the facility; frequently used in site impact analysis calculations.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Auto-Quantity related	Vehicle Density	AADT*length/lane miles	vehicles per mile per lane	A measure of congestion in terms of the geometric space available for vehicles. Density can be used as a performance measure to assess LOS for freeways.
Measure of Demand and System Utilization	Auto-Quantity related	Demand/capacity ratio	Demand/capacity ratio	-	
Measure of Demand and System Utilization	Auto-Quantity related	Maximum Service Volume	passenger cars/hr/lane	passenger cars/hr/lane	
Measure of Demand and System Utilization	Auto-Quantity related	Peak Hour LOS	level of service during peak hours	A-F	
Measure of Demand and System Utilization	Auto-Quantity related	Percent of Capacity Consumed	current vehicle flow/capacity	%	
Measure of Demand and System Utilization	Auto-Reliability	% of trips 'on time'	The % of trips that are completed within a designated threshold travel time	%	quantifies travel time reliability, measure of the consistency of the travel time along a corridor or facility;
Measure of Demand and System Utilization	Auto-Reliability	90th- or 95th percentile travel time	90th - or 95th %tile travel time	minutes	Quantifies a reasonable upper limit on the typical travel time within a corridor during a stated period (usually a peak period).
Measure of Demand and System Utilization	Auto-Reliability	Buffer index	Extra time, that travelers should add to avg travel time to ensure on-time arrival (2 ways): 1. (90th- or 95th %tile travel time - Avg travel time)/Avg travel time 2. 2.189*(travel time index-1)-1.799*(travel time index-1)^2	%	quantifies travel time reliability, measure of the consistency of the travel time along a corridor or facility;
Measure of Demand and System Utilization	Auto-Reliability	Planning time index (PTI)	Total time, a traveler should allow to ensure on-time arrival: 95th %tile travel time/posted speed or free flow travel time, PTI >= 1.0	unitless	Quantifies the extra percentage of time needed to arrive at a destination at a specific time 95% of the time. Difficult to measure.
Measure of Demand and System Utilization	Auto-Time related	Average Speed	Average travel speed across a corridor	mph	Average vehicle speed within a corridor. Can be used to assess project impacts before and after project implementation.
Measure of Demand and System Utilization	Auto-Time related	Average speed weighted by PMT	Average speed weighted by person miles traveled (PMT)	mph	Corridor efficiency measure that takes the vehicle type and occupancy into account. Can be applied to conditions before and after project implementation.
Measure of Demand and System Utilization	Auto-Time related	Congestion Duration	Lane mile hours at LOS E/F	hours	A measure of the time that a corridor or area experiences significant congestion.
Measure of Demand and System Utilization	Auto-Time related	Control delay	increased travel time due to traffic control devices such as a signal or stop signs.	usually seconds/ vehicle	Measures mobility efficiency, typically at an intersection or corridor level. Can be easily estimated using the HCM and associated software (such as the HCS) or simulation software. May be difficult to measure directly. Has been used to assess ability of adequate roadway facilities to serve a project.
Measure of Demand and System Utilization	Auto-Time related	Highway Reliability	% hours a facility operates at a minimum speed	%	Measure of the consistency of the travel time along a corridor or facility. Project impacts to Highway Reliability can be estimated

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Auto-Time related	Percent work trips within specific travel time	% of work trips departing from an area/zone, that take equal to or less than a set travel time	% work trips (0-100%)	Measures the duration of commute time for work trips, indirectly associated with peak congestion; Large projects could be assessed to establish whether they substantially increase the percent of work trips that exceed a specific duration.
Measure of Demand and System Utilization	Auto-Time related	Total segment delay	(actual travel time-FFS or PSL travel time)*vehicle volume*vehicle occupancy	person-minutes	The total amount of delay along a corridor experienced by the users of the corridor during a specific time period (usually a peak period). Directly applicable to site impact analysis.
Measure of Demand and System Utilization	Auto-Time related	Travel delay	measure of the increased time required to travel a route due to a combination of signal operations and/or link congestion	minutes	This metric is similar to control delay or an HCS estimated travel time delay but is slightly more difficult to estimate and measure. Simulation software (e.g. Synchro) can take into account link congestion while HCS cannot. Travel time and delay studies provide the 'gold standard' for directly measuring total average delay, but are costly to perform and the consistency of results could be in question. Directly applied to pre-post project asssessment.
Measure of Demand and System Utilization	Auto-Time related	Travel time	actual travel rate (min/mile) * length * veh volume*veh occupancy	person-minutes	The average travel time may be estimated using simulation software or measured directly with a travel time and delay study. Used to compare congested travel to free flow travel. Directly applicable to site impact analysis.
Measure of Demand and System Utilization	Auto-Time related	Travel Time-based LOS	uses weighted LOS standards or travel time rates for different modes ex) [SOV travel rate (miles in 30 min) + HOV travel rate + (2 x Transit travel rate)] / 3	Travel speeds, converted to LOS	This metric takes into account the travel times for different travel modes and assigns the final LOS based on the weighted travel speed. Directly applicable to site impact analysis.
Measure of Demand and System Utilization	Auto-Time related	Travel time index	actual travel rate (min/mile)/Free flow speed (FFS) or Posted speed limit (PSL) travel rate	unitless	indicates the extent of delay (during the peak hour) in ratio terms. Gives a relative measure of the delays along a corridor. Could be applied to site impact analysis.
Measure of Demand and System Utilization	Auto-Time related	Vehicle hours traveled (VHT)	cumulative vehicle time traveled to/from an area within a typical day	hours (minutes)	Reductions in VHT will reduce energy consumption and decrease GHG production; improve quality of driver experience; Estimated using travel demand models. Can be applied as a metric for large scale projects.
Measure of Demand and System Utilization	Auto-Time related	Time by trip purpose	average travel time by trip purpose	minutes	The travel time by trip purpose may be estimated using simulation software
Measure of Demand and System Utilization	Auto-Time related	Vehicle hours of delay (VHD)	Vehicle hours of delay per day	hours	
Measure of Demand and System Utilization	Auto-Time related	Vehicle speed/VHD by mode	Vehile speed/VHD by mode	speed/VHD	

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Auto-Time related	Travel distance index	Average travel distance from a downtown with 30 minute by auto, transit, and HOV	miles	
Measure of Demand and System Utilization	Freight	Truck miles traveled	AADT*TL*%trucks	Miles (thousands to millions)	Indication of freight quantity. This metric is applicable to freight projects.
Measure of Demand and System Utilization	Freight	Truck throughput efficiency	Daily truck volumes per lane*truck operational speed	truck-miles per hr per lanes	Measures freight movement with a combination of truck volumes and speeds. Applicable both to freight projects and to projects (developer or agency led) that are in heavy freight areas or impact freight routes.
Measure of Demand and System Utilization	Freight	Freight delay		time	
Measure of Demand and System Utilization	Freight	Number of violation of weight restrictions		number	
Measure of Demand and System Utilization	Freight	Overweight permits	number of overweight permits	numbers	Presence of overweight permits
Measure of Demand and System Utilization	Multimodal	Auto/Demand response transit (DRT) travel time ratio	Auto trip time/ demand responsive transportation (DRT) travel time	ratio; 0-1	Measures the relative efficiency of a DRT system. Average DRT time available from transit logs. Average auto time can be measured using travel time and delay studies or estimated. Project impacts on a DRT system should be estimated to determine if it can continue to operate successfully or if conversion to a fixed route system should be encouraged.
Measure of Demand and System Utilization	Multimodal	Auto/transit travel time ratio	ratio of travel time (door to door) for auto vs. transit	generally a ratio between 0 and 1	Relative efficiency and competitiveness of transit service in comparison to personal vehicle travel. Can be applied to pre/post site impact analysis
Measure of Demand and System Utilization	Multimodal	Multimodal LOS	LOS determined for each mode and weighted by percentage of users in that mode. E.g., 0.7 (car)*6 (LOS F) + 0.2 (bus)*3 (LOS C) + 0.04*2 + 0.06*2 = 5 (LOS E)	LOS A-F	Provides a LOS measurement that is most relevant to the mode that is used the most; directly applicable to site impact analysis.
Measure of Demand and System Utilization	Multimodal	Seat capacity/Person capacity	Network capacity is defined in terms of the number of vehicle "seats" crossing an area screenline during a defined time period.	SOV's would have 1 seat; buses would have roughly 40 seats, etc.	Roadway capacity defined in terms of "seats" crossing a predetermined screenline around an area where a SOV would have 1 seat but a bus could have either a fixed number of seats or a variable number of seats based on the attractiveness of the lines reviewed. The seat capacity would be compared against the number of trips estimated to be generated within a geographic area plus the number of through trips to pass through. Seat capacity could also account for bike and ped capacity if desired.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Non-motorized mode	Average trip length per traveler	Average Trip Length of the trips from a specific TAZ or land use type	miles	The average length of trips from a specific land use or area in miles. This can be applied to site impact analysis to establish operational improvements needed for a specific development within its average impact area or to establish the reduction in ATL based on changes in land use type or design form.
Measure of Demand and System Utilization	Non-motorized mode	Delay per traveler	(actual travel time-FFS or PSL travel time)*(250 weekdays/year)*(hr/60min)	annual hours	A summation of the typical average weekday delays along a corridor throughout the course of a year. Typically used to calculate the economic costs of delay. Directly applicable to site impact analysis.
Measure of Demand and System Utilization	Non-motorized mode	Door to door travel time	average of door-door travel time	minutes, seconds	Indirect measurement of land use mix/availablilty and congestion. Can be used to assess conditions before and after project implementation.
Measure of Demand and System Utilization	Non-motorized mode	HCM-based Bicycle LOS	LOS measured in terms of the number of passing events or interruptions in flow for uninterrupted facilities or in terms of speed or delay for interrupted facilities	A-F	LOS is measured related to the operational interruptions to the bicyclist. This is directly impacted by the volume of bicyclists in uninterrupted conditions or the signal delays in urban conditions. This LOS measure is most appropriate where the volume of bicycles has the potential to exceed the capacity of the facility and a site is required to meet adequate facilities provisions.
Measure of Demand and System Utilization	Non-motorized mode	Proportion of total PMT for non-SOVs	The ratio of PMT by non-SOVs to total PMT : (PMThov+PMTbus+PMTrail)/PMTtot PMThov is daily PMT by high occupancy vehicles, PMTbus is by bus, and PMTrail is by rail. PMTtot is total daily PMT by all modes.	%	Examines the proportion of PMT in non-SOVs. Project level analysis could examine how a transit-oriented project adjusts the SOV travel rate for an area or region
Measure of Demand and System Utilization	Transit-Occupancy	Load Factor	% of seats occupied	% each day	The degree of passenger crowding on a transit vehicle based on the occupancy of the vehicle relative to the number of seats. Can be a metric for site impact analysis.
Measure of Demand and System Utilization	Transit-Occupancy	Passengers per transit vehicle mile	Passengers/transit vehicle mile	Passengers per transit vehicle mile	Measures transit productivity. Applicable to site impact analysis.
Measure of Demand and System Utilization	Transit-Occupancy	Ridership	total passenger trips	passengers	Scale of transit service; Project ridership estimates are a crucial first step in evaluating transit system impacts.
Measure of Demand and System Utilization	Transit-Occupancy	Transit peak hour occupancy	average number of occupants in a vehicle during the peak hour	1 or more	Indicates the current usage levels for transit. Usage levels surrounding proposed projects can provide an indication of the potential for transit utilization within the project.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Transit-Occupancy	Percent person-minutes served	the percentage of time that an average person has transit service available	% person minutes served	Measures the transit service quality using multiple variables including headways and accessibility. Transit level of service (TLOS) can be evaluated by a project to establishe whether adequate service will be available to serve their impacts.
Measure of Demand and System Utilization	Transit-Operation	Fleet spare ratio	% of vehicle fleet available for replacements	%	Measures availability of extra vehicles for unexpected situations. Reliability analysis with and without a project can establish whether a project warrants the addition of spare vehicles to maintain reliability.
Measure of Demand and System Utilization	Transit-Operation	Transit Productivity	could be defined using at least 50 various different indicators including: passenger trips, passengers/hr, passengers/mile, cost/mile, cost/hr	-	Multiple variables are generally tabulated by transit agencies, generally on an annual basis, and compared to both past performance and other systems to identify the success of a transit system in relationship to the goals identified in their transit management plan. There are at least 48 different performance measures that affect transit productivity. The majority of the variables could be applied to project impacts or the effects of project contributions.
Measure of Demand and System Utilization	Transit-Operation	Number of transfers	number of transfers between origin and destination	transfers	The number of times a transit rider has to change buses to arrive at their destination. The number of transfers required for a successful origin and destination pair can be determined at a project level using the number of transfers needed between the project and the CBD, the project and various destinations, or between the project and all other TAZ's within its impact area.
Measure of Demand and System Utilization	Transit-Operation	Transfer time	time for transfer	min	Transferring time from one transit service vehicle to another transit vehicle or mode. Transfer time can be obtained from published schedule at the transfer stops.
Measure of Demand and System Utilization	Transit-Operation	Transfer time between modes	time to transfer from one mode to another	minutes	Indirect measure of the suitability of the design of transfer stations and park and ride facilities. Can be a design variable for park and ride or transfer facilities.
Measure of Demand and System Utilization	Transit-Operation	Transit priority delay reductions	The reductions in transit travel time delay due to transit signal prioritization.	minutes/hours	A comparison of travel time with and without transit prioritization. Can be used to justify a prioritization project.
Measure of Demand and System Utilization	Transit-Operation	Number of fare media sales outlets	Number of fare media sales outlets	numbers	
Measure of Demand and System Utilization	Transit-Operation	Road Calls	Number of calls needed for emergency or fleet operation fails	numbers	
Measure of Demand and System Utilization	Transit-Operation	Average life of vehicle components	Average life cycle of vehicle components	years	
Measure of Demand and System Utilization	Transit-Operation	Average age of vehicle components	Average year of vehicle components	years	

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Transit-Operation	Transit Reliability (Quantitative)	% of on time arrival (on-time is a 0-5 minute late from a scheduled time for fixed schedule transit, and 30 minute time window from the requested pick-up time for demand responsive transit)	%	Measure of the consistency of the travel time along a line or within a system. On time is generally considered to be defined as a vehicle leaving the stop within 0 to 5 minutes after its scheduled stop time. Project demand may impact service reliability.
Measure of Demand and System Utilization	Transit-Service availability	Average frequency	number of buses per hour	number of buses	fundamental measure of transit availability. Projects can determine whether development impacts can provide sufficient demand to increase frequency.
Measure of Demand and System Utilization	Transit-Service availability	Average headways	time between buses, or the inverse of average frequency	minutes, seconds	Fundamental measure of transit service quality. Project impact studies can establish whether the project demand can justify shorter headways.
Measure of Demand and System Utilization	Transit-Service availability	Hours of service	Total cumulative hours of service provided by a transit system each day	hours	For fixed transit routes and segments, measures total service transit hours. Refers to the total hours of transit service provided on all vehicles. Projects could be reviewed to determine if additional hours of service should be provided to serve it.
Measure of Demand and System Utilization	Transit-Service availability	Off-peak transit availability	availability of transit service in non-peak periods	Off peak headways (minutes or hours), number of lines with OP service	A list or map of areas that are served by off-peak transit that may include documentation of specific off-peak headways. Areas with off-peak transit availability may be able to serve transit dependent persons. It is reasonable to reduce their vehicular impacts accordingly.
Measure of Demand and System Utilization	Transit-Service availability	Transit service density	(miles of transit routes x # of times the route is traveled each day)/geographic area in acres	routes per day per acre	Used to compare transit system service intensity; Can be evaluated to establish whether service will be adequate for a proposed project.
Measure of Demand and System Utilization	Transit-Service availability	Transit type availability	types of transit service available	list of options	Provides a list or map of the transit types available for an area or new development.
Measure of Demand and System Utilization	Transit-Service availability	DRT trips not served	% of DRT trips not served	%	Measures the % of trips denied due to capacity issues or booked where the service doesn't arrive. Projections of trips not served due to increased demand from development may indiate the need to upgrade to fixed route service.
Measure of Demand and System Utilization	Transit-Service availability	Response Time for DRT	Average waiting time for pickup in demand responsive transit (DRT)	minutes	Measures the initial wait time for demand responsive transit; Data available from usage logs; Site impact analysis can assess whether a project will substantially degrade response time.
Measure of Demand and System Utilization	Transit-Service availability	Fixed route missed trips	number of missed trips on fixed routes	trips	
Measure of Demand and System Utilization	Transit-Service availability	On time performance	number of times that are late more than 5 minutes at each stop/number of time operated at each stop	%	

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Travel demand-Mode share	Average Vehicle Occupancy	Average number of people per vehicle	person/vehicle	The average number of people in a vehicle. This metric is used to convert vehicle trips to person trips. Can be used for sites that have specific travel demand management strategies that would increase carpooling or ridesharing to reduce impact fees or project impacts.
Measure of Demand and System Utilization	Travel demand-Mode share	Bicycle and Pedestrian activity	Number of trips by bicyclists and pedestrians	count	Measures the existing use of bicycling and walking, Can be used in monitoring of a site post-construction to track whether congestion mitigation activities had the predicted impact.
Measure of Demand and System Utilization	Travel demand-Mode share	Bicycle and Pedestrian mode share	% of travel using bicycle or walking	-	used to identify increases or decreases in bicycle and pedestrian mode use over time or due to a development
Measure of Demand and System Utilization	Travel demand-Mode share	Mode choice availability	Available transporataion alternatives	Number of modes	
Measure of Demand and System Utilization	Travel demand-Mode share	Mode Split	mode split estimated using a model. Development denied only if nonSOV split decreased below a specific threshold	% non-SOV trips as measured by a travel demand model	links concurrency to regional policy;
Measure of Demand and System Utilization	Travel demand-Mode share	Safe Routes to School Program (SRTS) effectiveness	Percentage of school children within a 2 mile radius of walk or bike to school	%	Measures the percentage of children within the "no busing" zone that walk or bicycle to school. Projects within this zone can be required to meet walkability requirements and encourage SRTS programs.
Measure of Demand and System Utilization	Travel demand-Mode share	SOV mode split	percentage of travel in single occupant vehicle; percentage in other modes	0-100%	measures effectiveness of strategies toward mode shift; can be used to measure the impact of development requirements that support alternate modes.
Measure of Demand and System Utilization	Travel demand-Trip generation	Community Capture	The reduction in the number of forecast external trips generated by a defined community affecting the transportation network outside the community	xx% of A land use trips are satisfied by XX% of B land use trips	This variable quantifies the ability of a project to attract trips at short distances and possibly across different modes that occur within a specific geographic area.
Measure of Demand and System Utilization	Travel demand-Trip generation	Internal Capture	Reduction in the number of forecast external trips generated by a development affecting the roadway network outside the development	% of total trip generation satisfied internally	This variable identifies the amount of "cross-pollination" of trips that may occur within a mixed use development.
Measure of Demand and System Utilization	Travel demand-Trip generation	Mean daily trips per household	Daily number of trips per household	person trips/household	Generally used in travel demand modeling. Projects that have atypical target populations could use this variable to modify their projected trip generation. This variable specifically identifies person trips which could be applied to any mode.
Measure of Demand and System Utilization	Travel demand-Trip generation	Mean daily vehicle trips per household	Daily number of vehicle trips per household	vehicle trips/household	Generally used in travel demand modeling. Projects that have atypical target populations could use this variable to modify their projected trip generation. This variable identifies vehicle trips which are only applicable to passenger vehicles

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Demand and System Utilization	Travel demand-Trip generation	Person miles traveled (PMT)	AADT*TL*VehOcc	Miles (in millions)	indication of overall travel used in auto
Measure of Demand and System Utilization	Travel demand-Trip generation	Person trips	person trips	number of trips	Indication of persons transported, typically including only auto and transit modes. Can be expanded to include ped and bike travel but these are not typically included; Generally used in travel demand modeling. Modeling of specific projects are generally required to match the forecasted person trip estimates to assure that the modeled distribution takes congestion levels into account.
Measure of Demand and System Utilization	Travel demand-Trip generation	Trip length by mode	trip distance by mode	miles	
Measure of Demand and System Utilization	Travel demand-Trip generation	VMT (by mode)	cumulative vehicle miles traveled to/from an area, household or person within a typical day	miles	A measurement used to identify energy consumption and travel quantity. Both VMT and VMT per capita have been proposed as more appropriate ways to assess impact or mobility fees for new development as they more directly identify the vehicular impacts of a project and can be made to account for alternative mode usage.
Measure of Demand and System Utilization	Travel demand-Trip generation	VMT per capita	VMT/population	miles per person	
Measure of User Perception	User Perception	Bicycle LOS (FDOT)	A measure of the user's perception of the safety and comfort of a particular facility	LOS A-F	Indicates the quality of the bicycle and pedestrian amenitites. Can be used to assess the existing amenities and establish what improvements may be needed to encourage the use of alternate modes.
Measure of User Perception	User Perception	Pedestrian LOS (FDOT)	A measure of the user's perception of the safety and comfort of a particular facility	LOS A-F	Indicates the quality of the bicycle and pedestrian amenitites. Can be used to assess the existing amenities and establish what improvements may be needed to encourage the use of alternate modes.
Measure of User Perception	User Perception	LOS-based on traveler perception	perceived trip quality	A-F	Research sought to identify measures that directly impact user perceived trip quality. Once fully developed, it could be used to assess the qualitative impacts of commercial projects or agency-based improvements
Measure of User Perception	User Perception	Perception of Transit safety	User perceived safety of Transit environment	-	Measures overall safety aspects of transit environment from the transit user perspective: Safety from crime while riding, Safety at stations/bus stops, Safety related to the behavior of other persons, Safety related to the rail/bus operation; Site plan review can help identify amenities that will improve user's perception of safety.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of User Perception	User Perception	Transit comfort	user perception of the comfort of the transit environment	-	Measures transit comfort from the user perspective: availability of seating at the station/bus stop, availability of seats on the train/bus, smoothness of the train/bus ride, comfort of the seats, degree of crowding on the train/bus, comfortable temperatures on the train/bus, availability of handrails/grab bars; Some comfort variables can be impacted by project demand and that could warrant project contributions.
Measure of User Perception	User Perception	Transit condition of vehicles and facilities	cleanliness of transit environment	0-7 scale	Measures transit cleanliness from the user perspective: Cleanliness of the train/bus interior/exterior, Stations/bus shelters clean of graffiti, Cleanliness of train stations/bus stops; Project site reviews could identify design features that help maintain the cleanliness of the overall transit service.
Measure of User Perception	User Perception	Transit ease of using the system	user perception of the ease of using the transit, availability of information about transit system	-	Measures the ease of using a transit system from the user perspective: Knowing when trains/buses arrive and depart, availability of printed schedules, ease of getting information by telephone, ease of purchasing tickets/passes/tokens, visibility of train/bus names/route numbers/colors from the outside, ease of getting on/off train/bus, ease of paying fare, ease of making connections/transfers, availability of information about delays from conductors/drivers, clear/timely stop announcements; Some developments have provided wayfinding assistance as well as informational support to their users as a TDM strategy.
Measure of User Perception	User Perception	Transit Reliability/ Performance (Perceived)	Travel time reliability of using transit	-	Measures the user's perception of the transit reliability: Frequency of service, Travel time by train/bus, On-time performance, Wait time when transferring; New service, or service upgrades provided as a result of a new development can directly impact user perception of the service.
Measure of User Perception	User Perception	Transit complaint rate	Number of transit complaint	numbers	
Measure of User Perception	User Perception	Transit customer loyalty	Combined index of overall satisfaction, likelihood of continued riding, and likelihood of recommending to others	-	
Measure of User Perception	User Perception	Pedestrian Friendliness	User perception of the friendliness and ability to accommodate pedestrian usage	-	Qualitative measure of pedestrian features that encourage or detract from pedestrian activity; Specific improvements could be required of a site developer to improve components that affect the pedestrian friendliness within its impact area.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Safety	History	Bike/Pedestrian injuries/fatalities	injuries and fatalities for bicycles and pedestrians on a specific segment or in an area. Can be tabulated per mile or per vmt	accidents, accidents/mile, accidents per vmt	identifies overall safety of the amenities and/or specific locations that may have hazards; Redevelopment of areas with high accident rates should explore the safety issues and propose mitigation measures.
Measure of Safety	History	Traffic fatalities	Traffic fatalities per 100 million VMT	Fatalities/100 million VMT	Provides an indication of the overall safety of a roadway system; Used as a variable in PD&E studies to identify potential impacts of proposed roadway projects (positive or negative.
Measure of Safety	History	Transit accident rate		number/year	
Measure of Safety	History	Transit vandalism incidents		number/year	
Measure of Safety	History	Transit related Crime rate	Crime rate per year at a location, or along a corridor, or within a geographic area	Crimes per 100 riders	Crime rates on or adjacent to transit facilities or transit served areas; Projects can have some impact on crime rates through design features or mainenance practices.
Measure of Safety	History	Vehicle accident rate	Frequency of vehicle accidents	Accidents per mile per year, or accidents per 100,000 vehicle service miles	A crash rates while operating transit: Data available from historic crash reports; Locations with significant numbers of crashes within the impact area of a proposed project could be required as a part of a project's impact analysis.
Measure of Safety	History	Crash statistics/locations	Number of crashes by location	chashes or rate by location	A geographic and numerical identification of locations, number and severity of accidents; Can also include number of accidents by type. Identifies geometric and operational safety needs; assures acceptability of alternate mode; At a minimum, developments are required not to exacerbate high accident locations. Agency projects are often targeted for safety remediation.
Measure of Safety	History	Annual severe crashes	roadway segments: 0.000365*BaseCrashRate*ADT*Length Intersection (only for rural hwy or urban st): 0.000365*BaseCrashRate*(ADT on major+ADT on minor)	severe crashes per mile per year	Provides a comparative metric to identify locations that have unusually high accident rates. Improvement projects are often targeted for these areas using safety funds.
Measure of Safety	Risk Management	Percent of lane-miles under traffic monitoring center (TMC) surveillance	lane-miles with TMC surveillance/ total lane-miles	%	presence of surveillance facilities by TMC; Additions to the system or permission to utilize buildings for surveilance installations can be required as a condition of developent.
Measure of Safety	Risk Management	Average clearance times for major incidents	average clearance times	minutes	Measures the success of efforts to relieve congestion due to incidents. Projects that substantially increase connectivity may decrease average clearance times.
Measure of Safety	Risk Management	Speed suitability	Difference between posted speed limit and operational speed	-	measures if the posted speed limit is appropriate for the specific roadway;
Measure of Safety	Risk Management	% vehicle with safety devices	vehicles with safety devices/total number of vehicles	%	measures preparedness for emergencies. Provision of safety devices can be offered by a project as a development contribution where inadequacies are identified.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Safety	Risk Management	Ratio of police officers to transit vehicles		number/vehicle	
Measure of Sustainability	Ecological impact	Attainment of ambient air quality standards	score for current scenario+projected reduction in VOC and NOx/max reduction in VOC and Nox	unitless	Provides an indication of whether a proposed project increases or decreases an area's air quality.
Measure of Sustainability	Ecological impact	Daily CO2 emissions	use tabulated values	grams per mile per day	Quantifies CO_2 emissions. Emissions rates are calculated based on the operating speed, temperature and other relevent environmental variables. Projects may be assessed based on their ability to increase or decrease CO_2 emissions.
Measure of Sustainability	Ecological impact	Daily NOx, CO, and VOC emissions	NOx+W_NOx+CO*W_CO+VOC*W_VOC W_=weights based on each pollutant's damage cost (VOC:NOx:CO=0.42:0.56:0.02)	grams per mile per day	Quantifies mobile-source emissions. Projects may be assessed based on their ability to increase or decrease CO2 emissions.
Measure of Sustainability	Ecological impact	Noise pollution	degree of loudness	db	Measures the degree of loudness
Measure of Sustainability	Ecological impact	Impact on wildlife habitat	degree of impact in wildlife habitat	-	Identify how transportation system does impact on wildlife
Measure of Sustainability	Ecological impact	Water runoff	number of water runoff	number	Provides ecological impact by identifying the places that cut off water run
Measure of Sustainability	Fiscal impact	Additional Fuel Tax	Locally assessed fuel tax.	cents per gallon	An additional tax assessed per gallon of motor fuel.
Measure of Sustainability	Fiscal impact	Transportation Utility Fee (TUF)	Utility fee for existing development based on its individual VMT generated on a typical day or proportioned based on the "functional population" of a given area and the functional population of an individual property.	$ per VMT or $ per functional person equivalent	The procedure for calculating the utility fee would mirror that of a VMT-based impact fee, but would be applied to all properties within the region. Properties with strong connections to pedestrian, bicycle or transit service could be afforded discounts on the TUF.
Measure of Sustainability	Fiscal impact	VMT-based Impact fee	Impact Fee for new development calculated based on projected growth in VMT across a regional scale geography in conjunction with the additional facilities and services needed to meet that demand.	$ per new VMT	This procedure ties new development impact fees to the additional VMT added to the roadway network from a specific project. Test cases have included a county wide rate and a tiered rate based on urban, suburban and rural conditions (Alachua, Pasco County). Could be refined to assess fees at a TAZ level or completely recalculated when large projects are proposed that might dramatically impact regional VMT.
Measure of Sustainability	Fiscal impact	Consumption-Based Mobility Fee	Fee intended to replace concurrency requirements that would provide for funding to address future mobility needs in a community. The fee would be based on the increment of improvements needed to serve the vehicle miles traveled by traffic from a specific project.	$ per lane mile used in terms of vmt,	Fee charged to development based on the increment of improvements needed to serve the VMT generated by the proposed development after existing backlogs have been addressed.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Sustainability	Fiscal impact	Improvements-Based Mobility Fee	Fee intended to replace concurrency requirements that would provide for funding to address unfunded future mobility needs in a community. The fee would be based on the total improvements needed to meet the community's mobility goals in a specific horizon year. The increase in VMT between the present year and the horizon year would be determined and a project's percentage of that increment would be used establish the percentage of the total improvement cost for which the project would be responsible.	$ per new VMT	A mobility fee is similar to a VMT-based impact fee, except that the improvements to be funded through the fees are specifically tied to improvements identified in a long-range mobility plan. Mobility fees can be tied directly to the VMT generated by a specific project in a specific location, or can be determined based on the trip generation expected from a specific land use and the trip length and mode split expected in specific geographic regions.
Measure of Sustainability	Fiscal impact	Cost recovery from alternate sources	(Wc*Cext/Ctot)+(Wom*OMext/OMtot), where Wc and Wom=weights of importance of capital recovery vs. operating cost recovery (40 vs. 60), Cext=capital costs from external sources, Ctot=total capital costs, OMext=operating external costs, and OMtot=total operating costs, on scale of 0-1	unitless	Evaluate the ability of cost recovery in terms of capital and O&M expenditures for a roadway section; Basically measures how much of a facility can be financed through means outside of the agency that intends to construct it. Project contributions are included as a part of the formula.
Measure of Sustainability	Fiscal impact	Variable fees based on LOS	Fee rates dependent on roadway LOS within a project's impact area	based on trips or VMT; fees start at LOS D and increase with each average increase of LOS	Projects that impact roadways with greater levels of congestion are assessed larger impact fees
Measure of Sustainability	Fiscal impact	Benefit cost ratio	Ratio of benefit to cost	-	Identify how a project effects to the cost spent
Measure of Sustainability	Fiscal impact	Parking pricing	Average user pay per a given time	$	the parking pricing can reduce traffics, improve user conveniences, and provide new revenues.
Measure of Sustainability	Fiscal impact	Capital funding for bike/Pedestrian	Per capita $ for bicycling and walking	$	Identify funding proportion spent for bike/pedestrian
Measure of Sustainability	Social impact	Distribution of benefit by income group	The time and congestion benefits + traveler welfare benefits of a particular mode (usually transit) stratefied into income categories.	Benefits can be tabulated in terms of benefit per trip, reduced trip time, or value of time per hour	Benefits provided by an alternate transportation mode (usually transit) are tabulated by both user value and congestion benefits and then stratified by income group. Measures the fairness of distribution of benefit by income group. Could be used to identify projects that provide benefits that rectify existing inequities.
Measure of Sustainability	Social impact	Transportation Affordability	the ratio of transportation cost to total annual income (low- and medium-income households spend generally less than 20% of budgets on transport)	%	Indicates the affordibility of the available transportation options within an area or sub-region; Could be used to help identify areas that provide affordable transportation when selecting locations for affordable housing.

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Sustainability	Social impact	Equitable distribution of accessibility	Spatial distribution of transportation accessibility by different socio-demographic group	-	Generally maps the spatial distribution of transportation accessibility by different socio-demographic group. Used to identify locations where inequities exist in the residents ability to travel within the community; Can be used to identify the best locations for projects that serve the transit dependent.
Measure of Sustainability	Social impact	Commute Cost	Total cost of work commute including fuel, repairs, registration, maintenance, taxes, financing, insurance depreciation and parking	$	A measure of the total cost of transportation for an average household or mode; Projects can be evaluated based on their commute cost and can be encouraged to provide financing to buyers that takes commute cost into account.
Measure of Sustainability	Social impact	Transit values	The costs of using transit, availability of discounted fare options	-	Measures transit values from the user perspective: Cost of a one-way ride, Cost of a transfer, Availability of discounted fares, e.g., senior citizens, students, Availability of volume discounts, e.g., monthly passes, Cost of parking at stations/bus stops; Can be used as a variable to assess whether service is affordable for users from a proposed site.
Measure of Sustainability	Social impact	Fee charged for employee parking spaces	rate of employee parking fee to others	%	Employers can be encouraged not to subsidize or provide parking for their employees as an encouragement for their employees to use alternate modes. This can be included as a deed restriction in return for lower impact fees or as a mitigation strategy.
Measure of Sustainability	Social impact	TDM effectiveness based on TRIMMS model	Social benefit changes of trip reduction impacts of wide range of transporation demand management (TDM) effectiveness	varies	Spreadsheet system that uses multiple performance measures to estimate the impacts of transportation demand management (TDM) measures that are proposed or have been implemented by a development. Specific outputs are provided for reductions in emissions, accidents, congestion, and fuel consumption as well as other climate change impacts.
Measure of Sustainability	Social impact	Travel costs by incom group	Travel cost distribution by income group	$	Identify equity of travel cost by diverse income group
Measure of Sustainability	Social impact	Travel costs by race	Travel cost distribution by race	$	Identify equity of travel cost by diverse race group
Measure of Sustainability	Social impact	VMT by income group	VMT distribution by income group	VMT/income	Identify equity of VMT by diverse income group
Measure of Sustainability	Social impact	VMT by race	VMT distribution by race	VMT/race	Identify equity of VMT by diverse race group
Measure of Sustainability	Social impact	Mode share by income group	Mode share distribution by income group	%	Identify equity of mode share by diverse income group
Measure of Sustainability	Social impact	Mode share by race	Mode share distribution by race	%	Identify equity of mode share by diverse race group

Table A.22 Details of Performance Measures (continued)

Dimension	Sub-dimension	Performance Measure	Definition	Scale/units	Description
Measure of Sustainability	Social impact	Walk to transit by income group	Distribution of walk time to transit by income group	minutes	Identify equity of walk access time by diverse income group
Measure of Sustainability	Social impact	Walk to transit by race	Distribution of walk time to transit by race	minutes	Identify equity of walk access time by diverse race group

APPENDIX B: ***Objectives and Characteristics of Performance Measures***

This appendix first relates each of the performance measures listed in Appendix A to each of the seven mobility-related planning objectives. The measures are assessed as: strongly applicable (O), applicable (Δ), or not applicable (-). It is useful to note that these assessments are rather broad as the research team was not performing the analysis for a specific context or agencies. The following discussions serve to illustrate some broad thoughts behind the assessments:

Minimize ecological impact:

Increasing land use intensity and density can reduce ecological impacts in three ways. High intensity land uses clustered in close proximity support travel modes like walking, biking and transit trips that have lower environmental impacts per trip. Reducing the parking and building footprint or increasing shade through tree cover also reduces heat island effects and run-off. Clustering and intensification of land use in appropriate locations can allow for the preservation of environmentally sensitive systems in other areas. However, the mere intensification of land uses without attention to the mix of uses that can be served within the scale of the pedestrian, bicyclist or transit user will not produce the mode shift desired and therefore will not produce the environmental benefits that accompany this mode shift. To understand the importance of these components, it is useful to consider each of them separately. Density without a mix of land uses means that residents have few destinations within a typical walk or bike distance; they may need to drive or use transit in order to go about the activities of daily living available to them. A mix of land uses without density or connectivity means that people cannot easily walk from their residence to other non-residential land uses, though their vehicular trips may be shorter, thus reducing fuel consumption to some degree. Good street connectivity with a single land use or with low density residential affords few opportunities for interaction between people. Increasing internal capture can provide secondary support for environmental goals as well by reducing VMT, VHT, and vehicular trips. Increasing the cost of vehicular trips through increased fuel taxes or consumption taxes also supports an environmentally beneficial mode shift.

Increase accessibility:

The coordination of land use and transportation can create neighborhoods that are inaccessible. For non-vehicular modes, the primary barriers are often in the realm of accessibility. The measures that assess the physical, safety and financial limitations associated with these modes provide insights into removing these barriers and increasing mode shift. From a land use perspective, the scale and quality of the land use mix can also support non-vehicular accessibility. Increasing vehicular accessibility can reduce trip lengths, provides route redundancy and promotes significant community benefit through congestion reduction, lower resource consumption and potential reduction in the need for future roadway facilities.

School accessibility is valuable to a community in both the short and long-term. Congestion due to school trips can account for a large percentage of the AM peak hour volume on some roadways, thus mode shift within the school population can reap immediate congestion related benefits to drivers as well as benefits to the student population in the form of improved health (lower rates of obesity and related health problems) and greater attention (the connection between physical activity and concentration is found in studies). In the long-term, students that become comfortable biking or walking to school may be more likely to continue that pattern throughout their lives.

Increase non-SOV travel:
To achieve mode shift away from the single occupancy vehicle (SOV), mere accessibility for alternate modes is insufficient. Transportation and vehicle design engineers have spent nearly a century making automobile travel convenient, safe, comfortable and efficient. Many of the measures included in this category address the same issues for users of alternate modes. Most of them reflect pedestrian, bicycle or transit environment variables. However, parking supply and land use mix at a pedestrian scale are also crucial considerations where non-SOV travel is concerned.

One major issue for mode shift is the way that costs for travel and parking are bundled together. For instance, in most high density neighborhoods, the parking for a condominium is bundled as a part of the cost for the unit. Selling the parking separately in areas where transit is readily available and goods and services are within walking or biking distance provides a choice to the traveler that can encourage transit usage. Most drivers fail to recognize that the most significant capital cost for passenger vehicle travel--roadway construction--has been bundled into federal, state and local taxes. There are many reasons why major universities and theme parks have high non-motorized mode splits, but one of those reasons is that cost bundling within the typical financial structure is common. At a university, on campus housing usually provides limited, expensive parking that is usually located at quite a distance from the living space. Parking costs on campus are controlled by a single entity that has little ability to buy additional land and high motivation to use their existing land resources for buildings rather than parking. Many universities bundle transit costs into either employee costs or student fees. Similarly, theme parks charge a premium price for parking adjacent to the major attractions, but provide extensive, free transit service throughout their properties for both their customers and their employees. Performance measures that account for these costs and bundling effects can be used to significantly impact mode shift away from SOV travel both within the development review process and within long-range financing and funding implementation.

Reduce congestion:

Many tools are available for reducing congestion. Most jurisdictions consider the addition of roadway capacity, or system optimization to reduce vehicle delays before they consider other options. Parking pricing supply and demand management strategies in conjunction with the provision of high quality alternate modes can reduce congestion through mode shift. Increasing connectivity can expand the extent that the network that can be used for through travel, reduce the distance that drivers have to travel around unconnected areas and increase the opportunity for travel on foot or by bicycle. Improved land use mix can reduce trip lengths by increasing accessibility to goods and services or even shift travel to non-vehicular modes which also reduces congestion. Fuel taxes or transportation fees can also reduce vehicle miles traveled through reduction in the number of trips, trip chaining or other strategies to minimize overall travel costs. Incident reduction and management can reduce incident-related congestion.

Optimize freight movement:

Freight management is a significant component of the transportation system and is crucial for both economic vitality and congestion management. As commerce shifts to electronic forms and land uses intensify, the opportunity to purchase online can substitute multiple comparison shopping trips with single chained trips via freight delivery. The successful provisioning of a community can significantly decrease vehicle trips and reduce congestion. The high quality measures that directly impact freight movement include the ability to connect to intermodal freight systems (air, rail and fleet), the distances that must be traveled between distribution centers and locations within urban areas and the continuity of street systems that reduces the number of difficult large vehicle movements.

Enhance safety:

Safety and security are broad topics and are impacted by a wide range of measures. Most communities track major vehicle incidents and accident rates. However, safety and security can also be significantly improved through increases in activity that accompanies improved connectivity within the pedestrian realm. Areas that have high amounts of pedestrian activity have more people watching for security threats. Therefore, the activity that comes from connected street and pedestrian systems, short distances to transit service and well-lit pedestrian networks can significantly impact the security of the area. The provision of transit service outside of peak hours reduces the risk of transit users being stranded. Assuring that a significant percentage of students have a safe accessible route to school reduces their risk of being in a vehicle accident and increases the opportunity for children to walk. Assuring that there is adequate funding to maintain high quality bicycle and pedestrian systems in good condition also reduces the chance for incidents on those facilities. Safety issues can also become an alternate source for funding facility improvements.

Reduce air pollution:

One of the primary uses of the regional travel demand models is to provide input to air quality analysis. The factors that directly impact air quality are largely tied to the amount of time vehicles remain on the roadway, regardless of which criteria pollutant is considered. Therefore, both vehicle hours of delay and vehicle hours traveled can provide important information regarding air quality while simultaneously providing an indication regarding other environmental consumption issues like fuel consumption. Reduction in vehicular trips due to mode shift or TDM strategies will also reduce emissions.

The measures are also classified based on the nature and applicability of the measures to specific contexts and modes. *Measure classification* identifies whether a performance measure can be obtained directly from the observed field data or indirectly as an output from a (statistical/simulation) model, or represented as an index (combination of multiple measures). *Scale* relates to the context that a measure can be applied and ranges from project level to system level (network, local, or regional scale). *Target Mode* indicates the primary mode for which the measure is appropriate. Each measure is characterized under each of these three categories using the symbols (letters) under each category presented in Table B.1.

Table B.1 Performance Measure Characteristics

Performance Measure Characteristics	**Description**
Measure Classification	- ***Measured*** *(M)* performance measures can be directly measured in the field, but they may also be estimated using calibrated models or approved calculation procedures especially for future conditions. - ***Estimated (E)*** measures are generally data extrapolations generated from a limited data set. - ***Index (I)*** measures are collections of multiple individual measures that are aggregated and calibrated to provide a broad assessment of the quality of a system from multiple points of view. - ***Model-generated (G)*** measures are estimates that are extrapolated from detailed system-wide models of land use and transportation systems. Many of these model-generated measures have correlates in smaller-scale, measured variables, but take into account system level changes that could impact specific operations in specific locations.
Scale	Level of scale at which a indicator is typically applied: ***Project (P), Network (N), Local/Jurisdictional (L), or Region (R)***
Target mode	Target modes for which an indicator measures influence: ***Auto (A), Transit (T), Bicycle (B), Walking (W), or Multimodal (M)***

Table B.2 provides performance measures by objectives and characteristics.

Table B.2 Objectives and Characteristics of Performance Measures

Mobility Dimensions	Indicators (from Literature)	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Infra & Env-Density	Average School Size		Δ	O	-	O	-	Δ	-		M	LR	B
Infra & Env-Density	Building coverage ratio		O	O	-	-	-	-	-		M	LR	B
Infra & Env-Density	Density at median distance		O	-	-	-	-	-	-		M	LR	T
Infra & Env-Density	Density Gradient		Δ	-	-	-	-	-	-		M	LR	M
Infra & Env-Density	Density of development		O	-	-	-	-	-	-		M	LR	T
Infra & Env-Density	Development Scale		-	Δ	-	-	-	-	-		M	PL	W
Infra & Env-Density	Non-residential intensity		O	Δ	Δ	Δ	-	-	-		M	LR	-
Infra & Env-Density	Percent of lane-miles under traffic monitoring center (TMC) Surveillance		-	-	-	O	-	Δ	-		M	NLR	M
Infra & Env-Density	Percentage increase in residential density		Δ	-	-	-	-	-	-		M	LR	A
Infra & Env-Density	Population density gradient		O	-	-	-	-	-	-		I	NL	B
Infra & Env-Density	Population Service Coverage		-	O	O	-	-	-	-		M	PLR	T
Infra & Env-Density	Residential density		O	Δ	Δ	Δ	-	-	-		M	PLR	-
Infra & Env-Density	Road density		-	O	-	Δ	-	-	-		I	NL	W
Infra & Env-Density	Transit-oriented employment density		O	Δ	O	O	-	-	Δ		M	PL	BW
Infra & Env-Density	Transit-oriented residential density		Δ	Δ	Δ	-	-	-	Δ		M	LR	T
Infra & Env-Density	Transit service to site		-	O	O	-	-	-	-		M	N	A
Infra & Env-Design-Community	Age of transit vehicle/fleet		-	-	O	-	-	-	Δ		M	NLR	BW
Infra & Env-Design-Community	Bicycle network density		-	O	Δ	-	-	-	-		M	NL	BW
Infra & Env-Design-Community	Bicycle parking requirements		-	O	O	-	-	-	-		G	LR	A
Infra & Env-Design-Community	Bicycle parking spaces at schools		-	Δ	Δ	-	-	-	-		G	LR	A
Infra & Env-Design-Community	Bus shelter locations		-	-	O	-	-	Δ	-		M	PLR	-
Infra & Env-Design-Community	Connectivity to intermodal facilities		-	O	Δ	Δ	O	-	-		M	LR	T
Infra & Env-Design-Community	Intermodal Connections		-	O	O	-	-	-	-		M	PL	A
Infra & Env-Design-Community	Parking Spaces per 1000 workers		-	Δ	O	O	-	-	Δ		M	PLR	-
Infra & Env-Design-Community	Parking supply		-	-	O	Δ	-	-	-		M	PLR	-
Infra & Env-Design-Community	Project Adjacency to transit		-	Δ	O	-	-	-	-		M	PL	BW

→ Strongly applicable (O), Applicable(Δ), Not applicable (-), Measured (M), Estimated (E), Index (I), Model-generated (G), Project (P), Network (N), Local/Jurisdictional (L), Region (R), Auto (A), Transit (T), Bicycle (B), Walking (W), and Multimodal (M)

Table B.2 Objectives and Characteristics of Performance Measures

Mobility Dimensions	Indicators (from Literature)	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Infra & Env-Design-Community	Transit network coverage		-	O	O	-	-	-	Δ		I	N	A
Infra & Env-Design-Community	Transit service index		-	-	Δ	-	-	-	-		M	PLR	A
Infra & Env-Design-Community	Walking distance to transit		-	O	O	-	-	Δ	-		G	PLR	A
Infra & Env-Design-Corridor	Access requirements		-	O	-	-	-	-	-		M	L	BW
Infra & Env-Design-Corridor	Bicycle Compatibility Index		-	O	O	-	-	O	-		M	LR	T
Infra & Env-Design-Corridor	Bus turnout facilities		-	-	O	-	-	-	-		M	PLR	-
Infra & Env-Design-Corridor	Posted information		-	-	O	O	-	-	-		G	LR	W
Infra & Env-Design-Corridor	Street continuity		-	O	-	Δ	Δ	-	-		M	LR	T
Infra & Env-Design-Neighborhood	Bicycle maintenance stations		-	-	O	-	-	-	-		G	LR	M
Infra & Env-Design-Neighborhood	Bicycle parking at stops and stations		-	Δ	O	-	-	-	-		M	PLR	-
Infra & Env-Design-Neighborhood	Bicycle path condition		-	O	Δ	-	-	O	-		G	L	M
Infra & Env-Design-Neighborhood	Bicycle/pedestrian connectivity		-	O	O	-	-	-	-		M	PL	M
Infra & Env-Design-Neighborhood	Block length		-	O	Δ	-	-	-	-		M	PL	BW
Infra & Env-Design-Neighborhood	Connected and open community		-	Δ	-	Δ	Δ	-	-		M	LR	T
Infra & Env-Design-Neighborhood	Connected sidewalks/paths		-	Δ	Δ	-	-	-	-		M	NL	BW
Infra & Env-Design-Neighborhood	Connected streets		-	O	-	O	-	Δ	-		M	NL	W
Infra & Env-Design-Neighborhood	Connectivity Index		-	O	-	O	-	Δ	-		M	PL	A
Infra & Env-Design-Neighborhood	Connectivity Index, Polygons		-	O	-	O	-	Δ	-		M	PL	A
Infra & Env-Design-Neighborhood	Cross access		-	O	-	-	-	-	-		M	PL	M
Infra & Env-Design-Neighborhood	Crosswalk spacing		-	Δ	O	-	-	Δ	-		M	PLR	T
Infra & Env-Design-Neighborhood	Land use buffers		Δ	-	-	-	-	-	-		G	LR	M
Infra & Env-Design-Neighborhood	Number of safe crossings per mile		-	O	O	-	-	Δ	-		M	PLR	T
Infra & Env-Design-Neighborhood	Parking footprint		O	-	-	-	-	-	-		M	PLR	-
Infra & Env-Design-Neighborhood	Parking location		-	Δ	O	-	-	Δ	-		M	PL	M
Infra & Env-Design-Neighborhood	Pedestrian/bicycle route directness		-	O	O	-	-	-	-		M	N	A
Infra & Env-Design-Neighborhood	Project Adjacency to existing network		-	Δ	-	-	-	-	-		M	PL	A
Infra & Env-Design-Neighborhood	Square feet of pathways/sidewalks		-	Δ	O	-	-	-	-		G	LR	W

→ Strongly applicable (O), Applicable(Δ), Not applicable (-), Measured (M), Estimated (E), Index (I), Model-generated (G), Project (P), Network (N), Local/Jurisdictional (L), Region (R), Auto (A), Transit (T), Bicycle (B), Walking (W), and Multimodal (M)

Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	Indicators (from Literature)	Indicator objectives	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	Indicator characteristics	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Infra & Env-Design-Neighborhood	Walking environment		-	O	Δ	-	-	-	-		G	LR	M
Infra & Env-Design-Point	Availability of on-site bicycle amenities		-	Δ	O	-	-	-	-		M	LR	-
Infra & Env-Design-Point	Bus pass program utilization		-	-	O	O	-	-	-		M	PL	-
Infra & Env-Design-Point	Commercial on-site amenities to support alternative modes		-	Δ	Δ	-	-	-	-		M	LR	-
Infra & Env-Design-Point	Parking screening		-	Δ	-	-	-	O	-		M	L	-
Infra & Env-Design-Point	Parking shading		-	Δ	-	-	-	-	-		M	PL	A
Infra & Env-Design-Point	Pedestrian scaled lighting		-	O	O	-	-	O	-		M	PLR	M
Infra & Env-Design-Point	Ratio of street width to building height		-	-	Δ	-	-	-	-		G	LR	M
Infra & Env-Design-Point	Sidewalk quality		-	Δ	O	-	-	Δ	-		M	LR	BW
Infra & Env-Design-Point	Sidewalk shade		-	Δ	O	-	-	-	-		M	L	BW
Infra & Env-Design-Point	Sidewalk width		-	-	O	Δ	-	-	-		M	LR	B
Infra & Env-Design-Point	Systematic Pedestrian and Cycling Environmental Scan Instrument (SPACES)		-	-	Δ	-	-	-	-		M	PLR	-
Infra & Env-Design-Point	Tree-Lined/Shaded Streets		Δ	Δ	Δ	-	-	-	-		M	P	T
Infra & Env-Design-Point	Walkable Streets		-	O	Δ	-	-	Δ	-		M	LR	-
Infra & Env-Design-Point	Wayfinding information		-	-	Δ	Δ	-	-	-		I	LR	M
Infra & Env-Design-Regional	Lane miles per capita		-	O	-	Δ	-	-	-		M	LR	B
Infra & Env-Design-Regional	Miles of dedicated bus lanes		-	Δ	O	Δ	-	-	-		M	PL	B
Infra & Env-Design-Regional	On-vehicle bicycle-carrying facilities		-	Δ	O	Δ	-	-	-		M	PLR	-
Infra & Env-Design-Regional	Park-and-rides with express service		-	Δ	O	O	-	-	Δ		M	PLR	-
Infra & Env-Design-Regional	Parking spaces designated for carpools or vanpools		-	Δ	O	O	-	-	-		M	PLR	-
Infra & Env-Design-Regional	Percent miles bicycle accommodations		Δ	Δ	O	Δ	-	-	-		M	L	B
Infra & Env-Design-Regional	Percent miles pedestrian accommodations		-	Δ	O	-	-	-	-		M	PL	B
Infra & Env-Design-Regional	Percent of residential areas within 1 mile of an elementary school		-	-	Δ	Δ	-	Δ	-		M	LR	T
Infra & Env-Design-Regional	Roadway network balance		-	O	-	Δ	Δ	-	-		M	LR	M
Infra & Env-Design-Regional	Traffic cells		-	-	O	-	-	-	-		G	LR	M
Infra & Env-Design-Regional	Transit passes		-	O	O	-	-	-	-		M	PL	M

→ Strongly applicable (O), Applicable(Δ), Not applicable (-), Measured (M), Estimated (E), Index (I), Model-generated (G), Project (P), Network (N), Local/Jurisdictional (L), Region (R), Auto (A), Transit (T), Bicycle (B), Walking (W), and Multimodal (M)

Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	**Indicators (from Literature)**	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Infra & Env-Destination-Area	Employment proximity		O	-	-	-	-	-	-		M	PLR	TB
Infra & Env-Destination-Area	Geographic Service Coverage		-	O	O	Δ	-	-	Δ		M	PLR	T
Infra & Env-Destination-Area	Industrial/warehouse proximity		O	-	-	-	Δ	-	Δ		M	PLR	-
Infra & Env-Destination-Area	Number of key destinations accessible via a connected pedestrian system		-	O	O	-	-	Δ	-		G	PL	BW
Infra & Env-Destination-Area	Percent in Proximity measurements		O	Δ	Δ	-	-	-	-		M	PLR	T
Infra & Env-Destination-Area	Possible capacity addition within ROW		-	-	-	Δ	-	-	-		M	PLR	T
Infra & Env-Destination-Area	Residence proximity		O	-	-	-	-	-	-		M	PLR	TB
Infra & Env-Destination-Area	Transit Accessibility		-	O	O	-	-	Δ	Δ		M	PLR	T
Infra & Env-Destination-Area	Transit convenience/Stop accessibility		-	Δ	O	-	-	-	Δ		M	PLR	T
Infra & Env-Destination-Area	Work accessibility Index		-	O	-	-	-	-	-		I	PLR	M
Infra & Env-Destination-Network	Average walking distance between land use pairs		-	Δ	O	-	-	-	-		M	PL	T
Infra & Env-Destination-Network	Bike/pedestrian accessibility		-	O	O	-	-	-	-		M	N	A
Infra & Env-Destination-Network	Destination Accessibility		-	O	-	-	-	-	-		M	PL	T
Infra & Env-Destination-Network	Multiple Route Choices		-	Δ	-	Δ	-	-	-		E	N	A
Infra & Env-Destination-Network	Residential Accessibility		-	O	-	-	-	-	-		M	PL	T
Infra & Env-Destination-Network	Spacing between Village Centers		-	Δ	-	Δ	-	-	-		I	N	A
Infra & Env-Diversity	Core Land Use		-	O	-	-	-	-	-		M	LR	-
Infra & Env-Diversity	Jobs/housing balance		Δ	O	Δ	O	-	-	-		G	L	M
Infra & Env-Diversity	Land Consumption		O	-	-	-	-	-	-		I	LR	-
Infra & Env-Diversity	Land use balance		-	Δ	Δ	-	-	-	-		M	LR	-
Infra & Env-Diversity	Land use ratios/mix		-	Δ	-	Δ	-	-	-		I	LR	-
Infra & Env-Diversity	Land use separation		-	Δ	-	O	-	-	Δ		M	LR	-
Infra & Env-Diversity	Land Use within Transit Supportive Area		-	O	-	-	-	-	-		M	N	A
Infra & Env-Diversity	Land Use within Village Center		-	O	-	-	-	-	-		M	P	T
Infra & Env-Diversity	Minimum thresholds of land use intensity		O	Δ	-	-	-	-	Δ		M	LR	-
Infra & Env-Diversity	Nearby Neighborhood Assets		O	Δ	-	Δ	-	-	-		G	LR	-

→ Strongly applicable (O), Applicable(Δ), Not applicable (-), Measured (M), Estimated (E), Index (I), Model-generated (G), Project (P), Network (N), Local/Jurisdictional (L), Region (R), Auto (A), Transit (T), Bicycle (B), Walking (W), and Multimodal (M)

Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	Indicators (from Literature)	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Infra & Env-Diversity	Significant Land Uses		-	O	-	-	-	-	-		M	PL	W
Infra & Env-Diversity	Smart Growth Index		-	Δ	-	-	-	-	-		M	PL	M
Infra & Env-Diversity	Sprawl Index (Ewing et al., 2002)		O	Δ	-	-	-	-	-		M	LR	-
Infra & Env-Diversity	Sprawl Index (Galster et al., 2001)		O	Δ	Δ	-	-	-	-		M	P	-
Infra & Env-Diversity	Transportation-Efficient Land Use Mapping Index Model		-	O	O	O	-	Δ	Δ		M	LR	-
Infra & Env-Diversity	Variation of agricultural of green fields		O	O	-	-	-	-	Δ		M	LR	-
Safety-History	Annual severe crashes		-	-	-	-	-	O	-		M	LR	A
Safety-History	Bike/Pedestrian injuries/fatalities		-	-	-	-	-	O	-		M	LR	BW
Safety-History	Crash statistics/locations		-	-	-	Δ	-	O	-		M	LR	A
Safety-History	Traffic fatalities		-	-	-	-	-	O	-		M	LR	A
Safety-History	Transit accident rate		-	-	-	-	-	O	-		M	LR	A
Safety-History	Transit related Crime rate		-	-	-	-	-	Δ	-		M	LR	T
Safety-History	Transit vandalism incidents		-	-	-	-	-	O	-		M	LR	A
Safety-History	Vehicle accident rate		-	-	-	Δ	-	O	-		M	LR	A
Safety-Risk management	% vehicle with safety devices		-	-	-	-	-	Δ	-		M	LR	T
Safety-Risk management	Average clearance times for major incidents		-	-	-	O	-	Δ	-		M	LR	AT
Safety-Risk management	Percent of network that is "Effective"		-	Δ	-	O	-	-	-		M	LR	T
Safety-Risk management	Ratio of police officers to transit vehicles		-	Δ	O	-	-	Δ	-		M	LR	BW
Safety-Risk management	Speed suitability		-	Δ	-	-	-	Δ	-		E	N	A
Sustainability-Ecological	Attainment of ambient air quality standards		-	-	-	-	-	-	Δ		G	LR	A
Sustainability-Ecological	Daily CO2 emissions		-	-	-	-	-	-	O		G	LR	A
Sustainability-Ecological	Daily NOx, CO, and VOC emissions		-	-	-	-	-	-	O		G	LR	A
Sustainability-Ecological	Impact on wildlife habitat		O	-	-	-	-	-	-		G	LR	-
Sustainability-Ecological	Noise pollution		Δ	-	-	-	-	-	-		G	LR	A
Sustainability-Ecological	Water runoff		O	-	-	-	-	-	-		M	LR	-
Sustainability-Fiscal	Additional Fuel Tax		Δ	-	-	Δ	-	-	Δ		M	LR	A
Sustainability-Fiscal	Benefit cost ratio		Δ	-	-	-	-	-	-		M	LR	-

→ Strongly applicable (O), Applicable(Δ), Not applicable (-), Measured (M), Estimated (E), Index (I), Model-generated (G), Project (P), Network (N), Local/Jurisdictional (L), Region (R), Auto (A), Transit (T), Bicycle (B), Walking (W), and Multimodal (M)

Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	Indicators (from Literature)	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Sustainability-Fiscal	Capital funding for bike/Pedestrian facilities		-	Δ	O	-	-	Δ	-		I	LR	-
Sustainability-Fiscal	Consumption-Based Mobility Fee		O	-	-	Δ	-	-	-		M	LR	A
Sustainability-Fiscal	Cost recovery from alternate sources		-	-	-	Δ	-	Δ	-		M	LR	-
Sustainability-Fiscal	Improvements-Based Mobility Fee		-	-	-	Δ	-	-	-		M	LR	A
Sustainability-Fiscal	Parking pricing		-	-	O	O	-	-	-		I	LR	-
Sustainability-Fiscal	Variable fees based on LOS		-	-	-	O	-	-	-		M	LR	A
Sustainability-Fiscal	VMT-based Impact fee		-	-	-	Δ	-	-	Δ		M	LR	A
Sustainability-Fiscal	VMT by race		Δ	-	-	-	-	-	-		M	P	M
Sustainability-Social	Commute Cost		Δ	-	O	O	-	-	-		M	LR	M
Sustainability-Social	Distribution of benefit by income group		Δ	-	-	-	-	-	-		M	LR	M
Sustainability-Social	Equitable distribution of accessibility		-	O	-	-	-	-	-		M	LR	M
Sustainability-Social	Fee charged for employee parking spaces		-	-	O	Δ	-	-	-		M	LR	-
Sustainability-Social	Mode share by income group		-	-	Δ	-	-	-	-		M	PL	M
Sustainability-Social	Mode share by race		-	-	Δ	-	-	-	-		M	L	M
Sustainability-Social	TDM effectiveness based on TRIMMS model		Δ	-	O	Δ	-	-	Δ		G	LR	M
Sustainability-Social	Transit values		-	-	Δ	-	-	-	-		M	LR	M
Sustainability-Social	Transportation Affordability		-	-	Δ	-	-	-	-		M	LR	M
Sustainability-Social	Transportation Utility Fee (TUF)		-	-	-	Δ	-	-	Δ		M	LR	A
Sustainability-Social	Travel costs by income group		-	-	Δ	Δ	-	-	-		I	LR	M
Sustainability-Social	Travel costs by race		-	-	Δ	Δ	-	-	-		I	LR	M
Sustainability-Social	VMT by income group		Δ	-	-	-	-	-	-		M	P	M
Sustainability-Social	Walk to transit by income group		-	O	O	-	-	-	-		I	NL	B
Sustainability-Social	Walk to transit by race		-	O	O	-	-	-	-		M	NL	A
User perception	Bicycle LOS (FDOT)		-	Δ	Δ	-	-	-	-		E	LR	BW
User perception	Pedestrian LOS (FDOT)		-	Δ	Δ	-	-	-	-		E	LR	BW
User perception	LOS based on traveler perception		-	-	-	O	-	-	-		E	LR	A
User perception	Pedestrian Friendliness		-	Δ	O	-	-	Δ	-		E	LR	W

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Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	Indicators (from Literature)	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
User perception	Perception of Transit safety		-	-	Δ	-	-	O	-		E	LR	T
User perception	Transit comfort		-	-	O	-	-	-	-		E	LR	T
User perception	Transit complaint rate		-	-	-	-	-	O	-		M	LR	A
User perception	Transit condition of vehicles and facilities		-	-	Δ	-	-	-	-		E	LR	T
User perception	Transit customer loyalty		-	-	-	-	-	O	-		M	LR	A
User perception	Transit ease of using the system		-	-	O	-	-	-	-		E	LR	T
User perception	Transit Reliability/ Performance (Perceived)		-	-	Δ	-	-	-	-		E	LR	T
User perception	Transit service density		-	Δ	O	-	-	-	-		M	PNL	BW
Utilization-Auto-Quantity	Demand/capacity ratio		-	-	-	O	-	-	-		M	NLR	W
Utilization-Auto-Quantity	Districtwide Level of Service (LOS)/Quality of Service (QOS)		-	-	-	O	-	-	-		E	NL	A
Utilization-Auto-Quantity	Local traffic diversion		-	-	-	O	-	-	-		E	NL	A
Utilization-Auto-Quantity	LOS based on HCM 2010		-	-	-	O	-	-	-		M	LR	T
Utilization-Auto-Quantity	Maximum Service Volume		-	-	-	O	-	-	-		E	NL	A
Utilization-Auto-Quantity	Peak Hour LOS		-	-	-	O	-	-	Δ		G	NL	A
Utilization-Auto-Quantity	Percent of Capacity Consumed		-	-	-	O	-	-	-		G	NL	A
Utilization-Auto-Quantity	Percent of system heavily congested		-	-	-	O	-	-	Δ		M	LR	T
Utilization-Auto-Quantity	v/C ratio		-	-	-	O	-	-	-		M	LR	-
Utilization-Auto-Quantity	Vehicle Density		-	-	-	O	-	-	Δ		M	NLR	B
Utilization-Auto-Quantity	Vehicle occupancy by land use		-	-	-	Δ	-	-	-		G	PL	A
Utilization-Auto-Reliability	% of trips 'on time'		-	-	-	Δ	-	-	-		G	P	A
Utilization-Auto-Reliability	90th- or 95th percentile travel time		-	-	-	O	-	-	-		I	NL	A
Utilization-Auto-Reliability	Buffer index		-	-	-	O	-	-	-		E	NLR	A
Utilization-Auto-Reliability	Population and employment centrality		Δ	-	-	-	-	-	-		M	LR	A
Utilization-Auto-Time	Average commute time		-	-	-	Δ	-	-	-		E	LR	A
Utilization-Auto-Time	Average Speed		-	O	-	O	-	-	-		E	LR	A
Utilization-Auto-Time	Average speed weighted by PMT		-	-	-	O	-	-	-		I	N	A
Utilization-Auto-Time	Congestion Duration		-	-	-	O	-	-	Δ		M	N	A

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Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	**Indicators (from Literature)**	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Utilization-Auto-Time	Control delay		-	-	-	O	-	-	-		M	N	A
Utilization-Auto-Time	Highway Reliability		-	-	-	O	-	-	-		G	N	A
Utilization-Auto-Time	Percent work trips within specific travel time		-	-	-	Δ	-	-	-		M	N	A
Utilization-Auto-Time	Time by trip purpose		-	-	-	Δ	-	-	-		M	NLR	T
Utilization-Auto-Time	Total segment delay		-	-	-	Δ	-	-	-		M	N	A
Utilization-Auto-Time	Travel delay		-	-	-	a	-	-	Δ		M	N	A
Utilization-Auto-Time	Travel distance index		-	-	Δ	Δ	-	-	-		I	LR	M
Utilization-Auto-Time	Travel time		-	-	-	Δ	-	-	Δ		M	N	A
Utilization-Auto-Time	Travel Time-based LOS		-	-	-	Δ	-	-	-		M	NL	A
Utilization-Auto-Time	Travel time index		-	-	-	Δ	-	-	-		E	N	A
Utilization-Auto-Time	Vehicle hours of delay (VHD)		-	-	-	O	-	-	O		M	LR	BW
Utilization-Auto-Time	Vehicle hours traveled (VHT)		O	-	-	Δ	-	-	O		M	N	A
Utilization-Auto-Time	Vehicle speed/VHD by mode		-	-	-	O	-	-	Δ		M	LR	M
Utilization-Freight	Freight delay		-	-	-	-	O	-	-		M	NLR	-
Utilization-Freight	Number of violation of weight restrictions		-	-	-	-	O	-	-		M	LR	-
Utilization-Freight	Overweight permits		-	-	O	-	Δ	-	-		M	N	A
Utilization-Freight	Truck miles traveled		-	-	-	-	O	-	Δ		M	NLR	-
Utilization-Freight	Truck throughput efficiency		-	-	-	-	O	-	Δ		E	NLR	-
Utilization-Multimodal	Auto/Demand response transit (DRT) travel time ratio		-	-	Δ	-	-	-	-		M	NLR	T
Utilization-Multimodal	Auto/transit travel time ratio		-	-	Δ	Δ	-	-	-		M	NLR	T
Utilization-Multimodal	Multimodal LOS		-	-	Δ	Δ	-	-	-		I	NLR	M
Utilization-Multimodal	Safe Routes to School Program (SRTS) effectiveness		-	Δ	Δ	-	-	O	-		M	LR	M
Utilization-NonMotorized Modes	ATL per traveler		Δ	-	-	Δ	-	-	-		G	LR	M
Utilization-NonMotorized Modes	Delay per traveler		-	-	-	O	-	-	-		M	NLR	A
Utilization-NonMotorized Modes	Door to door travel time		-	-	-	Δ	-	-	-		E	NLR	M
Utilization-NonMotorized Modes	HCM-based Bicycle LOS		-	-	O	-	-	-	-		I	NLR	B
Utilization-NonMotorized Modes	Proportion of total PMT for non-SOVs		-	-	O	-		-	-		G	LR	M

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Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	**Indicators (from Literature)**	**Indicator objectives**	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	**Indicator characteristics**	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Utilization-Transit-Occupancy	Load Factor		-	-	Δ	-	-	-	-		M	LR	T
Utilization-Transit-Occupancy	Passengers per transit vehicle mile		-	-	Δ	-	-	-	-		M	LR	T
Utilization-Transit-Occupancy	Percent person-minutes served		-	-	Δ	-	-	-	-		M	LR	T
Utilization-Transit-Occupancy	Ridership		-	-	Δ	Δ	-	-	-		M	LR	T
Utilization-Transit-Occupancy	Transit peak hour occupancy		-	-	Δ	O	-	-	-		M	LR	T
Utilization-Transit-Operation	Average age of vehicle components		-	-	O	-	-	-	Δ		M	NLR	BW
Utilization-Transit-Operation	Average life of vehicle components		-	-	O	-	-	-	Δ		M	NLR	BW
Utilization-Transit-Operation	Fleet spare ratio		-	-	Δ	-	-	-	-		M	LR	T
Utilization-Transit-Operation	Number of fare media sales outlets		-	Δ	O	-	-	-	-		E	PNL	BW
Utilization-Transit-Operation	Number of transfers		-	-	Δ	-	-	-	-		M	N	T
Utilization-Transit-Operation	Road Calls		-	Δ	O	-	-	Δ	-		M	LR	BW
Utilization-Transit-Operation	Transfer time		-	-	Δ	-	-	-	-		M	NLR	T
Utilization-Transit-Operation	Transfer time between modes		-	O	Δ	-	-	Δ	-		M	NLR	T
Utilization-Transit-Operation	Transit priority delay reductions		-	-	Δ	-	-	-	Δ		M	NLR	T
Utilization-Transit-Operation	Transit Productivity		-	-	Δ	-	-	-	Δ		M	LR	T
Utilization-Transit-Operation	Transit Reliability (Quantitative)		-	-	Δ	-	-	-	-		M	NLR	T
Utilization-Transit-Service	Average frequency		-	Δ	O	-	-	-	-		M	PLR	-
Utilization-Transit-Service	Average headways		-	Δ	O	-	-	-	-		M	L	T
Utilization-Transit-Service	DRT trips not served		-	-	Δ	-	-	-	-		M	LR	T
Utilization-Transit-Service	Fixed route missed trips		-	Δ	-	Δ	-	-	-		E	N	A
Utilization-Transit-Service	Hours of service		-	-	O	-	-	Δ	-		M	NLR	BW
Utilization-Transit-Service	Off-peak transit availability		-	Δ	O	-	-	-	-		E	PNL	BW
Utilization-Transit-Service	On time performance		-	Δ	O	-	-	-	-		E	PNL	BW
Utilization-Transit-Service	Response Time for DRT		-	-	Δ	-	-	-	-		M	LR	T
Utilization-Transit-Service	Transit type availability		-	-	O	-	-	-	-		M	PNL	BW
Utilization-Travel demand-Mode share	Average Vehicle Occupancy		-	-	O	Δ	-	-	-		G	LR	A
Utilization-Travel demand-Mode share	Bicycle and Pedestrian activity		-	-	O	-	-	Δ	-		G	LR	BW

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Table B.2 Objectives and Characteristics of Performance Measures (continuted)

Mobility Dimensions	Indicators (from Literature)	Indicator objectives	Minimize ecological impact	Increase accessibility	Increase non-SOV travels	Reduce congestion	Optimize freight movement	Enhance safety	Reduce air pollution	Indicator characteristics	Process/Outcome (M,E,I,G)	Level of scale (P,N,L,R)	Target mode (A,T,B,W,M)
Utilization-Travel demand-Mode share	Bicycle and Pedestrian mode share		-	-	Δ	Δ	-	-	-		G	LR	BW
Utilization-Travel demand-Mode share	Mode choice availability		-	Δ	O	Δ	-	-	-		M	PLR	M
Utilization-Travel demand-Mode share	Mode Split		-	-	Δ	-	-	-	-		G	LR	M
Utilization-Travel demand-Mode share	Seat capacity/Person capacity		-	-	O	-	-	-	-		M	N	AT
Utilization-Travel demand-Mode share	SOV mode split		-	-	O	O	-	-	-		G	LR	M
Utilization-Travel demand-Trip gen.	Community Capture		O	Δ	-	O	-	-	Δ		G	LR	-
Utilization-Travel demand-Trip gen.	Internal Capture		Δ	-	-	Δ	-	-	Δ		G	LR	-
Utilization-Travel demand-Trip gen.	Mean daily trips per household		Δ	-	-	Δ	-	-	-		G	LR	-
Utilization-Travel demand-Trip gen.	Mean daily vehicle trips per household		Δ	-	-	Δ	-	-	-		G	LR	-
Utilization-Travel demand-Trip gen.	Person miles traveled (PMT)		Δ	-	-	Δ	-	-	-		G	LR	-
Utilization-Travel demand-Trip gen.	Planning time index (PTI)		-	-	-	Δ	-	-	-		M	N	A
Utilization-Travel demand-Trip gen.	Trip length by mode		Δ	-	Δ	-	-	-	-		G	LR	M
Utilization-Travel demand-Trip gen.	VMT (by mode)		Δ	-	-	-	-	-	Δ		G	LR	M
Utilization-Travel demand-Trip gen.	VMT per capita		Δ	-	-	Δ	-	-	Δ		G	LR	M

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APPENDIX C: Data Requirements

Table C.1 Data Requirement

Mobility Dimensions	Indicators	Data requirements
Infra & Env-Density	Average School Size	Number of students, School location
Infra & Env-Density	Building coverage ratio	Project Site Plan, Land use map (detailed types)
Infra & Env-Density	Density at median distance	Census data, Land use map (detailed types), Number of employees (parcel)
Infra & Env-Density	Density Gradient	Transit service network and route schedule, Land use map (detailed types)
Infra & Env-Density	Density of development	Census data, Land use map (detailed types)
Infra & Env-Density	Development Scale	Number of employees (parcel), Number of residents (parcel), Number of residents (parcel)
Infra & Env-Density	Non-residential intensity	Land use map (detailed types)
Infra & Env-Density	Percent of lane-miles under traffic monitoring center (TMC) surveillance	Lane-miles with TMC surveillance
Infra & Env-Density	Percentage increase in residential density	Land use map (detailed types), Number of residents (parcel)
Infra & Env-Density	Population density gradient	Census data, Land use map (detailed types)
Infra & Env-Density	Population Service Coverage	Census data, Land use map (detailed types), Transit service network and route schedule
Infra & Env-Density	Residential density	Land use map (detailed types), Number of residents (parcel)
Infra & Env-Density	Road density	Roadway Network Inventory, Land use map (detailed types)
Infra & Env-Density	Transit-oriented employment density	Number of employees (parcel), Transit service network and route schedule
Infra & Env-Density	Transit-oriented residential density	Number of residents (parcel), Transit service network and route schedule, Number of residents (parcel)
Infra & Env-Density	Transit service to site	Transit service network and route schedule
Infra & Env-Design-Community	Age of transit vehicle/fleet	Transit fleet inventory by type and amenity
Infra & Env-Design-Community	Bicycle network density	Bicycle network inventory/Geometry/Parking, Land use map (detailed types)
Infra & Env-Design-Community	Bicycle parking requirements	Bicycle network inventory/Geometry/Parking
Infra & Env-Design-Community	Bicycle parking spaces at schools	Bicycle network inventory/Geometry/Parking, School location
Infra & Env-Design-Community	Bus shelter locations	Transit facility inventory
Infra & Env-Design-Community	Connectivity to intermodal facilities	Roadway Network Inventory, Intermodal facility location, Transit service network and route schedule
Infra & Env-Design-Community	Intermodal Connections	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory, Roadway Network Inventory, Property Database, Transit service network and route schedule
Infra & Env-Design-Community	Parking Spaces per 1000 workers	Land use map (detailed types), Number of employees (parcel), Detailed Parking Inventory
Infra & Env-Design-Community	Parking supply	Detailed Parking Inventory
Infra & Env-Design-Community	Project Adjacency to transit	Project Site Plan, Transit service network and route schedule
Infra & Env-Design-Community	Transit network coverage	Transit service network and route schedule
Infra & Env-Design-Community	Transit service index	Land use map (detailed types), Transit service network and route schedule

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Infra & Env-Design-Community	Walking distance to transit	Pedestrian network inventory, Individuals' trip details (with stop locations), Transit service network and route schedule
Infra & Env-Design-Corridor	Access requirements	Roadway Network Inventory
Infra & Env-Design-Corridor	Bicycle Compatibility Index	Bicycle network inventory/Geometry/Parking, Roadway Network Inventory, Roadway Geometry, Heavy vehicle percentage, Parking utilization rate (on street), Posted speed limit, Traffic volume, Vehicle speed (85th percentile), Vehicle turning movement volumes
Infra & Env-Design-Corridor	Bus turnout facilities	Roadway Geometry, Transit facility inventory
Infra & Env-Design-Corridor	Posted information	Transit fleet inventory by type and amenity, Transit service network and route schedule
Infra & Env-Design-Corridor	Street continuity	Roadway Network Inventory
Infra & Env-Design-Neighborhood	Bicycle maintenance stations	Bicycle network inventory/Geometry/Parking
Infra & Env-Design-Neighborhood	Bicycle parking at stops and stations	Bicycle network inventory/Geometry/Parking, Transit service network and route schedule
Infra & Env-Design-Neighborhood	Bicycle path condition	Bicycle network inventory/Geometry/Parking
Infra & Env-Design-Neighborhood	Bicycle/pedestrian connectivity	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory
Infra & Env-Design-Neighborhood	Block length	Roadway Network Inventory
Infra & Env-Design-Neighborhood	Connected and open community	Roadway Network Inventory, Project Site Plan
Infra & Env-Design-Neighborhood	Connected sidewalks/paths	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory, Roadway Network Inventory
Infra & Env-Design-Neighborhood	Connected streets	Roadway Network Inventory
Infra & Env-Design-Neighborhood	Connectivity Index	Roadway Network Inventory, Land use map (detailed types)
Infra & Env-Design-Neighborhood	Connectivity Index, Polygons	Roadway Network Inventory, Land use map (detailed types)
Infra & Env-Design-Neighborhood	Cross access	Roadway Network Inventory, Land use map (detailed types)
Infra & Env-Design-Neighborhood	Crosswalk spacing	Pedestrian network inventory
Infra & Env-Design-Neighborhood	Land use buffers	Land use map (detailed types)
Infra & Env-Design-Neighborhood	Number of safe crossings per mile	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory
Infra & Env-Design-Neighborhood	Parking footprint	Project Site Plan
Infra & Env-Design-Neighborhood	Parking location	Detailed Parking Inventory
Infra & Env-Design-Neighborhood	Pedestrian/bicycle route directness	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory
Infra & Env-Design-Neighborhood	Project Adjacency to existing network	Roadway Network Inventory, Land use map (detailed types)
Infra & Env-Design-Neighborhood	Square feet of pathways/sidewalks	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory, Pedestrian system geometry
Infra & Env-Design-Neighborhood	Walking environment	Pedestrian network inventory, Pedestrian system geometry
Infra & Env-Design-Point	Availability of on-site bicycle amenities	Bicycle network inventory/Geometry/Parking
Infra & Env-Design-Point	Bus pass program utilization	Transit fare options and program

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Infra & Env-Design-Point	Commercial on-site amenities to support alternative modes	Pedestrian network inventory, Project Site Plan
Infra & Env-Design-Point	Parking screening	Detailed Parking Inventory
Infra & Env-Design-Point	Parking shading	Detailed Parking Inventory
Infra & Env-Design-Point	Pedestrian scaled lighting	Pedestrian system geometry
Infra & Env-Design-Point	Ratio of street width to building height	Pedestrian network inventory, Pedestrian system geometry, Building height
Infra & Env-Design-Point	Sidewalk quality	Pedestrian system geometry
Infra & Env-Design-Point	Sidewalk shade	Pedestrian network inventory, Pedestrian system geometry
Infra & Env-Design-Point	Sidewalk width	Pedestrian system geometry
Infra & Env-Design-Point	Systematic Pedestrian and Cycling Environmental Scan Instrument (SPACES)	Pedestrian system geometry, Roadway Geometry, Land use map (detailed types), Detailed Parking Inventory, Street aesthetics survey, Street lighting location, Traffic volume
Infra & Env-Design-Point	Tree-Lined/Shaded Streets	Roadway Network Inventory, Arbor Inventory
Infra & Env-Design-Point	Walkable Streets	Pedestrian network inventory, Pedestrian system geometry, Roadway Network Inventory
Infra & Env-Design-Point	Wayfinding information	Roadway sign inventory
Infra & Env-Design-Regional	Lane miles per capita	Census data, Roadway Network Inventory, Land use map (detailed types)
Infra & Env-Design-Regional	Miles of dedicated bus lanes	Exclusive Transit Network/Geometry
Infra & Env-Design-Regional	On-vehicle bicycle-carrying facilities	Transit fleet inventory by type and amenity
Infra & Env-Design-Regional	Park-and-rides with express service	Property Database, Transit service network and route schedule
Infra & Env-Design-Regional	Parking spaces designated for carpools or vanpools	Detailed Parking Inventory
Infra & Env-Design-Regional	Percent miles bicycle accommodations	Bicycle network inventory/Geometry/Parking, Roadway Network Inventory
Infra & Env-Design-Regional	Percent miles pedestrian accommodations	Pedestrian network inventory, Roadway Network Inventory,
Infra & Env-Design-Regional	Percent of residential areas within 1 mile of an elementary school	Number of residents (parcel), School location
Infra & Env-Design-Regional	Roadway network balance	Roadway Geometry
Infra & Env-Design-Regional	Traffic cells	Roadway Network Inventory
Infra & Env-Design-Regional	Transit passes	Transit fare options and program
Infra & Env-Destination-Area	Employment proximity	Number of employees (parcel), Transit service network and route schedule
Infra & Env-Destination-Area	Geographic Service Coverage	Land use map (detailed types), Transit service network and route schedule
Infra & Env-Destination-Area	Industrial/warehouse proximity	Land use map (detailed types), Transit service network and route schedule
Infra & Env-Destination-Area	Number of key destinations accessible via a connected pedestrian system	Pedestrian network inventory, Individuals' trip details (with stop locations), Land use map (detailed types)
Infra & Env-Destination-Area	Percent in Proximity measurements	Census data, Intermodal facility location

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Infra & Env-Destination-Area	Possible capacity addition within ROW	Roadway Network Inventory, Roadway Geometry, Arbor Inventory
Infra & Env-Destination-Area	Residence proximity	Number of residents (parcel), Transit service network and route schedule
Infra & Env-Destination-Area	Transit Accessibility	Census data, Pedestrian network inventory, Transit service network and route schedule
Infra & Env-Destination-Area	Transit convenience/Stop accessibility	Individuals' trip details (with stop locations), Transit service network and route schedule
Infra & Env-Destination-Area	Work accessibility Index	Pedestrian network inventory, Roadway Network Inventory, Land use map (detailed types), Number of employees (parcel)
Infra & Env-Destination-Network	Average walking distance between land use pairs	Pedestrian network inventory, Land use map (detailed types)
Infra & Env-Destination-Network	Bike/pedestrian accessibility	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory
Infra & Env-Destination-Network	Destination Accessibility	Roadway Network Inventory, Land use map (detailed types), Number of employees (parcel), Number of residents (parcel)
Infra & Env-Destination-Network	Multiple Route Choices	Roadway Network Inventory
Infra & Env-Destination-Network	Residential Accessibility	Roadway Network Inventory, Land use map (detailed types), Number of employees (parcel), Number of residents (parcel)
Infra & Env-Destination-Network	Spacing between Village Centers	Land use map (detailed types)
Infra & Env-Diversity	Core Land Use	Land use map (detailed types)
Infra & Env-Diversity	Jobs/housing balance	Land use map (detailed types), Number of employees (parcel), Number of residents (parcel)
Infra & Env-Diversity	Land Consumption	Census data, Land use map (detailed types)
Infra & Env-Diversity	Land use balance	Land use map (detailed types)
Infra & Env-Diversity	Land use ratios/mix	Land use map (detailed types)
Infra & Env-Diversity	Land use separation	Bicycle network inventory/Geometry/Parking, Pedestrian network inventory, Roadway Network Inventory, Land use map (detailed types), Transit service network and route schedule
Infra & Env-Diversity	Land Use within Transit Supportive Area	Land use map (detailed types), Transit service network and route schedule
Infra & Env-Diversity	Land Use within Village Center	Land use map (detailed types)
Infra & Env-Diversity	Minimum thresholds of land use intensity	Land use map (detailed types), Number of employees (parcel), Number of residents (parcel)
Infra & Env-Diversity	Nearby Neighborhood Assets	Pedestrian network inventory, Project Site Plan, Land use map (detailed types)
Infra & Env-Diversity	Significant Land Uses	Land use map (detailed types)
Infra & Env-Diversity	Smart Growth Index	Roadway Network Inventory, Land use map (detailed types), Number of employees (parcel), Number of residents (parcel), Transit service network and route schedule
Infra & Env-Diversity	Sprawl Index (Ewing et al., 2002)	Land use map (detailed types)

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Infra & Env-Diversity	Sprawl Index (Galster et al., 2001)	Land use map (detailed types)
Infra & Env-Diversity	Transportation-Efficient Land Use Mapping Index Model	Pedestrian network inventory, Land use map (detailed types), Transit ridership by stops
Infra & Env-Diversity	Variation of agricultural of green fields	Land use map (detailed types)
Safety-History	Annual severe crashes	Roadway network, Vehicle crash records
Safety-History	Bike/Pedestrian injuries/fatalities	Bicycle network, Number of injuries/fatalities (Bike, Pedestrian), Sidewalk (or walk) path
Safety-History	Crash statistics/locations	Roadway network, Vehicle crash records
Safety-History	Traffic fatalities	Vehicle crash records, Vehicle miles of travel (& projected)
Safety-History	Transit accident rate	Vehicle crash records, Vehicle miles of travel (& projected)
Safety-History	Transit related Crime rate	Number of transit crimes by location, Transit network
Safety-History	Transit vandalism incidents	Number of transit vandalism incidents
Safety-History	Vehicle accident rate	Roadway network, Vehicle crash records
Safety-Risk management	Average clearance times for major incidents	Incident clearance times
Safety-Risk management	Percent of network that is "Effective"	Roadway Network Inventory
Safety-Risk management	Percent vehicle with safety devices	Number of vehicle fleets (& with safety devices)
Safety-Risk management	Ratio of police officers to transit vehicles	Transit fleet inventory, Number of police officers by location
Safety-Risk management	Speed suitability	Posted speed limit, Spot speed
Sustainability-Ecological	Attainment of ambient air quality standards	Classification for NAAQS eight-hour ozone standards ozone precursor emissions
Sustainability-Ecological	Daily CO2 emissions	Emission rates, Operating speeds, Peak and off-peak volumes
Sustainability-Ecological	Daily NOx, CO, and VOC emissions	Emission rates, Operating speeds, Peak and off-peak volumes
Sustainability-Ecological	Impact on wildlife habitat	Wildlife habitat preservation location map, Roadway network
Sustainability-Ecological	Noise pollution	Noise data by location
Sustainability-Ecological	Water runoff	Water flow maps, Roadway network
Sustainability-Fiscal	Additional Fuel Tax	Fuel tax composition
Sustainability-Fiscal	Benefit cost ratio	Project expenditures, Project benefits
Sustainability-Fiscal	Capital funding for bike/Pedestrian facilities	Project capital costs and sources for bike/Pedestrian
Sustainability-Fiscal	Consumption Based Mobility Fee	Vehicle miles of travel (& projected), Cost per vehicle mile of travel, Land use maps
Sustainability-Fiscal	Cost recovery from alternate sources	Annual operating and maintenance costs and sources, Project capital costs and sources
Sustainability-Fiscal	Improvements Based Mobility Fee	Vehicle miles of travel (& projected), Cost of mobility plan, Gas tax revenue
Sustainability-Fiscal	Parking pricing	Parking fee, Parking locations

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Sustainability-Fiscal	Variable fees based on LOS	Vehicle miles of travel (& projected), LOS based on HCM 2010, Trip generation rate
Sustainability-Fiscal	VMT-based Impact fee	Dwelling unit size, Number of occupants, Vehicle miles of travel (& projected)
Sustainability-Fiscal	VMT by race	Free flow speed (or posted speed limit), Travel time by time of day, Demographic data
Sustainability-Social	Commute Cost	Commute cost, Land use maps
Sustainability-Social	Distribution of benefit by income group	Time reduction benefits, Traveler's welfare by transit, Land use maps, Household income
Sustainability-Social	Equitable distribution of accessibility	Destination accessibility, Land use maps
Sustainability-Social	Fee charged for employee parking spaces	Parking fee options by different user
Sustainability-Social	Mode share by income group	Calibrated Regional Travel Demand Model, Mode split percentage, Demographic data by census track
Sustainability-Social	Mode share by race	Calibrated Regional Travel Demand Model, Mode split percentage, Demographic data by census track
Sustainability-Social	TDM effectiveness based on TRIMMS model	Social benefit changes
Sustainability-Social	Transit values	Costs of using transit
Sustainability-Social	Transportation Affordability	Land use maps, Household transportation costs (vehicle purchases, fuel costs, tolls, transit fares and etc.), Household income
Sustainability-Social	Transportation Utility Fee (TUF)	Land use maps, Number of employments, Number of residences, Regional transportation expenditures, Trip generation rate
Sustainability-Social	Travel costs by income group	Calibrated Regional Travel Demand Model, Demographic data by census track
Sustainability-Social	Travel costs by race	Calibrated Regional Travel Demand Model, Demographic data by census track
Sustainability-Social	VMT by income group	Free flow speed (or posted speed limit), Travel time by time of day, Demographic data
Sustainability-Social	Walk to transit by income group	Calibrated Regional Travel Demand Model, Demographic data by census track
Sustainability-Social	Walk to transit by race	Calibrated Regional Travel Demand Model, Demographic data by census track
User perception	Bicycle LOS (FDOT)	Bicycle network, Sidewalk (or walk) path, User perception survey data (bicycle environment)
User perception	LOS based on traveler perception	LOS based on HCM 2010, LOS user perception survey
User perception	Pedestrian Friendliness	Pedestrian survey data (walking environment)
User perception	Pedestrian LOS (FDOT)	Sidewalk (or walk) path, User perception survey data (pedestrian environment)
User perception	Perception of Transit safety	Transit rider survey data (cleanliness, comfort, information, reliability, safety)
User perception	Transit comfort	Transit rider survey data (cleanliness, comfort, information, reliability, safety)
User perception	Transit complaint rate	Transit complaint records
User perception	Transit condition of vehicles and facilities	Transit rider survey data (cleanliness, comfort, information, reliability, safety)

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
User perception	Transit customer loyalty	Customer survey data for overall satisfaction, likelihood of continued riding, and likelihood of recommending to others
User perception	Transit ease of using the system	Transit rider survey data (cleanliness, comfort, information, reliability, safety)
User perception	Transit Reliability/ Performance (Perceived)	Transit rider survey data (cleanliness, comfort, information, reliability, safety)
User perception	Transit service density	Transit service network and route schedule
Utilization-Auto-Quantity	Demand/capacity ratio	Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Flow rate (pc/h/ln), Roadway network
Utilization-Auto-Quantity	Districtwide Level of Service (LOS)/Quality of Service (QOS)	Highway LOS
Utilization-Auto-Quantity	Local traffic diversion	Roadway network, Vehicle volume by types
Utilization-Auto-Quantity	LOS based on HCM 2010	Average travel speed, Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Flow rate (pc/h/ln), Heavy vehicle percentage, Roadway network
Utilization-Auto-Quantity	Maximum Service Volume	Roadway capacity, Travel demand by time of day
Utilization-Auto-Quantity	Peak Hour LOS	Average travel speed, Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Flow rate (pc/h/ln), Heavy vehicle percentage, Roadway network
Utilization-Auto-Quantity	Percent of Capacity Consumed	Average travel speed, Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Flow rate (pc/h/ln), Heavy vehicle percentage, Roadway network
Utilization-Auto-Quantity	Percent of system heavily congested	Length of congested segments, Roadway network
Utilization-Auto-Quantity	v/C ratio	Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Vehicle volume by types
Utilization-Auto-Quantity	Vehicle Density	AADT /Adjusted Roadway Counts, Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Travel distance
Utilization-Auto-Quantity	Vehicle occupancy by land use	Vehicle occupancy by land use, Land use map (detailed types)
Utilization-Auto-Reliability	90th- or 95th percentile travel time	Travel time by time of day
Utilization-Auto-Reliability	Buffer index	Travel time by time of day
Utilization-Auto-Reliability	Percent of trips 'on time'	Travel time expected, Travel time by time of day
Utilization-Auto-Reliability	Population and employment centrality	Census data, Number of employees (parcel)
Utilization-Auto-Time	Average commute time	Travel time by time of day
Utilization-Auto-Time	Average Speed	Travel distance, Travel time by time of day
Utilization-Auto-Time	Average speed weighted by PMT	AADT /Adjusted Roadway Counts, Calibrated Regional Travel Demand Model, Travel distance, Travel time by time of day, Vehicle occupancy
Utilization-Auto-Time	Congestion Duration	Average travel speed, Flow rate (pc/h/ln), Travel time by time of day
Utilization-Auto-Time	Control delay	Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Signal timing plan , Vehicle volume by types
Utilization-Auto-Time	Highway Reliability	Average travel speed, Travel time by time of day

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Utilization-Auto-Time	Percent work trips within specific travel time	Land use map (detailed types), Number of work trips, Travel time by time of day
Utilization-Auto-Time	Time by trip purpose	Calibrated Regional Travel Demand Model
Utilization-Auto-Time	Total segment delay	Free flow speed (or posted speed limit), Travel time by time of day, Vehicle volume by types
Utilization-Auto-Time	Travel delay	Travel time by time of day
Utilization-Auto-Time	Travel distance index	Travel distance
Utilization-Auto-Time	Travel time	Actual travel rate (min/mile) (SOV, HOV, Transit), Travel distance, Vehicle occupancy, Vehicle volume by types
Utilization-Auto-Time	Travel Time-based LOS	Actual travel rate (min/mile) (SOV, HOV, Transit), Calibrated Regional Travel Demand Model, Free flow speed (or posted speed limit), Travel time by time of day
Utilization-Auto-Time	Travel time index	Expected travel time, Actual travel time
Utilization-Auto-Time	Vehicle hours of delay (VHD)	Free flow speed (or posted speed limit), Travel time by time of day
Utilization-Auto-Time	Vehicle hours traveled (VHT)	Calibrated Regional Travel Demand Model
Utilization-Auto-Time	Vehicle speed/VHD by mode	Free flow speed (or posted speed limit), Travel time by time of day
Utilization-Freight	Freight delay	Travel time by time of day
Utilization-Freight	Number of violation of weight restrictions	Number of violation of weight restrictions
Utilization-Freight	Overweight permits	Weight permits
Utilization-Freight	Truck miles traveled	AADT /Adjusted Roadway Counts, Heavy vehicle percentage, Travel distance
Utilization-Freight	Truck throughput efficiency	AADT /Adjusted Roadway Counts, Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Heavy vehicle percentage, Truck operational speed
Utilization-Multimodal	Auto/Demand response transit (DRT) travel time ratio	Travel time by time of day
Utilization-Multimodal	Auto/transit travel time ratio	Travel time by time of day
Utilization-Multimodal	Multimodal LOS	LOS by mode, Mode split percentage
Utilization-Multimodal	Safe Routes to School Program (SRTS) effectiveness	Roadway Network Inventory
Utilization-NonMotorized Modes	ATL per traveler	Calibrated Regional Travel Demand Model, Travel Surveys/vehicle logs, Roadway network
Utilization-NonMotorized Modes	Delay per traveler	Free flow speed (or posted speed limit), Travel time by time of day
Utilization-NonMotorized Modes	Door to door travel time	Travel time by time of day
Utilization-NonMotorized Modes	HCM-based Bicycle LOS	Bicycle network, Facility Geometry (Roadway, Bicycle, Pedestrian and/or Transit), Heavy vehicle percentage, Pavement condition of bicycle lane, Vehicle speed, Vehicle volume by types

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Utilization-NonMotorized Modes	Proportion of total PMT for non-SOVs	AADT /Adjusted Roadway Counts, Calibrated Regional Travel Demand Model, Trip length (by mode), Vehicle occupancy
Utilization-Transit-Occupancy	Load Factor	Seat capacity by vehicle type, Transit ridership by stop (& time), Transit route map/Schedule
Utilization-Transit-Occupancy	Passengers per transit vehicle mile	Transit ridership by stop (& time), Transit route map/Schedule
Utilization-Transit-Occupancy	Percent person-minutes served	Land use map (detailed types), Number of residences, Sidewalk (or walk) path network, Transit route map/Schedule
Utilization-Transit-Occupancy	Ridership	Transit ridership by stop (& time), Transit route map/Schedule
Utilization-Transit-Occupancy	Transit peak hour occupancy	Transit ridership by stop (& time), Transit route map/Schedule
Utilization-Transit-Operation	Average age of vehicle components	Vehicle fleet inventory, Component maintenance records, Vehicle operating records
Utilization-Transit-Operation	Average life of vehicle components	Vehicle fleet inventory, Component maintenance records, Vehicle operating records
Utilization-Transit-Operation	Fleet spare ratio	Vehicle Fleet Inventory/Amenities, Transit route map/Schedule
Utilization-Transit-Operation	Number of fare media sales outlets	Transit route and stop map, Presence of fare media sales outlets
Utilization-Transit-Operation	Number of transfers	Transit ridership by stop (& time)
Utilization-Transit-Operation	Road Calls	Transit fleet inventory, Number of emergency calls
Utilization-Transit-Operation	Transfer time	Transfer time
Utilization-Transit-Operation	Transfer time between modes	Transfer time
Utilization-Transit-Operation	Transit priority delay reductions	Signal timing plan
Utilization-Transit-Operation	Transit Productivity	Transit Financials, Transit ridership by stop (& time), Transit route map/Schedule
Utilization-Transit-Operation	Transit Reliability (Quantitative)	Travel Surveys/vehicle logs, Transit route map/Schedule
Utilization-Transit-Service	Average frequency	Transit service network and route schedule
Utilization-Transit-Service	Average headways	Transit service network and route schedule
Utilization-Transit-Service	DRT trips not served	Predicted/Served DRT trips
Utilization-Transit-Service	Fixed route missed trips	Transit ridership by stop (& time), Transit route map/Schedule
Utilization-Transit-Service	Hours of service	Transit service network and route schedule
Utilization-Transit-Service	Off-peak transit availability	Transit service network and route schedule
Utilization-Transit-Service	On time performance	Transit service network and route schedule, Transit trajectory records
Utilization-Transit-Service	Response Time for DRT	Waiting time for DRT
Utilization-Transit-Service	Transit type availability	Transit service network and route schedule
Utilization-Travel demand-Mode share	Average Vehicle Occupancy	Calibrated Regional Travel Demand Model, Travel Surveys/vehicle logs, Number of passengers by vehicle type, Vehicle volume by types
Utilization-Travel demand-Mode share	Bicycle and Pedestrian activity	Travel Surveys/vehicle logs, Number of bicycle trips, Number of pedestrian trips
Utilization-Travel demand-Mode share	Bicycle and Pedestrian mode share	Mode split percentage
Utilization-Travel demand-Mode share	Mode choice availability	Bicycle network, Transit route map/Schedule

Table C.1 Data Requirement (continuted)

Mobility Dimensions	Indicators	Data requirements
Utilization-Travel demand-Mode share	Mode Split	Calibrated Regional Travel Demand Model, Mode split percentage
Utilization-Travel demand-Mode share	Seat capacity/Person capacity	Seat capacity by vehicle type, Vehicle volume by types
Utilization-Travel demand-Mode share	SOV mode split	Calibrated Regional Travel Demand Model, Mode split percentage, Roadway network
Utilization-Travel demand-Trip gen.	Community Capture	Calibrated Regional Travel Demand Model, Trip generation rate
Utilization-Travel demand-Trip gen.	Internal Capture	Calibrated Regional Travel Demand Model, Trip generation rate
Utilization-Travel demand-Trip gen.	Mean daily trips per household	Calibrated Regional Travel Demand Model, Travel Surveys/vehicle logs
Utilization-Travel demand-Trip gen.	Mean daily vehicle trips per household	Calibrated Regional Travel Demand Model, Travel Surveys/vehicle logs
Utilization-Travel demand-Trip gen.	Person miles traveled (PMT)	Calibrated Regional Travel Demand Model, Trip length (by mode), Vehicle occupancy
Utilization-Travel demand-Trip gen.	Planning time index (PTI)	Free flow speed (or posted speed limit), Travel time by time of day
Utilization-Travel demand-Trip gen.	Trip length by mode	Calibrated Regional Travel Demand Model, Trip length (by mode)
Utilization-Travel demand-Trip gen.	VMT (by mode)	Calibrated Regional Travel Demand Model, Roadway network, Trip length (by mode)
Utilization-Travel demand-Trip gen.	VMT per capita	Calibrated Regional Travel Demand Model, Census data, Roadway network, Trip length (by mode)

APPENDIX D: CUBE Scripts

```
; Script for program MATRIX in file "C:\FSUTMS\D5\CFRPMV50\CUBE\VMMAT00A.S"
; Do not change filenames or add or remove FILEI/FILEO statements using an editor. Use
Cube/Application Manager.
RUN PGM=MATRIX PRNFILE="C:\FSUTMS\D5\CFRPMV50\CUBE\VMMAT00A.PRN"
FILEO RECO[1] = "{SCENARIO_DIR}\Output\VMT_{SCENARIO_CODE}.DBF", FIELDS=TAZ, VMT, VHT,
ATL, MPCAP, WKACC
;FILEO MATO = "{SCENARIO_DIR}\OUTPUT\VMT_{SCENARIO_CODE}.MAT"
;  MO=1-2, NAME=VMT,VHT
FILEI ZDATI[2] = "{SCENARIO_DIR}\Input\ZDATA2_{YEAR}{ALT}.DBF",
 Z=TAZ
FILEI ZDATI[1] = "{SCENARIO_DIR}\INPUT\ZDATA1_{YEAR}{ALT}.DBF",
 Z=TAZ
FILEI MATI[2] = "{SCENARIO_DIR}\output\HTTAB.{ALT}{YEAR}"
FILEI MATI[1] = "{SCENARIO_DIR}\Output\CONGSKIM_{ALT}{Year}.MAT"
;
; The MATRIX module does not have any explicit phases.  The module does run within an
implied ILOOP
; where I is the origin zones.  All user statements in the module are processed once
for each origin.
; Matrix computation (MW[#]=) are solved for all values of J for each I.  Thus for a
given origin zone I
; the values for all destination zones J are automatically computed.  The user can
control the computations
; at each J by using a JLOOP.
;
TAZ=I; PASS ALONG TAZ NUMBER TO OUTPUT FILE
FILLMW MW[11]=MI.2.1(4);  CREATE AND FILL 4 NEW MATRICES (IX1) FOR THE 4 TRIP PURPOSES
MW[15]=MW[11]+MW[12]+MW[13]+MW[14]; SUM THESE MATRICES TO GET TOTAL TRIPS (IXJ)
RESPOP=ZI.1.SFPOP[I]+ZI.1.MFPOP[I]+ZI.1.HMPOP[I]; SUM POPULATION FROM ZDATA (IX1)
TOTPOP=ZI.1.SFPOP[I]+ZI.1.MFPOP[I]+ZI.1.HMPOP[I]+ZI.2.TOTEMP[I]+ZI.2.SCHENRL[I]; SUM
POPULATION AND EMPLOYMENT (IX1)
;
;*******************************************
;MULTIPLY CONGESTED SKIMS BY THE TRIPS
;*******************************************
MW[1]=MI.1.TIME1 * MW[15] ; MULTIPLY TIME(I,J) WITH TRIPS (I,J), OUTPUT MATRIX IS (I,J)
;MW[1]=(MI.1.TIME1+MI.1.TERMTIME) * MW[15]; USE THIS IF YOU WANT TO INCLUDE THE
TERIMINAL TIME IN YOUR VHT CALCULATIONS
MW[2]=MI.1.DISTANCE * MW[15]; MULTIPLY DISTANCE (I,J) WITH TRIPS (I,J), OUTPUT MATRIX
IS (I,J)
;
;********************************************
;FINAL VARIABLE CALCULATIONS:
;********************************************
;
```

;VMT CALCULATION

```
VMT=ROWSUM(2); SUM ACROSS THE ROW OF DISTANCE*TRIPS TO GET VMT TOTALS FOR EACH ZONE
;
```

;VHT CALCULATION

```
VHT=ROWSUM(1)/60; SUM ACROSS THE ROW OF TIME*TRIPS TO GET VHT TOTALS FOR EACH ZONE
;
;AVERAGE VMT CALCULATION
IF (ROWSUM(15)=0); CHECK FOR ZERO TRIPS IN THE ZONE (NO DIVIDING BY ZERO!!)
ATL=0
ELSE
ATL=VMT / ROWSUM(15); VMT/TOTAL TRIPS
ENDIF
;
```

;VMT PER CAPITA CALCULATION

```
IF (TOTPOP=0); CHECK FOR ZERO POPULATION IN THE ZONE (STILL NO DIVIDING BY ZERO!!)
MPCAP=0
```

```
ELSE
MPCAP=VMT/TOTPOP; VMT PER CAPITA
ENDIF
;
```

;WORK ACCESSIBILITY CALCULATION

```
MW[21]=MI.1.TIME1; PULL OUT A MATRIX WITH ONLY THE TIME SKIMS
JLOOP; LOOPS ON EACH J CALCULATION
EMPPOP=ZI.2.TOTEMP[J]+ZI.2.SCHENRL[J]; SUM EMPLOYMENT FROM ZDATA (1XJ)
IF (I=J) ; CHECK FOR ZERO TIME
MW[22]=0 ; IF THE VALUE ISN'T SET TO ZERO, THE CALCULATION WILL FAIL BECAUSE YOU ARE
PERFORMING A NEGATIVE SQUARE ON A ZERO
ELSE
MW[22]=(POW(MW[21],(-2)))*EMPPOP; GRAVITY EQUATION FOR WORK ACCESSIBILITY
ENDIF
ENDJLOOP
WKACC=ROWSUM(22); SUM OF ACCESSIBILITY FOR ALL ACCESSED ZONES
;
WRITE RECO=1; WRITE TO OUTPUT DATABASE
;
;THIS SCRIPT DOES NOT INCLUDE TERMINAL TIME AS A PART OF THE VHT CALCULATION, AND IT
PROBABLY SHOULDNT BECAUSE THE VEHICLE
;TECHNICALLY ISN'T TRAVELING DURING THAT TIME.  STILL, IF YOU WANT TO INCLUDE TERMINAL
TIME, TAKE THE ";" OUT OF THE
;BEGINNING OF LINE 23 AND PLACE IT AT THE BEGINNING OF LINE 22.
;
ENDRUN
```