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1998 Level Of Service Handbook

Florida Department of Transportation
Systems Planning Office

EXECUTIVE SUMMARY

This handbook and its accompanying computer software is to be used by engineers, planners, and decision-makers in the development and review of roadway level of service (LOS). LOS is a qualitative assessment of road users' perceptions of roadway quality of flow and is represented by the letters "A" through "F", with "A" generally representing the most favorable conditions and "F" representing the least favorable. Measures of effectiveness such as average travel speed or volume to capacity ratio have been developed to approximate these qualitative representations quantitatively.

This handbook

- identifies Florida's Level of Service Standards by area type, facility type, and number of lanes,
- uses methodologies established in the 1997 Highway Capacity Manual (HCM) Update and Florida traffic, roadway, and signalization data, for broad planning applications and general LOS estimations, and
- provides methodologies in easy-to-use computer models that allow the analyst to use locally-specific input data for detailed facility planning.

A major element in the establishment of Florida's LOS standards is the division of the State Highway System into two basic elements: the Florida Intrastate Highway System and other state roads. The Florida Intrastate Highway System was introduced into state law in 1990 and consists of roadways which perform a mobility function that differs from local travel and property access by emphasizing high speed and accommodating higher service volumes. In general, roads on the Florida Intrastate Highway System are subject to a higher quality LOS standard than other roads, reflecting the importance of these roads to the state.

Equally important as adopting LOS standards is having professionally accepted measurement techniques. For transportation planning, the HCM's techniques help meet this need of measurement. Nationwide, the FDOT is the leader in developing generalized LOS tables and planning computer models based on the HCM. Unlike operational and design analyses, planning techniques are often based on forecasts of average annual daily traffic, and on assumed or planned traffic, roadway, and signalization control conditions. Generalized LOS tables have been developed and updated to reflect changes made to the HCM over the years. Effective March 1, 1999, the FDOT will not accept analyses using generalized tables from earlier editions of this handbook.

The values shown in the generalized tables are based on the definitions and measurement techniques of the 1997 Highway Capacity Manual Update. A major concept in the HCM is that signalization characteristics (*e.g.,* number of signals per mile, "green" time) are equally important as roadway characteristics (*e.g.,* number of roadway lanes) in determining arterial level of service. The tables reflect this emphasis. The tables are also based on actual Florida traffic, roadway, and signalization data, making the tables applicable throughout the state. However, it is recognized that traffic characteristics vary by area and facility. Thus, unlike the LOS standards, the generalized tables are not statewide standards; rather, they are guidelines on the measurement of highway level of service.

Florida's level of service standards, generalized tables, and computer models represent the state-of-the-art in highway planning applications. Together, they implement growth management concepts. In addition to containing FDOT's level of service standards, this handbook includes guidelines on determining roadways parallel to exclusive transit facilities, constrained roadways and backlogged roadways, and FDOT's maximum through lane standards.

Users of this document who are interested in a specific aspect of level of service are encouraged to glance through the table of contents or glossary for the topic. For a more complete understanding of the standards, generalized tables, and computer models, the entire document should be reviewed.

Implementation Date

This handbook may be implemented immediately. FDOT will not accept analyses employing superseded methods, techniques, volumes, or generalized tables from previous versions of this publication after March 1, 1999.

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INTRODUCTION

1.1

THE LOS CONCEPT

The roadway level of service (LOS) concept is applied nationwide as a qualitative assessment of the road user's perception of the quality of flow. The LOS is represented by one of the letters "A" through "F", with "A" generally representing the most favorable driving conditions and "F" representing the least favorable. The LOS reflects the quality of flow as measured by a scale of driver satisfaction. The definitions and measures of LOS reflect a national consensus of driver quality of flow.

Measures of effectiveness such as average travel speed or volume to capacity ratio have been developed to approximate these qualitative representations quantitatively. Different measures of effectiveness are used for different types of roadways because the user's perception of quality of flow varies by road type.

LOS Standards are used in project prioritization and land-use planning.

The Florida Department of Transportation (FDOT) has adopted statewide minimum acceptable operating LOS standards for the State Highway System. These standards, established in Chapter 14-94, Florida Administrative Code, (included as Appendix 1 of this handbook) were intended as a method of measuring highway performance. They are intended as 1) prioritization tools for the FDOT and 2) a reasonable set of criteria for use by local governments and the DCA to assist them in their land-use planning efforts.

Equally important as adopting LOS standards is having professionally accepted measurement techniques. The techniques for computing highway capacity are described in detail in the HCM, and have been implemented in the FDOT LOS software and other various software products. Since the HCM is neither designed nor intended to serve as a legal standard for highway planning or construction, local governing bodies need to establish those standards for roadways within their jurisdiction. This was done at the state level when FDOT adopted its LOS standards for the Florida Intrastate Highway System (FIHS). Local governments establish standards for

the remainder of the State Highway System (SHS) and non-State roads in their respective comprehensive plans.

For transportation planning, the HCM's techniques help meet this need of measurement. Nationwide, the FDOT is the leader in developing generalized LOS tables and planning models based on the HCM. Unlike operational and design analyses, planning techniques are often based on forecasts of average annual daily traffic (AADT), and on assumed or planned traffic, roadway, and signalization control conditions. Generalized LOS tables have been developed and updated to reflect changes made to the HCM over the years.

One of the most important, although subtle, components in the LOS standards adopted by FDOT was the use of the 100th highest hour (K_{100}) instead of the 30th highest hour (K_{30}) of the year as the basic time reference. The 100th highest hour approximates a typical peak hour in a developed area's peak season. It is believed this hour better typifies driver perception of LOS than the design period of the 30th highest hour. The difference is extremely important because it results in approximately 5 to 35 percent higher average annual daily traffic volumes in urbanized and rural areas, respectively, compared to previous standards which used the 30th highest hour.

Another major element was the division of the State Highway System into two basic elements: the Florida Intrastate Highway System and other state roads. The Florida Intrastate Highway System was introduced into state law in 1990 and consists of roadways which perform a mobility function that transcends local travel and property access. In general, roads on the Florida Intrastate Highway System are subject to a higher quality LOS standard than other roads, reflecting the importance of these roads to the state. Local governments are required to adopt FDOT's LOS standards for FIHS facilities within their jurisdiction. In developing State LOS standards applicable to the development of local government comprehensive plans, FDOT recognized the importance of local government participation and local desires.

1.2

MAJOR REVISIONS IN THIS EDITION OF THE HANDBOOK

A number of revisions have been made to this handbook compared to the 1995 edition. These revisions resulted from:

- the 1997 HCM Update;
- additional data refinement on Florida's traffic characteristics;
- improvement of software that facilitates the LOS computations;
- formatting changes to better facilitate electronic distribution; and
- comments and suggestions resulting from user experience with previous editions.

The revisions to this edition are evident in modifications to the narrative material and Generalized Tables, and the introduction of new software reflecting the improvements in the computational methodology. Many of the changes in this edition are the result of research efforts documented in the 1997 HCM Update.

The changes in the computational methodology presented in this edition will naturally change the numerical results of the LOS computations compared to previous revisions. For the most part, the numerical changes will be minor. There is no general trend towards more optimistic or pessimistic LOS assessments inherent in the revisions. In all cases, changes in either direction result from improved computational techniques prescribed by revisions to the HCM.

A brief description of these changes is presented in this section with references to the detailed description of those revisions. The following discussion assumes that the reader is familiar with previous editions.

Changes in Manual Structure

For the first time, the Florida Level of Service Handbook has been reformatted to take advantage of the benefits of electronic multi-media. Although this edition does not depart significantly from the linear book format, some differences exist that users should find welcome.

Users of the electronic version will be able to make use of the extensive hypertext linking format. By simply using the mouse to click on blue colored text, analysts will be automatically transferred to the portion of text dealing with that particular topic. Further, by using the "Search" function, readers can instantly locate all occurrences of any given word throughout the entire document.

Each chapter of this manual has been designed to stand alone; thus, there is some redundancy in the sections. Users of this document who are interested in a specific aspect of level of service are encouraged to glance through the table of contents for the topic. For a more complete understanding of the standards, tables and models, the entire document should be reviewed. The chapter structure is as follows:

Chapter 1 - **Introduction** provides background information and an overview of the manual and the changes reflected in this edition.

Chapter 2 - **Florida's Planning LOS Standards** contains a discussion of FDOT's LOS standards for state roads. The substance of this chapter has not changed much from previous editions.

Chapter 3 - **Methodology for Calculating LOS** contains an overall description and review of the methodology for calculating roadway LOS. This chapter provides the analyst with an understanding of the various methods and guidelines on selecting the most appropriate tool for the particular analysis need.

Chapter 4 - **Data Requirements** describes the data requirements needed to calculate LOS using the hierarchy of analysis tools, from the Generalized Tables to the operational analysis software.

Chapter 5 - **Generalized Tables - Procedures and Applications Guidelines** discusses the use of the Generalized Tables and provides guidelines and procedures for using them. Sample problems for using the Urbanized, Transitioning/Urban, and Rural Tables are provided.

Chapter 6 - **Table Generating Spreadsheets - Procedures and Applications Guidelines** discusses the use of the spreadsheet generating programs (such as ART_TAB) and provides guidelines and procedures for running the programs. Sample problems are provided for each of the programs.

Chapter 7 - **LOS Calculation Software - Procedures and Applications Guidelines** provides guidelines and procedures for running the level of service calculation program, ART_PLAN. Sample problems are presented.

Chapter 8 - **Sources for Additional Information** - provides guidance on obtaining additional information

New Running Speeds

Based on recent research commissioned by the FDOT, the arterial segment running times used in this manual and the accompanying planning computer models depart from those suggested for use in Table 11-4 of the HCM. Unlike those in HCM Table 11-4, the running speeds used in this manual and software were derived using an equation including traffic volume as a variable. The FDOT running speeds also better reflect *through* vehicle running speeds, as opposed to the total mix of through and turning vehicles. The only other factors which enter into determining the running speeds are free flow speed, average segment length and arterial classification.

Method for Factoring Add-on/Drop-off Lanes

When a lane is added upstream of an intersection and dropped downstream of the intersection, lane utilization is not uniform. The length of the taper downstream affects the number of vehicles that will use the added lane. The previous edition of this manual introduced a factoring technique based on a 1:3 length ratio to estimate capacity enhancement from expanded intersections. Additional research has revised the previous factor significantly. Analyses should no longer be made based on the previous 1:3 length ratio and should instead use the technique described in Section 4.6.

1.3

Congestion Management System / Mobility Management Process

A great deal of effort has been taken in the State to develop the Congestion Management System/Mobility Management Process (CMS/MMP). The following provides an overview of the requirements and the correlation with level of service analysis.

FHWA/FTA's rule on management and monitoring systems requires "performance measures" as a component of a CMS. Specifically, "[p]arameters shall be defined that will provide a measure of the extent of congestion and permit the evaluation of the effectiveness of congestion reduction and mobility enhancement strategies for the movement of people and goods." Furthermore, performance measures are to be established in consultation with the major operators of major modes of transportation in the coverage area.

Throughout Florida, the setting of highway level of service standards and determining compatibility with those standards by appropriate measurement techniques is generally accepted because of Florida's growth management laws. To a lesser extent, transit performance measures have also been adopted.

In the development of Florida's CMS, the Florida MMP Task Team chose to emphasize "mobility" instead of "traffic congestion". "Mobility" may be defined as the ability to complete desired trips. Implied in this term are "people movement", "accessibility", "modal choice", "reasonable speeds or travel time", "reasonable costs to society", and "making or satisfying the trip objective". By selecting "mobility" with an emphasis on modal choice over "congestion" (of which most people primarily think in terms of automobile traffic), performance measures must go beyond highway level of service measures and probably beyond transit performance measures.

There is no single measure of mobility.

Upon the recommendation of Florida's MMP Task Team, FDOT concurred that no single performance measure is robust enough to fully measure congestion or address mobility for multiple modes of transportation. A series of modal performance measures are considered superior to a single performance measure. At a minimum, each MMP/CMS in Florida must include both highway and transit performance measures. In metropolitan areas, each MPO must develop appropriate performance measures based on the concept of improving mobility.

A major feature of Florida's MMP Work Plan is the recommendation to use a tiered process to evaluate corridors. Consistent with Florida's MMP Task Team overall position that the MMP/CMS be the implementation strategy of the long-range plans, MMP/CMS efforts should be concentrated at the corridor/subarea level on actions that will improve mobility. Highway level of service was deemed an adequate, convenient, and readily-understood indicator of where congestion exists and therefore, was suggested as the triggering device to determine where highway congestion exists. Using level of service standards and appropriate measurement techniques, analysts can focus on current problem areas and areas likely to be congested in the near future. By working with Florida's Generalized Level of Service Tables, an area's road network can quickly and efficiently be analyzed. Roadways identified as congested or "near" congestion can be analyzed further with highway planning software presented in this manual and more specific roadway data.

Notes:

2

FLORIDA'S PLANNING LEVEL OF SERVICE STANDARDS

FDOT's minimum acceptable operating level of service standards for the State Highway System were adopted by Administrative Rule in 1992. The rule chapter mutually supports the Department of Community Affairs Rule 9J-5 on Minimum Criteria for Review of Local Government Comprehensive Plans and Determination of Compliance. They replaced the standards appearing in FDOT's 1989 Level of Service Manual. The standards are contained in Table 2-1 with the rule chapter appearing in Appendix A.

What is the rationale behind LOS standards?

The standards include the following major concepts:

- urban infill as a desirable objective,
- the presence of infrastructure concurrent with the impact of development,
- recognition of the interaction between highways and exclusive transit systems serving commuters,
- local flexibility in setting standards in and around Transportation Concurrency Management Areas and Transportation Concurrency Exception Areas,
- the direct correlation between urban size and acceptance of some highway congestion as a tradeoff for other urban amenities,
- the different roles (*i.e.*, mobility versus access) provided by state facilities (*i.e.*, Florida Intrastate Highway System versus other state roads),
- recognition that many state facilities are constrained because they cannot be expanded because of physical or policy barriers, and
- recognition that the operation of many state facilities do not meet the standards (*e.g.*, are backlogged) and are not programmed for improvement in FDOT's 5-Year Work Program.

The area and roadway types in the level of service standards match well with FDOT's Generalized Level of Service Tables appearing in Section 5 of this manual; however, subtleties exist on delineation of areas, roadway characteristics, signalization characteristics, and maintaining conditions on constrained and backlogged facilities. Section 5.5 deals with area types in the Generalized Level of Service Tables. Chapter 4 (Data Requirements) discusses traffic, roadway and signalization characteristics. Assumptions and guidelines for the use of the tables are provided in Chapter 5. Constrained and backlogged facilities are addressed in detail in Appendixes C and D, respectively.

The indicated levels of service designate the lowest quality operating conditions acceptable for the 100th highest volume hour of the year from the present through the planning horizon, generally up to 20 years. The 100th highest hour approximates the typical weekday peak hour during the peak season in developed areas. Thus, it can be thought of as the typical drive during "rush" hour in an area's peak season.

2.1 APPLICABILITY OF STANDARDS

The standards are to be applied to FDOT's planning activities. The level of service standards in this manual are based on the 100th highest hour for planning purposes. The 30th highest hour (design hour) remains effective for design purposes and must be used in the review of new or modified interchanges on limited access facilities. The standards are statewide minimums, not to be lowered; however, a local government may adopt alternative level of service standards for non-FIHS facilities in its comprehensive plan pursuant to §163.3180(10), F.S. Additional information can be found in Section 3.7.

Table 2 -1
STATEWIDE MINIMUM LEVEL OF SERVICE STANDARDS FOR THE STATE HIGHWAY SYSTEM[1]

	Rural Areas[2]	Transitioning Urbanized Areas[3], Urban Areas[4], or Communities[5]	Urbanized Areas[6] under 500,000	Urbanized Areas over 500,000	Roadways Parallel to Exclusive Transit Facilities[7]	Inside Transportation Concurrency Management Areas[8]	Constrained[9] and Backlogged[10] Roadways
INTRASTATE[11]							
Limited Access Highway (Freeway)[12]	B	C	C(D)	D(E)	D(E)	D(E)	Maintain[15]
Controlled Access Highway[13]	B	C	C	D	E	E	Maintain
OTHER STATE ROADS[14]							
Other Multilane	B	C	D	D	E	*[16]	Maintain
Two-Lane	C	C	D	D	E	*	Maintain

Level of service standards inside of parentheses apply to general use lanes only when exclusive through lanes exist.

1. The indicated **levels of service** designate lowest quality operating conditions for the 100th highest volume hour of the year in the predominant traffic flow direction from the present through a 20-year planning horizon. The 100th highest hour approximates the typical peak hour during the peak season. Definitions and measurement criteria used for minimum level of service standards are based on the most recent updates of the Transportation Research Board Highway Capacity Manual "Special Report 209". All level of service evaluations are to be based on "Special Report 209", or a methodology which has been accepted by FDOT as having comparable reliability.

2. **Rural areas** are areas not included in a transportation concurrency management area, an urbanized area, a transitioning urbanized area, an urban area or a community.

3. **Transitioning urbanized areas** are the areas outside urbanized areas that are planned to be included within the urbanized areas within the next 20 years based primarily on the U.S. Bureau of Census urbanized criteria of a population density of at least 1,000 people per square mile.

4. **Urban Areas** are places with a population of at least 5,000 and are not included in urbanized areas. The applicable boundary encompasses the 1990 urban area as well as the surrounding geographical area as agreed upon by FDOT, local government, and Federal Highway Administration (FHWA). The boundaries are commonly called FHWA Urban Area Boundaries and include areas expected to have medium density development before the next decennial census.

5. **Communities** are incorporated places outside urban or urbanized areas, or unincorporated developed areas having 500 population or more identified by local governments in their local government comprehensive plans and located outside of urban or urbanized areas.

6. **Urbanized areas** are the 1990 urbanized areas designated by the U.S. Bureau of Census as well as the surrounding geographical areas as agreed upon by the FDOT, Metropolitan Planning Organization (MPO), and Federal Highway Administration (FHWA), commonly called FHWA Urbanized Area Boundaries. The over or under 500,000 classifications distinguish urbanized areas with a population over or under 500,000 based on the 1990 U.S. Census.

7. **Roadways parallel to exclusive transit facilities** are roads generally parallel to and within one-half mile of a physically separated rail or roadway lane reserved for multi-passenger use by rail cars or buses serving large volumes of home/work trips during peak travel hours. Exclusive transit facilities do not include downtown people movers, or high occupancy vehicle lanes unless physically separated from other travel lanes.

8. **Transportation Concurrency Management Areas** are geographically compact areas designated in local government comprehensive plans where intensive development exists or is planned in a manner that will ensure an adequate level of mobility and further the achievement of identified important state planning goals and policies, including discouraging the proliferation of urban sprawl, encouraging the revitalization of existing downtowns and designated redevelopment areas, protecting natural resources, protecting historic resources, maximizing the efficient use of existing public facilities, and promoting public transit, bicycling, walking and other alternatives to the single occupant automobile. Transportation concurrency management areas may be established in a comprehensive plan in accordance with Rule 9J-5.0057, Florida Administrative Code.

9. **Constrained roadways** are roads on the State Highway System which FDOT has determined will not be expanded by the addition of two or more through lanes because of physical, environmental or policy constraints. Physical constraints primarily occur when intensive land use development is immediately adjacent to roads, thus making expansion costs prohibitive. Environmental and policy constraints primarily occur when decisions are made not to expand a road based on environmental, historical, archaeological, aesthetic or social impact considerations.

10. **Backlogged roadways** are roads on the State Highway System operating at a level of service below the minimum level of service standards, not programmed for construction in the first three years of FDOT's adopted work program or the five year schedule of improvements contained in a local government's capital improvements element, and not constrained.

11. **Intrastate** means the Florida Intrastate Highway System (FIHS) which comprises a statewide network of limited and controlled access highways. The primary function of the system is for high speed and high volume traffic movements within the state. Access to abutting land is subordinate to this function and such access must be prohibited or highly regulated. Highways included as part of this system are designated in the Florida Transportation Plan. **General use lanes** are intrastate roadway lanes not exclusively designated for long distance high speed travel. In urbanized areas general use lanes include high occupancy vehicle lanes not physically separated from other travel lanes. **Exclusive through lanes** are roadway lanes exclusively designated for intrastate travel, which are physically separated from general use lanes and to which access is highly regulated. These lanes may be used for high occupancy vehicles and express buses during peak hours if the level of service standards can be maintained.

12. **Limited access highways (freeways)** are multilane divided highways having a minimum of two lanes for exclusive use of traffic in each direction and full control of ingress and egress; this includes freeways and all fully controlled access roadways.

13. **Controlled access highways** are non-limited access arterial facilities where access connections, median openings and traffic signals are highly regulated. The standards shown are the ultimate standards to be achieved for controlled access facilities on the Florida Intrastate Highway System (FIHS) within a 20 year period. For rural two-lane FIHS facilities, the standard is "C" until such time as the facility is improved to four or more lanes when the "B" standard would apply. Signalized intersections are to be minimized on these facilities within 20 years making an uninterrupted flow standard generally applicable. Controlled access facilities on the FIHS currently not meeting the ultimate standards shall be allowed to remain on the FIHS with a "maintain" status.

14. **Other state roads** are roads on the State Highway System which are not part of the Florida Intrastate Highway System.

15. **Maintain** means continuing operating conditions at a level such that significant degradation does not occur based on conditions existing at the time of local government comprehensive plan adoption. For roadways in rural areas, transitioning urbanized areas, urban areas or communities, significant degradation means (1) an increase in average annual daily traffic volume of 5 percent above the maximum service volume, or (2) a reduction in operating speed for the peak direction in the 100th highest hour of 5 percent below the speed, of the adopted LOS standard. For roadways in urbanized areas, for roadways parallel to exclusive transit facilities, or for intrastate roadways in transportation concurrency management areas, significant degradation means (1) an increase in average annual daily traffic volume of 10 percent above the maximum service volume, or (2) a reduction in operating speed for the peak direction in the 100th highest hour of 10 percent below the speed, of the adopted LOS standard. For other state roads in transportation concurrency management areas, significant degradation means that amount defined in the transportation mobility element. For constrained roadways meeting or exceeding the level of service standards, "maintain" does not apply until the roadway is operating below the applicable minimum level of service standard.

16. * means the level of service standard will be set in a transportation mobility element that meets the requirements of Rule 9J-5.0057.

2.2

CAUTIONARY NOTES

Area Boundaries

In geographic areas requiring interpretation (*e.g.*, transitioning urbanized areas), agreement(s) between FDOT's district planning office and the local entity should be documented. The determination and application of level of service standards and measurement techniques in transitioning urbanized areas have been frequently discussed since the publication of FDOT's 1989 Level of Service Manual. As used in these standards, transitioning urbanized areas are the "fringe" areas adjacent to FHWA urbanized areas that are expected to exhibit Census defined urbanized characteristics from the time of the latest Census (1990) through the next 20 years. An area can be designated as transitioning urbanized only if it is adjacent to an urbanized area. As used here FDOT is recognizing the FHWA urbanized limits which includes some geographical smoothing. The 20-year period represents the study period for urbanized area transportation studies.

FDOT will accept the urbanized limits established for urbanized areas in their long range plans; however, those limits must meet Census definitions. If an MPO does not develop those limits, FDOT will treat the area as either a "small city" or rural area and will apply the applicable standards (and if applicable, the appropriate generalized level of service table). MPOs may adjust the transitioning area boundary based on guidance found in FDOT's MPO Administrative Manual (Topic No. 525-010-025-a). The transitioning urbanized standard applies only to urbanized areas, not small cities.

For more definitive guidance on geographic areas, consult FDOT's MPO Administrative Manual (Topic No. 525-010-025-a).

Development interests and reviewers should recognize that the level of service standards are to be applied based on the current area type throughout the 20-year planning horizon. For example, if a development is proposed in a transitioning urbanized area, the applicable standard is the transitioning standard throughout the 20-year period. Also, see Section 5.15 for the use of generalized level of service tables for future situations.

Intersection Considerations

Although roadway level of service is stressed in the level of service standards, detailed volume to capacity analyses at selected intersections will be necessary to evaluate specific projects. The danger of using only a level of service criterion without evaluating signalized intersections is illustrated by the following example:

> Suppose that the existing condition at a signalized intersection has a volume to capacity ratio of 0.75, but the signalization is so poor that the level of service is D. A development is proposed which would increase the volume to capacity ratio to 0.95, but improved timing and coordination of the existing signalization system could keep the intersection operating at a level of service D. In this situation 80 percent of the remaining capacity (0.20 out of 0.25) is used by a development while adhering to the strict level of service criterion.

Clearly, both level of service and volume to capacity ratio criteria are appropriate to determine impacts from proposed developments and required mitigation efforts.

3

CALCULATING LEVEL OF SERVICE

This chapter presents an overview of the methodology endorsed by FDOT for computing level of service (LOS) along with guidelines for selecting the tool most appropriate for the analysis need. The relationships between the Highway Capacity Manual (HCM) and Florida's Level of Service Manual are also explored.

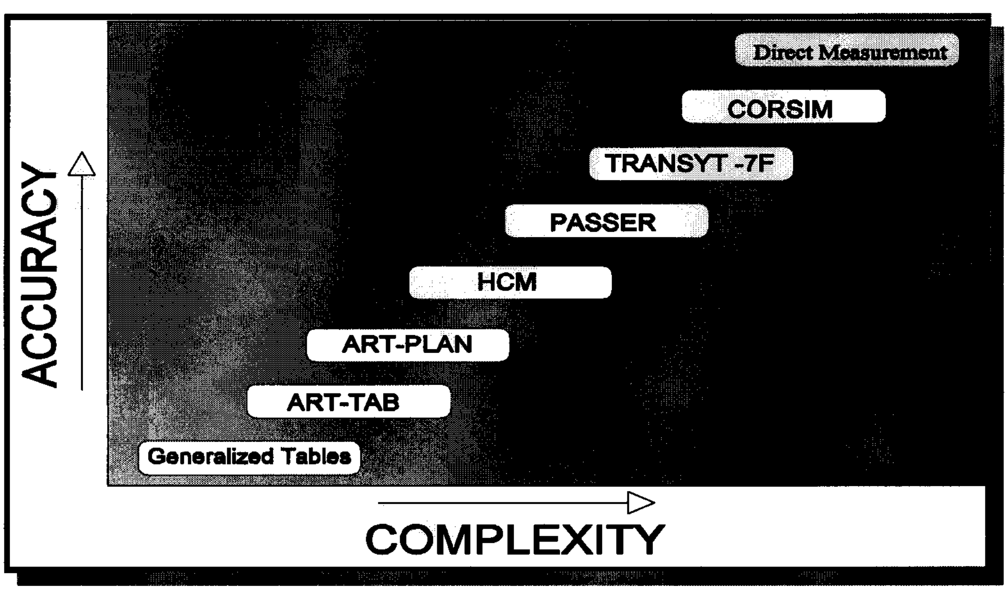
Available Tools

There are currently a number of methods for computing roadway LOS that are based, to varying degrees, upon the HCM methodology. They form a hierarchy ranging from the Generalized Tables (the simplest to use but not appropriate for all needs) to the spreadsheet producing programs, level of service computing programs and a variety of operational analysis tools. In selecting the appropriate tool, the tradeoff between the data preparation effort and the accuracy of the results must be considered carefully. FDOT acceptance of a tool for a particular purpose is also an important factor.

Increasing Accuracy requires increasing effort

Consider, for example, the arterial level of service computation tools represented below. Eight alternatives are represented in Figure 3-1, ranging from the Generalized Tables to direct field measurements. The list of tools is not exhaustive nor does it imply acceptance for all analysis purposes. Each analysis tool will be discussed in this chapter.

Figure 3-1



The tools are arranged to illustrate the tradeoff between accuracy and effort. The Generalized Tables appear at one end, and the accuracy and effort increase proportionally through the progression of tools up to direct field measurements. The first three tools (Generalized Tables, ART_TAB, and ART_PLAN) were designed primarily for planning applications. The last five were intended for more detailed operational analysis; however, they all deal in the measures of effectiveness that determine the LOS. The operational tools will be of most use to planners in situations where a higher level of accuracy is demanded.

Note that FDOT District approval is required to use any computational tool. Table 3.1 below provides an overview of the tools, arranged in increasing order of complexity, and indicates the specific purposes for which each of the tools is currently accepted by FDOT.

3.1 Measuring Highway Performance

Florida's methodology for calculating LOS is, as a matter of policy, based on the HCM. The LOS Manual is essentially an adaptation of the 1997 HCM Update for use in Florida. The HCM only prescribes procedures for computation of the LOS on various facilities. It does not provide the implementation methodology. In a sense, the LOS Manual begins at the point where the HCM ends. It adds two essential ingredients: the computational tools and a standardized framework in which these tools may be applied uniformly throughout the state. This section highlights main concepts contained in the HCM which are the basis for the models, programs, and tables developed for Florida.

Arterials

Previously, the HCM paid little attention to urban arterial speed. The essential concept was that intersection levels of service or capacities determined an arterial's LOS. For instance, if seven intersections were operating at LOS B, then the arterial would be operating at LOS B. Whereas, the purpose of the signalized *intersection* is to move vehicles past a point, the purpose of an *arterial* is to move through vehicles along the facility at a reasonable travel speed. **The measure of effectiveness for arterials is average travel speed, not volume.**

TABLE 3-1

STATUS OF FDOT APPROVAL FOR COMPUTATION TOOLS

COMPUTATIONAL TOOL	APPROVED BY FDOT FOR
Generalized Level of Service (LOS) Tables	Planning level analysis subject to restrictions described in Chapter 5.
ART-TAB, SIG-TAB	Planning level estimates of the breakpoint volumes expressed as directional, hourly and daily volumes along with peak hour peak direction through/right v/c ratios.
Other Spreadsheet Generating Models - FREE-TAB, RMUL-TAB, UMUL-TAB, R2LN-TAB and U2LN-TAB.	Planning level estimates of the breakpoint volumes expressed as directional, hourly and daily volumes
ART-PLAN	Planning level estimates of intersection stopped delay and LOS; arterial link travel speed and LOS; and overall arterial travel speed and LOS
HCM Software	All LOS Computations
PASSER II	Design and evaluation of signal timing plans
TRANSYT-7F	Design and evaluation of signal timing plans
CORSIM	Detailed evaluation on a case by case basis
SIDRA	Capacity / LOS at roundabouts
Direct Measurement	Specialized studies where a high level of accuracy is required.

District approval is required to use tools that are not included in Table 3.1, or to use tools that are included on this table for purposes other than those for which they are approved.

An arterial's performance is measured by its operating speed.

Intersection capacity is important, but taken together under most circumstances, other signalization aspects are even more important. Effective green time, cycle length, quality of signal progression and presence of left turn bays are all important. The HCM makes it clear that both traffic operation improvements and physical improvements (*e.g.*, number of lanes, grades) can yield substantial quality of flow enhancements.

Updates to the HCM recognized that the signalized intersections significantly affect the average travel speed. A greater emphasis on the effects of critical intersections on roadways with long signal spacing has been brought into the methodology. Specifically, the HCM discourages the combination of long open roadway sections and heavily congested intersections into a single section for analysis purposes. This change is reflected in this edition of the LOS Manual in a modified treatment of Uninterrupted Flow arterials.

The number of signals can significantly affect arterial level of service.

Frequently, the single most important factor in determining an arterial's LOS is signalized intersection spacing, (*i.e.*,the number of signalized intersections per mile). For instance, under normal operating conditions, if there are seven signalized intersections in a mile and all operate at LOS B, it would not be unusual for the arterial to be operating at LOS E. This seeming paradox occurs because even though each intersection is operating well, without excellent coordination, collectively the signals slow arterial traffic to a poor operating condition. The cumulative effect of signalized intersections can destroy the ability of the arterial to move through traffic effectively. Even with extremely low traffic volumes, an arterial might not be able to operate at an acceptable LOS. Because of the extreme importance of the number of signalized intersections per mile, FDOT's Generalized Tables are heavily oriented to that important concept.

An arterial may operate at a higher LOS than its individual intersections.

The arterial analysis methodology estimates operating conditions over the length of a roadway section. Therefore, it is possible for an *intersection* to operate at LOS F (more than 60 seconds of average stopped delay), and yet the *arterial* section as a whole operates at an acceptable LOS. This could occur if signal spacing is sufficiently distant that the average speed between signals more than offsets the delay at the intersections. However, eventually there would be enough queuing of vehicles that intolerable delays would occur at intersections. To account for this, the tables, and the computer models from which they are derived, do not allow the intersection volume to capacity ratio to exceed a value equal to the reciprocal of the peak hour factor for a 15 minute period or a value of 1.0 for a full hour. This also reflects the provisions of the HCM.

Rural Two-Lane Highways

The measure of effectiveness on two-lane rural highways is percent time delay behind other vehicles, without the ability to pass. For example, under the current criterion, a level two-lane rural highway with a volume to capacity ratio of 0.4 would be operating at LOS D because of the percentage of time vehicles would be delayed from operating at their desired speed.

Freeways

Freeways are measured in terms of vehicle density, not speed.

Freeways and other uninterrupted multilane facilities operate differently than interrupted facilities. The measure of effectiveness on freeways is vehicle density (expressed in terms of vehicles per mile per lane or vpmpl). As opposed to arterials where each additional vehicle incrementally decreases the average speed of every other vehicle, an increase in volume on a freeway does not always affect average speed. This is especially true at lower volumes and can be seen in the speed-flow diagrams found in Chapter 3 of the HCM. These diagrams show a relatively flat speed curve regardless of traffic volumes below LOS 'D' and indicate that density is a better measure of performance than speed.

General Development of Tables and Models

FDOT's Generalized LOS Tables and models were developed based on the definitions and methodology of the HCM. Calculation of maximum volumes for uninterrupted flow facilities is a relatively straight forward process based on the HCM methodology. The main contribution of the LOS Manual is the provision of Generalized Tables and spreadsheets to implement the procedures. The problem of interrupted flow at traffic signals is, however, much more complex.

One of the most complicated procedures in HCM Chapter 9 deals with the treatment of left turning traffic. Therefore, it was necessary to introduce some major simplifying assumptions in the development of planning level implementation tools **The most important assumption is that, for planning purposes, left turning vehicles get ample protected green time and left turn bays are adequate in length to prevent the vehicles from backing into through lanes.** Where this is not true, service volumes may be significantly lower and the validity of the planning level tools becomes questionable. The "planning assumption" allows the implementation tools to concentrate on the through movements, the main movements served by arterials, with protected turn volumes treated as an add-on to through volumes. The assumed values of green time must therefore apply only to the through movements. The green (arrow) time assigned to protected left turns must be considered as a part of the arterial red time.

FDOT's LOS tables and models assume there is no blockage of through lanes by turning vehicles.

Extensions of The HCM in Florida's LOS Handbook

The methodology prescribed in the HCM was followed carefully in developing the tables, models and evaluation software for Florida's LOS calculation needs. Occasionally, it was necessary to extend the HCM methodology to deal with implementation problems that were not addressed in the HCM, or to more accurately reflect Florida's characteristics. The extensions of the HCM which were deemed appropriate are discussed below.

Weighted Effective Green Time

Clearly the amount of green time traffic movements receive at signalized intersections is one of the most significant variables in capacity analysis. A major simplifying assumption, essential to development of the Generalized Tables and the models from which they were derived, was the selection of a single g/C (effective green time) ratio value for all intersections on the arterial section. Thus, a fundamental technical question is what green time value to assume for arterials. Should it represent the average green time through movements receive along the arterial section, or should it be the green time the through movement receives at the critical intersection where the greatest delay is likely to occur, or should it be some other value? The concept of "weighted effective green time ratio" was created for this purpose. Like the HCM, FDOT's effective green time (g) ratio is the ratio of the effective green time to the signal's cycle length (C) for a specific movement (the through movement).

$$g/C_{(weighted)} = \frac{g/C_{(critical)} + g/C_{(non\text{-}critical)}}{2}$$

The weighted g/C of an arterial is the average of the critical intersection through g/C and the average of the other intersections' through g/C. For instance, if over a four mile section of a principal arterial the smallest through g/C is 0.4 and the average through g/C for the other intersections is 0.6, then the weighted g/C is 0.5. The weighted g/C takes into account the adverse impact of the critical intersection and the overall quality of flow for the arterial length.

This weighted approach has been found to be a very reasonable simplifying assumption. Under typical traffic, roadway and signalization conditions, the "weighted g/C" approach yielded speeds within 2 mph of entering actual g/C ratios for each intersection. In general, the approach slightly overestimates speeds when the number of signalized intersections per mile is greater than 2.5 and slightly underestimates speeds when the number of signalized intersections per mile is less than 2.5.

NOTE: **The g/C in the Generalized Tables is not the average g/C which is frequently provided in site impact information.**

Mid-Block Considerations

Based on recent research commissioned by the FDOT, the arterial segment running times used in this handbook and the accompanying planning computer models depart from those suggested for use in Table 11-4 of the HCM. Unlike those in HCM Table 11-4, the running speeds used in this handbook and software were derived using an equation including traffic volume as a variable. The FDOT running speeds also better reflect *through* vehicle running speeds, as opposed to the total mix of through and turning vehicles. Other factors which enter into determining the running speeds are free flow speed, average segment length, quality of progression, number of lanes and arterial classification. The table's running speed is not sensitive to the number of driveways, medians, right turn deceleration lanes, other mid-block considerations affecting the smooth flow of traffic, or traffic flows.

Clearly, these mid-block access management considerations do affect running speeds to some extent. The only one of these mid-block access management considerations handled directly in the Generalized LOS Tables and associated computer models is the treatment of divided/undivided considerations. Essentially, a 5 percent volume penalty is assigned to undivided facilities. An upward adjustment factor for arterials with good mid-block access controls (*e.g.*, limitations on driveways, right turn deceleration lanes) may also be appropriate. These adjustment factors represent a consensus of the task team developing the tables, and are not calculated values. Any adjustment factor not suggested in the Generalized Tables should be discussed with FDOT District personnel prior to its application. It should be noted that in this handbook the adjustment factors described above are best thought of being applied to the calculated volume, rather than to the segment running speed.

Access management may affect traffic volumes.

Passing Zone Adjustments

Passing zone adjustments for rural undeveloped two-lane roads represent the LOS Task Team's consensus of opinion. These adjustments do not appear in the HCM.

Rural LOS Criteria

Many sections of Florida's (and other parts of the nation's) two-lane roadways cannot logically be evaluated using the HCM's "percent no passing" criterion. These situations typically occur on uninterrupted flow facilities in lightly developed areas or along the coast. In these areas motorists are primarily interested in sustaining a "reasonable" average travel speed. They typically are not trying to pass in small communities.

For these situations FDOT has developed LOS criteria based on volume to capacity ratios representing a hybrid of the volume to capacity ratios in the HCM's rural multilane and two-lane chapters. Similarly, FDOT revised the intersection LOS criteria in areas less than 5,000 population because the intersection level of service criteria in the HCM were developed for urban areas. The intersection criteria for these less developed areas is approximately one-half (rounded up) of the urbanized criteria. The two changes in criteria are found on the back of Table 5-3, Generalized Peak Hour Directional Volumes for Rural Areas and Cities or Developed Areas Less than 5000 Population, as well as on the back of the two-way peak hour and daily volume tables.

Analyzing different facility types

The HCM has different level of service criteria for uninterrupted flow facilities (*e.g.*, freeways) and interrupted flow facilities (*e.g.*, arterials). Volume to capacity ratios (v/c) are acceptable measures of effectiveness for uninterrupted flow facilities; however, average travel speed is the primary measure of effectiveness for arterials. As roadways transition from uninterrupted flow to interrupted flow conditions, the different criteria do not match up well. To overcome this conflict in changing criteria, FDOT recommends the following:

- Use of the Generalized Tables for arterials with long signal spacing is discouraged because of the inseparable mixture of interrupted and non-interrupted flow. Facilities in this category should be segmented to separate the two types of operation. Routes that cannot be segmented should be analyzed as Class I arterials.

- Use higher LOS speed criteria for interrupted flow arterials in developed areas less than 5,000 population The higher speed criteria for respective levels of service in these less densely developed areas better reflect quality of service than the HCM's urban criteria.

Without these two changes one can be erroneously led to the conclusion that signalizing uninterrupted flow facilities will improve the LOS for the through movements.

3.2

GENERALIZED LEVEL OF SERVICE TABLES

FDOT's level of service analysis tools fall into two types: the basic planning analysis models, or "TAB" programs (which includes the Generalized Tables and the models from which they are derived), and the more detailed planning model, ART-PLAN. Generalized LOS tables are in widespread use throughout the United States. The tables are generally used in transportation planning to determine existing and future levels of service on roads and in project development to estimate the number of through lanes needed.

FDOT's Generalized Level of Service Tables (Tables 5-1 through 5-3) were developed based on the definitions and methodology of the HCM. They are believed to be the most thoroughly researched and state-of-the-art generalized level of service tables in the United States. They are the product of a significant effort by FDOT, its consultants and the professional community within the State of Florida.

Development of the Generalized Tables

Statewide default values were measured and applied to the basic planning analysis models to produce the Generalized Tables. The models have been periodically reviewed and updated when necessary. FDOT personnel have conducted numerous traffic and signalization studies and have modified the initial values to reflect average conditions in Florida. Daily and directional data were derived from FDOT's continuous traffic count stations throughout Florida. Signal timing data were obtained from analyses of traffic signal timings in Miami, Tampa, Tallahassee, Gainesville, DeLand and Lake City, as well as several rural developed areas. FDOT's intent has been to develop the most realistic numbers based on actual traffic, roadway and signalization data.

Organization of the Generalized Tables

A total of nine Generalized Tables are presented in this manual, covering different area types and demand volume estimation categories. The overall organization is presented in Figure 3-2.

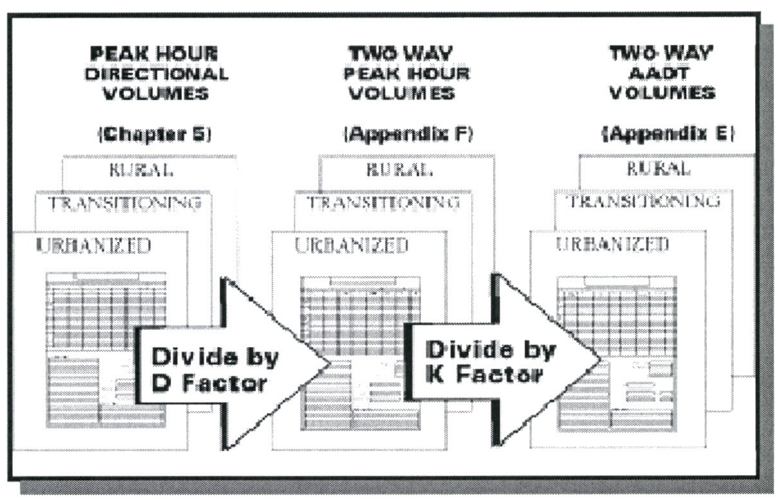


Figure 3.2
The nine tables are categorized by area type and time/ direction.

Florida's generalized level of service tables cover three area types...

AREA TYPES

- urbanized areas;
- areas transitioning into urbanized areas, or cities over 5,000 population not in urbanized areas; and
- rural undeveloped areas, or cities and developed areas less than 5,000 population.

...and three time / directional analyses.

TIME PERIODS/DIRECTION

- peak hour/peak direction
- peak hour/both directions
- daily/both directions (AADT)

The peak hour directional analysis is the basis for all of the tables.

The Peak Hour Directional Tables (Tables 5-1, 5-2 and 5-3) are provided because traffic engineering analyses are conducted on an hourly or subhourly basis. **The peak hour directional tables are based directly on the HCM methodology. The other two sets of tables are derived from the peak hour directional tables by applying adjustment factors.** The adjustment process is illustrated in Figure 3-2. It is important to note that the adjustment factors are empirically derived constants that are very familiar to transportation planners, however, they are not a part of the HCM methodology.

Situations under Which Traffic Demand Exceeds Capacity

Peak hour directional tables are stressed in this handbook because traffic engineering analyses are conducted on an hourly or subhourly basis, not on a daily basis. However, caution must be exercised when using hourly tables when traffic demand exceeds hourly capacities. This caution is primarily applicable when comparing measured hourly volumes on uninterrupted highways, especially freeways, with the capacity of the roadway (*i.e.*, the volume to capacity ratio criteria appearing on the back of the tables).

For example, assuming the correctness of an adjusted saturation flow rate of 2,225 vehicles per hour per lane and a peak hour factor of 0.95, the absolute capacity (maximum volume for level of service E) is 2,114 vehicles per hour per lane. Measured volumes can not exceed that value. Because of excess traffic demand (see Section 4.9), measured traffic volumes may approach that value for more than an hour or the operation of the freeway may be broken down, yet the LOS E volume will never be exceeded.

Comparing only measured volumes with roadway capacities can not result in LOS F conditions. Largely for this reason the primary measure of effectiveness for freeways in the HCM is density, not volume to capacity ratios. Alternatively, under situations where hourly traffic demand approaches or exceeds capacity, daily tables may give a better description of LOS than the hourly tables in which the volume to capacity ratio is being used as the primary measure of LOS, as is done in the tables in this handbook.

The K factor only affects daily volumes.

The service volumes in the peak hour directional tables were calculated using an application of the HCM methodology and are directly applicable for planning-level peak-hour analyses. They are the base from which the two-way peak hour and daily tables were developed. As such, they have not been factored. Thus, in use of the peak hour directional tables, questions about which planning analysis hour (K) factor , K_{30} or K_{100}, is appropriate are immaterial. The K factor is used simply to relate peak-hour service volumes to AADT.

Many areas have adopted two-direction peak hour standards. Tables 5-7 through 5-9 provide generalized two-way peak hour volume tables derived from the peak hour directional tables using the directional (D) factor. Many planning analyses are presented on a daily basis and Table 5-4 through 5-6 provide generalized daily (annual average daily traffic) level of service maximum volume tables derived by applying the planning analysis hour (K) factor to the two-way peak hour volumes based on the peak hour directional tables and typical traffic peaking (based on the 100th highest hour of the year) and distributional characteristics.

The service volumes in the daily and two-way peak hour tables are based on the higher directional flow of traffic for the 100th highest hour of the year with traffic fluctuations within the hour accounted for. The 100th highest hour is approximately equivalent to the typical peak hour of a day during a peak season in a developed area. Directional hourly volumes are divided by the directional factor (D) to obtain non-directional (or two-way) hourly volumes. Non-directional (two-way) hourly volumes are divided by the planning analysis hour factor (K_{100}) to obtain daily volumes.

A detailed description of data requirements for using the Generalized Tables is provided in Chapter 4. The methodology, applications and example problems are provided in Chapter 5.

3.3

ART-TAB AND OTHER TABLE GENERATING SPREADSHEETS

The service volumes in the Generalized Tables are based on assumed values for all of the operating parameters of the facility. The underlying assumptions are presented with each Generalized Table. These assumptions may vary among area types and facility types, but within a specific area type and facility type, they are beyond the control of the user. This means that the Tables are only appropriate for use when all of their assumed parameters are valid. The assumed parameters in the Tables reflect statewide averages that are based on well researched data. They cannot, however, be expected to apply to all situations, and a change in any of the assumed parameters would generate a completely new set of tables.

Table generating spreadsheets have therefore been developed for all facility types covered by the Generalized Tables. These spreadsheets extend the concept of the Generalized Tables in a very practical way because they allow an agency to work with a set of LOS tables that reflect local conditions more accurately.

The seven table-generating programs are sometimes called "TAB" programs

Program	Facility Type
ART-TAB	arterials
FREE-TAB	freeways
RMUL-TAB	rural multi-lane
UMUL-TAB	urban multi-lane
R2LN-TAB	rural two-lane
U2LN-TAB	urban two-lane
SIG-TAB	isolated signalized intersections

The "TAB" programs are spreadsheet models available for the analysis of arterial roadways that are not adequately represented in the Generalized Tables. The "TABs" allow analysts to create a localized table showing service volumes for each level of service. Appropriate uses of the "TAB" programs for various types of analyses are presented in Table 3-1. The models are spreadsheet templates requiring the user to supply basic data. Data requirements are explained in Chapter 4. The templates can be used with Lotus 1-2-3 ® Release 2.0 or greater, and other compatible spreadsheet programs. Detailed information is provided in Chapter 6.

3.4

LEVEL OF SERVICE CALCULATION SOFTWARE

Even with user-specified operating parameters, level of service tables have severe limitations, especially on arterial streets. The most critical limitation is the global nature of all of the assumed parameters. Each arterial route includes several signalized intersections which, in fact, may have very different characteristics. While a spreadsheet like ART-TAB may be appropriate for simple planning level analyses, there are many tasks that demand a higher level of accuracy that can only be achieved by treating each intersection individually. The ART-PLAN program, which is itself a spreadsheet template, provides this capability.

ART-PLAN

ART-PLAN is a Lotus 1-2-3 ® template replicating the procedures from Chapter 11 of the HCM. Although it is considered a planning model, it approaches a traffic operations model in depth. Nevertheless, it is fast, easy to use and allows for flexible application of the HCM procedure. It is recommended for use when an analyst is evaluating a specific interrupted flow facility. Many Florida analysts believe it is the most appropriate technique to analyze arterials in urbanized areas for local government comprehensive plans and for concurrency management systems. The use of ART-PLAN is therefore encouraged for this purpose by FDOT. Chapter 7 details ART-PLAN.

3.5

OPERATIONAL MODELS

Highway Capacity Software (HCS)

The HCS was developed as a faithful implementation of the HCM. Therefore, by definition, the HCS is the logical choice for the computation of the level of service on all facilities. Several other software products implement the HCM methodology on a variety of facility types. Such programs are legitimate tools for purposes of Florida's LOS Manual, provided that they are understood and accepted by the appropriate FDOT district offices.

The Signal Operations Analysis Package (SOAP)

SOAP was developed for the Florida DOT to facilitate the design and evaluation of timing plans at individual intersections. It has been used by FDOT for nearly twenty years for this purpose. Its evaluation methodology preceded the HCM and is not, therefore, fully compatible, although many of the features of SOAP's model were actually incorporated into the HCM.

SOAP should not be used by itself to evaluate the LOS at intersections in Florida. It does, however have one important application to LOS analysis. The HCM Chapter 9 methodology does not offer a technique for determining the signal timing plan, it simply evaluates a specified plan. If the signal timing at an intersection is not known, SOAP will be a useful tool for developing such a plan. SOAP should be used for this purpose when unusual phasing plans are used (*e.g.*, lead-lag phasing) or when an implementable signal timing plan must be ensured.

PASSER

PASSER is perhaps the most widely used signal timing optimization program, at least for arterial highways. While several arterial progression programs have been in use since the early 1970's, the state of the art in signal technology had advanced to the point that the earlier programs did not adequately deal with complex signal timings or multiphased controllers. The **P**rogression **A**nalysis **S**ignal **S**ystem **E**valuation **R**outine (PASSER) was written to facilitate the design of progression systems which have multiphase control with a variety of phasing strategies.

PASSER II is a macroscopic, deterministic optimization model designed to develop "maximal bandwidth" timing plans on an arterial highway. PASSER II can work with multiphase signals, variable speeds and priority directional weighing. Its optimization objective function (maximum "bandwidth efficiency") ensures good perceived progression timing plans as obtained from time-space diagram designs.

TRANSYT-7F

One of the most widely used design models is **TRA**ffic **N**etwork **S**tud**Y** **T**ool, or TRANSYT-7F. While TRANSYT-7F is generally applied to complex signal networks, it is also useful for minimizing stops, delay, fuel consumption, etc., on a linear arterial route.

TRANSYT can determine optimum signal timing for a coordinated network of up to 50 (or more if customized) intersections (nodes) with 250 (or more) directional links. Both signalized intersections and cross street stop sign-controlled intersections may be modeled. Control may be either fixed time or actuated with two to seven phases (including pedestrian movements), with fixed sequential phasing and offsets. Priority lanes may be designated for buses and/or carpools.

In contrast to the maximal bandwidth approach of PASSER II, earlier versions of TRANSYT developed signal timing plans to minimize a "disutility function." This is normally a combination of stops and delay or excess fuel consumption. However, TRANSYT-7F also has an optional progression-based design capability.

NETSIM / CORSIM

TRAF-NETSIM (commonly referred to as NETSIM) is an acronym for **TRAF**fic Simulation System and **NET**work **SIM**ulation. The package can simulate pretimed and actuated signal control along arterial streets, multi-phasing combinations, sign control, and pedestrians.

The NETSIM model is a microscopic, time-scanning traffic simulation for the urban surface street network. The NETSIM program is for:

- traffic engineers who desire to simulate their coordinated traffic signal systems; and
- transportation analysts and planners who need to perform detailed operational studies.

The program includes a graphics package which is used to view the traffic operations. Each vehicle is shown on the screen and moved every second. This provides a very useful tool for public presentations.

The NETSIM package runs on most IBM PC/MS-DOS compatible computers, yet it also remains compatible with mainframe computers when mainframe use is available for "heavy-duty" use of the NETSIM program. It may be used as a stand-alone package, or as part of the CORSIM (for **COR**ridor **SIM**ulation) package along with FRESIM, a **FRE**eway **SIM**ulation application. As with any program that has this level of detailed, data requirements are rather intensive which is one of the major obstacles for using this package for planning level analysis.

3.6

MODEL INTEGRATORS

Many of the traffic analysis models described in this document require the same general data inputs and generate similar measures of effectiveness as outputs. Taken collectively, they form an often confusing array of resources for the traffic analysis. Furthermore, it may be necessary to use more than one model for a given task (*e.g.*, SOAP for signal timing design and HCS for LOS analysis. It is not surprising therefore that some attempts have been made to integrate these models.

A model integrator typically accepts input data in a very simple format and prepares appropriate data files to supply the individual traffic model programs. This improves the productivity of the analysis considerably. It eliminates the need for a choice between models, and allows the user to gain access to the strongest features of all of the models.

3.7

APPLICABILITY OF COMPUTATIONAL TOOLS

Use of Generalized Tables

This section provides guidelines on the applicability of the tools for computing level of service. Table 3-2 provides the analyst an overview of typical analysis needs and the tools considered most appropriate for the task.

Any Table modifications based on changes in the assumptions should be justified, documented, and approved by the district planning office. Other approaches (e.g., travel time studies; see Appendix D) may also be appropriate if found acceptable by district and central planning offices.

Values shown in the generalized level of service tables are based on the HCM and actual Florida traffic and signalization data, making the tables applicable throughout Florida. However, it is recognized that traffic characteristics vary by area and facility. **They are guideline estimates** of highway level of service. The level of service standards appearing in Table 2-1 must be adhered to in FDOT's review of local government comprehensive plans (LGCPs) and developments of regional impact (DRIs) by FDOT personnel. However, the generalized level of service tables represent a first cut at estimating level of service and are **not** standards that must be used. The input value assumptions used in developing the tables appear on the back of the tables.

The generalized tables are most appropriate for the following analysis purposes:

- Statewide analysis of level of service
- Urban area transportation studies
- Congestion Management Systems/Mobility Management Process
- Local government comprehensive plans
- Planning review of development impacts

TABLE 3-2

APPLICABILITY OF GENERALIZED LEVEL OF SERVICE TABLES AND MODELS

Analysis Type	Generalized Tables	Planning Level Models*	Detailed Traffic Models**
Statewide Analysis of LOS	A	NA	NA
Urban Area Transportation Studies	A	A	NA
Local Government Comprehensive Plans	A	A	P
Initial Roadway Laneage Needs	A	A	P
Congestion Management/Mobility Management	P	A	A
Planning Review of Development Impacts	P	A	A
Project Development	NA	P	A
Signalized Intersection Spacing	NA	P	A
Final Roadway Laneage Needs	NA	P	A
Design Review of Development Impacts (DRIs)	NA	P	A
Signal Optimization	NA	NA	A
Roadway or Intersection Design	NA	NA	A

A = Applicable
P = Possibly Applicable
NA = Not Applicable
* For example, ART-PLAN, ART-TAB, OTHER "TAB" PROGRAMS,
** For example, 1997 HCM, PASSER, SOAP, TRANSYT-7F, CORSIM.
Source: Florida Department of Transportation, 1998.

Use of Other Computational Tools

With a substantial monitoring and data collection effort, regional, district and metropolitan jurisdictions may wish to develop tables similar to Tables 5-1 through 5-3. These would more accurately reflect the traffic characteristics in the area. Users also may wish to develop values for a particular facility whose characteristics are different from statewide averages. Assumptions used in modifying the generalized tables should be documented.

Alternate tables can be used on projects if a local government or other entity works with the applicable FDOT district planning office and they are in agreement on the analysis technique. Again, there is no requirement to use the tables or the models from which they are based if more appropriate models or methodologies exist. Since 1985, numerous level of service tables have been developed reportedly based on the HCM. However, few are sensitive to signal operation aspects (*e.g.*, signalized intersection spacing, quality of progression, timing). The HCM makes it clear that both traffic operation improvements and physical improvements (*e.g.*, number of lanes, grades) can yield substantial quality of flow enhancements. FDOT does not regard level of service tables for state arterials valid for use in Florida unless signal operation aspects are included in their derivation. Tables based exclusively on number of lanes lack sensitivity to new evaluation techniques and are not acceptable to FDOT.

A number of tools for computing LOS are available as shown in Table 3-2. However, use of tools other than the Generalized Tables, TAB programs and ART-PLAN could lengthen the review time for project approval and could result in project rejection. **Coordination with and approval by FDOT District Offices is required prior to use of the alternative tools.**

Applicability of the Tools

Generalized tables could not be developed which would apply to all traffic, roadway and signalization situations. Therefore, **users are strongly encouraged to work with the easy-to-use computer programs, primarily ART-PLAN,** when more precise input values are available or a more precise measure of LOS is needed. When used properly, the computer programs and models provide site specific measures of LOS with higher levels of confidence than the Tables.

When the desired level of accuracy is greater than can be obtained using the computer models, operational methodologies such as the Highway Capacity Software (HCS), PASSER, SOAP, TRANSYT-7F and CORSIM should be used. Travel time studies can be used if the FDOT District Office has approved of the methodology. Full documentation of the methodology and results must be presented.

An example of a case where actual data and computer models should be used in lieu of the tables is illustrated in the following example.

The computer models should be used in calculating level of service any time the traffic, roadway, or signalization variables for the road vary significantly from the assumptions used in the tables.

> South Dixie Highway (US 1) in Dade County has signalization characteristics far different from average conditions in Florida. The through movement has outstanding signal progression and receives a far greater percentage of green time at signalized intersections than the average arterial in Florida. Under these conditions the maximum volume for a given LOS on South Dixie Highway is much higher than the tables indicate. On the other hand, there are other state arterials that receive less green time than the state average and have poor progression. These conditions would result in volumes much lower than what the tables indicate.

The tables are neither conservative nor liberal.

The Generalized Level of Service Tables were developed to provide the most realistic service flow rates possible. With this premise, using the planning LOS computer models or more detailed methodologies should result in approximately an equal number of situations where derived values are higher and lower than the numbers in the tables. Using these more precise techniques will provide more accurate volumes, but not necessarily higher or lower volumes.

Travel Time Studies

Travel time studies have been conducted by several agencies over the past few years. Travel time study guidelines can be found in Appendix D. FDOT has expressed a great deal of interest in travel time studies because:

- average speed is the primary LOS measure of effectiveness for arterials;
- of the perception that travel time studies result in better LOS than use of traffic models; and
- of the need to assess LOS for local government comprehensive plans.

In coordination with FDOT district planning travel time study efforts, some research has been performed for analyzing and, as appropriate, calibrating computer models to more accurately reflect actual Florida driving conditions. The results of that effort are provided in Appendix D. The following paragraph provides an overview of Appendix D with an emphasis on application of travel time studies to individual roadway sections.

With regard to FDOT's LOS Manual, five purposes of travel time studies are presented:

- identifying running speed of link(s);
- assuring quality of analysis;
- refining the existing analytical model (*i.e.*, the Highway Capacity Manual methodology);
- using an alternative model; and
- evaluating critical projects.

Travel time studies have limited application in planning.

Travel time studies have the advantage of being real world data; however, their use in assigning LOS on a roadway section is limited. The variability from run to run usually dictates large sample sizes. For example, a one-mile section of roadway may require 40 runs to achieve a two mph confidence bound above or below the actual average travel speed. A plus or minus 1 mph confidence bound would require considerably more runs. Several cautions, including time period considerations exist in conducting travel time studies.

Although FDOT is not recommending travel time studies at this time, they can be used if the District FDOT and all agencies required to use the results of the studies agree on the methodology and uses of the results. Appendix D methodology and recommendations, as well as the FDOT Manual on Uniform Traffic Studies (MUTS), should be the bases of any travel time studies conducted in the State.

Combining or mixing analysis tools should be avoided.

FDOT does not regard mixing and matching of different evaluation techniques an acceptable practice. For example, if the ART-PLAN computer model is being used in the preparation of a local government comprehensive plan, it should generally be used for all arterials and the generalized tables should not be used. However, it is appropriate to use the generalized tables as an initial low cost screening tool to determine if roadways may be operating at or below minimum LOS standards. After the screening, a more detailed technique would be applied to the roadway sections which are at or below the standards. In cases where it is believed there is justification for mixing evaluation techniques, the FDOT district planning office should be contacted. District staff after consultation with central office planning would provide additional guidance.

Applicability in Congestion Management Systems/Mobility Management Process

The Congestion Management Systems/Mobility Management Process (CMS/MMP) Task Force suggested level of service be used as the triggering device to determine where highway congestion exists in the State of Florida. Methods for calculating level of service contained in this manual are appropriate for use in the CMS/MMP.

The generalized tables are appropriate as a screening tool for the CMS/MMP. Roadways with traffic volumes which exceed the minimum acceptable service volumes (or exceed an agreed upon percentage of the service volumes) could be designated as potentially congested. At that stage, more accurate data could be gathered and a more detailed analysis could be performed.

Care should, of course, always be taken to make sure the arterials analyzed can adequately be computed using the tables. Section 5.3 points out several instances in which the use of the tables for a specific arterial would not provide an adequate estimate of LOS.

Review of Local Government Comprehensive Plans and Amendments

Section 163.3180(10), F.S. (as amended in 1993), provides that:

> With regard to facilities on the Florida Intrastate Highway System as defined in s.338.001, local governments shall adopt the level-of-service standard established by the Department of Transportation by rule. For all other roads on the State Highway System, local governments shall establish an adequate level-of-service standard that need not be consistent with any level-of-service standard established by the Department of Transportation.

TCMAs, TCEAs, and Areawide LOS

District review of proposed tiered LOS standards, adopted by a local government pursuant to Rule 9J-5.0055(2)(d), F.A.C., affecting FIHS facilities should ensure that the FIHS level of service standards are maintained, to the extent possible, and that any potential degradation of the FIHS level of service indicated by such proposals is fully mitigated. FDOT should ensure that facilities included in areawide LOS averaging in Transportation Concurrency Management Areas, adopted by the local government pursuant to Rule 9J-0055(5)(a), F.A.C., are comparable facilities, *i.e.*, have similar functional classifications. In Transportation Concurrency Exception Areas, exceptions to the transportation concurrency requirement in specifically defined urban areas of a jurisdiction are allowable to promote urban infill and redevelopment. However, "[l]ocal governments must specifically consider the impacts of the exception areas on the Florida Intrastate Highway System" (Rule 9J-5.0055(6)(a), F.A.C.).

Effective Date for Implementation

FDOT will use this handbook for the review of all LGCPs and plan amendments proposed by the local government beginning no later than March 1, 1999. For LGCPs and plan amendments received by FDOT until then, FDOT will accept analyses based on the tables appearing in FDOT's 1995 edition or the tables in this handbook.

FDOT will continue to object to the use of generalized tables based on the 1965 HCM or tables included in pre-1992 editions of FDOT's LOS Manual. FDOT regards those analyses as professionally unacceptable. FDOT continues to maintain that if an LGCP was found in compliance by DCA using the 1965 HCM-based generalized tables, the level of service analyses should be updated at the next major update of the LGCP following the adoption of this manual.

Review of Developments of Regional Impact, Job Siting Applications, Campus Master Plans, and Other Appropriate Impact Analyses

The level of service standards in this handbook are to be used for Departmental review of developments of regional impact (DRIs), job siting certification applications reviews required under sections 403.950-403.972, F.S., campus master plans and plan amendments, and other applicable site impact analysis reviews. The generalized tables in this manual would be useful for broad planning applications such as determining impacted areas, evaluating impacts relatively remote from the area of the proposed development , evaluating impacts beyond the first phase of a development or five-year study period, and where project-specific data are lacking and a preliminary analysis is needed. For applications other than general planning level analyses, calculation of LOS is best determined by actual local traffic, roadway, and signalization data; and use of ART--PLAN (see Chapter 7), the HCM methodology, or a comparable traffic operations methodology.

FDOT's Site Impact Handbook and "Minimum Responsibilities for District Development of Regional Impact Review" procedure (Topic 525-030-115) establish the DRI review process. The DRI procedure relies on this manual for level of service analysis. (See Chapter 8 - Sources for Additional Information).

The DRI "Transportation Uniform Standard Rule," adopted by the Department of Community Affairs in 1994, states that DCA

> will evaluate transportation issues in accordance with the Florida Department of Transportation level of service standards for the Florida Intrastate Highway System consistent with Subsection 163.3180(10), F.S. For all other state and regional roadways, the Department will evaluate transportation issues in accordance with the adopted transportation level of service standards of the applicable local government comprehensive plan. (Rule 9J-2.045(5), F.A.C., see also Rule 9J-5.0055(2)(c), level of service in local concurrency management systems)

The LOS standards in this manual will be applied to all DRI and job siting preapplication conferences and traffic methodology meetings, and applications for development approval, scheduled or received after the effective date of this manual. The district should implement the use of the level of service standards in this manual as soon after adoption as possible for the review of notices of proposed change and substantial deviation determinations relating to approved DRI development orders, to the extent possible.

4

DATA REQUIREMENTS

Florida's Generalized Level of Service Tables, and the software developed to produce them, are based on the Highway Capacity Manual (HCM) and actual Florida traffic, roadway and signalization data. Thus, these tables and programs are valid in Florida and their use for general planning applications is encouraged by FDOT. Since it is recognized that traffic characteristics vary within Florida and that traffic, roadway, and signalization characteristics vary by road, the Generalized Tables are not adequate for all analysis needs. Therefore, to either recognize these variations or to analyze specific roadways, a description of data requirements needed to use the LOS computation and/or table-producing software is provided in this section. These guidelines may be used to compute a more accurate estimate of LOS and service volumes. **Deviation from the Generalized Tables should follow FDOT guidance and, most importantly, be coordinated with the FDOT's district planning offices.** Chapter 8 of the LOS Manual contains a list of personnel to be contacted. These guidelines do not cover design aspects of roadways (*e.g.*, design traffic). Data requirements needed to use the various computational tools are provided in Table 4-1.

4.1 VARIABLES

The Generalized Tables are based on three types of characteristics: traffic, roadway and signalization.

Traffic variables include:

- Planning analysis hour factor (K_{100})
- Directional distribution factor (D)
- Peak hour factor (PHF)
- Adjusted saturation flow rate
- Percent turns from exclusive lanes

Table 4-1

DATA REQUIREMENTS

	INPUT DATA ITEM	TABLES	ART-TAB	ART-PLAN	SIG-TAB	FREE-TAB	RMUL UMUL U2LN-TAB	R2LN-TAB
TRAFFIC	Planning Analysis Factor, K_{100}	D	R	R	I	R	R	R
	Directional Distribution, D	D	R	R	I	R	R	R
	Peak Hour Factor, PHF	D	R	R	I	R	R	R
	Adjusted Saturation Flow	D	R	R	I	R	R	R
	% Turns from Exclusive Lanes	D	R	A	I	-	-	-
	Daily/AADT	-	-	R	-	-	-	-
	Peak Hour Directional Volume	-	-	A	-	-	-	-
ROADWAY	Number of Through Lanes	D	-	A	-	-	-	-
	Shared Left Turn Lanes	R	R	A	-	-	-	-
	Medians	D	R	-	I	-	R	-
	Classification	D	R	R	-	-	-	-
	Area Type	D	R	R	I	-	-	-
	Terrain	D	D	D	D	D	D	D
	Free Flow Speed	D	R	R	-	R	R	R
	Percent Exclusive Passing Lanes	D	-	-	-	-	-	R
	Percent No Passing Zones	D	-	-	-	-	-	R
	Length	D	R	A	-	-	-	-
SIGNALIZATION	Arrival Type	D	R	A	A	-	-	-
	Signal Type	D	R	R	I	-	-	-
	Signals per Mile	D	-	-	-	-	-	-
	Cycle Length	D	R	A	I	-	-	-
	Effective g/C ratio	D*	R*	A	I	-	-	-

LEGEND

D	DEFAULT CANNOT BE ALTERED	**A**	APPROACH SPECIFIC
R	ROUTE SPECIFIC	**M**	MOVEMENT SPECIFIC
I	INTERSECTION SPECIFIC	*	WEIGHTED g/C RATIO

Roadway variables include:

- Number of through lanes
- Arterial classification
- Free flow speed
- Existence of medians
- Existence of left turn bays
- Terrain
- Percent no passing
- Exclusive passing lanes

Signalization variables include:

- Arrival type
- Signal type (pretimed, traffic actuated, or semiactuated)
- Signalized intersections per mile
- Cycle length (C)
- Weighted effective green time to cycle length (g/C)

Each variable is defined and discussed in this chapter. Depending upon the roadway being analyzed, the variables may or may not be applicable. Nevertheless, when using any of the software to compute LOS or develop service volumes for a roadway, the data requirements should be reviewed.

4.2

MINIMUM VARIABLES REQUIRING ANALYSIS

There are six variables which have a significant impact on the calculated volumes and must, as a minimum, be analyzed and appropriate changes made for input to the computer models. The first three variables are applicable for all roads, while the latter three are primarily applicable to interrupted flow arterials.

- Planning analysis hour factor (K_{100})
- Directional distribution factor (D)
- Number of through lanes
- Left turn bays
- Signalized intersections per mile
- Weighted effective green time to cycle length (g/C)

4.3

GUIDANCE ON VARIABLES

The effects that individual variables have on the computational process vary. Table 4-2 indicates the sensitivity of the variables and references the section in this manual where additional information can be found.

Table 4 - 2

SENSITIVITY OF VARIABLES ON TRAFFIC VOLUMES

	Traffic/Roadway/Signalization Variables	Sensitivity on Traffic Volumes
TRAFFIC	Planning analysis hour factor (K_{100})	high
TRAFFIC	Directional distribution factor (D)	high
TRAFFIC	Peak hour factor (PHF)	medium
TRAFFIC	Adjusted saturation flow rate	medium
TRAFFIC	Turns from exclusive lanes	high
ROADWAY	Number of through lanes	high
ROADWAY	Arterial classification	medium
ROADWAY	Free flow speed	medium
ROADWAY	Medians / left turn bays	high
ROADWAY	Terrain / % no passing / passing lanes	low
SIGNALIZATION	Arrival type	medium
SIGNALIZATION	Signal type	low
SIGNALIZATION	Signalized intersection spacing	high
SIGNALIZATION	Cycle length (C)	medium
SIGNALIZATION	Weighted effective green time to cycle length (g/C)	high

4.4

FIELD DATA COLLECTION

When developing variables, the following must be taken into account:

- **All acquired data used to develop factors should be current and from the same time period** *i.e.*, within one year. Data that has been collected previously should be approved by the responsible agency prior to its use.

- Traffic count data should be obtained at 15-minute intervals when estimating K_{100} and D.

- Three day counts (taken from Monday afternoon through Friday morning) in urbanized areas and seven day counts elsewhere should be collected for deriving the appropriate estimated K_{100}, D and PHF. Exceptions, resulting in a different number of counts or time periods, may be based on such phenomena as shopping center or recreation traffic. Exceptions should be approved by district planning offices. If a continuous count station is directly applicable to a roadway, the K, D and PHF data from it should be used instead of the three day count data. Demand traffic also must be taken into consideration because it affects the appropriate K, D and PHF to be used.

- Traffic counters should be placed at "mid-block" locations. If data on turning movements is desired, additional counters should be placed appropriately. Note that the percentage of turns from exclusive lanes is taken from the factored (K, D, PHF) mid-block link volumes. Counts should be collected in both directions.

- The length of the arterial being analyzed (which may comprise several segments) should be at least one mile in downtown areas and at least two miles in other areas. In general, arterial length should be increased rather than decreased if there is uncertainty about length. To obtain a reasonable sample of average conditions, at least one count station should be used for each roadway section (major intersections normally define sections). If the single station does not obtain a representative sample of traffic, more should be used.

- If significant changes in trip characteristics (volumes) take place during peak and off-peak seasons, it is preferable to obtain traffic data during both of these seasons so that a more valid judgement about traffic variables can take place. Seasonal adjustment factors are available from FDOT District Offices.

- Be aware of the need for axle adjustments. See FDOT's "Design Traffic Procedure" (Topic 525-030-120) and the "Design Traffic Handbook" for more information.

4.5

TRAFFIC VARIABLES

Planning Analysis Hour Factor or K_{100} Factor

The Planning Analysis Hour Factor or K_{100} Factor is the ratio of the 100th highest volume hour of the year to the annual average daily traffic. In developed areas the 100th highest volume hour of the year is representative of a typical weekday peak traffic hour during the area's peak travel season. In Florida's developed areas the daily peak hour usually occurs in the late afternoon for most state roads. Thus, in developed areas of the state the 100th highest hour of the year is representative of the typical "rush" hour during the area's peak traffic season. The K_{100} factor should be representative of a demand volume, not necessarily a measured volume.

As volume increases, the peak period becomes longer thus decreasing the K factor.

The K_{100} factor is used to convert a peak hour volume to an annual average daily volume and vice-versa. The K_{100} factors used in the Generalized Tables (See Table 4-3) were obtained from FDOT's continuous count stations throughout the state with consideration given to demand volumes. Actual 100th highest hourly volumes and AADTs were used to determine the K_{100}s. The K factor generally drops as an area becomes more urbanized and high traffic volumes are spread out over longer time periods. Thus, FDOT would consider somewhat lower future values than appear in the tables if adequate documentation is provided.

The K_{100} Factor is not a peak to daily ratio. A peak to daily ratio is usually determined by obtaining hourly traffic counts for a day and dividing by the measured daily volume. In the Florida professional community, peak to daily ratios are frequently used as K factors. In most cases, especially in urbanized areas, peak to daily ratios are lower than K factors. Whereas, a K factor relates to the whole year, a one-day peak to daily ratio only accounts for traffic variability in one day. Traffic volumes derived from FSUTMS or other UTPS type models are generally peak season volumes due to use of peak season population and employment data as model input. See Section 5.15 for more information about model-generated volumes.

Table 4-3

STATEWIDE AVERAGE K_{100}s

Area	Uninterrupted Highways	Class I/II Arterials	Other Arterials
Rural Undeveloped	0.100	-	-
Rural Developed	0.095	0.095	-
Transitioning/Urban	0.093	0.094	0.092
Urbanized	0.091	0.093	0.092
Freeways			
Rural Undeveloped	0.101		
Rural Developed	0.101		
Transitioning/Urban	0.097		
Urbanized (Group 2)	0.092		
Urbanized (Group 1)	0.088		

Estimating Alternative K_{100}s

If the user believes the K values in Table 4-3 are not appropriate, local K_{100} factors may be estimated based on three day counts (*i.e.*, a 72-hour consecutive count taken within the time frame of Monday morning through Friday morning) in urbanized areas and seven day counts elsewhere. The approach makes use of FDOT's Seasonal Factors for weekday traffic counts and peak to daily ratios. The first step is to obtain appropriate Seasonal Factors (SF) for the project or area for the most recent three years from the FDOT District Planning Office. The Seasonal Factor may be for the county, a nearby count station or from some other source.

Procedure

Step 1: Determine the average Seasonal Factor (SF_{avg}) for the thirteen highest consecutive weeks of the year. (FDOT's Peak Season Factor Report includes this value, also known as the Model Output Conversion Factor or MOCF,) Do this for each of the three years. Take the average of those three average values. For example, the value may be 0.90 in 1995, 0.89 in 1996 and 0.88 in 1997 and the resultant 3-year average SF_{avg} would be 0.89.

Step 2: Determine the average peak to daily ratio (peak hour volume ÷ daily volume) for the 72-hour count as illustrated below:

Measured Day	Peak Hour	Daily Volume	Peak Hour Volume	Peak to Daily Ratio
1/22	4-5 PM	21,000	1700	0.081
1/23	5-6 PM	22,000	1800	0.082
1/24	5-6 PM	22,000	1900	0.086
Averages	NA	21,667	NA	0.083

Step 3: The estimated K_{100} is then the average peak to daily ratio divided by the average adjusted Seasonal Factor. Using the example shown above:

Step 1: 3-year average of SF_{adj} = 0.89;
Step 2: average peak to daily ratio = 0.083;
Step 3: estimated K_{100} = 0.083 ÷ 0.89 = 0.093.

Capacity Constraints and K_{100} ranges

It should be noted that the K_{100} estimation process described above makes use of measured traffic volumes, not necessarily more appropriate demand traffic volumes (see Section 4.9). The estimated demand traffic K_{100} should be used, not the measured K_{100}. The minimum acceptable K_{100} values FDOT will accept are presented in Table 4-4. If the estimation process above yields a number lower than in Table 4-4, the roadway(s) probably exhibits capacity constraints and is currently not accommodating demand traffic volumes. Under this situation FDOT may accept values as low as but not lower than those in Table 4-4. Additional documentation may also be required that the estimated K_{100} reflects a demand situation.

Table 4-4

MINIMUM ACCEPTABLE K_{100}s

Area	Uninterrupted Highways	Class I/II Arterials	Other Arterials
Rural Undeveloped	0.090	-	-
Rural Developed	0.086	0.086	-
Transitioning/Urban	0.083	0.084	0.082
Urbanized	0.080	0.082	0.080
Freeways			
Rural Undeveloped	0.092		
Rural Developed	0.092		
Transitioning/Urban	0.090		
Urbanized (Group 2)	0.087		
Urbanized (Group 1)	0.083		

Directional Distribution Factor (D)

The D or Directional Distribution Factor is used in converting annual average daily traffic to directional peak traffic. The peak hour D factor is the proportion of traffic during the peak hour traveling in the predominant direction. The default D factor recommended for use in Florida is 0.568. The default D factors were obtained from FDOT's continuous count stations using the 100th highest hour of traffic. The minimum D factor allowed by FDOT is 0.52. This is assuming that 52% of the peak hour traffic is traveling in one direction. If a roadway's traffic is constrained, the D will drop. Thus, consideration should be given to raising the D from the process illustrated below if a roadway is constrained.

Alternative Directional Distribution Factors

To estimate the D from a three (or seven) day count, calculate the average of the daily peak hour Ds. The process illustrated below shows how to obtain the estimated D from a 3-day count.

ESTIMATING D

Measured Day	Peak Hour	Peak Hour Volume	Predominate Direction Peak Volume	Opposite Direction Peak Volume	D
1/22	4-5 PM	1,700	884	816	0.520
1/23	5-6 PM	1,800	1,152	648	0.640
1/24	5-6 PM	1,900	1,102	798	0.580
Sums	NA	5,400	3,138	2,262	NA
Averages	NA	1,800	1,046	754	0.580

Estimated D = (0.520 + 0.640 + 0.580)/3 = 0.580

Peak Hour Factor (PHF)

The PHF or Peak Hour Factor is the hourly volume during the peak hour divided by the peak 15-minute rate of flow within the peak hour, or:

hourly volume ÷ (4 x peak 15 minute volume)

PHF indicates the uniformity of traffic volume within an hour.

Consideration of subhour peaks is important because congestion due to inadequate capacity occurring over a short time may take a substantial time to dissipate. The default PHF factors were obtained from FDOT's classification stations.

The maximum PHF FDOT will normally accept is 0.95. However, if adequate justification is provided by the applicant that a higher PHF is appropriate and represents an unconstrained situation, FDOT may accept a somewhat higher value.

Estimating PHF

To estimate the PHF from a three (or seven) day count, calculate the average PHF from the three highest measured peak hour volumes. The process shown below is an example of obtaining the estimated PHF from a 3-day count.

ESTIMATING PHF

Measured Day	Peak Hour	Peak Hour Volumes	15 Minute Volumes 1st	2nd	3rd	4th	Daily Peak Hour Factor
1/22	4-5 PM	1700	400	400	450	450	0.944
1/23	5-6 PM	1800	400	500	450	450	0.900
1/24	5-6 PM	1900	450	500	500	450	0.950
Average	NA	NA	NA	NA	NA	NA	0.931

Estimated PHF = 0.931

If a roadway's traffic is constrained, the PHF will generally increase. Thus, consideration should be given to lowering the PHF if a roadway is constrained.

Adjusted Saturation Flow Rate

The Adjusted Saturation Flow Rate is the maximum hourly flow rate per through (or through-right) lane at which vehicles can reasonably be expected to discharge from an intersection during an hour under full demand, all green time, and prevailing roadway and traffic conditions, expressed as vehicles per hour per lane. Roadway and traffic characteristics such as lane widths, driver population and truck percentages are applied to the maximum ideal saturation flow rate to obtain the adjusted rate.

Driver familiarity is the most significant adjustment.

Driver population (familiarity), which accounts for such differences in driving habits of commuters and recreation drivers, is the major factor accounting for different adjusted saturation flow rates on freeways and other uninterrupted flow facilities in the Generalized Tables. Lane utilization factors are not incorporated because the adjusted saturation flow rate used is for the average of all through or through-right lanes. A central business district adjustment factor was not included in dense urban areas because of the lack of documented data. Signalized arterials with a high degree of access control (*e.g.*, frontage roads, no driveways within 200 feet of the approach to the intersection) may have higher adjusted saturation flow rates than indicated in the Generalized Tables. It may be appropriate to increase capacities slightly for those types of facilities.

Turns from Exclusive Lanes

"Turns from Exclusive Lanes" is the percent of vehicles performing left or right turning movements at signalized intersections from lanes solely dedicated to turning movements. Most of the complicated aspects of the HCM chapter on signalized intersections deal with accommodating left turn movements. The Generalized Tables and models from which they are derived assume that left turns are adequately accommodated; there is no backing up of left turning traffic into the through lanes. **If this assumption cannot be made with confidence, results obtained from the planning analysis tools should be carefully scrutinized for accuracy.** Primarily for that reason the tables and programs must not be used for intersection design or traffic operations work.

Where a right turn lane of sufficient length exists, it is proper to add the percent of right turns to the percent of left turns (assuming a left turn bay/lane) to determine the percent turns from exclusive lanes.

The arterial LOS estimation methodology described in this document applies the HCM procedures to the through traffic at each signalized intersection. For planning purposes, it is assumed that the turning movements are accommodated by the signal timing plan. The service volumes computed by this technique do not include any turning movements made from exclusive lanes.

FDOT's planning tools assume there is no blockage of the through lanes by turning vehicles.

Turning volumes must therefore be added to the through volumes in determining the overall service volumes computed by the Generalized Tables and by ART-TAB. Conversely, the turning volumes must be subtracted from the overall demand volumes for purposes of computing arterial through-traffic delay by ART-PLAN. These operations are inherent in the techniques mentioned. The turning movement adjustments are made internally, based on the user-specified value of percent turns from exclusive lanes.

The accuracy of the results is understandably very sensitive to this variable. The Generalized Tables assume, for example, statewide averages for 0.44 g/C and 12 percent turns from exclusive lanes on state roads in urbanized and transitioning areas. These are user-specified items for ART-TAB and ART-PLAN. Proper use of these two programs requires some knowledge of field conditions.

Estimating Turns from Exclusive Lanes

To estimate turns from exclusive lanes would require turning movement counts at all signalized intersections to account for (1) through and shared through/right turns and (2) turn movements from exclusive lanes.

If it is desired to calculate turns for exclusive lanes, then the average turns from exclusive lanes for a roadway section's largest intersection(s) for the daily peak hours from a three (or seven) day count should be determined. For ART-PLAN, calculate the percentage for all intersections.

Measured Day	Peak Hour	Signalized Intersection	Total Peak Hr Predominant Approach Vol	Exclusive Lane Volume	Exclusive Lane Turn Vol %
1/22	4-5 PM	A	884	110	12.44
		B	900	100	11.11
1/23	5-6 PM	A	1152	120	10.42
		B	1150	120	10.44
1/24	5-6 PM	A	1102	120	10.89
		B	1090	130	11.93
Totals	NA	NA	6,278	700	NA

Estimated Percent Turns from Exclusive Lanes = 700/6278 = 11.15%

The factored mid-block link volume is the basis for the calculation of the percentage of turns from exclusive lanes.

Weighted g/C and % Turns Limitations

Another closely related variable is the signal characteristic of weighted green time to cycle length ratio (discussed in Section 4.7) In general, there is a trade off between the g/C ratio and the percent left turns from exclusive lanes, since both require longer green times. Furthermore, high g/C ratios imply heavy through traffic volumes which create a need for more green time for the associated left turns. If these variables are estimated without adequate field data, it is possible to create combinations of g/C ratio and percent left turns that exceed the parameters of a reasonable signal timing plan (*i.e.*, the timing plan will not be able to provide reasonable green times for the other movements that are assumed to be accommodated). This is especially true of six and eight lane arterials. If turning movement count and signal timing plans are the basis for the values, no check is needed.

It is possible to verify the adequacy of the timing plan by the procedure illustrated in Figure 4-1. This procedure computes the maximum allowable percent turns from left turn bays and is based on the following assumptions:

- The minimum cross street green time for minor cross streets is 20 seconds if cross street left turns are not protected, 30 seconds if they are protected with conventional left turn phasing and 40 seconds if they are protected with split phase operation. If the cross streets are major arterials themselves, then ten seconds should be added to the minimum green times in each of the above categories.

- The lost time is 4 seconds per phase for the arterial movements.

- The effective green time required to accommodate the arterial left turns is two seconds per vehicle per lane.

A high percentage of left turns may require so much green time that a high g/C for the through movement is not possible.

Figure 4-1 implements a rational procedure that determines the maximum allowable percent turns from exclusive lanes (Row 16) and compares this result with the assumed value (Row 7). If the assumed value exceeds the maximum allowable value, then the check fails, and g/C or the percent turns from exclusive left lanes may require adjustment. A more detailed analysis with field data would be needed to provide an adequate review.

Note that this procedure does not identify the recommended values for these data items. It simply provides a check to ensure that the assumed values are compatible with a reasonable signal timing plan. The default values used in the Generalized Tables are well within the maximum values that would be computed using Figure 4-1.

Figure 4-1

Procedure to Check the Maximum Allowable Percent Turns from Exclusive Lanes

Row	Description	Major	Minor
1	Enter cycle length		
2	Enter number of left turn lanes		
3	Enter directional peak hour demand volume (vph)		
4	Enter assumed g/C ratio for arterial through traffic		
5	Enter assumed value for % left turns from exclusive lanes		
6	Enter assumed value for % right turns from exclusive lanes		
7	Determine total % turns from exclusive lanes (Row 5) + (Row 6)		
8	Enter total cross street green time if known, or Determine minimum cross street green time: 20 seconds for unprotected left turns 30 seconds for protected left turns 40 seconds for split phase operation (add 10 seconds if the cross street is a major arterial)		
9	Compute time available for arterial movements: (Row 1) - (Row 8) - 6 seconds		
10	Compute effective arterial through green time: (Row 1) x (Row 4)		
11	Compute time available for arterial left turns: (Row 9) - (Row 10)		
12	Compute left turn capacity per lane: (Row 11) x 1800 / (Row 1)		
13	Compute total left turn capacity: (Row 12) x (Row 2)		
14	Compute maximum allowable left turn percent: 100 x (Row 13) / (Row 3)		
15	Compute maximum allowable % turns from exclusive lanes (Row 14) + (Row 6)		
16	If Row 15 is less than row 7 then the combined assumptions for arterial g/C ratio and percent left turns from exclusive lanes would not be viable.		

There is generally no need for this supplemental check if the assumed values are close to the default values. Either of the two assumptions (g/C or percent turns) may be increased slightly without violating the requirement for a viable signal timing plan. However, when both of these assumptions are increased significantly at the same time, the results should be checked using Figure 4-1. As a matter of practice, the check should be performed if the sum of the g/C and turns from exclusive lanes (both expressed in percent) exceeds 65%. Note that the default values of .44 (*i.e.*, 44%) for g/C and 12% for turns add up to 56%.

An example of the use of this check is presented as follows. Consider a six lane facility with peak hour demand volumes of 2500 vph in the major direction and 1900 in the minor direction. The assumed g/C values for the major and minor directions are .62 and .55, respectively. The assumed percent turns from exclusive lanes are 10% and 12%, respectively.

Figure 4-2 shows the computations for this example in the format of Figure 4-1

Note: The analyst should be cautioned to review individual intersection characteristics carefully. There are many intersections where there are no left or right turning movements from exclusive lanes (when the arterial to the right is a T intersection or a one-way facility, for example). This is especially important on multilane highways since 12% of the trips can be a great number of vehicles and often, intersecting roadways do not attract a large number of trips (*i.e.*, the signalized intersection to a housing development). This data is highly sensitive to the peak direction when there can be turning movements for one peak period and none or few for the other peak.

Procedure to Check the Maximum Allowable Percent Turns from Exclusive Lanes (Sample Calculation)			
Row	**Description**	**Major**	**Minor**
1	Enter cycle length	120	120
2	Enter number of left turn lanes	1	1
3	Enter directional peak hour demand volume (vph)	2500	1900
4	Enter assumed g/C ratio for arterial through traffic	.62	.55
5	Enter assumed value for % left turns from exclusive lanes	10	12
6	Enter assumed value for % right turns from exclusive lanes	0	0
7	Determine total % turns from exclusive lanes (Row 5) + (Row 6)	10	12
8	Enter total cross street green time if known, or Determine minimum cross street green time: 20 seconds for unprotected left turns 30 seconds for protected left turns 40 seconds for split phase operation (add 10 seconds if the cross street is a major arterial)	30	30
9	Compute time available for arterial movements: (Row 1) - (Row 8) - 6 seconds	84	84
10	Compute effective arterial through green time: (Row 1) x (Row 4)	74.4	66
11	Compute time available for arterial left turns: (Row 9) - (Row 10)	9.6	18
12	Compute left turn capacity per lane: (Row 11) x 1800 / (Row 1)	144	270
13	Compute total left turn capacity: (Row 12) x (Row 2)	144	270
14	Compute maximum allowable left turn percent: 100 x (Row 13) / (Row 3)	5.8%	14.2%
15	Compute maximum allowable % turns from exclusive lanes (Row 14) + (Row 6)	5.8%	14.2%
16	If Row 15 is less than row 7 then the combined assumptions for arterial g/C ratio and percent left turns from exclusive lanes would not be viable.	Fails	OK

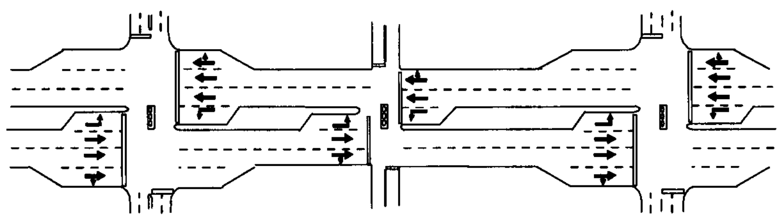
4.6

ROADWAY VARIABLES

Number of Lanes

Among the more unconventional aspects of the FDOT LOS Manual is the methodology for determining a road's "number of lanes". **For *Generalized Tables* capacity analysis purposes, a facility's number of lanes is determined by the through and shared through/right-turn lanes at major intersections, *not* at midblock.** In the illustration below, the midblock segments have four lanes - two in each direction. The major intersections each have six lanes - two through and one shared through/right turn add/drop lane with tapers adequate for safe weaving as defined below). In this illustration, as in many cases, minor signalized intersections have green times so heavily weighted to the arterial that they do not cause significant delays to through traffic. When this is the case, it is

This road should be considered as six laned due to the expanded major intersections. (Assuming that the minor intersection is not a cause of significant delay and the add/drop lanes are of sufficient length.)



sometimes acceptable to disregard the number of lanes at these minor intersections, instead basing the determination on the major intersections' laneage. So in terms of LOS, this particular section has six lanes.

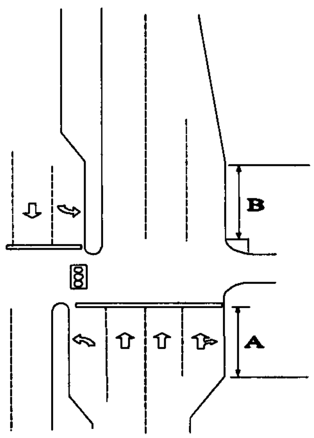
Since the ultimate result of the capacity analysis is a section-wide estimation of LOS, and it is widely recognized that signalized intersections are the most limiting components of the section, it is appropriate to place more emphasis on the intersections' characteristics than the mid-blocks'. Generally, most mid-block segments have capacities far exceeding those of major intersections and it is rare for significant delays to occur at mid-block. By weighting the effects of intersections more heavily, a more accurate aggregate estimation is possible.

For Uninterrupted Flow Facilities

The number of lanes is the basic section (mid-block) laneage. Thus, for example, a freeway with basically six lanes which is widened to eight lanes at an interchange should be considered a six-lane freeway

Analysis of Add/Drop Lanes (Expanded Intersections)

When lanes that carry through traffic are added before the intersection and dropped after the intersection, the add/drop lane (or expanded intersection) will contribute to intersection capacity, but probably not to the extent of a full through lane.



Add / Drop Lanes
(A + B = usable length)

Site-specific characteristics (*e.g.*, intensity and type of land use, driver behavior, speed, etc.) can dramatically affect the viability of add/drop pairs as through lanes; therefore, each application must be examined in a case-by-case manner. Analysts are strongly cautioned to review all pertinent characteristics prior to applying an effective-lane factor. ANALYSTS ARE STRONGLY ENCOURAGED TO CONSULT WITH FDOT DISTRICT PERSONNEL PRIOR TO APPLICATION OF THIS CONCEPT. These analysis guidelines are offered as a capacity estimating tool only. In no case, should this analysis process be used for the design or redesign of an expanded intersection.

If the add/drop pair is at least one-third mile (roughly divided equally between approach and departure and exclusive of tapers and cross-street width, *i.e.,* A + B in the accompanying diagram), it may be reasonable to consider an additional ½ lane for capacity purposes. For example, in the accompanying diagram if A = 1000' and B = 1000' then it would be reasonable to consider that the intersection approach has 2.5 effective through lanes. With a length of at least ½ mile (roughly divided equally between approach and departure and exclusive of tapers and cross-street width, *i.e.,* A + B in the accompanying diagram), it may be reasonable to consider that the add/drop pair as providing an additional fully effective through lane.

Arterial Class

Arterial Class is a categorization of arterials involving function, design and free flow speed. In Florida, arterial class is primarily determined by the posted speed limit (a surrogate for free flow speed), and signal density. The general categories are:

- Class I- arterials with speed limits of at least 45 mph and a signal density of less than two signals per mile;
- Class II - arterials with speed limits of at least 35 mph and a signal density from two to four and one-half signals per mile;

- Class III - arterials with speed limits of at least 35 mph and a signal density of at least four and a one-half signals per mile; and
- Class IV arterials are assumed in the downtowns of core cities in urbanized areas over 500,000.

When a facility's speed limit is 35 mph, the level of development (*e.g.*, business districts) and number of signalized intersections per mile are recommended as the primary determinants for arterial class. For additional guidance consult FDOT District staff.

Free Flow Speed

Free flow speed is the average speed of vehicles over an arterial segment not close to signalized intersections under conditions of low volume. In Florida the posted speed limit is often used as a surrogate for free flow speed . Speeds higher than the posted speed **may** be used if evidence dictates. (Analyses of uninterrupted facilities sometimes use a free flow speed equal to the posted speed limit plus five miles per hour.) The relevant District must approve any deviation from the posted speed and the measurement must comply with HCM measurement techniques.

Medians

Medians are painted, raised or grassed areas at least 10 feet in width that separate opposing mid-block traffic lanes and, for arterials, that allow midblock left turning vehicles to exit from through traffic lanes. Although this factor is not in the HCM, FDOT included it in the treatment of interrupted flow arterials to account for a lowering of mid-block average travel speeds. Continuous center left turn lanes are considered as a median in this analysis.

Left Turn Bays or Exclusive Left Turn Lanes

Left turn bays or exclusive left turn lanes are storage areas at signalized intersections to accommodate left turn movements. The length of these bays/lanes must be of sufficient length to accommodate left turns such that the through movement is not impeded. The HCM offers guidelines on this subject. When left turn bays or exclusive left turn lanes are not present, a shared lane exists. Guidance for shared lane analyses follows:

Treatment of Arterials Without Left Turn Bays

All of the planning level arterial analysis methods assume that left turns are accommodated by the geometric and signal operation design. Specifically, all methods assume that proper storage exists for all left turns. If this is not the case, then left turns will impede through traffic and intersection delays will suffer. To estimate the effect of left turns on through traffic in shared lanes accurately, it is necessary to know the traffic volumes and signal timing parameters to a level of detail that far exceeds any planning requirements.

Use of the Generalized Tables and ART-TAB in Shared Lane Situations

For simplicity, the Generalized Tables have intuitive factors (approved by the Level of Service Task Team but not contained in the HCM) to adjust for the lack of left turn bays. To account for the absence of left turn lanes, adjustment factors (found in the lower right of the tables) must be manually applied to the service volumes established in the table. Likewise, if an ART-TAB analysis is performed, the resulting service volume are internally reduced by the same factor. However, research indicates that the true value of the reduction is highly dependent on the distribution of traffic volumes among all the various movements, and a constant reduction factor (as used in the tables and ART-TAB) is inappropriate. Therefore, **the use of the Generalized Tables and ART-TAB when analyzing arterials without left turn bays is discouraged in all but the most basic analyses.** When possible, an ART-PLAN or HCM analysis should be performed, using the fractional lane methodology described below and in Table 4-5.

Shared Lanes on Multi-lane Roadways

A fractional number of lanes reflecting the degree of left turn blockage should be used with ART-PLAN at intersections which do not have a left turn bay. Table 4-5 indicates the appropriate fractional value as a function of the number of lanes on the facility, the left turn volume, and the volume of opposing traffic. Note that the fractional result always falls between the full number of lanes on the facility (indicating no interference from the left turns), and one lane less than the full number of lanes (indicating that the left turn has completely taken over the shared lane).

Shared-Lanes on Two-lane Roadways

The planning level shared lane model presented in the HCM treats the single lane case differently from the multilane cases. This is because the through traffic in a single shared lane is unable to divert to an alternate lane to avoid interference from the left turns. The single lane case is also treated in Table 4-5.

Table 4-5
Equivalent Number of Through Lanes

Opposing Volume	2 Through Lanes*				3 Through Lanes*				4 Through Lanes*			
	Left Turn Volume				Left Turn Volume				Left Turn Volume			
	50	100	150	200	50	100	150	200	50	100	150	200
0	1.8	1.70	1.59	1.50	2.77	2.59	2.45	2.35	3.70	3.50	3.35	3.2
50	1.8	1.66	1.53	1.43	2.73	2.54	2.40	2.29	3.66	3.44	3.29	3.1
100	1.7	1.61	1.48	1.37	2.70	2.49	2.34	2.24	3.62	3.39	3.24	3.1
150	1.7	1.57	1.43	1.32	2.67	2.45	2.30	2.20	3.58	3.34	3.20	3.1
200	1.7	1.53	1.39	1.28	2.64	2.41	2.26	2.17	3.55	3.30	3.17	3.0
250	1.7	1.50	1.35	1.25	2.61	2.37	2.23	2.14	3.52	3.27	3.14	3.0
300	1.6	1.47	1.32	1.22	2.58	2.34	2.20	2.12	3.49	3.24	3.12	3.0
350	1.6	1.45	1.30	1.20	2.56	2.31	2.17	2.10	3.46	3.21	3.10	3.0
400	1.6	1.42	1.27	1.18	2.54	2.29	2.15	2.08	3.43	3.19	3.08	3.0
450	1.6	1.39	1.24	1.15	2.51	2.26	2.13	2.07	3.40	3.16	3.07	3.0
500	1.6	1.36	1.21	1.13	2.48	2.23	2.11	2.05	3.37	3.14	3.05	3.0
550	1.5	1.33	1.19	1.11	2.45	2.20	2.09	2.04	3.35	3.12	3.04	3.0
600	1.5	1.30	1.17	1.09	2.43	2.18	2.08	2.03	3.32	3.10	3.03	3.0
650	1.5	1.25	1.12	1.06	2.40	2.16	2.06	2.03	3.29	3.09	3.03	3.0
700	1.4	1.20	1.09	1.04	2.37	2.14	2.05	2.02	3.27	3.07	3.02	3.0
750	1.4	1.17	1.07	1.03	2.35	2.12	2.04	2.01	3.24	3.06	3.01	3.0
800	1.3	1.14	1.05	1.02	2.32	2.11	2.03	2.01	3.22	3.05	3.01	3.0
850	1.2	1.06	1.01	1.00	2.30	2.09	2.03	2.01	3.20	3.04	3.01	3.0
900	1.1	1.03	1.00	1.00	2.27	2.07	2.02	2.01	3.17	3.03	3.01	3.0
950	1.1	1.01	1.00	1.00	2.25	2.06	2.01	2.00	3.15	3.02	3.00	3.0
1000	1.0	1.00	1.00	1.00	2.22	2.05	2.01	2.00	3.14	3.02	3.00	3.0
1050	1.0	1.00	1.00	1.00	2.12	2.01	2.00	2.00	3.06	3.00	3.00	3.0
1100	1.0	1.00	1.00	1.00	2.06	2.00	2.00	2.00	3.03	3.00	3.00	3.0
1150	1.0	1.00	1.00	1.00	2.03	2.00	2.00	2.00	3.01	3.00	3.00	3.0
1200	1.0	1.00	1.00	1.00	2.02	2.00	2.00	2.00	3.00	3.00	3.00	3.0
1250	1.0	1.00	1.00	1.00	2.02	2.00	2.00	2.00	3.00	3.00	3.00	3.0

* including shared left turns

Table 4-5 (cont.)
Equivalent Number of Through Lanes for One Lane

Opposing Volume	5% Left Turns				10% Left Turns				15% Left Turns				20% Left Turns			
	Through Volume				Through Volume				Through Volume				Through Volume			
	50	100	150	200	50	1000	150	200	50	100	150	200	50	100	150	200
0	.98	.97	.95	.94	.96	.92	.88	.85	.93	.86	.79	.74	.89	.78	.69	.61
50	.98	.96	.95	.93	.96	.91	.87	.83	.92	.85	.78	.72	.88	.77	.67	.59
100	.98	.96	.94	.92	.95	.90	.86	.82	.91	.83	.76	.70	.87	.75	.66	.57
150	.98	.96	.93	.91	.95	.90	.85	.80	.91	.82	.75	.68	.86	.74	.64	.55
200	.98	.95	.93	.90	.94	.89	.84	.79	.90	.81	.73	.66	.85	.73	.62	.53
250	.97	.95	.92	.89	.94	.88	.82	.77	.89	.79	.71	.63	.84	.71	.60	.50
300	.97	.94	.91	.88	.93	.86	.80	.75	.88	.78	.69	.61	.83	.69	.57	.48
350	.97	.93	.90	.87	.92	.85	.79	.73	.87	.76	.67	.58	.82	.67	.55	.45
400	.96	.93	.89	.86	.92	.84	.77	.71	.87	.75	.65	.56	.81	.65	.53	.43
450	.96	.91	.87	.83	.90	.82	.74	.66	.85	.71	.60	.51	.78	.61	.48	.38
500	.95	.90	.85	.81	.89	.79	.70	.62	.83	.68	.56	.46	.76	.58	.44	.33
550	.94	.88	.83	.78	.87	.76	.67	.59	.81	.65	.52	.42	.73	.54	.40	.29
600	.93	.87	.81	.76	.86	.74	.64	.55	.79	.62	.49	.38	.71	.51	.36	.26
650	.91	.83	.75	.69	.82	.67	.55	.45	.73	.54	.39	.29	.65	.42	.27	.18
700	.89	.79	.70	.63	.78	.61	.48	.38	.68	.47	.32	.22	.59	.35	.20	.12
750	.87	.75	.65	.57	.75	.56	.42	.31	.64	.40	.26	.16	.54	.29	.15	.08
800	.85	.72	.61	.52	.71	.51	.36	.26	.59	.35	.21	.12	.49	.24	.12	.06
850	.85	.72	.61	.52	.71	.51	.36	.26	.59	.35	.21	.12	.49	.24	.12	.06

Some care is necessary in dealing with the single lane case, because the methodology assumes that a left turning vehicle will block all of the following through vehicles while it waits for an opportunity to move. This will be true at some intersections; however, at others it may be possible for through vehicles to "squeeze by" a left turn using roadway capacity that does not theoretically exist. This treatment cannot be generalized for analysis purposes and field observations provide the only acceptable way to determine the appropriate treatment for LOS analysis.

Length of Exclusive Left-Turn Lanes

According to the HCM, "Left-turn lanes are provided to accommodate heavy left-turn movements without disruption to through and right-turning vehicles." It also states that "the length of the storage bay should be sufficient to handle the turning traffic without reducing the safety or capacity of the approach." A method for estimating the length needed for a particular intersection is found in Chapter 9 (Appendix I) of the Highway Capacity Manual; refer to Figure I.9-1 and Table I.9-1. The FDOT tables, "TAB" programs, and ART-PLAN assume that the length of left turn lanes is adequate to prevent blockage of through trips. If this assumption cannot be made with relative confidence, other tools should be employed.

Level Terrain

Level terrain is any combination of horizontal and vertical alignments which permits heavy vehicles to maintain approximately the same speed as passenger cars. The Generalized Tables assume level terrain.

Percent No Passing

Percent no passing refers to the percent of a section of a two-lane, two-way highway along which passing is prohibited in one or both directions. The Generalized Tables assume a range of 20 to 40 percent no passing for these roads in rural undeveloped areas. It is determined by measuring the percentage of no passing zones for each direction and then taking the average of both.

Exclusive Passing Lanes

An exclusive passing lane is an extra lane or a turnout on a section of a two-lane, two-way highway along which vehicles are free and legally able to pass. Continuous left turn lanes are not considered exclusive passing lanes.

4.7

SIGNALIZATION CHARACTERISTICS

Arrival Type

Arrival type is a general categorization of quality of signal progression. It is discussed in detail in the Highway Capacity Manual, and is summarized briefly here.

Progression quality resulting from arterial signal coordination has always been expressed in the HCM in terms of an "arrival type" (AT). The HCM defines six arrival types, with AT-1 representing the worst possible progression quality and AT-6 representing the best. (Very low delays are associated with AT-6, which suggests that nearly all of the vehicles are able to proceed through an intersection virtually unimpeded.) Uncoordinated operation (*i.e.*, random arrivals) is represented by AT-3. Chapter 11 of the HCM offers both a narrative and numerical description of the various arrival types.

Since AT-4 is currently the default assumption for coordinated systems, it is necessary to establish specific conditions under which more optimistic arrival types should be assumed to prevail.

A high AT in one direction very often dictates a low AT in the other direction.

The conditions that identify favorable progression can only be applied on an intersection-by-intersection basis. AT-5 or 6 may well apply at specific intersections along a route; however, it would be rare to see these conditions apply to an entire route. Furthermore, the assumption of very good progression in one direction implies that a lower progression quality may prevail in the other direction. With a relatively even directional distribution, the off-peak direction speeds could be lower than the arterial LOS if very favorable progression has been established for the peak direction. For these reasons, progression quality better than AT-4 should not be assigned in LOS analyses that use either the Generalized Tables or ART-TAB.

For ART-PLAN analyses, AT-5 or 6 may be assigned to individual links that meet **all** of the criteria listed below:

Arrival type 5 may be appropriate when:

- Intersection spacing is less than 1/4 mile on Class 2 arterials and ½ mile on Class 1 arterials.

- There is minimal entry onto the arterial from cross street turning movements, and no T intersections or access from major generators such as shopping centers.

- The progression design favors the direction of traffic movement being analyzed. At least 70% of the green time at the nearest upstream intersection should be included in the progression band through the intersection in question.

- The g/C ratio at the intersection in question is not greater than 0.6 and not less than the g/C ratio at the nearest upstream intersection.

Arrival type 6 may be appropriate when: (NOTE: When arrival type 6 is assigned to a specific direction at an intersection, the arrival type for the opposite direction should be no better than AT-3.)

- Intersection spacing is less than 800 feet on Class 2 arterials and 1200 feet on Class 1 arterials.

- There is negligible entry onto the arterial from cross street turning movements from any source.

- The progression design strongly favors the direction of traffic movement being analyzed. At least 90% of the green time at the nearest upstream intersection should be included in the progression band through the intersection in question.

- The g/C ratio at the intersection in question is not greater than 0.6 and not less than the g/C ratio at the nearest upstream intersection.

Signal Type

The signal type indicates the degree to which a traffic signal's cycle length, phase plan, and phase times are preset or actuated. The types are:

- Actuated signals - all approaches to the intersection have vehicle detectors. Each phase is subject to a minimum and maximum green time and some phases may be "skipped" if no vehicle demand is detected.

The most common signal control type in Florida's urbanized areas is semi-actuated.

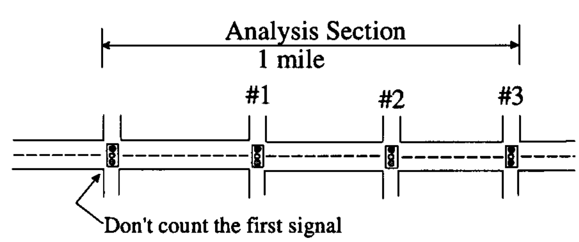
- Semi-actuated signals - vehicle detectors are only located on the minor street. The signal is set such that the green is always on the major street unless a vehicle is detected on the minor street.

- Pretimed - the signal times out a preset sequence of phases in repetitive order. Each phase has a fixed green time and change interval that is repeated in each cycle. Cycle length is constant.

In the Generalized Tables, actuated signals are assumed when the number of signalized intersections per mile is less than 2. Semiactuated signals are assumed when the number of signalized intersections per mile is at least 2.

Signalized Intersections per Mile

When determining the number of signalized intersections per mile, both signalized intersections at the ends of the analysis section should not be counted. Because Florida's Generalized Tables are based on peak hour volumes, generally, the roadway's first signalized intersection should not be counted and the last one should.



3 Signals Per Mile

For example, often in southeast Florida, principal arterials are spaced one mile apart with other signalized intersections between them. In this situation only one of the signalized intersections at the end of the road section, plus the signals in between should be counted when determining the number of signalized intersections per mile. In general, the first intersection in the peak flow direction would not be counted and the last one would. Alternatively, the number of signalized intersections per mile can be considered as the number of roadway segments or links between signalized intersections within the appropriate distance. Do not count the signal at the end of a section as one-half of a signal.

An arterial containing a flashing red signal and stop or yield conditions should not be analyzed using the Generalized Tables or ART-TAB.

For ART-PLAN applications, specific values of equivalent signal operating parameters are presented for two-way and all-way stops. Because these parameters must be applied carefully to individual locations, they cannot be used to represent the arterial as a whole. **Therefore, arterials with stopped delay other than signalized intersections cannot be accurately analyzed using the Generalized Tables or ART-TAB.**

On rare occasions, unsignalized intersections will introduce additional delay on arterial routes. It is not possible to accommodate unsignalized treatments in either of the tabular methods (Generalized Tables or ART-TAB) because of their assumption of homogeneity among intersections.

It is, however, possible to derive approximations of signalized intersection operating parameters for use in ART-PLAN. Recognizing that these are indeed approximations, the following guidelines are offered:

- **For two-way stop control** in which the arterial traffic is stopped (stop signs or flashing red light), the equivalent cycle length should be assumed to be 30 seconds. The effective green time ratio, g/C should be computed as:

$$g/C = 1 - (V_c/1400)$$

where V_c = The sum of the cross street hourly volumes.

- **For all-way stop control** (both the arterial and cross street are stopped) the equivalent cycle length should be set at 15 seconds. The effective g/C ratio should be estimated as:

$$g/C = (15(V_{AH} / V_{CH}) - 3) / 15$$

where V_{AH} = The arterial volume in the heaviest direction
and V_{CH} = The cross street volume in the heaviest direction

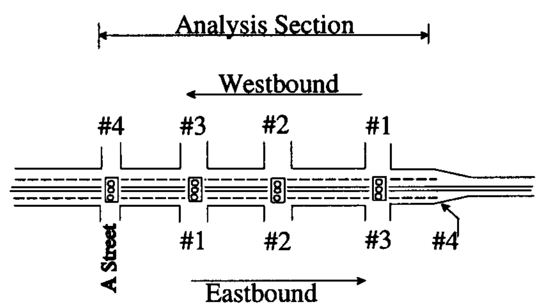
These g/C values are subject to minimum and maximum values of 0.3 and 0.7, respectively.

If the approximations suggested above indicate that the intersection in question would operate beyond its capacity, then a more detailed analysis should be conducted using the full HCM Chapter 10 methodology for analyzing two-way or all-way stop control.

Arterials Terminating Where There Is No Intersection

When determining the number of signalized intersections for LOS calculation using the Generalized Tables, an arterial section that ends where there is no intersection (*e.g.*,lane drops, ramp junctions) should be treated as if the termini is a signalized intersection with a g/C ratio of .99.

For example, a four-lane highway leads eastward out of an



urbanized area. The western terminus is A Street. There are three signalized intersections east of A Street. However, the analysis section extends one mile past the last signal as a four-lane road. At that point, the road tapers and becomes a two-lane (transitioning) arterial.

This arterial section should be analyzed by counting the section terminus as a signal, which means there would be four signalized intersections along the arterial. In ART-TAB and ART-PLAN analyses, the g/C of the eastbound terminus (#4) is assumed to be .99. It should be noted that if analyzed westbound and counting the downstream signals, there are four, since the western terminus is signalized.

Signalized intersection spacing

The distance between signalized intersections is required to determine specific service volumes for a section of roadway. FDOT's Generalized Tables use signalized intersections per mile as a variable and assume uniform spacing. While this spacing may be acceptable for an areawide analysis, precise distances between signalized intersections should be determined when an individual roadway is being analyzed. The ART-PLAN model is a more accurate tool to calculate LOS when specific intersection spacing is known.

See Section 4.6 for information on signalization in arterial classification.

NOTE: Those who use the Generalized Tables or develop unique tables using ART-TAB are cautioned that, over time, roadway and traffic characteristics change. The number of signalized intersections per mile is frequently the most significant change. As development takes place and an area urbanizes, the number of signals is likely to increase. Thus, capacity analysis for the future must take into account changes in roadway and signalization characteristics.

Cycle Length (C)

C or cycle length is the total time for a signal to complete a sequence of signal indications. For actuated and possibly semiactuated signals the cycle length may vary depending on side street traffic. Usually these signals have a maximum cycle length, assuming the maximum time is allocated for each phase. As used in the Generalized Tables the cycle length represents this maximum cycle length.

Weighted Effective Green Ratio (g/C)

The g/C ratio (effective green time to signal cycle length), as it pertains to arterial analysis in this manual, is the ratio of the time at signalized intersections allocated for only the through traffic movement, *i.e.,* green plus yellow plus all red minus the start-up lost time minus the clearance lost time, (g) (this is also known as effective green time) to the cycle length (C). The "g/C" term is consistent with the definition in the HCM. The weighted g/C of an arterial is the average of the critical intersection through g/C and the average of the other intersections' through g/C ratios.

Weighting the g/C allows the aggregation of data from multiple signals.

Clearly the amount of green time that traffic movements receive at signalized intersections is one of the most significant variables in capacity analysis. A major simplifying assumption, essential to development of the models and the Generalized Tables, was the selection of a single g/C ratio value for all intersections on the arterial section. Thus, a fundamental technical question is what green time value to assume for arterials. Should it represent the average green time that through movements receive along the arterial section, or should it be the green time that the through movement receives at the critical intersection where the greatest delay is likely to occur, or should it be some other value? The concept of "weighted effective green time ratio" was created for this purpose. Like the HCM, FDOT's effective green time ratio is the ratio of the effective green time to the signal's cycle length (C) for a specific movement (the through movement).

For instance, if over a four mile section of a principal arterial the lowest through g/C is 0.4 and the average through g/C for the other intersections is 0.6, then the weighted g/C is 0.5. The weighted g/C takes into account the adverse impact of the critical intersection and the overall quality of flow for the arterial length.

This weighted approach has been found to be a reasonable simplifying assumption. Under typical traffic, roadway and signalization conditions, the "weighted g/C" approach yielded speeds within 2 mph of entering actual g/C ratios for each intersection. In general, the approach slightly overestimates speeds when the number of signalized intersections per mile is greater than 2.5 and slightly underestimates speeds when the number of signalized intersections per mile is less than 2.5.

NOTE: The g/C in the Tables is not the average g/C which is frequently provided in site impact information.

Determining the Critical Intersection

The critical intersection is typically the intersection with the lowest g/C. However, in determining the critical intersection along an arterial, the analyst is cautioned about using g/C ratios from intersections with a different number of lanes from the arterial being analyzed. Because of the difference in the number of lanes, the green time needed to accommodate the through trips would be different. The green time allocated for a two lane road will not handle as many trips as the same green time on a four-lane road. For example, Arterial A has 4 intersections. Intersections 1, 2 and 3 have two through lanes. Intersection 4 has three through lanes which continue for more than 1,500 feet. More vehicles can pass through Intersection 4 because of the additional lanes so it does not require as much green time. Therefore, the g/C ratio could be lower. Thus, this g/C should not be considered as critical when calculating the weighted g/C ratio.

For making a rough estimate of the g/C at an intersection with a fractional additional lane (for use in calculating the weighted g/C to be used in an ART-TAB analysis), the adjusted g/C ratio may be derived as:

Adjusted g/C = Actual g/C x (N+P)/N

where N = The number of full through lanes (one direction)
and P = The partial lane value as determined in Section 4.6

For example, Arterial A, described above, has g/C ratios of .45, .53 and .38 for the three intersections with two through lanes. Intersection 4 with three through lanes has a true g/C of .31. The "adjusted" g/C would be calculated by

$$\begin{aligned}\text{Adjusted g/C} &= .31\ (2+1)/2\\ &= .31(3)/2\\ &= .465 \text{ or } .47\end{aligned}$$

Therefore, the intersection with the g/C of .38 would be the critical intersection and the "weighted" g/C would be the average of the critical intersection with the average of the non critical intersections

$$\begin{aligned}\text{"weighted" g/C} &= [.38 + (.45+.53+.47)/3\}]/2\\ &= [.38 + .48]/2\\ &= .43\end{aligned}$$

The weighted g/C is used in the Generalized Tables and the ART-TAB computer model, but not in the ART-PLAN computer model in which g/C is entered for each signal (see Chapter 7). This weighted approach has been found to be a reasonable simplifying assumption.

4.8

Characteristics And Their Sensitivity

The volumes in the Generalized Tables are sensitive to many of the input values appearing on the back of the Tables. Summarized in Table 4-6 is a sensitivity analysis of the input assumptions using selected modified values. The Table is based on a LOS D daily volume for a four-lane, two-way arterial with three signals per mile (Class I) as the base case. That type of roadway can be thought of as a typical situation in the state. Also many of the input value assumptions used in the Tables are indicative of peak hour volumes. Thus, the service flow rates in the Generalized Tables better reflect LOS D and E situations than A and B situations.

As indicated in Table 4-6, a roadway's service volumes can vary significantly because of either traffic, roadway, or signal characteristics. All three types of inputs are important in determining levels of service in developed areas. The **most important** input variable is the number of through lanes passing through intersections. The **next most important** variables are the number of signalized intersections per mile and the effective green time. **Other significant variables** are the planning analysis hour factor (K_{100}), directional distribution factor (D), and whether the roadway has left turn bays at major intersections .

The following provides some comments on the input values used in the sensitivity analysis:

- Unlike other variables, the decision to use K_{100} (as opposed to K_{30}, or peak-to-daily) is a policy decision, not a technical decision. There are valid reasons for using a time period other than the 100th highest hour volume of the year; however, as part of the FDOT's planning LOS standards, K_{100} must be used. Using a different peak hour condition like K_{30} (design hour) or a peak-to-daily ratio would alter the tables' values significantly.

- Florida's permanent count stations indicate an average directional distribution factor (D) in peak hours of 56.8%. Increasing the D factor would generally decrease the values in the Tables. As stated previously, the models from which the Generalized Tables are derived assume that turn movements are accommodated. Turn movements are considered in the models as add-ons to the through movement. The models are inappropriate when significant turn movements exist. In fact, because of their structure, the models incorrectly show a small positive relationship between left turn movements and volumes. For this reason Table 4-6 does not include a sensitivity analysis of protected turn movements.

Table 4 -6
SENSITIVITY ANALYSIS OF INPUT VARIABLES

	INPUT VARIABLE	BASE CASE	INPUT CHANGE VALUE	LOGIC FOR MODIFICATION	MODIFICATION LOS "D" SFR **	RESULTING CHANGE IN LOS "D" SFR
TRAFFIC	K_{100}	0.093	0.097	Design hour analysis (K_{30})	31,100	-4%
	K_{100}	0.093	0.080	Typical peak hour analysis (P/D)	37,700	16%
	D	0.568	0.67	Commuter road	27,500	-15%
	D	0.568	0.60	Widely used value	30,700	-6%
	PHF	0.925	0.90	HCM default value	31,600	-3%
	PHF	0.925	0.95	Capacity constrained roadway	33,300	2%
	PHF	0.925	1.00	Widely used in Florida	35,000	8%
	Adj. Sat.Flow	1,850	1,700	Widely used value	29,800	-8%
ROADWAY	Through Lanes	4	2 Undiv.	Typ. road section in Florida	14,900	-54%
	Through Lanes	4	6	Typ. road section in Florida	48,900	50%
	Arterial Class	II	III	Downtown LOS criterion	33,000	2%
	Arterial Class	II	VI	Metro downtown LOS criterion	35,000	8%
	Posted Speed	45	35	Lower range for Arterial Class I	29,800	-8%
	Divided	Yes	Undiv.	Roadway w/ left turn bays	30,800	-5%
	Divided	Yes	Undiv.	Roadway w/out left turn bays	24,300	-25%
SIGNAL	Signal. Intersects/Mi.	3	5	Higher range for Arterial Class I	21,300	-34%
	Signal. Intersects/Mi.	3	1	Lower range for Arterial Class I	35,000	8%
	Arrival Type	4	3	Random arrival at intersections	31,000	-5%
	Arrival Type	4	5	Very good signal progression	33,500	3%
	Signal Type	Semi	Pre	Typ. signal system in Florida	32,500	0%
	Signal Type	Semi	Act	Typ signal system in Florida	32,500	0%
	Cycle Length	120	90	Typ cycle length (same g/C)	33,100	2%
	Cycle Length	120	90	Typ. cycle length (approp. lost time)	32,300	-1%
	g/C	0.44	0.32	Critical intersection g/C for arterials	20,700	-36%
	g/C (Funct. Class)	0.44	0.395	Weighted g/C for minor arterials	28,800	-14%
	g/C (Funct. Class)	0.44	0.465	Weighted g/C principal arterials	34,500	6%
	g/C	0.44	0.47	Weighted g/C with no lost time	34,900	7%
	g/C	0.44	0.52	Average through g/C for arterials	39,100	20%
	LOS Standard	D	C	FDOT std. in nonurbanized areas	22,900	-30%
	LOS Standard	D	E	Alternative standard	34,300	6%

* Based on a level of service D daily volume of 32,500 for a four-lane, two-way arterial with three signals per mile in an urbanized area as the base case.

** Service flow rate.

Source: Florida Department of Transportation, 1998.

- As stated previously, the models from which the Generalized Tables are derived assume that turn movements are accommodated. Turn movements are considered in the models as add-ons to the through movement. The models are inappropriate when significant turn movements exist. In fact, because of their structure, the models incorrectly show a small positive relationship between left turn movements and volumes. For this reason Table 4-6 does not include a sensitivity analysis of protected turn movements.

- Arterial classification is not a precise measure; judgement is involved. A full two-step shift in arterial classification is an important change. The arterial classification variations in Table 4-6 also provide some insight into what might happen if a government chooses to use an average travel speed LOS criterion that differs from the HCM.

- National research indicates that average free flow speeds in urban areas generally range from 2 to 8 mph higher or approximately 5 mph higher than posted speed limits. In any case, free flow speed is a relatively inconsequential variable. Losses in average travel speed primarily occur at signalized intersections, not mid-block. A maximum saturation flow rate of 1900 passenger cars per hour per lane is used as a starting point in FDOT's Tables. After minimal adjustments for lane widths and truck volumes the Tables assume an adjusted saturation flow rate of 1850 passenger cars per hour per lane. Using more traditional lower input values the resulting output volumes also would be lower.

- Because of the importance of intersection spacing or the number of signalized intersections per mile, FDOT's Tables are largely built around that input variable. The other exceptionally important signalization input variable is the g/C ratio. FDOT's g/C approach was described in section 4.7. Frequently, average g/C ratios are used in transportation studies. This approach would substantially raise the tables' volumes. Another approach would be to use the g/C of a critical intersection in determining an arterial's service flow rate. This approach would substantially lower the tables' volumes. Another approach would be to distinguish between principal and minor arterials (a functional classification approach), and their corresponding g/C ratios. In general, principal arterials receive greater green time and thus, would have greater service flow rates. Minor arterials, on the other hand, would have less green time and would have lower service flow rates.

Table 4-6 only addresses input sensitivity as they apply to the LOS D flow rate. Using a different road type or different LOS flow rate could greatly alter the sensitivity of the input variables. Also, in rural areas because of widely varying traffic characteristics and changing LOS measures of effectiveness in the HCM, changing input assumptions may significantly affect results when using the computer programs.

4.9

TRAFFIC VOLUME AND TRAFFIC DEMAND RELATIONSHIPS

Traffic volume is the most basic of all traffic parameters and is defined as the number of vehicles passing a point on a highway during a specified time period (15 minutes). Volume is the parameter most often used to quantify traffic demand; however, the relationship between traffic demand and traffic volume is not a simple one. Traffic demand is the number of vehicles that desire to traverse a particular section of highway during a specified time period. Whereas, traffic demand expresses a desire, traffic volume represents actual measurements.

Traffic studies result in the observation and measurement of conditions as they presently exist. Current observations do not indicate what will be in the future, nor do they reflect constraints in the existing highway system that may prevent vehicles from accessing a desired section of the system at any given point in time. Thus, even current volumes may not accurately reflect current demand where such constraints exist. Congestion on a surface network severely distorts demand patterns, and observed volumes are more a reflection of capacity constraints than of true demand. The impact of bottlenecks, alternative routes, latent travel demand and future growth further complicate the relationship between traffic volume and traffic demand.

Demand versus Measured Volumes

For convenience, the Generalized Tables are presented in terms of "volumes"; however, they more accurately reflect "traffic demand". **As used in this manual "volume" represents "traffic demand".** Because of the complexities of determining traffic demand, techniques in this manual make use of "measured volumes" to approximate demand; however, if a question arises as to the appropriateness of using "measured volumes" or "demand volumes", it is clear **"demand volumes" are to be used.**

For additional information and background on traffic demand consult Chapter 2 of the Highway Capacity Manual.

4.10

LENGTH OF ROADWAY SECTIONS

In order to use the Generalized Tables or compute LOS using one of the planning models, it is necessary to separate a roadway into "sections" appropriate for the analysis tool. This section provides guidelines on the development of "level of service sections" for analysis purposes in the state of Florida. The beginning and end of each section is referred to as the termini. The factors considered in selecting the appropriate termini for a roadway section relate to use of the Generalized Tables and other analysis considerations. For example, the Tables are based on a particular number of lanes so a change in the number of lanes on a roadway is a necessary terminus for a section. Other logical termini may be signalized intersections or geographical barriers. Likewise, area boundaries, (urban, transitioning and rural) form necessary section termini.

The values shown in the Tables are based on and are suitable for a reasonable length of roadway. The Generalized Tables were developed to estimate LOS for "sections of roadways". The **values shown in the Tables do not indicate "segment" or "link" volumes**, volumes between signalized intersections. The purpose of an arterial is to move through vehicles along the facility at a reasonable travel speed.

No precise guidelines can be given on the proper termini or length of reasonable freeway and arterial sections. However, the following guidelines for freeways and arterial sections are suggested:

- general lengths
    - at least 1 mile in downtown areas
    - at least 2 miles in other areas
- termini
    - intersecting principal arterials or freeways
    - from the urban(ized) boundary to the first intersecting principal arterial
    - changes in the number of through lanes
    - when the LOS for a roadway segment varies by at least two levels in a consistent manner
    - when traffic volumes vary significantly from one area to another, especially if the variation is associated with changes in adjacent land uses, traffic volumes, signalization characteristics or peak directions
    - from city limit to city limit in cities under 5,000 population

NOTES:

5

GENERALIZED TABLES

Generalized level of service (LOS) tables are in widespread use throughout the United States. The tables are generally used in transportation planning to determine existing and future levels of service on roads and in project development to determine the number of through lanes.

FDOT's Generalized Tables are used throughout the U.S.

FDOT's Generalized Level of Service Tables (Tables 5-1 through 5-9) were developed based on the definitions and methodology of the HCM as updated in 1997. They are believed to be the most thoroughly researched and state-of-the-art Generalized Tables in the United States.

Roadway levels of service are qualitative measures describing the operational conditions of the roadways. Six levels of service are defined for each facility type and are given designations ranging from "A" (the best) to "F" (the worst). Thus, levels of service indicate quality of flow measured by some scale of driver satisfaction. The definitions and measures of levels of service reflect a national consensus of driver quality of flow.

The tables were developed from data collected around the state.

FDOT personnel conducted numerous traffic and signalization studies and developed values to reflect average conditions in Florida. Daily and directional data were derived from FDOT's continuous traffic count stations throughout Florida. Signal timing data were obtained from analyses of traffic signal timings in Miami, Tampa, Tallahassee, Gainesville, DeLand and Lake City. FDOT's intent has been to develop the most realistic numbers based on actual traffic, roadway and signalization data.

5.1

USING THE GENERALIZED LEVEL OF SERVICE TABLES

Florida's Generalized LOS Tables consist of three area groupings:

- urbanized areas;
- areas transitioning into urbanized areas or cities over 5000 population not in urbanized areas; and
- rural undeveloped areas or cities and developed areas less than 5000 population.

Peak Hour Directional Tables (Tables 5-1, 5-2 and 5-3) are provided because traffic engineering analyses are conducted on an hourly or subhourly basis. However, since many planning analyses are presented on a daily basis, Generalized Daily (annual average daily traffic) LOS Maximum Volume Tables (Tables 5-4 through 5-6) are provided. These tables are based on the Peak Hour Directional Tables and typical traffic peaking (based on the 100th highest hour of the year) and distributional characteristics. Many areas have adopted two-direction peak hour standards. Tables 5-7 through 5-9 provide Generalized Two-way Peak Hour Volumes also based on the Peak Hour Directional Tables.

All three sets of tables are internally consistent. More specifically, all of the volumes are based on the higher directional flow of traffic for the 100th highest hour of the year with traffic fluctuations within the hour accounted for. The 100th highest hour is approximately equivalent to the typical peak hour of a day during a peak season in a developed area (based on a default K factor). Directional hourly volumes are divided by the directional factor (D) (a default D factor) to obtain non-directional hourly volumes. Non-directional hourly volumes are divided by the planning analysis hour factor (K_{100}) to obtain daily volumes. Again, it is stressed that the daily, two-way peak hour and peak hour directional tables are internally consistent. The daily and peak hour tables measure the same time period and direction if the analyst is basing the analysis on default K and D factors, therefore roadways which experience peak-hour characteristics which are significantly different than the generalized planning analysis hour and/or directional factors should not be analyzed using the Daily or Two-Way Peak Hour tables at the daily or non-directional peak-hour level.

5.2

A Description of Florida's Level of Service Tables

Urbanized Areas

Florida's generalized peak hour directional volumes for Florida's urbanized areas are presented in Table 5-1. Annualized average daily traffic volumes are presented in Table 5-4. Two-way peak hour volumes are presented in Table 5-7.

Areas Transitioning into Urbanized Areas or Areas over 5000 Not in Urbanized Areas

Florida's generalized peak hour directional volumes for Florida's areas transitioning into urbanized areas or areas over 5,000 not in urbanized areas are presented in Table 5-2. Annualized average daily traffic volumes are presented in Table 5-5. Two-way peak hour volumes are presented in Table 5-8.

Rural Undeveloped Areas and Cities or Developed Areas less than 5000 Population

Florida's generalized peak directional volumes for Florida's rural undeveloped areas and cities or developed areas less than 5,000 population are presented in Table 5-3. Annualized average daily traffic volumes are presented in Table 5-6. Two-way peak hour volumes are presented in Table 5-9.

NOTES:

Table 5-1

GENERALIZED PEAK HOUR PEAK DIRECTIONAL VOLUMES FOR FLORIDA'S URBANIZED AREAS*

STATE TWO- WAY ARTERIALS

UNINTERRUPTED FLOW

Unsignalized

Lanes/ Divided	A	B	C	D	E
2 Undivided	460	720	980	1,280	1,710
4 Divided	1,110	1,850	2,590	3,110	3,700
6 Divided	1,670	2,780	3,890	4,660	5,550

INTERRUPTED FLOW

Class I (>0.00 to 1.99 signalized intersections per mile)

Lanes/ Divided	A**	B	C	D***	E***
2 Undivided	N/ A	570	820	880	880
4 Divided	N/ A	1,240	1,750	1,850	1,850
6 Divided	N/ A	1,890	2,640	2,780	2,780
8 Divided	N/ A	2,390	3,240	3,400	3,400

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/ A	N/ A	520	790	850
4 Divided	N/ A	N/ A	1,210	1,710	1,810
6 Divided	N/ A	N/ A	1,880	2,580	2,730
8 Divided	N/ A	N/ A	2,360	3,180	3,350

Class III (more than 4.50 signalized intersections per mile and not within primary city central business district of urbanized area over 500,000)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/ A	N/ A	170	630	820
4 Divided	N/ A	N/ A	410	1,450	1,750
6 Divided	N/ A	N/ A	630	2,260	2,640
8 Divided	N/ A	N/ A	800	2,830	3,240

Class IV (more than 4.50 signalized intersections per mile and within primary city central business district of urbanized area over 500,000)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/ A	N/ A	190	720	800
4 Divided	N/ A	N/ A	470	1,560	1,700
6 Divided	N/ A	N/ A	730	2,380	2,560
8 Divided	N/ A	N/ A	920	2,930	3,140

Source: The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street - Mail Station 19
Tallahassee, Florida 32399-0450

http:/ / www.dot.state.fl.us/ planning

FREEWAYS

Group 1 (within urbanized area over 500,000 and leading to or passing within 5 miles of the primary city central business district)

Lanes	A	B	C	D	E
4	1,060	1,720	2,570	3,310	4,090
6	1,630	2,630	3,950	5,080	6,270
8	2,220	3,590	5,390	6,930	8,550
10	2,780	4,490	6,730	8,660	10,690
12	3,260	5,270	7,900	10,160	12,540

Group 2 (within urbanized area and not in Group 1)

Lanes	A	B	C	D	E
4	1,090	1,710	2,570	3,270	3,900
6	1,680	2,630	3,950	5,030	5,990
8	2,290	3,590	5,390	6,860	8,170
10	2,860	4,490	6,740	8,580	10,210
12	3,350	5,270	7,900	10,050	11,970

NON- STATE ROADWAYS

MAJOR CITY/COUNTY ROADWAYS

Lanes	A**	B**	C	D	E
2 Undivided	N/ A	N/ A	440	760	830
4 Divided	N/ A	N/ A	1,030	1,640	1,750
6 Divided	N/ A	N/ A	1,590	2,470	2,640

OTHER SIGNALIZED ROADWAYS
(signalized intersection analysis)

Lanes	A**	B**	C	D	E
2 Undivided	N/	N/	250	560	620
4 Divided	N/	N/	600	1,230	1,310

ADJUSTMENTS

DIVIDED/UNDIVIDED

(alter corresponding directional volume indicated percent)

Lanes	Median	Left Turn Bays	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

ONE- WAY

(alter corresponding directional volume indicated percent)

One-Way Lanes	Equivalent Two-Way Lanes	Adjustment Factors
2	4	+20%
3	6	+20%
4	8	+20%
5	8	+50%

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are hourly directional volumes for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. To convert to annual average daily traffic volumes, these volumes must be divided by an appropriate D factor and K100 factor (not peak-to-daily ratio). The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

September 1998

Table 5-1 (Continued)

INPUT VALUE ASSUMPTIONS

STATE TWO-WAY ARTERIALS

CHARACTERISTIC	UNINTERRUPTED		Class I			Class II			Class III			Class IV		
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln
Planning Analysis Hour Factor (K100)	0.091	0.091	0.093	0.093	0.093	0.093	0.093	0.093	0.092	0.092	0.092	0.092	0.092	0.092
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,850	2,000	1,850	1,850	1,700	1,850	1,850	1,700	1,850	1,850	1,700	1,800	1,800	1,650
% Turns from Exclusive Lanes			12	12	12	12	12	12	12	12	12	12	12	12
Urbanized, Transitioning/Urban, Rural	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Arterial Class			1	1	1	2	2	2	3	3	3	4	4	4
Free Flow Speed (mph)	50	50	50	50	50	45	45	45	35	35	35	30	30	30
Base Length of Arterial (mi.)			1	1	1	1	1	1	1	1	1	1	1	1
Medians (Y/N)	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Signalized Intersections			1	1	1	3	3	3	5	5	5	8	8	8
Arrival Type			3	3	3	4	4	4	4	4	4	4	4	4
Signal Type			A	A	A	S	S	S	S	S	S	S	S	S
Cycle Length (C)			120	120	120	120	120	120	120	120	120	120	120	120
Weighted Effective Green Ratio (g/C)			0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44

FREEWAYS

CHARACTERISTIC	Group I				Group II			
Number of Through Lanes	4 Ln	6 Ln	8-10 Ln	12 Ln	4 Ln	6 Ln	8-10 Ln	12 Ln
Planning Analysis Hour Factor (K100)	0.088	0.088	0.088	0.088	0.092	0.092	0.092	0.092
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950
Adjusted Saturation Flow Rate	2,150	2,200	2,250	2,200	2,050	2,100	2,150	2,100
% Turns from Exclusive Lanes								
Urbanized, Transitioning/Urban, Rural								
Arterial Class								
Free Flow Speed (mph)	60	60	60	60	65	65	65	65
Base Length of Arterial (mi.)								
Medians (Y/N)								
Left Turn Bays (Y/N)								
Signalized Intersections								
Arrival Type								
Signal Type								
Cycle Length (C)								
Weighted Effective Green Ratio (g/C)								

Non-State Roadways

CHARACTERISTIC	Major City / Co.		Other Signalized	
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln
Planning Analysis Hour Factor (K100)	0.091	0.091	0.091	0.091
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,850	1,850	1,800	1,800
% Turns from Exclusive Lanes	14	14	16	16
Urbanized, Transitioning/Urban, Rural	U	U	U	U
Arterial Class	2	2		
Free Flow Speed (mph)	40	40		
Base Length of Arterial (mi.)	1	1		
Medians (Y/N)	N	Y	N	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y
Signalized Intersections	2.5	2.5		
Arrival Type	4	4	3	3
Signal Type	S	S	S	S
Cycle Length (C)	120	120	120	120
Weighted Effective Green Ratio (g/C)	0.41	0.41	0.31	0.31

LEVEL OF SERVICE THRESHOLDS

Level of Service	STATE TWO-WAY ARTERIALS: Uninterrupted (vol./cap.)	Class I (avg. travel speed)	Class II (avg. travel speed)	Class III (avg. travel speed)	Class IV (avg. travel speed)	FREEWAYS: Group I (vol./cap.)	Group II (vol./cap.)	Non-State Roadways: Major City / Co. (avg. travel speed)	Other Signalized (control delay)
A	≤ 0.30	≥ 42 mph	≥ 35 mph	≥ 30 mph	≥ 25 mph	≤ 0.26	≤ 0.28	Same as State Arterials	≤ 10 sec
B	≤ 0.50	≥ 34 mph	≥ 28 mph	≥ 24 mph	≥ 19 mph	≤ 0.42	≤ 0.44		≤ 20 sec
C	≤ 0.70	≥ 27 mph	≥ 22 mph	≥ 18 mph	≥ 13 mph	≤ 0.63	≤ 0.66		≤ 35 sec
D	≤ 0.84	≥ 21 mph	≥ 17 mph	≥ 14 mph	≥ 9 mph	≤ 0.81	≤ 0.84		≤ 55 sec
E	≤ 1.00	≥ 16 mph	≥ 13 mph	≥ 10 mph	≥ 7 mph	≤ 1.00	≤ 1.00		≤ 80 sec
F	> 1.00	< 16 mph	< 13 mph	< 10 mph	< 7 mph	> 1.00	> 1.00		> 80 sec

Table 5-2

GENERALIZED PEAK HOUR PEAK DIRECTIONAL VOLUMES FOR FLORIDA'S AREAS TRANSITIONING INTO URBANIZED AREAS OR AREAS OVER 5000 NOT IN URBANIZED AREAS*

STATE TWO-WAY ARTERIALS

UNINTERRUPTED FLOW

Unsignalized

Lanes/ Divided	A	B	C	D	E
2 Undivided	440	690	930	1,230	1,640
4 Divided	1,090	1,820	2,520	3,010	3,500
6 Divided	1,630	2,730	3,780	4,520	5,260

INTERRUPTED FLOW

Class I (>0.00 to 1.99 signalized intersections per mile)

Lanes/ Divided	A**	B	C	D***	E***
2 Undivided	N/A	540	770	830	830
4 Divided	N/A	1,170	1,630	1,750	1,750
6 Divided	N/A	1,790	2,460	2,630	2,630

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	480	730	790
4 Divided	N/A	N/A	1,130	1,600	1,690
6 Divided	N/A	N/A	1,750	2,410	2,540

Class III (more than 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	160	580	770
4 Divided	N/A	N/A	380	1,350	1,630
6 Divided	N/A	N/A	590	2,110	2,460

Source: The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street - Mail Station 19
Tallahassee, Florida 32399-0450

http://www.dot.state.fl.us/planning

FREEWAYS

Level of Service

Lanes	A	B	C	D	E
4	1,100	1,790	2,580	3,230	3,800
6	1,690	2,750	3,970	4,970	5,840
8	2,260	3,660	5,300	6,620	7,790
10	2,890	4,690	6,780	8,480	9,980

NON-STATE ROADWAYS

MAJOR CITY/COUNTY ROADWAYS

Level of Service

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	420	710	780
4 Divided	N/A	N/A	980	1,550	1,660
6 Divided	N/A	N/A	1,520	2,340	2,490

OTHER SIGNALIZED ROADWAYS
(signalized intersection analysis)

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	230	530	580
4 Divided	N/A	N/A	560	1,160	1,240

ADJUSTMENTS

DIVIDED/UNDIVIDED
(alter corresponding directional volume indicated percent)

Lanes	Median	Left Turn Bays	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

ONE- WAY
(alter corresponding directional volume indicated percent)

One-Way Lanes	Equivalent Two-Way Lanes	Adjustment Factors
2	4	+20%
3	6	+20%
4	6	+50%

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are hourly directional volumes for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. To convert to annual average daily traffic volumes, these volumes must be divided by an appropriate D factor and K100 factor (not peak-to-daily ratio). The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

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Table 5-2 (Continued)

INPUT VALUE ASSUMPTIONS

CHARACTERISTIC	STATE TWO-WAY ARTERIALS								FREEWAYS			Non-State Roadways			
	UNINTERRUPTED		Class I		Class II		Class III					Major City / Co.		Other Signalized	
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln	4 Ln	6 Ln	8-10 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln
Planning Analysis Hour Factor (K100)	0.093	0.093	0.094	0.094	0.094	0.094	0.092	0.092	0.097	0.097	0.097	0.093	0.093	0.091	0.091
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.950	0.950	0.950	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,800	1,925	1,750	1,750	1,750	1,750	1,750	1,750	2,000	2,050	2,100	1,750	1,750	1,700	1,700
% Turns from Exclusive Lanes			12	12	12	12	12	12				14	14	16	16
Urbanized, Transitioning/Urban, Rural	T	T	T	T	T	T	T	T				T	T	T	T
Arterial Class			1	1	2	2	3	3				2	2		
Free Flow Speed (mph)	55	55	50	50	45	45	35	35	70	70	70	40	40		
Base Length of Arterial (mi.)			1	1	1	1	1	1				1	1		
Medians (Y/N)	N	Y	N	Y	N	Y	N	Y				N	Y	N	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y				Y	Y	Y	Y
Signalized Intersections			1	1	3	3	5	5				2.5	2.5		
Arrival Type			3	3	4	4	4	4				4	4	3	3
Signal Type			A	A	S	S	S	S				S	S	S	S
Cycle Length (C)			120	120	120	120	120	120				120	120	120	120
Weighted Effective Green Ratio (g/C)			0.44	0.44	0.44	0.44	0.44	0.44				0.41	0.41	0.31	0.31

LEVEL OF SERVICE THRESHOLDS

Level of Service	STATE TWO-WAY ARTERIALS				FREEWAYS	Non-State Roadways	
	Uninterrupted (vol./cap.)	Class I (avg. travel speed)	Class II (avg. travel speed)	Class III (avg. travel speed)	(vol./cap.)	Major City / Co. (avg. travel speed)	Other Signalized (control delay)
A	≤ 0.31	≥ 42	≥ 35	≥ 30	≤ 0.29	Same as State Arterials	≤ 10 sec
B	≤ 0.52	≥ 34	≥ 28	≥ 24	≤ 0.47		≤ 20 sec
C	≤ 0.72	≥ 27	≥ 22	≥ 18	≤ 0.68		≤ 35 sec
D	≤ 0.86	≥ 21	≥ 17	≥ 14	≤ 0.85		≤ 55 sec
E	≤ 1.00	≥ 16	≥ 13	≥ 10	≤ 1		≤ 80 sec
F	> 1.00	< 16	< 13	< 10	> 1		> 80 sec

Table 5-3

GENERALIZED PEAK HOUR PEAK DIRECTIONAL VOLUMES FOR FLORIDA'S RURAL UNDEVELOPED AREAS AND CITIES OR DEVELOPED AREAS LESS THAN 5,000 POPULATION*

RURAL UNDEVELOPED AREAS

FREEWAYS

Lanes	A	B	C	D	E
4	1,150	1,850	2,630	3,220	3,710
6	1,770	2,850	4,050	4,960	5,700
8	2,410	3,900	5,530	6,780	7,790

MULTILANE UNINTERRUPTED HIGHWAYS

Lanes/ Divided/Left Bays	A	B	C	D	E
4 Undiv/No Bays	810	1,340	1,830	2,170	2,440
4 Undiv/Bays	1,020	1,700	2,320	2,750	3,090
4 Div/Bays	1,070	1,790	2,440	2,900	3,260
6 Div/Bays	1,610	2,690	3,660	4,350	4,880

TWO-LANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Left Turn Bays	A	B	C	D	E
2 No Bays	140	280	460	740	1,190
2 Bays	150	300	490	770	1,250

45 MPH POSTED SPEED

Lanes/ Left Turn Bays	A**	B	C	D	E
2 No Bays	N/A	140	370	600	1,140
2 Bays	N/A	140	380	640	1,200

EXCLUSIVE PASSING LANE ADJUSTMENTS

Percent of Miles with Exclusive Passing Lanes	Adjustment
60+	+30%
20-59	+20%
5-19	+10%
1-4	+5%

ISOLATED SIGNALIZED INTERSECTIONS

Lanes	A**	B	C	D	E
2 Lane / No Bays	N/A	70	380	530	570
2 Lane / Bays	N/A	80	480	670	730
4 Lane / No Bays	N/A	140	820	1,090	1,160
4 Lane / Bays	N/A	180	1,040	1,380	1,470

CITIES OR RURAL DEVELOPED AREAS LESS THAN 5,000 POPULATION

FREEWAYS

Lanes	A	B	C	D	E
4	1,150	1,850	2,630	3,220	3,710
6	1,770	2,850	4,050	4,960	5,700
8	2,410	3,900	5,530	6,780	7,790

INTERRUPTED FLOW ARTERIALS

Class Ia (up to 1.50 signalized intersections per mile)

Lanes/Divided/ /Bays	A	B	C	D***	E***
2 Undiv/No Bays	240	540	600	640	640
2 Undiv/Bays	310	690	770	810	810
2 Div/Bays	330	730	810	850	850
4 Undiv/No Bays	500	1,130	1,220	1,280	1,280
4 Undiv/Bays	630	1,430	1,550	1,620	1,620
4 Div/ Bays	670	1,500	1,630	1,700	1,700
6 Div/Bays	1,010	2,290	2,450	2,550	2,550

Class Ib (more than 1.50 signalized intersections per mile)

Lanes/Divided/ /Bays	A**	B	C	D	E
2 Undiv/No Bays	N/A	200	520	580	630
2 Undiv/Bays	N/A	250	660	740	800
2 Div/Bays	N/A	270	690	780	840
4 Undiv/No Bays	N/A	410	1,070	1,180	1,260
4 Undiv/Bays	N/A	520	1,360	1,500	1,600
4 Div/ Bays	N/A	550	1,430	1,570	1,680
6 Div/Bays	N/A	830	2,180	2,370	2,530

NON-STATE SIGNALIZED ROADWAYS

(Signalized Intersection Analysis)

Lanes/ Left Turn Bays	A**	B**	C	D	E
2 No Bays	N/A	N/A	60	390	420
2 Bays	N/A	N/A	70	450	530

Source: The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street, Mail Station 19
Tallahassee, FL 32399-0450

http://www.dot.state.fl.us/planning

MULTILANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Divided/Left Bays	A	B	C	D	E
4 Undiv/No Bays	770	1,290	1,790	2,140	2,480
4 Undiv/Bays	980	1,640	2,270	2,710	3,150
4 Div/Bays	1,030	1,720	2,380	2,850	3,310
6 Div/Bays	1,540	2,580	3,580	4,270	4,970

45 MPH POSTED SPEED

Lanes/ Divided/Left Bays	A	B	C	D	E
4 Undiv/No Bays	700	1,170	1,640	1,960	2,480
4 Undiv/Bays	880	1,480	2,080	2,490	3,150
4 Div/Bays	930	1,560	2,190	2,620	3,310
6 Div/Bays	1,390	2,330	3,280	3,920	4,970

TWO-LANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Left Turn Bays	A	B	C	D	E
2 Undiv/No Bays	230	400	570	800	1,150
2 Undiv/ Bays	290	500	720	1,000	1,430
2 Div/Bays	300	530	750	1,050	1,500

45 MPH POSTED SPEED

Lanes/ Left Turn Bays	A**	B	C	D	E
2 Undiv/No Bays	30	330	490	720	1,070
2 Undiv/ Bays	40	420	620	900	1,340
2 Div/Bays	40	440	650	940	1,410

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are hourly directional volumes for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. To convert to annual average daily traffic volumes, these volumes must be divided by an appropriate D factor and K100 factor (not peak-to-daily ratio). The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

September 1998

Table 5-3 (Continued)

INPUT VALUE ASSUMPTIONS

CHARACTERISTIC	Rural Undeveloped: Rural Freeways			Multilane Uninterrupted			Two-Lane				Isolated Sigs.	
Number of Through Lanes Divided/Undivided Left-tur Bays	4 Ln	6 Ln	8 Ln	4-6 Ln/Bays	4 Undiv/No Bays	4-6 Ln/Undiv/Bays	2 Ln / Bays	2 Ln/No Bays	2 Ln/No Bays	2 Ln/No Bays	2-4 Ln / Bays	2-4 Ln/No Bays
Planning Analysis Hour Factor (K100)	0.101	0.101	0.101	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.950	0.950	0.950	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880
Adjusted Saturation Flow Rate*	1,850	2,000	2,050	1,850	1,850	1,850	2,600	2,600	2,500	2,500	1,700	1,700
% Turns from Exclusive Lanes											12	12
Urbanized, Transitioning/Urban, Rural											R	R
Arterial Class												
Free Flow Speed (mph)	75	75	75	60	60	60	55	55	45	45		
Base Length (mi.) or % No Passing							20	20	40	40		
Medians or % Exclusive Passing Lanes				Y	N	N	0	0	0	0	N	N
Left Turn Bays (Y/N)				Y	N	Y	Y	N	N	Y	Y	N
Signalized Intersections												
Arrival Type											3	3
Signal Type											A	A
Cycle Length (C)											60	60
Weighted Effective Green Ratio (g/C)											0.44	0.44

CHARACTERISTIC	Cities or Rural Developed Areas Less than 5000: Interrupted Flow Arterials						Non-State Sig. Roads		Multilane Uninterrupted						Rural Developed Two-Lane Uninterrupted					
Number of Through Lanes Divided/Undivided Left-tur Bays	2-6 Ln/Div/Bays	2-4 Ln/ Undiv/Bays	2-4 Ln/Undiv/No Bays	2-6 Ln/Div/Bays	2-4 Ln/Undiv/Bays	2-4 Ln/Undiv/No Bays	2 Ln/Bays	2 Ln/No Bays	4-6 Ln/Div/Bays	4-6 Ln/Undiv/Bays	4-6 Ln/Undiv/NoBays	4-6 Ln/Div/Bays	4-6 Ln/Undiv/Bays	4-6 Ln/Undiv/NoBays	Div/Bays	Undiv/ Bays	Undiv/No Bays	Div/ Bays	Undiv/ Bays	Undiv/No Bays
Planning Analysis Hour Factor (K100)	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895
Adjusted Saturation Flow Rate*	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,850	1,850	1,850	1,850	1,850	1,850	1,600	1,600	1,600	1,500	1,500	1,500
% Turns from Exclusive Lanes	12	12	12	12	12	12	16	16												
Urbanized, Transitioning/Urban, Rural	R	R	R	R	R	R	R	R							R	R	R	R	R	R
Arterial Class	1	1	1	1	1	1														
Free Flow Speed (mph)	50	50	50	45	45	45			55	55	55	45	45	45	55	55	55	45	45	45
Base Length (mi.) or % No Passing	1	1	1	1	1	1														
Medians or % Exclusive Passing Lanes	Y	N	N	Y	N	N	N	N	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Left Turn Bays (Y/N)	Y	Y	N	Y	Y	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N
Signalized Intersections	1	1	1	2	2	2														
Arrival Type	3	3	3	3	3	3	3	3												
Signal Type	A	A	A	A	A	A	A	A												
Cycle Length (C)	60	60	60	60	60	60	60	60												
Weighted Effective Green Ratio (g/C)	0.44	0.44	0.44	0.44	0.44	0.44	0.31	0.31												

* Adjusted Saturation Flow Rate is for both directions in Rural Undeveloped Two-Lane calculations.

LEVEL OF SERVICE THRESHOLDS

	Rural Undeveloped: Rural Freeways	Multilane Uninterrupted	Two-Lane Uninterrupted		Isolated Intersections	Cities or Rural Developed Areas Less than 5000: Multilane Uninterrupted		Two-Lane Uninterrupted		Arterials	Non-State Signalized Roadways
	(vol./cap.)	(vol./cap.)	(vol./cap.)		(control delay)	(vol./cap.)		(vol./cap.)			
Level of Service		60mph	55mph	45mph		55mph	45mph	55mph	45mph	(avg. travel speed)	(control delay)
A	≤ 0.31	≤ 0.33	≤ 0.12	≤ n/a	≤ 5 sec	≤ 0.31	≤ 0.28	≤ 0.20	N/A	≥ 42 mph	≤ 5 sec
B	≤ 0.50	≤ 0.55	≤ 0.24	≤ 0.12	≤ 10 sec	≤ 0.52	≤ 0.47	≤ 0.35	≤ 0.31	≥ 34 mph	≤ 10 sec
C	≤ 0.71	≤ 0.75	≤ 0.39	≤ 0.32	≤ 15 sec	≤ 0.72	≤ 0.66	≤ 0.50	≤ 0.46	≥ 27 mph	≤ 15 sec
D	≤ 0.87	≤ 0.89	≤ 0.62	≤ 0.53	≤ 25 sec	≤ 0.86	≤ 0.79	≤ 0.70	≤ 0.67	≥ 21 mph	≤ 25 sec
E	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00	≤ 40 sec	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00	≥ 16 mph	≤ 40 sec
F	> 1.00	> 1.00	> 1.00	≥ 1.00	> 40 sec	> 1.00	≥ 1.00	> 1.00	> 1.00	< 16 mph	> 40 sec

Table 5-4

GENERALIZED ANNUAL AVERAGE DAILY VOLUMES FOR FLORIDA'S URBANIZED AREAS*

STATE TWO-WAY ARTERIALS

UNINTERRUPTED FLOW

Unsignalized

Lanes/ Divided	A	B	C	D	E
2 Undivided	8,900	13,900	18,900	24,800	33,100
4 Divided	21,500	35,800	50,100	60,100	71,600
6 Divided	32,200	53,700	75,200	90,200	107,400

INTERRUPTED FLOW

Class I (>0.00 to 1.99 signalized intersections per mile)

Lanes/ Divided	A**	B	C	D***	E***
2 Undivided	N/A	10,800	15,600	16,600	16,600
4 Divided	N/A	23,500	33,200	35,000	35,000
6 Divided	N/A	35,800	49,900	52,500	52,500
8 Divided	N/A	45,300	61,400	64,400	64,400

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	9,900	14,900	16,200
4 Divided	N/A	N/A	22,900	32,500	34,300
6 Divided	N/A	N/A	35,500	48,900	51,700
8 Divided	N/A	N/A	44,700	60,100	63,400

Class III (more than 4.50 signalized intersections per mile and not within primary city central business district of urbanized area over 500,000)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	3,300	12,100	15,800
4 Divided	N/A	N/A	7,800	27,800	33,600
6 Divided	N/A	N/A	12,100	43,300	50,500
8 Divided	N/A	N/A	15,300	54,200	62,100

Class IV (more than 4.50 signalized intersections per mile and within primary city central business district of urbanized area over 500,000)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	3,700	13,800	15,300
4 Divided	N/A	N/A	8,900	29,900	32,600
6 Divided	N/A	N/A	14,000	45,500	49,000
8 Divided	N/A	N/A	17,500	56,200	60,100

Source: The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street - Mail Station 19
Tallahassee, Florida 32399-0450

http://www.dot.state.fl.us/planning

FREEWAYS

Group 1 (within urbanized area over 500,000 and leading to or passing within 5 miles of the primary city central business district)

Lanes	A	B	C	D	E
4	21,200	34,300	51,500	66,200	81,700
6	32,600	52,700	79,000	101,600	125,400
8	44,500	71,800	107,800	138,600	171,100
10	55,600	89,800	134,700	173,200	213,800
12	65,200	105,400	158,100	203,200	250,900

Group 2 (within urbanized area and not in Group 1)

Lanes	A	B	C	D	E
4	20,900	32,800	49,200	62,600	74,500
6	32,100	50,400	75,600	96,200	114,500
8	43,800	68,800	103,200	131,300	156,300
10	54,700	86,000	129,000	164,200	195,400
12	64,100	100,800	151,200	192,400	229,100

NON-STATE ROADWAYS

MAJOR CITY/COUNTY ROADWAYS

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	8,600	14,600	16,000
4 Divided	N/A	N/A	19,800	31,700	33,900
6 Divided	N/A	N/A	30,800	47,800	51,000

OTHER SIGNALIZED ROADWAYS
(signalized intersection analysis)

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	4,800	10,900	11,900
4 Divided	N/A	N/A	11,600	23,800	25,400

ADJUSTMENTS

DIVIDED/UNDIVIDED

(alter corresponding two-way volume indicated percent)

Lanes	Median	Left Turn Bays	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

ONE-WAY

(alter corresponding two-way volume indicated percent)

One-Way Lanes	Equivalent Two-Way Lanes	Adjustment Factors
2	4	- 40%
3	6	- 40%
4	8	- 40%
5	8	-25%

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are annual average daily volumes (based on K100 factors, not peak-to-daily ratios) for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

September 1998

Table 5-4 (Continued)

INPUT VALUE ASSUMPTIONS

CHARACTERISTIC	STATE TWO-WAY ARTERIALS														FREEWAYS								Non-State Roadways			
	UNINTERRUPTED		Class I			Class II			Class III			Class IV			Group I				Group II				Major City / Co.		Other Signalized	
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln	4 Ln	6Ln	8-10 Ln	12 Ln	4 Ln	6Ln	8-10 Ln	12 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln
Planning Analysis Hour Factor (K100)	0.091	0.091	0.093	0.093	0.093	0.093	0.093	0.093	0.092	0.092	0.092	0.092	0.092	0.092	0.088	0.088	0.088	0.088	0.092	0.092	0.092	0.092	0.091	0.091	0.091	0.091
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,850	2,000	1,850	1,850	1,700	1,850	1,850	1,700	1,850	1,850	1,700	1,800	1,800	1,650	2,150	2,200	2,250	2,200	2,050	2,100	2,150	2,100	1,850	1,850	1,800	1,800
% Turns from Exclusive Lanes			12	12	12	12	12	12	12	12	12	12	12	12									14	14	16	16
Urbanized, Transitioning/Urban, Rural	U	U	U	U	U	U	U	U	U	U	U	U	U	U									U	U	U	U
Arterial Class			1	1	1	2	2	2	3	3	3	4	4	4									2	2		
Free Flow Speed (mph)	50	50	50	50	50	45	45	45	35	35	35	30	30	30	60	60	60	60	65	65	65	65	40	40		
Base Length of Arterial (mi.)			1	1	1	1	1	1	1	1	1	1	1	1									1	1		
Medians (Y/N)	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y									N	Y	N	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y									Y	Y	Y	Y
Signalized Intersections			1	1	1	3	3	3	5	5	5	8	8	8									2.5	2.5		
Arrival Type			3	3	3	4	4	4	4	4	4	4	4	4									4	4	3	3
Signal Type			A	A	A	S	S	S	S	S	S	S	S	S									S	S	S	S
Cycle Length (C)			120	120	120	120	120	120	120	120	120	120	120	120									120	120	120	120
Weighted Effective Green Ratio (g/C)			0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44									0.41	0.41	0.31	0.31

LEVEL OF SERVICE THRESHOLDS

Level of Service	STATE TWO-WAY ARTERIALS					FREEWAYS		Non-State Roadways	
	Uninterrupted (vol./cap.)	Class I (avg. travel speed)	Class II (avg. travel speed)	Class III (avg. travel speed)	Class IV (avg. travel speed)	Group I (vol./cap.)	Group II (vol./cap.)	Major City / Co. (avg. travel speed)	Other Signalized (control delay)
A	≤ 0.30	≥ 42 mph	≥ 35 mph	≥ 30 mph	≥ 25 mph	≤ 0.26	≤ 0.28	Same as State Arterials	≤ 10 sec
B	≤ 0.50	≥ 34 mph	≥ 28 mph	≥ 24 mph	≥ 19 mph	≤ 0.42	≤ 0.44		≤ 20 sec
C	≤ 0.70	≥ 27 mph	≥ 22 mph	≥ 18 mph	≥ 13 mph	≤ 0.63	≤ 0.66		≤ 35 sec
D	≤ 0.84	≥ 21 mph	≥ 17 mph	≥ 14 mph	≥ 9 mph	≤ 0.81	≤ 0.84		≤ 55 sec
E	≤ 1.00	≥ 16 mph	≥ 13 mph	≥ 10 mph	≥ 7 mph	≤ 1.00	≤ 1.00		≤ 80 sec
F	> 1.00	< 16 mph	< 13 mph	< 10 mph	< 7 mph	> 1.00	> 1.00		> 80 sec

Table 5-5

GENERALIZED ANNUAL AVERAGE DAILY VOLUMES FOR FLORIDA'S
AREAS TRANSITIONING INTO URBANIZED AREAS OR AREAS OVER 5000 NOT IN URBANIZED AREAS*

STATE TWO-WAY ARTERIALS

UNINTERRUPTED FLOW

Unsignalized Lanes/ Divided	A	B	C	D	E
2 Undivided	8,400	13,000	17,700	23,300	31,000
4 Divided	20,600	34,500	47,800	57,000	66,300
6 Divided	30,800	51,700	71,600	85,600	99,500

Level of Service

INTERRUPTED FLOW

Class I (>0.00 to 1.99 signalized intersections per mile)

Lanes/ Divided	A**	B	C	D***	E***
2 Undivided	N/A	10,000	14,400	15,600	15,600
4 Divided	N/A	22,000	30,500	32,800	32,800
6 Divided	N/A	33,500	46,000	49,200	49,200

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	9,100	13,700	14,900
4 Divided	N/A	N/A	21,100	29,900	31,600
6 Divided	N/A	N/A	32,800	45,000	47,600

Class III (more than 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	3,100	11,200	14,700
4 Divided	N/A	N/A	7,200	25,900	31,200
6 Divided	N/A	N/A	11,300	40,300	47,000

Source:
The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street - Mail Station 19
Tallahassee, Florida 32399-0450

http://www.dot.state.fl.us/planning

FREEWAYS

Level of Service

Lanes	A	B	C	D	E
4	20,000	32,400	46,900	58,600	69,000
6	30,800	49,800	72,100	90,100	106,000
8	41,000	66,500	96,100	120,200	141,400
10	52,500	85,100	123,100	153,900	181,000

NON-STATE ROADWAYS

MAJOR CITY/COUNTY ROADWAYS

Level of Service

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	8,000	13,500	14,800
4 Divided	N/A	N/A	18,500	29,300	31,400
6 Divided	N/A	N/A	28,700	44,200	47,200

OTHER SIGNALIZED ROADWAYS
(signalized intersection analysis)

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	4,400	10,200	11,300
4 Divided	N/A	N/A	10,900	22,500	24,000

ADJUSTMENTS

DIVIDED/UNDIVIDED

(alter corresponding two-way volume indicated percent)

Lanes	Median	Left Turn Bays	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

ONE-WAY

(alter corresponding two-way volume indicated percent)

One-Way Lanes	Equivalent Two-Way Lanes	Adjustment Factors
2	4	-40%
3	6	-40%
4	6	-25%

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are annual average daily volumes (based on K100 factors, not peak-to-daily ratios) for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

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Table 5-5 (Continued)

INPUT VALUE ASSUMPTIONS

CHARACTERISTIC	STATE TWO-WAY ARTERIALS: UNINTERRUPTED		Class I		Class II		Class III		FREEWAYS			Non-State Roadways: Major City / Co.		Other Signalized	
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln	4 Ln	6 Ln	8-10 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln
Planning Analysis Hour Factor (K100)	0.093	0.093	0.094	0.094	0.094	0.094	0.092	0.092	0.097	0.097	0.097	0.093	0.093	0.091	0.091
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.950	0.950	0.950	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,800	1,925	1,750	1,750	1,750	1,750	1,750	1,750	2,000	2,050	2,100	1,750	1,750	1,700	1,700
% Turns from Exclusive Lanes			12	12	12	12	12	12				14	14	16	16
Urbanized, Transitioning/Urban, Rural	T	T	T	T	T	T	T	T				T	T	T	T
Arterial Class			1	1	2	2	3	3				2	2		
Free Flow Speed (mph)	55	55	50	50	45	45	35	35	70	70	70	40	40		
Base Length of Arterial (mi.)			1	1	1	1	1	1				1	1		
Medians (Y/N)	N	Y	N	Y	N	Y	N	Y				N	Y	N	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y				Y	Y	Y	Y
Signalized Intersections			1	1	3	3	5	5				2.5	2.5		
Arrival Type			3	3	4	4	4	4				4	4	3	3
Signal Type			A	A	S	S	S	S				S	S	S	S
Cycle Length (C)			120	120	120	120	120	120				120	120	120	120
Weighted Effective Green Ratio (g/C)			0.44	0.44	0.44	0.44	0.44	0.44				0.41	0.41	0.31	0.31

LEVEL OF SERVICE THRESHOLDS

Level of Service	STATE TWO-WAY ARTERIALS: Uninterrupted (vol./cap.)	Class I (avg. travel speed)	Class II (avg. travel speed)	Class III (avg. travel speed)	FREEWAYS (vol./cap.)	Non-State Roadways: Major City / Co. (avg. travel speed)	Other Signalized (control delay)
A	≤ 0.31	≥ 42	≥ 35	≥ 30	≤ 0.29	Same as State Arterials	≤ 10 sec
B	≤ 0.52	≥ 34	≥ 28	≥ 24	≤ 0.47		≤ 20 sec
C	≤ 0.72	≥ 27	≥ 22	≥ 18	≤ 0.68		≤ 35 sec
D	≤ 0.86	≥ 21	≥ 17	≥ 14	≤ 0.85		≤ 55 sec
E	≤ 1.00	≥ 16	≥ 13	≥ 10	≤ 1		≤ 80 sec
F	> 1.00	< 16	< 13	< 10	> 1		> 80 sec

Table 5-6

GENERALIZED ANNUAL AVERAGE DAILY VOLUMES FOR FLORIDA'S RURAL UNDEVELOPED AREAS AND CITIES OR DEVELOPED AREAS LESS THAN 5,000 POPULATION*

RURAL UNDEVELOPED AREAS

FREEWAYS

Lanes	A	B	C	D	E
	Level of Service				
4	20,000	32,300	45,900	56,200	64,600
6	30,800	49,700	70,500	86,400	99,400
8	42,100	67,900	96,400	118,100	135,800

MULTILANE UNINTERRUPTED HIGHWAYS

Lanes/ Divided/Left Bays	A	B	C	D	E
	Level of Service				
4 Undiv/No Bays	14,200	23,600	32,200	38,300	43,000
4 Undiv/Bays	18,000	30,000	40,800	48,500	54,500
4 Div/Bays	18,900	31,500	43,000	51,000	57,300
6 Div/Bays	28,400	47,300	64,500	76,500	86,000

TWO-LANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Left Turn Bays	A	B	C	D	E
	Level of Service				
2 No Bays	2,500	5,000	8,200	13,000	20,900
2 Bays	2,600	5,300	8,600	13,600	22,000

45 MPH POSTED SPEED

Lanes/ Left Turn Bays	A**	B	C	D	E
	Level of Service				
2 No Bays	N/A	2,400	6,400	10,700	20,100
2 Bays	N/A	2,500	6,800	11,200	21,200

EXCLUSIVE PASSING LANE ADJUSTMENTS

Percent of Miles with Exclusive Passing Lanes	Adjustment
60+	+30%
20-59	+20%
5-19	+10%
1-4	+5%

ISOLATED SIGNALIZED INTERSECTIONS

Lanes	A**	B	C	D	E
	Level of Service				
2 Lane / No Bays	N/A	1,200	6,600	9,300	10,100
2 Lane / Bays	N/A	1,500	8,400	11,700	12,800
4 Lane / No Bays	N/A	2,500	14,400	19,200	20,400
4 Lane / Bays	N/A	3,100	18,200	24,300	25,800

CITIES OR RURAL DEVELOPED AREAS LESS THAN 5,000 POPULATION

FREEWAYS

Lanes	A	B	C	D	E
	Level of Service				
4	20,000	32,300	45,900	56,200	64,600
6	30,800	49,700	70,500	86,400	99,400
8	42,100	67,900	96,400	118,100	135,800

INTERRUPTED FLOW ARTERIALS

Class Ia (up to 1.50 signalized intersections per mile)

Lanes/Divided/ /Bays	A	B	C	D***	E***
	Level of Service				
2 Undiv/No Bays	4,500	10,100	11,200	11,800	11,800
2 Undiv/Bays	5,700	12,800	14,200	15,000	15,000
2 Div/Bays	6,000	13,400	14,900	15,800	15,800
4 Undiv/No Bays	9,300	20,900	22,600	23,600	23,600
4 Undiv/Bays	11,800	26,400	28,600	29,900	29,900
4 Div/ Bays	12,400	27,800	30,100	31,500	31,500
6 Div/Bays	18,700	42,400	45,300	47,300	47,300

Class Ib (more than 1.50 signalized intersections per mile)

Lanes/Divided/ /Bays	A**	B	C	D	E
	Level of Service				
2 Undiv/No Bays	N/A	3,700	9,700	10,800	11,600
2 Undiv/Bays	N/A	4,700	12,200	13,700	14,700
2 Div/Bays	N/A	4,900	12,900	14,400	15,500
4 Undiv/No Bays	N/A	7,600	19,900	21,900	23,400
4 Undiv/Bays	N/A	9,700	25,200	27,700	29,600
4 Div/ Bays	N/A	10,200	26,500	29,200	31,200
6 Div/Bays	N/A	15,400	40,400	43,900	46,800

NON-STATE SIGNALIZED ROADWAYS

(Signalized Intersection Analysis)

Lanes/ Left Turn Bays	A**	B**	C	D	E
	Level of Service				
2 No Bays	N/A	N/A	1,000	7,200	7,800
2 Bays	N/A	N/A	1,300	8,400	9,900

Source: The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street, Mail Station 19
Tallahassee, FL 32399-0450

http://www.dot.state.fl.us/planning

MULTILANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Divided/Left Bays	A	B	C	D	E
	Level of Service				
4 Undiv/No Bays	14,300	23,900	33,100	39,600	46,000
4 Undiv/Bays	18,100	30,300	42,000	50,100	58,300
4 Div/Bays	19,000	31,900	44,200	52,800	61,400
6 Div/Bays	28,500	47,900	66,300	79,200	92,100

45 MPH POSTED SPEED

Lanes/ Divided/Left Bays	A	B	C	D	E
	Level of Service				
4 Undiv/No Bays	12,900	21,600	30,400	36,400	46,000
4 Undiv/Bays	16,300	27,400	38,500	46,100	58,300
4 Div/Bays	17,200	28,800	40,500	48,500	61,400
6 Div/Bays	25,800	43,300	60,800	72,700	92,100

TWO-LANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Left Turn Bays	A	B	C	D	E
	Level of Service				
2 Undiv/No Bays	4,200	7,400	10,600	14,900	21,200
2 Undiv/ Bays	5,300	9,300	13,300	18,600	26,500
2 Div/Bays	5,600	9,800	13,900	19,500	27,900

45 MPH POSTED SPEED

Lanes/ Left Turn Bays	A**	B	C	D	E
	Level of Service				
2 Undiv/No Bays	N/A	6,200	9,200	13,300	19,900
2 Undiv/ Bays	N/A	7,700	11,400	16,700	24,900
2 Div/Bays	N/A	8,100	12,000	17,500	26,100

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are annual average daily volumes (based on K100 factors, not peak-to-daily ratios) for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

September 1998

Table 5-6 (Continued)

INPUT VALUE ASSUMPTIONS

Rural Undeveloped

CHARACTERISTIC	Rural Freeways			Multilane Uninterrupted			Two-Lane				Isolated Sigs.	
Number of Through Lanes / Divided/Undivided / Left-turn Bays	4 Ln	6 Ln	8 Ln	4-6 Ln/Bays	4 Undiv/No Bays	4-6 Ln/Undiv/Bays	2 Ln / Bays	2 Ln/No Bays	2 Ln/No Bays	2 Ln/No Bays	2-4 Ln / Bays	2-4 Ln/No Bays
Planning Analysis Hour Factor (K100)	0.101	0.101	0.101	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.950	0.950	0.950	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880
Adjusted Saturation Flow Rate*	1,950	2,000	2,050	1,850	1,850	1,850	2,600	2,600	2,500	2,500	1,700	1,700
% Turns from Exclusive Lanes											12	12
Urbanized, Transitioning/Urban, Rural											R	R
Arterial Class												
Free Flow Speed (mph)	75	75	75	60	60	60	55	55	45	45		
Base Length (mi.) or % No Passing							20	20	40	40		
Medians or % Exclusive Passing Lanes				Y	N	N	0	0	0	0	N	N
Left Turn Bays (Y/N)				Y	N	Y	Y	N	N	Y	Y	N
Signalized Intersections												
Arrival Type											3	3
Signal Type											A	A
Cycle Length (C)											60	60
Weighted Effective Green Ratio (g/C)											0.44	0.44

Cities or Rural Developed Areas Less than 5000

CHARACTERISTIC	Interrupted Flow Arterials						Non-State Sig. Roads		Multilane Uninterrupted						Rural Developed Two-Lane Uninterrupted					
Number of Through Lanes / Divided/Undivided / Left-turn Bays	2-6 Ln/Div/Bays	2-4 Ln/ Undiv/Bays	2-4 Ln/Undiv/No Bays	2-6 Ln/Div/Bays	2-4 Ln/Undiv/Bays	2-4 Ln/Und/No Bays	2 Ln/Bays	2 Ln/No Bays	4-6 Ln/Div/Bays	4-6 Ln/Undiv/Bays	4-6 Ln/Undiv/NoBays	4-6 Ln/Div/Bays	4-6 Ln/Undiv/Bays	4-6 Ln/Undiv/NoBays	Div/Bays	Undiv/ Bays	Undiv/No Bays	Div/ Bays	Undiv/ Bays	Undiv/No Bays
Planning Analysis Hour Factor (K100)	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895
Adjusted Saturation Flow Rate*	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,850	1,850	1,850	1,850	1,850	1,850	1,600	1,600	1,600	1,500	1,500	1,500
% Turns from Exclusive Lanes	12	12	12	12	12	12	16	16												
Urbanized, Transitioning/Urban, Rural	R	R	R	R	R	R	R	R							R	R	R	R	R	R
Arterial Class	1	1	1	1	1	1														
Free Flow Speed (mph)	50	50	50	45	45	45			55	55	55	45	45	45	55	55	55	45	45	45
Base Length (mi.) or % No Passing	1	1	1	1	1	1														
Medians or % Exclusive Passing Lanes	Y	N	N	Y	N	N	N	N	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Left Turn Bays (Y/N)	Y	Y	N	Y	Y	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N
Signalized Intersections	1	1	1	2	2	2														
Arrival Type	3	3	3	3	3	3	3	3												
Signal Type	A	A	A	A	A	A	A	A												
Cycle Length (C)	60	60	60	60	60	60	60	60												
Weighted Effective Green Ratio (g/C)	0.44	0.44	0.44	0.44	0.44	0.44	0.31	0.31												

* Adjusted Saturation Flow Rate is for both directions in Rural Undeveloped Two-Lane calculations.

LEVEL OF SERVICE THRESHOLDS

	Rural Undeveloped					Cities or Rural Developed Areas Less than 5000					
	Rural Freeways	Multilane Uninterrupted	Two-Lane Uninterrupted		Isolated Intersections	Multilane Uninterrupted		Two-Lane Uninterrupted		Arterials	Non-State Signalized Roadways
	(vol./cap.)	(vol./cap.)	(vol./cap.)		(control delay)	(vol./cap.)		(vol./cap.)			
Level of Service		60mph	55mph	45mph		55mph	45mph	55mph	45mph	(avg. travel speed)	(control delay)
A	≤ 0.31	≤ 0.33	≤ 0.12	≤ n/a	≤ 5 sec	≤ 0.31	≤ 0.28	≤ 0.20	N/A	≥ 42 mph	≤ 5 sec
B	≤ 0.50	≤ 0.55	≤ 0.24	≤ 0.12	≤ 10 sec	≤ 0.52	≤ 0.47	≤ 0.35	≤ 0.31	≥ 34 mph	≤ 10 sec
C	≤ 0.71	≤ 0.75	≤ 0.39	≤ 0.32	≤ 15 sec	≤ 0.72	≤ 0.66	≤ 0.50	≤ 0.46	≥ 27 mph	≤ 15 sec
D	≤ 0.87	≤ 0.89	≤ 0.62	≤ 0.53	≤ 25 sec	≤ 0.86	≤ 0.79	≤ 0.70	≤ 0.67	≥ 21 mph	≤ 25 sec
E	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00	≤ 40 sec	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00	≥ 16 mph	≤ 40 sec
F	> 1.00	> 1.00	> 1.00	> 1.00	> 40 sec	> 1.00	> 1.00	> 1.00	> 1.00	< 16 mph	> 40 sec

Table 5-7

GENERALIZED TWO WAY PEAK HOUR VOLUMES FOR FLORIDA'S URBANIZED AREAS*

STATE TWO-WAY ARTERIALS

UNINTERRUPTED FLOW

Unsignalized

Lanes/ Divided	A	B	C	D	E
2 Undivided	810	1,270	1,720	2,260	3,010
4 Divided	1,950	3,260	4,560	5,470	6,510
6 Divided	2,930	4,890	6,840	8,210	9,770

INTERRUPTED FLOW

Class I (>0.00 to 1.99 signalized intersections per mile)

Lanes/ Divided	A**	B	C	D***	E***
2 Undivided	N/A	1,000	1,450	1,550	1,550
4 Divided	N/A	2,190	3,080	3,260	3,260
6 Divided	N/A	3,330	4,640	4,890	4,890
8 Divided	N/A	4,210	5,710	5,990	5,990

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	920	1,390	1,500
4 Divided	N/A	N/A	2,130	3,020	3,190
6 Divided	N/A	N/A	3,300	4,550	4,810
8 Divided	N/A	N/A	4,160	5,590	5,900

Class III (more than 4.50 signalized intersections per mile and not within primary city central business district of urbanized area over 500,000)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	310	1,110	1,450
4 Divided	N/A	N/A	720	2,560	3,090
6 Divided	N/A	N/A	1,120	3,980	4,650
8 Divided	N/A	N/A	1,410	4,990	5,710

Class IV (more than 4.50 signalized intersections per mile and within primary city central business district of urbanized area over 500,000)

Lanes/ Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	340	1,270	1,410
4 Divided	N/A	N/A	820	2,750	2,990
6 Divided	N/A	N/A	1,290	4,190	4,510
8 Divided	N/A	N/A	1,610	5,170	5,530

Source: The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street - Mail Station 19
Tallahassee, Florida 32399-0450

http://www.dot.state.fl.us/planning

FREEWAYS

Group 1 (within urbanized area over 500,000 and leading to or passing within 5 miles of the primary city central business district)

Lanes	A	B	C	D	E
4	1,900	3,000	4,500	5,800	7,200
6	2,900	4,600	7,000	8,900	11,000
8	3,900	6,300	9,500	12,200	15,100
10	4,900	7,900	11,900	15,200	18,800
12	5,700	9,300	13,900	17,900	22,100

Group 2 (within urbanized area and not in Group 1)

Lanes	A	B	C	D	E
4	1,900	3,000	4,500	5,800	6,900
6	3,000	4,600	7,000	8,900	10,500
8	4,000	6,300	9,500	12,100	14,400
10	5,000	7,900	11,900	15,100	18,000
12	5,900	9,300	13,900	17,700	21,100

NON-STATE ROADWAYS

MAJOR CITY/COUNTY ROADWAYS

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	780	1,330	1,450
4 Divided	N/A	N/A	1,810	2,880	3,080
6 Divided	N/A	N/A	2,800	4,350	4,640

OTHER SIGNALIZED ROADWAYS
(signalized intersection analysis)

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	430	990	1,090
4 Divided	N/A	N/A	1,060	2,170	2,310

ADJUSTMENTS

DIVIDED/UNDIVIDED

(alter corresponding two-way volume indicated percent)

Lanes	Median	Left Turn Bays	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

ONE-WAY

(alter corresponding two-way volume indicated percent)

One-Way Lanes	Equivalent Two-Way Lanes	Adjustment Factors
2	4	- 40%
3	6	- 40%
4	8	- 40%
5	8	-25%

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are two-way hourly maximum volumes for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. To convert to annual average daily traffic volumes, these volumes must be divided by an appropriate K100 factor (not peak-to-daily ratio). The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

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Table 5-7 (Continued)

INPUT VALUE ASSUMPTIONS

STATE TWO-WAY ARTERIALS

CHARACTERISTIC	UNINTERRUPTED		Class I			Class II			Class III			Class IV		
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln	2 Ln	4-6 Ln	8 Ln
Planning Analysis Hour Factor (K100)	0.091	0.091	0.093	0.093	0.093	0.093	0.093	0.093	0.092	0.092	0.092	0.092	0.092	0.092
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,850	2,000	1,850	1,850	1,700	1,850	1,650	1,700	1,850	1,850	1,700	1,800	1,800	1,650
% Turns from Exclusive Lanes			12	12	12	12	12	12	12	12	12	12	12	12
Urbanized, Transitioning/Urban, Rural	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Arterial Class			1	1	1	2	2	2	3	3	3	4	4	4
Free Flow Speed (mph)	50	50	50	50	50	45	45	45	35	35	35	30	30	30
Base Length of Arterial (mi.)			1	1	1	1	1	1	1	1	1	1	1	1
Medians (Y/N)	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Signalized Intersections			1	1	1	3	3	3	5	5	5	8	8	8
Arrival Type			3	3	3	4	4	4	4	4	4	4	4	4
Signal Type			A	A	A	S	S	S	S	S	S	S	S	S
Cycle Length (C)			120	120	120	120	120	120	120	120	120	120	120	120
Weighted Effective Green Ratio (g/C)			0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44

FREEWAYS

CHARACTERISTIC	Group I				Group II			
Number of Through Lanes	4 Ln	6Ln	8-10 Ln	12 Ln	4 Ln	6Ln	8-10 Ln	12 Ln
Planning Analysis Hour Factor (K100)	0.088	0.088	0.088	0.088	0.092	0.092	0.092	0.092
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.950	0.950	0.950	0.950	0.950	0.950	0.950	0.950
Adjusted Saturation Flow Rate	2,150	2,200	2,250	2,200	2,050	2,100	2,150	2,100
% Turns from Exclusive Lanes								
Urbanized, Transitioning/Urban, Rural								
Arterial Class								
Free Flow Speed (mph)	60	60	60	60	65	65	65	65
Base Length of Arterial (mi.)								
Medians (Y/N)								
Left Turn Bays (Y/N)								
Signalized Intersections								
Arrival Type								
Signal Type								
Cycle Length (C)								
Weighted Effective Green Ratio (g/C)								

Non-State Roadways

CHARACTERISTIC	Major City / Co.		Other Signalized	
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln
Planning Analysis Hour Factor (K100)	0.091	0.091	0.091	0.091
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,850	1,850	1,800	1,800
% Turns from Exclusive Lanes	14	14	16	16
Urbanized, Transitioning/Urban, Rural	U	U	U	U
Arterial Class	2	2		
Free Flow Speed (mph)	40	40		
Base Length of Arterial (mi.)	1	1		
Medians (Y/N)	N	Y	N	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y
Signalized Intersections	2.5	2.5		
Arrival Type	4	4	3	3
Signal Type	S	S	S	S
Cycle Length (C)	120	120	120	120
Weighted Effective Green Ratio (g/C)	0.41	0.41	0.31	0.31

LEVEL OF SERVICE THRESHOLDS

	STATE TWO-WAY ARTERIALS					FREEWAYS		Non-State Roadways	
Level of Service	Uninterrupted (vol./cap.)	Class I (avg. travel speed)	Class II (avg. travel speed)	Class III (avg. travel speed)	Class IV (avg. travel speed)	Group I (vol./cap.)	Group II (vol./cap.)	Major City / Co. (avg. travel speed)	Other Signalized (control delay)
A	≤ 0.30	≥ 42 mph	≥ 35 mph	≥ 30 mph	≥ 25 mph	≤ 0.26	≤ 0.28	Same as State Arterials	≤ 10 sec
B	≤ 0.50	≥ 34 mph	≥ 28 mph	≥ 24 mph	≥ 19 mph	≤ 0.42	≤ 0.44		≤ 20 sec
C	≤ 0.70	≥ 27 mph	≥ 22 mph	≥ 18 mph	≥ 13 mph	≤ 0.63	≤ 0.66		≤ 35 sec
D	≤ 0.84	≥ 21 mph	≥ 17 mph	≥ 14 mph	≥ 9 mph	≤ 0.81	≤ 0.84		≤ 55 sec
E	≤ 1.00	≥ 16 mph	≥ 13 mph	≥ 10 mph	≥ 7 mph	≤ 1.00	≤ 1.00		≤ 80 sec
F	> 1.00	< 16 mph	< 13 mph	< 10 mph	< 7 mph	> 1.00	> 1.00		> 80 sec

Table 5-8

GENERALIZED TWO-WAY PEAK HOUR VOLUMES FOR FLORIDA'S AREAS TRANSITIONING INTO URBANIZED AREAS OR AREAS OVER 5000 NOT IN URBANIZED AREAS*

STATE TWO-WAY ARTERIALS

UNINTERRUPTED FLOW

Unsignalized Lanes/Divided	A	B	C	D	E
2 Undivided	780	1,210	1,640	2,160	2,880
4 Divided	1,910	3,210	4,440	5,300	6,170
6 Divided	2,870	4,810	6,660	7,960	9,250

INTERRUPTED FLOW

Class I (>0.00 to 1.99 signalized intersections per mile)

Lanes/Divided	A**	B	C	D***	E***
2 Undivided	N/A	940	1,350	1,460	1,460
4 Divided	N/A	2,060	2,870	3,080	3,080
6 Divided	N/A	3,150	4,330	4,620	4,620

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes/Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	850	1,290	1,400
4 Divided	N/A	N/A	1,990	2,810	2,970
6 Divided	N/A	N/A	3,090	4,230	4,470

Class III (more than 4.50 signalized intersections per mile)

Lanes/Divided	A**	B**	C	D	E
2 Undivided	N/A	N/A	280	1,030	1,350
4 Divided	N/A	N/A	670	2,380	2,870
6 Divided	N/A	N/A	1,040	3,710	4,330

Source: The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street - Mail Station 19
Tallahassee, Florida 32399-0450

http://www.dot.state.fl.us/planning

FREEWAYS

Level of Service

Lanes	A	B	C	D	E
4	1,900	3,100	4,500	5,700	6,700
6	3,000	4,800	7,000	8,700	10,300
8	4,000	6,400	9,300	11,700	13,700
10	5,100	8,300	11,900	14,900	17,600

NON-STATE ROADWAYS

MAJOR CITY/COUNTY ROADWAYS

Level of Service

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	740	1,260	1,370
4 Divided	N/A	N/A	1,720	2,730	2,920
6 Divided	N/A	N/A	2,670	4,110	4,390

OTHER SIGNALIZED ROADWAYS
(signalized intersection analysis)

Lanes	A**	B**	C	D	E
2 Undivided	N/A	N/A	400	930	1,030
4 Divided	N/A	N/A	990	2,050	2,180

ADJUSTMENTS

DIVIDED/UNDIVIDED
(alter corresponding two-way volume indicated percent)

Lanes	Median	Left Turn Bays	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

ONE WAY
(alter corresponding two-way volume indicated percent)

One-Way Lanes	Equivalent Two-Way Lanes	Adjustment Factors
2	4	-40%
3	6	-40%
4	6	-25%

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are two-way hourly maximum volumes for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. To convert to annual average daily traffic volumes, these volumes must be divided by an appropriate K100 factor (not peak-to-daily ratio). The table's input value assumptions and level of service criteria appear on the following page.
** Cannot be achieved.
*** Volumes are comparable because intersection capacities have been reached.

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Table 5-8 (continued)

INPUT VALUE ASSUMPTIONS

CHARACTERISTIC	STATE TWO-WAY ARTERIALS								FREEWAYS			Non-State Roadways			
	UNINTERRUPTED		Class I		Class II		Class III					Major City / Co.		Other Signalized	
Number of Through Lanes	2 Ln	4-6 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln	4 Ln	6 Ln	8-10 Ln	2 Ln	4-6 Ln	2 Ln	4-6 Ln
Planning Analysis Hour Factor (K100)	0.093	0.093	0.094	0.094	0.094	0.094	0.092	0.092	0.097	0.097	0.097	0.093	0.093	0.091	0.091
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.950	0.950	0.950	0.925	0.925	0.925	0.925
Adjusted Saturation Flow Rate	1,800	1,925	1,750	1,750	1,750	1,750	1,750	1,750	2,000	2,050	2,100	1,750	1,750	1,700	1,700
% Turns from Exclusive Lanes			12	12	12	12	12	12				14	14	16	16
Urbanized, Transitioning/Urban, Rural	T	T	T	T	T	T	T	T				T	T	T	T
Arterial Class			1	1	2	2	3	3				2	2		
Free Flow Speed (mph)	55	55	50	50	45	45	35	35	70	70	70	40	40		
Base Length of Arterial (mi.)			1	1	1	1	1	1				1	1		
Medians (Y/N)	N	Y	N	Y	N	Y	N	Y				N	Y	N	Y
Left Turn Bays (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y				Y	Y	Y	Y
Signalized Intersections			1	1	3	3	5	5				2.5	2.5		
Arrival Type			3	3	4	4	4	4				4	4	3	3
Signal Type			A	A	S	S	S	S				S	S	S	S
Cycle Length (C)			120	120	120	120	120	120				120	120	120	120
Weighted Effective Green Ratio (g/C)			0.44	0.44	0.44	0.44	0.44	0.44				0.41	0.41	0.31	0.31

LEVEL OF SERVICE THRESHOLDS

Level of Service	STATE TWO-WAY ARTERIALS				FREEWAYS	Non-State Roadways	
	Uninterrupted (vol./cap.)	Class I (avg. travel speed)	Class II (avg. travel speed)	Class III (avg. travel speed)	(vol./cap.)	Major City / Co. (avg. travel speed)	Other Signalized (control delay)
A	≤ 0.31	≥ 42	≥ 35	≥ 30	≤ 0.29	Same as State Arterials	≤ 10 sec
B	≤ 0.52	≥ 34	≥ 28	≥ 24	≤ 0.47		≤ 20 sec
C	≤ 0.72	≥ 27	≥ 22	≥ 18	≤ 0.68		≤ 35 sec
D	≤ 0.86	≥ 21	≥ 17	≥ 14	≤ 0.85		≤ 55 sec
E	≤ 1.00	≥ 16	≥ 13	≥ 10	≤ 1		≤ 80 sec
F	> 1.00	< 16	< 13	< 10	> 1		> 80 sec

Table 5-9

GENERALIZED TWO-WAY PEAK HOUR VOLUMES FOR FLORIDA'S RURAL UNDEVELOPED AREAS AND CITIES OR DEVELOPED AREAS LESS THAN 5,000 POPULATION*

RURAL UNDEVELOPED AREAS

FREEWAYS

Lanes	A	B	C	D	E
	Level of Service				
4	2,000	3,300	4,600	5,700	6,500
6	3,100	5,000	7,100	8,700	10,000
8	4,300	6,900	9,700	11,900	13,700

MULTILANE UNINTERRUPTED HIGHWAYS

Lanes/ Divided/Left Bays	A	B	C	D	E
	Level of Service				
4 Undiv/No Bays	1,420	2,360	3,220	3,830	4,300
4 Undiv/Bays	1,800	3,000	4,080	4,850	5,450
4 Div/Bays	1,890	3,150	4,300	5,100	5,730
6 Div/Bays	2,840	4,730	6,450	7,650	8,600

TWO-LANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Left Turn Bays	A	B	C	D	E
	Level of Service				
2 No Bays	250	500	820	1,300	2,090
2 Bays	260	530	860	1,360	2,200

45 MPH POSTED SPEED

Lanes/ Left Turn Bays	A**	B	C	D	E
	Level of Service				
2 No Bays	N/A	240	640	1,070	2,010
2 Bays	N/A	250	680	1,120	2,120

EXCLUSIVE PASSING LANE ADJUSTMENTS

Percent of Miles with Exclusive Passing Lanes	Adjustment
60+	+30%
20-59	+20%
5-19	+10%
1-4	+5%

ISOLATED SIGNALIZED INTERSECTIONS

Lanes	A**	B	C	D	E
	Level of Service				
2 Lane / No Bays	N/A	120	660	930	1,010
2 Lane / Bays	N/A	150	840	1,170	1,280
4 Lane / No Bays	N/A	250	1,440	1,920	2,040
4 Lane / Bays	N/A	310	1,820	2,430	2,580

CITIES OR RURAL DEVELOPED AREAS LESS THAN 5,000 POPULATION

FREEWAYS

Lanes	A	B	C	D	E
	Level of Service				
4	2,000	3,300	4,600	5,700	6,500
6	3,100	5,000	7,100	8,700	10,000
8	4,300	6,900	9,700	11,900	13,700

INTERRUPTED FLOW ARTERIALS

Class Ia (up to 1.50 signalized intersections per mile)

Lanes/Divided/ /Bays	A	B	C	D***	E***
	Level of Service				
2 Undiv/No Bays	430	960	1,060	1,120	1,120
2 Undiv/Bays	540	1,210	1,350	1,420	1,420
2 Div/Bays	570	1,280	1,420	1,500	1,500
4 Undiv/No Bays	880	1,980	2,150	2,240	2,240
4 Undiv/Bays	1,120	2,510	2,720	2,840	2,840
4 Div/ Bays	1,180	2,640	2,860	2,990	2,990
6 Div/Bays	1,780	4,020	4,310	4,490	4,490

Class Ib (more than 1.50 signalized intersections per mile)

Lanes/Divided/ /Bays	A**	B	C	D	E
	Level of Service				
2 Undiv/No Bays	N/A	350	920	1,030	1,110
2 Undiv/Bays	N/A	450	1,160	1,300	1,400
2 Div/Bays	N/A	470	1,220	1,370	1,470
4 Undiv/No Bays	N/A	720	1,890	2,080	2,220
4 Undiv/Bays	N/A	920	2,390	2,630	2,810
4 Div/ Bays	N/A	970	2,520	2,770	2,960
6 Div/Bays	N/A	1,460	3,840	4,180	4,450

NON-STATE SIGNALIZED ROADWAYS

(Signalized Intersection Analysis)

Lanes/ Left Turn Bays	A**	B**	C	D	E
	Level of Service				
2 No Bays	N/A	N/A	100	690	740
2 Bays	N/A	N/A	120	790	940

Source:

The Florida Department of Transportation
Systems Planning Office
605 Suwannee Street, Mail Station 19
Tallahassee, FL 32399-0450

http://www.dot.state.fl.us/planning

MULTILANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Divided/Left Bays	A	B	C	D	E
	Level of Service				
4 Undiv/No Bays	1,360	2,270	3,150	3,760	4,370
4 Undiv/Bays	1,720	2,880	3,990	4,760	5,540
4 Div/Bays	1,810	3,030	4,200	5,010	5,830
6 Div/Bays	2,710	4,550	6,300	7,520	8,750

45 MPH POSTED SPEED

Lanes/ Divided/Left Bays	A	B	C	D	E
	Level of Service				
4 Undiv/No Bays	1,220	2,060	2,890	3,450	4,370
4 Undiv/Bays	1,550	2,600	3,660	4,380	5,540
4 Div/Bays	1,630	2,740	3,850	4,610	5,830
6 Div/Bays	2,450	4,110	5,770	6,910	8,750

TWO-LANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Left Turn Bays	A	B	C	D	E
	Level of Service				
2 Undiv/No Bays	400	710	1,010	1,410	2,020
2 Undiv/ Bays	500	880	1,260	1,760	2,520
2 Div/Bays	530	930	1,320	1,850	2,650

45 MPH POSTED SPEED

Lanes/ Left Turn Bays	A**	B	C	D	E
	Level of Service				
2 Undiv/No Bays	60	590	870	1,270	1,890
2 Undiv/ Bays	70	730	1,090	1,580	2,360
2 Div/Bays	70	770	1,140	1,660	2,480

* The table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are two-way hourly maximum volumes for levels of service, and are based on the 1997 Update to the Highway Capacity Manual and Florida traffic, roadway, and signalization data. To convert to annual average daily traffic volumes, these volumes must be divided by an appropriate K100 factor (not peak-to-daily ratio). The table's input value assumptions and level of service criteria appear on the following page.

** Cannot be achieved.

*** Volumes are comparable because intersection capacities have been reached.

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Table 5-9 (continued)

INPUT VALUE ASSUMPTIONS

Rural Undeveloped

CHARACTERISTIC	Rural Freeways			Multilane Uninterrupted			Two-Lane				Isolated Sigs.	
Number of Through Lanes Divided/Undivided Left-turn Bays	4 Ln	6 Ln	8 Ln	4-6 Ln/Bays	4 Undv/No Bays	4-6 Ln/Undv/Bays	2 Ln / Bays	2 Ln/No Bays	2 Ln/No Bays	2 Ln/No Bays	2-4 Ln / Bays	2-4 Ln/No Bays
Planning Analysis Hour Factor (K100)	0.101	0.101	0.101	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.950	0.950	0.950	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880
Adjusted Saturation Flow Rate*	1,950	2,000	2,050	1,850	1,850	1,850	2,600	2,600	2,500	2,500	1,700	1,700
% Turns from Exclusive Lanes											12	12
Urbanized, Transitioning/Urban, Rural											R	R
Arterial Class												
Free Flow Speed (mph)	75	75	75	60	60	60	55	55	45	45		
Base Length (mi.) or % No Passing							20	20	40	40		
Medians or % Exclusive Passing Lanes				Y	N	N	0	0	0	0	N	N
Left Turn Bays (Y/N)				Y	N	Y	Y	N	N	Y	Y	N
Signalized Intersections												
Arrival Type											3	3
Signal Type											A	A
Cycle Length (C)											60	60
Weighted Effective Green Ratio (g/C)											0.44	0.44

Cities or Rural Developed Areas Less than 5000

CHARACTERISTIC	Interrupted Flow Arterials						Non-State Sig. Roads	
Number of Through Lanes Divided/Undivided Left-turn Bays	2-6 Ln/Dv/Bays	2-4 Ln/ Undv/Bays	2-4 Ln/Undv/No Bays	2-6 Ln/Dv/Bays	2-4 Ln/Undv/Bays	2-4 Ln/Und/No Bays	2 Ln/Bays	2 Ln/No Bays
Planning Analysis Hour Factor (K100)	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895
Adjusted Saturation Flow Rate*	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700
% Turns from Exclusive Lanes	12	12	12	12	12	12	16	16
Urbanized, Transitioning/Urban, Rural	R	R	R	R	R	R	R	R
Arterial Class	1	1	1	1	1	1		
Free Flow Speed (mph)	50	50	50	45	45	45		
Base Length (mi.) or % No Passing	1	1	1	1	1	1		
Medians or % Exclusive Passing Lanes	Y	N	N	Y	N	N	N	N
Left Turn Bays (Y/N)	Y	Y	N	Y	Y	N	Y	N
Signalized Intersections	1	1	1	2	2	2		
Arrival Type	3	3	3	3	3	3	3	3
Signal Type	A	A	A	A	A	A	A	A
Cycle Length (C)	60	60	60	60	60	60	60	60
Weighted Effective Green Ratio (g/C)	0.44	0.44	0.44	0.44	0.44	0.44	0.31	0.31

CHARACTERISTIC	Multilane Uninterrupted						Rural Developed Two-Lane Uninterrupted					
Number of Through Lanes Divided/Undivided Left-turn Bays	4-6 Ln/Dv/Bays	4-6 Ln/Undv/Bays	4-6 Ln/Undv/NoBays	4-6 Ln/Dv/Bays	4-6 Ln/Undv/Bays	4-6 Ln/Undv/NoBays	Dv/Bays	Undv/ Bays	Undv/No Bays	Dv/ Bays	Undv/ Bays	Undv/No Bays
Planning Analysis Hour Factor (K100)	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
Directional Distribution Factor (D)	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568	0.568
Peak Hour Factor (PHF)	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895	0.895
Adjusted Saturation Flow Rate*	1,850	1,850	1,850	1,850	1,850	1,850	1,600	1,600	1,600	1,500	1,500	1,500
% Turns from Exclusive Lanes												
Urbanized, Transitioning/Urban, Rural							R	R	R	R	R	R
Arterial Class												
Free Flow Speed (mph)	55	55	55	45	45	45	55	55	55	45	45	45
Base Length (mi.) or % No Passing												
Medians or % Exclusive Passing Lanes	Y	N	N	Y	N	N	Y	N	N	Y	N	N
Left Turn Bays (Y/N)	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N
Signalized Intersections												
Arrival Type												
Signal Type												
Cycle Length (C)												
Weighted Effective Green Ratio (g/C)												

* Adjusted Saturation Flow Rate is for both directions in Rural Undeveloped Two-Lane calculations.

LEVEL OF SERVICE THRESHOLDS

	Rural Undeveloped					Cities or Rural Developed Areas Less than 5000					
	Rural Freeways	Multilane Uninterrupted	Two-Lane Uninterrupted		Isolated Intersections	Multilane Uninterrupted		Two-Lane Uninterrupted		Arterials	Non-State Signalized Roadways
	(vol./cap.)	(vol./cap.)	(vol./cap.)		(control delay)	(vol./cap.)		(vol./cap.)			
Level of Service		60mph	55mph	45mph		55mph	45mph	55mph	45mph	(avg. travel speed)	(control delay)
A	≤ 0.31	≤ 0.33	≤ 0.12	≤ n/a	≤ 5 sec	≤ 0.31	≤ 0.28	≤ 0.20	N/A	≥ 42 mph	≤ 5 sec
B	≤ 0.50	≤ 0.55	≤ 0.24	≤ 0.12	≤ 10 sec	≤ 0.52	≤ 0.47	≤ 0.35	≤ 0.31	≥ 34 mph	≤ 10 sec
C	≤ 0.71	≤ 0.75	≤ 0.39	≤ 0.32	≤ 15 sec	≤ 0.72	≤ 0.66	≤ 0.50	≤ 0.46	≥ 27 mph	≤ 15 sec
D	≤ 0.87	≤ 0.89	≤ 0.62	≤ 0.53	≤ 25 sec	≤ 0.86	≤ 0.79	≤ 0.70	≤ 0.67	≥ 21 mph	≤ 25 sec
E	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00	≤ 40 sec	≤ 1.00	≤ 1.00	≤ 1.00	≤ 1.00	≥ 16 mph	≤ 40 sec
F	> 1.00	> 1.00	> 1.00	> 1.00	> 40 sec	> 1.00	> 1.00	> 1.00	> 1.00	< 16 mph	> 40 sec

5.3

NON-SUITABLE USES AND CAUTIONS FOR GENERALIZED LOS TABLES

The following are specific situations or scenarios where the use of the Generalized Tables may yield grossly inaccurate results:

Non-Suitable Uses for Generalized Tables
Split phase operation
Absence of left turn lanes
Stopped delay other than signalized intersection(s)
Significant variability in AADT
Off-peak analyses
Add-on/drop-off lanes

Each of these is described more fully below. Refer to Section 3.7 for additional information regarding general applicability of the Generalized Tables.

Split-phase Operation

It is occasionally necessary when designing phase plans for signalized intersections to provide complete directional separation for movements in opposing directions. Under this arrangement, known as "split-phase" operation, all of the movements in one direction (*e.g.*, northbound) will move on one signal phase and all of the movements in the other (*e.g.*, southbound) will move on the next phase. This phasing alternative is usually very inefficient because it does not allow the through movements, which are usually the heaviest movements, to proceed concurrently.

Split phase operation is generally invoked for safety reasons, and is typically applied to the cross streets only. The result is a very low g/C ratio for the arterial through movements. **The Generalized Tables should not be used to analyze arterial routes with split phase operation** unless a detailed analysis of the signal timing indicates that the weighted g/C ratio for the arterial is very close to the assumed value of 0.45.

Stopped Delay Other than Signalized Intersection Along Roadway

On rare occasions, unsignalized intersections (*e.g.*,draw bridges, railroad crossings, tollbooths) will introduce delay on arterial routes. It is not possible to accommodate unsignalized treatments in either of the tabular methods (Generalized Tables or ART-TAB) because of their assumption of homogeneity among intersections. **Therefore, arterials with stopped delay other than signalized intersections cannot be accurately analyzed using the Generalized Tables.** Chapters 4 and 7 provide instructions on the method for analyzing these roadways.

No Left Turn Lanes

For simplicity, the Generalized Tables have intuitive factors (approved by the Level of Service Task Team but not contained in the HCM) to adjust for the lack of left turn bays. Adjustment factors (found in the lower right of the tables) must be manually applied to the service volumes established in the table. However, research indicates that the true value of the reduction is highly dependent on the distribution of traffic volumes among all the various movements, and a constant reduction factor is inappropriate. Therefore, **the use of the Generalized Tables and ART-TAB when analyzing arterials without left turn bays is discouraged in all but the most basic analyses.** When possible, an ART-PLAN or HCM analysis should be performed. For more information see Section 4.6.

Significant Variability in AADT Counts

Caution should be used when the AADT counts along an arterial vary significantly. A median AADT can be much lower than the volumes along one portion and delay incurred along that portion could cause the arterial to fail.

Add/Drop Lanes

Caution should be used in computing LOS on roadways with Add/Drop lanes. Refer to Section 4.6. for guidance.

Off Peak Analyses

The tables should not be used to analyze level of service in off peak hours or off peak direction. Sections 5.6 and 5.15 offer additional guidance. Off peak direction may be analyzed using ART-PLAN.

5.4

Data Requirements Summary

All major assumptions and LOS criteria are shown on the back of Florida's Generalized Tables. These assumptions may be divided into the three broad categories:

(1) traffic characteristics;
(2) roadway characteristics; and
(3) signalization characteristics.

Traffic and roadway characteristics determine levels of service for uninterrupted flow facilities. Signalization, in conjunction with traffic and roadway characteristics play an important part in estimating LOS along interrupted flow facilities.

The tables use default data collected around the state and aggregated for each area/facility type.

Daily and directional data were obtained from FDOT's continuous count stations throughout Florida. Signalization data were obtained from the signalization systems in Miami, Tampa, Tallahassee, Gainesville, DeLand and Lake City. Traffic characteristics are based on the planning analysis hour, the 100th highest traffic volume hour of the year. The 100th highest hour approximates the typical weekday peak hour during the peak season in developed areas. Most peak hours occur in the evening peak and thus, signalization characteristics were generally derived from that time period.

Data requirements for determining LOS using the tables or one of the computer programs is provided in Chapter 4. Chapter 4 should be consulted whenever adjustments or refinement in the input value assumptions for a specific roadway or areawide analysis is needed.

Critical Assumptions in Generalized Tables

Three key assumptions are briefly presented here for emphasis and because of previous misapplications:

- All **non-through (*e.g.,* left turns) vehicles are adequately accommodated** by sufficient lane storage, green time, intersection geometry, etc. No blockage of the through lanes occurs due to non-through movements.

- The tables are based on 100th highest hour traffic volume hour of the year (K_{100}) conditions. **The K_{100} factor is not a peak to daily ratio** which is commonly used throughout the state. Peak to daily ratios must be adjusted to approximate K_{100} conditions [Section 4.5].

- The assumed ratio of green time to cycle length (g/C) at signalized intersections for arterials used in the tables is the average of the arterial's critical intersection through g/C and the average of the arterial's non-critical intersections' through g/C ratios. Traditionally, most planning analyses in Florida use average g/C ratios. That approach can result in the absurd situation where the through movement of two intersecting principal arterials is each given 60 percent of the green time. The impact of critical intersections needs to be a factor in determining an arterial's LOS. In a specific case where g/C becomes a critical issue, the ART-PLAN computer model (see Chapter 7) should be applied with appropriate g/C ratios for each intersection.

5.5

AREA TYPES

Florida's Generalized LOS Tables are broken down into three primary area types:

- urbanized areas;
- transitioning into urbanized areas or areas over 5000 population not in urbanized areas; and
- rural undeveloped areas and cities or developed areas less than 5000 population.

The area types in Generalized Tables match well with FDOT's LOS standards; however, a few points are noteworthy.

Urbanized Areas

Urbanized areas are defined by the Federal Highway Administration (FHWA) approved boundary which encompasses the entire Census Urbanized Area as well as a surrounding geographic area as agreed upon by FDOT, FHWA and the Metropolitan Planning Organization (MPO).

In the Generalized Level of Service Tables for Urbanized Areas, all urbanized areas are included, regardless of size. However, some of the roadway groupings are distinguished by whether an urbanized area is over or under 500,000 population. Currently, the over 500,000 groupings only apply to the Ft. Lauderdale, Miami, Jacksonville, Tampa, Orlando, West Palm Beach and St. Petersburg urbanized areas.

Transitioning/Urban Areas

Tables 5-2, 5-5, and 5-8 actually consists of two distinct areas; (areas transitioning into urbanized areas and areas over 5,000 not in urbanized areas) however, because their traffic characteristics are similar they are treated with one table. Transitioning urbanized areas are the areas outside of, but contiguous to, urbanized areas with which they are expected to be included within the next 20 years. LOS standards for transitioning areas are applicable for a full 20 year period. For example, if an area was designated as transitioning in 1995 then the standard for a freeway within the boundaries would be LOS "C" through the end of 2015.

Transitioning areas are always adjacent to urbanized areas.

Transitioning areas are only found adjacent to urbanized areas. They generally are not isolated small cities that are expected to meet urbanized area thresholds in the future. These are "fringe" areas that exhibit characteristics between rural and urbanized characteristics. These boundaries are established through the transportation planning process of MPOs. Over time these boundaries may change as MPOs update their plans. FDOT will apply these boundaries only if an MPO formally establishes the boundaries. If they are not formally established, the developed area less than 5,000 population table should apply.

Be sure to note the difference between urbanized and urban area types.

Boundaries for cities with over 5,000 population not in urbanized areas are primarily set by existing city limits and must be agreed upon by FDOT, the local government and FHWA. However, the 5,000 population threshold is primarily a surrogate for areas that exhibit urban traffic characteristics. In situations where a city has less than 5,000 population (*e.g.*, 3,000) but the surrounding area has more than 5,000 population (*e.g.*, 10,000) and the city has an urban character, then it is reasonable to use the over 5,000 population table.

Other situations exist where an area has over 5,000 population (*e.g.*, 10,000) and yet, the area is more characteristic of a developed rural area. In this situation it is reasonable to use the developed area less than 5,000 population section of Table 5-3. In both of these situations FDOT district planning offices, after consultation with the central office, should make a determination as to the appropriate table to use. FDOT's MPO Administration Manual (Topic# 525-010-025-a) contains additional guidance.

Rural Areas

Tables 5-3, 5-6, and 5-9 also consist of two areas, undeveloped rural areas and other areas with small populations. Generally, the cities or developed areas portion of the table should be applied to non-urban areas with a population of at least 500. This portion of the table also should be generally applied to non-urban coastal roads. In questionable situations, FDOT district planning offices, after consultation with the central office, should make a determination on applying the rural undeveloped table or rural developed table.

NOTE: the "rural undeveloped area" in Tables 5-3, 5-6, and 5-9 corresponds to the "rural area" in the LOS standards (Table 2-1) and the "cities or developed areas less than 5000 population" portion of Tables 5-3, 5-6, and 5-9 corresponds to different LOS standards under the "communities" category in Table 2-1.

5.6 Subhourly, Hourly, Daily and Directional Considerations

The understanding of relationships among peak 15-minute periods of flow, hourly directional volumes, peak hour directional, peak hour two-way volumes, annual average daily volumes and peak season daily volumes is important. Fundamental to the HCM methodology is the concept of service flow rate, the maximum hourly rate at which vehicles can reasonably be expected to traverse a section of roadway during a given period (usually 15 minutes) under prevailing traffic, roadway, and signalization control conditions while maintaining a specified LOS. Tables 5-1 through 5-9 are presented in terms of annual average daily and two-way peak hour volumes for the benefit of different users.

Subhourly Considerations (Peak Hour Factor, PHF)

National traffic engineering standards/practices, as indicated by the HCM, are to conduct capacity analyses based on 15-minute flow rates. Roadways are designed on an hourly basis and take into consideration 15-minute peaking characteristics. The importance of taking into consideration 15-minute peak volumes can be understood by considering the operation of a freeway. If traffic were evenly spaced over time, a Florida freeway may be able to handle 2,200 vehicles per lane per hour before its operation fails. However, traffic does not arrive uniformly over time. One high demand 15-minute period may break down the operation of the freeway. Even though demand volumes over the rest of the hour may not be so high that the operation of the freeway would fail, the freeway operation can not recover from the first breakdown.

Daily, Hourly and Directional Considerations

The Generalized Tables 5-1, 5-2 and 5-3 are expressed in terms of peak hour directional volumes and account for peaking characteristics within the hour. **The tables should not be used to evaluate levels of service in off peak hours because many of the input assumptions (*e.g.*, PHF, C, and g/C) vary during the day.**

To obtain two-way hourly volumes in the peak hour, the peak hour directional volumes are divided by the directional distribution factor (D). The results of this are displayed in Tables 5-7 through 5-9. Off peak directional considerations are discussed more fully in Section 5.15.

The volumes shown in the daily tables are not 24 hour capacities - they reflect peaking tendencies throughout the day.

Daily tables (such as Tables 5-4 through 5-6)are often used because traffic volumes are frequently reported in terms of annual average daily traffic (AADT). Using daily tables would not require factoring daily volumes to peak hour directional volumes. However, it is improper to consider the volumes shown in the daily tables as capacities of roads for a whole day. Roadway "capacities" far exceed the volumes shown in the daily tables; all roads are under utilized in the early morning hours. Daily LOS tables are all based on a subdaily period. **Florida's Generalized Tables are specifically based on peak hour directional characteristics with consideration given to subhourly traffic variability.**

Daily volumes are also reported in the Florida Standard Urban Model Structure (FSUTMS) used in most long range urbanized area transportation plans. These daily volumes, however, are usually based on socioeconomic data for the peak season, not for average yearly conditions. For more information refer to Section 5.15.

Noteworthy, the Peak Hour Directional Tables (Tables 5-1, 5-2 and 5-3) and the Daily and Two-Way Peak Hour Tables (Tables 5-4 through 5-9) are internally consistent. More specifically, all the volumes are based on the higher directional flow of traffic for the 100th highest hour of the year, approximately equivalent to the typical peak hour of a day during a peak season for a developed area. Directional hourly volumes are divided by the directional distribution factor (D) to obtain two-way hourly volumes. Two-way hourly volumes are divided by the planning analysis hour factor (K_{100}) to obtain daily volumes.

Using the Generalized Tables with Arterial Specific K and D Factors

All of the Generalized Tables are based on a set of default variables for the traffic, roadway and signal characteristics. When using the tables in conjunction with local K and D factors, it is recommended to either develop local tables using the "TAB" programs or follow the procedures contained in this section.

The generalized **daily** tables require default values for all variables. The **two-way directional volume tables** require default values for all variables except the K factor; and the **peak hour directional tables** require default values for all except the K and D factors. The hierarchy of the table development starts with the peak hour directional service volumes, then the two-way peak hour volume table, and finally the annual average twenty four hour volume table as was illustrated in Figure 3-2.

The directional service volume (SV_{P1}) tables can be used directly regardless of the K and D factors since these tables are independent of K and D. Caution must be taken when the two-way peak volume (SV_{P2}) tables or the annual average daily traffic (AADT) tables are used since these are dependent on the K and D factors.

If , K and D are known and the K and D differ from the default values in the tables, then only the peak hour directional volume tables can be used directly. The SV_{P1} can be computed from the field data and compared directly to the values in the peak hour directional volume tables. The two-way peak volume and daily tables cannot be used unless a correction is applied to the AADT or two-way peak hour volume.

Once an adjusted $AADT'$ is computed then, and only then, can the daily tables be used to estimate LOS. The field values for AADT, K, and D must be known to adjust AADT, and the following equation will convert field data to AADT

$$AADT' = (ADT_F * K_F * D_F) / (K_D * D_D)$$

where $AADT'$= The adjusted AADT for use in the daily tables,

ADT_F = field ADT,
K_F = field K factor,
D_F = field D factor,
K_D = default K factor in table, and
D_D = default D factor in tables.

The equation is simple and the result is easy to use. Now that field ADT has been adjusted to match the values in the tables, the adjusted average annual daily volume, $AADT'$ can be used to determine the arterial LOS.

Same as the daily tables, the field value for the two-way peak hour volume must be adjusted using the default values of K and D, the equation follows:

$$SV_{P2}' = (ADT_F * K_F * D_F) / (D_D),$$

where SV_{P2}' is the adjusted two-way peak hour volume. The SV_{P2}' can be used as the look up value in the tables for estimating the LOS.

The peak hour directional volume can be computed directly using the field values as follows:

$$SV_{P1} = ADT_F * K_F * D_F.$$

Now the computed SV_{P1} can be used as the look up value in the tables for estimating the ranges of SV_{P1} arterial LOS. Again the SV_{P1} needs no adjustment for K and D.

5.7

ROADWAY TYPES

The Generalized Tables are used to analyze six major types of roadways:

- **freeways** - a multi-lane divided highway having a minimum of two lanes for exclusive use of traffic in each direction and full control of access and egress;
- **multilane uninterrupted flow highways** - a highway with at least two lanes for the exclusive use of traffic in each direction with no fixed causes of delay or interruptions external to the traffic stream;
- **two-lane uninterrupted flow highways** - a highway with one lane for the exclusive use of traffic in each direction with no fixed causes of delay or interruptions external to the traffic stream;
- **interrupted flow two-way arterials** - In the HCM, these are defined as a highway with at least one lane for the exclusive use of traffic in each direction with traffic signals, STOP or Yield signals, or other fixed causes of periodic delay or interruption to the traffic stream. For use with the Generalized Tables, only delay created by signalized intersections should be analyzed. Other forms of periodic delay or interruptions (such as stop or yield signs) should be analyzed using the guidelines contained in Chapters 6 and 7;
- **interrupted flow major city/county roadways** - non-state roadways with characteristics of interrupted flow two-way arterials.
- **other interrupted flow non-state roadways with signalized intersections** - local roads with signalized intersections which do not have characteristics similar to interrupted flow two-way arterials.

5.8

FUNCTIONAL CLASSIFICATION

FDOT functionally classifies all public roads in Florida using federal guidelines. The Generalized Tables are consistent with the functional classification process, yet are not dependent on functional classification. Freeways are the state's principal arterials with full control of access and egress. In all the tables covering areas with at least 5000 population all arterials, whether principal or minor, are considered arterials. Although combining principal and minor arterials into one overall arterial category somewhat overstates service volumes on minor arterials, it makes the tables easier to use and keeps functional classification out of the capacity analysis.

5.9

NON-STATE ROADS

The primary purpose of the Generalized Tables is to compute the LOS of state facilities. However, because the tables have great potential use by local governments, the tables also have been structured for their needs. The tables are reasonably well suited to local governments who desire to use them to evaluate roads under local jurisdiction.

A feature of the urbanized and transitioning Generalized Tables is that two types of non-state roads are addressed: major city/county roadways and other signalized roadways.

Major City/County Roadways

Major city/county roadways are streets that would be classified as an arterial road on a city/county major thoroughfare plan or similar planning document. These roads have characteristics (*e.g.*, cross section, alignment, access control, trip lengths, speed limits, signalization) similar to state roads classified as urban minor arterials.

Other Signalized Roadways

"Other" signalized roadways refers to city/county roads with signalized intersections that do not act like arterials. FDOT's position is that because these two types of roads are not included in the state highway system, local governments should primarily make the determination of whether the roads are major or not. FDOT's role would generally be advisory.

Using State Tables to Analyze Non-state Roadways

Although state arterials are divided into five types in the Generalized Tables to account for the effects of signalization density, space was only provided for one "grouping" of these non-state roads that act like arterials. Thus, the major city/county roadways entries are **not** reflective of signalized intersection density. A medium density of signalized intersections (2.5 signalized intersections per mile) is assumed.

To better account for signal density, a five percent reduction in the state two-way arterial volumes using the state road section of the tables is a reasonable general approach. The reason for this reduction is that these roads resemble state minor arterials as opposed to state principal arterials and, as stated in Section 5.8 the service volumes in the tables are somewhat high for state minor arterials.

Evaluating Collectors

There is no acceptable technique to evaluate collectors. The HCM addresses arterials and signalized intersections, not collectors or local streets. By using the above approach for planning purposes, non-state signalized roadways would either be evaluated as (minor) arterials using an arterial LOS approach or as other signalized roadways using a signalized intersection approach. Specifically, FDOT considers it appropriate for local governments to decide whether to analyze these roads as "major city/county roadways" or "other signalized roadways".

Non-state Rural Roadways

Uninterrupted flow facilities in areas with less than 5000 population are analyzed the same, regardless of whether they are state facilities or not. Where non-state roads are signalized, volumes are provided in Table 5-3.

In the rural undeveloped portion of Table 5-3 it should be noted that non-state roadways should be treated as two-lane uninterrupted highways.

5.10

Determining the Number of Signalized Intersections

When determining the number of signalized intersections per mile, do not count the signalized intersections at both ends of the analysis section. Because Florida's Generalized Tables are based on peak hour volumes, generally, the roadway's initial signalized intersection should not be counted and the last one should. Do not count signals at the end of a section as one-half of a signal. See Section 4.7 for more information.

Signalized Arterials Terminating Where There Is No Intersection

Occasionally, roadway sections end at mid-link, not at intersections. This occurs most frequently at the boundary of developed areas, but may occasionally occur within developed areas. When performing the analysis using the Generalized Tables, these termini are counted as signalized intersections. See Section 4.7 for more information.

5.11

Arterial Classification and Uninterrupted Arterials

Because of the importance of the number of signalized intersections in determining levels of service, FDOT found it useful to use arterial classes to identify the number of signalized intersections per mile on interrupted flow arterials. The classification system is very similar to that appearing in the HCM. Classes I, II, III, and IV in Tables 5-1 and 5-2 provide a general indication of the impact of increased signalization on levels of service (*i.e.*, average travel speed) on interrupted flow arterials.

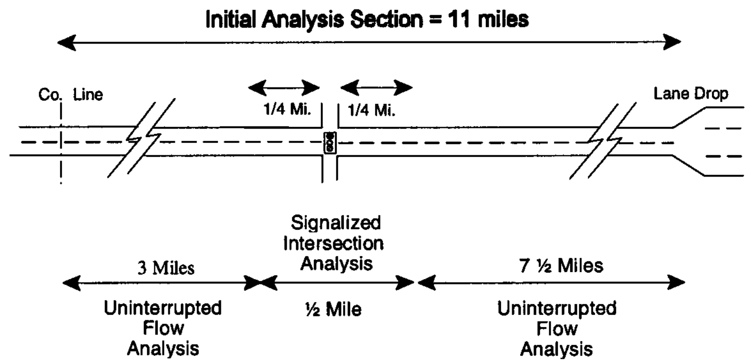
A generalized planning treatment of uninterrupted flow arterials in developed areas presents an interesting challenge. If analyzed strictly as uninterrupted flow multilane (assuming 4 or more lanes) highways, service volumes approach those of freeways. However, these uninterrupted flow arterials almost always have capacity restrictions at terminal and interface areas. Frequently these capacity constraints are caused by isolated intersections.

The use of the Generalized Tables for arterials with long signal spacing be discouraged because of the inseparable mixture of interrupted and non-interrupted flow. Routes in this category should be segmented to separate the two types of operation as shown below. Routes that cannot be segmented should be analyzed as Class I arterials.

Analyzing Isolated Intersections

Long sections with isolated signals should be broken into 3 sections.

Many times, rural facilities that might otherwise be considered uninterrupted flow are interrupted by isolated intersections. In determining section lengths for long stretches of facilities with isolated intersections in rural (and some developed) areas, the analysis section should be broken into smaller sections. For example, the initial length of the facility depicted below is 11 miles measured from the lane drop to the county line (for



guidance on selecting section termini, see Section 4.10). To measure the effects of the signalized intersection, a new one-half mile section is formed by breaking the initial section. (In this case, the section is determined by measuring 1/4 mile on either side however; it may be appropriate to delineate the section using posted speed zones or other logical termini.) The one-half mile section is analyzed using the isolated signalized intersection portion of the generalized tables or SIG-TAB. The remaining longer sections are analyzed using the uninterrupted flow portion of the generalized tables or the appropriate uninterrupted flow TAB program (e.g., RMUL-TAB, R2LN-TAB).

The tabular values for uninterrupted flow in the Generalized Tables reflect truly uninterrupted flow conditions. If a particular route cannot be segmented to eliminate the constraints of signal control, it should be placed in Class I regardless of the signal spacing. The UMUL-TAB and U2LN-TAB computer programs are generally appropriate for use on the uninterrupted portions and SIG-TAB for the area influenced by a signalized intersection. Arterials designated as Class I can be analyzed using SIG-TAB or the HCS planning method to check the signalized intersection's operation and ART-TAB can be used to develop service volumes.

5.12

INTERPRETATION OF THE NUMBER OF LANES

The number of lanes, for capacity analysis purposes, is determined by the through and shared through/right-turn lanes at major intersections, not at mid-block. Since the ultimate result of the capacity analysis is a section-long estimation of LOS and it is widely recognized that signalized intersections are the most limiting components of the section, it is appropriate to place more emphasis on the intersections' characteristics than the mid-block's. See Section 4.6 for more information.

Number of Lanes on Interrupted Flow Facilities

For consistency among Tables 5-1 through 5-3 and Tables 5-4 through 5-9, the number of lanes are two-way totals. Thus, although the volumes in Tables 5-1 through 5-3 are directional volumes, the number of lanes are for the roadway as a whole.

Number of Lanes on Uninterrupted Flow Facilities

For uninterrupted flow facilities the number of lanes in the Generalized Tables is the basic section (mid-block) laneage. Thus, for example, a freeway's basic section has six lanes, but has eight lanes at an interchange, the freeway should be considered a six-lane freeway.

5.13

LEFT TURN BAYS

The Generalized Tables are based on the assumption that there are left turn bays at signalized intersections with adequate storage so that the through movements are not impeded by left turning vehicles. A fractional lane concept has been developed to calculate the delay created by such intersections. However, the use of the fractional lane concept is strongly discouraged in the Generalized Tables and in ART-TAB, because the complexity of the computations does not lend itself to a tabular solution.

Therefore, **the use of the Generalized Tables and ART-TAB when analyzing arterials without left turn bays is discouraged in all but the most basic analyses.** When possible, an ART-PLAN or HCM analysis should be performed, using the fractional lane methodology described in Section 4.6 and in Table 4-5.

5.14

ONE-WAY FACILITIES

In the Generalized Tables, analysis of one-way facilities is accomplished using adjustment factors. (found in the Adjustments section of the appropriate table). An example application follows:

> In an urbanized area a three-lane one-way facility with 3 signalized intersections per mile is being analyzed with Table 5-1. The applicable table indicates a 20 percent increase from the corresponding six-lane two-way Class II arterial. For a LOS D this would correspond to 3,100 (*i.e.*, 1.2 * 2,580) vehicles per hour.

The Generalized Tables treat each facility of a one-way pair as a separate facility. In the above example, if there were a parallel one-way facility operating in the opposite direction it would also have a 3,100 LOS D volume. Under these conditions one-way pairs are assumed to have 20 percent higher service volume thresholds than their corresponding two-way facilities. Since the Daily and Two-Way Peak Hour tables contain two-way volumes a 40% *reduction* factor is applied. In the case above, this would be 29,300 (*i.e.,* 0.6 * 48,900) vehicles per day per direction. This is the equivalent of halving the number of lanes and adding 20%.

In the unusual case of a one-way facility with five lanes, Tables 5-1 and 5-4 indicate a 50 percent increase from a corresponding eight-lane two-way facility. The different adjustment factor (50%) is used because the tables do not contain corresponding ten-lane two-way facilities.

5.15

MISCELLANEOUS CONSIDERATIONS AND ISSUES

This section provides guidance and insight into issues and areas of consideration which will assist the analyst in using the Generalized Tables in an appropriate and effective manner.

Mid-Block Considerations

In general, highway capacity analysis for interrupted flow facilities primarily centers on the signalized intersections and uninterrupted flow facilities primarily center on the basic section (mid-block). The difference in concentration essentially is based on how and where drivers perceive problems. In general, most motorists on arterials are aggravated by the delay they incur at signalized intersections while motorists on freeways are bothered by maneuvering limitations over the entire roadway section. Thus, in this manual the relative importance of mid-block considerations vary by type of facility.

Although allowing vehicles to approach or obtain desired running speeds (increasing average travel speed and thus, arterial level of service), in urbanized areas mid-block arterial segments primarily allow travelers to proceed to subsequent signalized intersections. It is at signalized intersections where the vehicles lose most of their average travel speed. Generally, mid-block segments (*i.e.*, the number of through lanes) have capacities far exceeding that of signalized intersections. Mid-block segments are largely designed to match intersection configurations for the smooth operation of vehicles and to obtain reasonably similar flow rates on all lanes through the intersections. Thus, the number of lanes indicated in the Generalized Tables primarily represent through lanes at signalized intersection, not necessarily the mid-block number of lanes.

Recently, interest has been expressed in implementing long continuous right turn lanes; however, FDOT discourages them for numerous reasons including the following:

- First, as discussed above, mid-block capacities generally far exceed intersection capacities; therefore, providing additional mid-block laneage provides limited benefit;

- Although sometimes intended for safety reasons, long right turn lanes generally have an adverse safety impact. Some motorists use these lanes for "queue jumping" (passing on the right) which create risk to exiting and entering motorists, who may misread the motorist's intent. Numerous side impact crashes have occurred between motorists who enter the lane earlier than needed, and then cross the path of a motorist entering the lane from the side of the road at the appropriate point; and

- Designing safe bicycle and pedestrian facilities becomes virtually impossible.

Arterial Segment Running Times

Based on recent research commissioned by the FDOT, the arterial segment running times used in this manual and the accompanying planning computer models depart from those suggested for use in Table 11-4 of the HCM. Unlike those in Table 11-4, the running speeds used in this manual and software were derived using an equation including traffic volume as a variable. The FDOT running speeds also better reflect *through* vehicle running speeds, as opposed to the total mix of through and turning vehicles. Other factors which enter into determining the running speeds are free flow speed, average segment length, quality of progression, number of lanes and arterial classification. The table's running speed is not sensitive to the number of driveways, medians, right turn deceleration lanes, other mid-block considerations affecting the smooth flow of traffic, or traffic flows.

Obviously, these mid-block access management considerations do affect running speeds to some extent. The only one of these mid-block access management considerations handled directly in the Generalized Tables and associated computer models is the treatment of divided/undivided considerations. **Essentially, a 5 percent volume penalty is assigned to undivided facilities. An upward adjustment factor for arterials with good mid-block access controls (*e.g.*, limitations on driveways, right turn deceleration lanes) may also be appropriate.** These adjustment factors represent a consensus of the task team developing the tables, and are not calculated values.

It should be noted that in this manual the adjustment factors described above are best thought of as being applied to either the calculated volume or to the adjusted saturation flow rate, rather than to running speed.

Maximum Volumes and Ideal Conditions

The values presented in the Generalized Tables are maximum volumes for a given LOS. Levels of service represent a range of operational conditions, not a precise number or volume. Thus, a volume greater than the values shown would indicate a lower quality LOS.

The service flow rates are based on ideal conditions, characteristics which are assumed to be the best possible from the point of view of capacity. It should be noted that these conditions are considered "ideal" only in terms of capacity and LOS, and that the term "ideal" has no connotation with respect to safety or other factors. Thus, such factors as adverse weather and accidents do not enter into the calculation of the volumes in the tables. Obviously, if ideal conditions do not exist, volumes would be lower than those in the tables. Based on the assumption of ideal conditions, **impediments such as draw bridge openings, railroad crossings and construction should generally not be included in the calculation of service flow rates.**

Off Peak Direction Considerations

The Generalized Tables do not address the actual off peak direction levels of service. Implicit in all the tables is that the peak direction will be operating at a lower LOS than the off peak direction. In general, this is true; however, on signalized arterials it may not be. A lower level of service may occur in the off peak direction because the adverse effect of poorer signal progression may more than offset the beneficial effect of lower volumes of traffic. Assumed in the tables is that for major roads good progression exists; however, this assumption is not appropriate for the off peak direction. If a peak hour off peak direction analysis is desired, the following guidance is provided.

For freeways and uninterrupted multilane facilities, peak hour directional volumes produced in FREE-TAB, RMUL-TAB and UMUL-TAB computer programs (Chapter 6) are equally applicable for both directions. Similarly, the volumes shown for freeways and uninterrupted flow multilane facilities are equally applicable to both directions if all the default assumptions (other than the K_{100} and D factors which are not relevant) are the same. The R2LN-TAB program and the Generalized Tables are also applicable for rural two-lane uninterrupted highways, except where the D factor is high. In that case Table 8-4 of the HCM should be consulted.

For interrupted flow facilities the use of the ART-PLAN computer program (see Chapter 7) is recommended for off peak direction analyses. A favorable arrival type in the off peak direction should not be used unless adequate justification is provided. ART-PLAN directly calculates off peak direction levels of service.

Relationship with Maximum Through Lane Standards

The Generalized Tables show up to twelve lanes for freeways and up to eight lanes for other facilities. These lane numbers are beyond FDOT's Maximum Through Lane Standards (Table 5-10, below) because Florida does have some of these high laneage facilities and occasionally there will be exceptions.

Nevertheless, it should be recognized there are decreasing returns to increasing capacity by adding these lanes as can be deduced from the volumes on the front of the Generalized Tables and the lower adjusted saturation flow rates appearing on the back of the tables.

As defined in the maximum through lane standards, auxiliary lanes, frontage roads and collector-distributor lanes are not considered through lanes. **High occupancy vehicle (HOV) and other special-use lanes are considered through lanes.** In this case, bicycle lanes are not considered special use lanes.

Another way of looking at eight-lane arterials is that the outside lane is used as an exclusive right turn lane. If the road operates or is signed that way, then it would be proper to treat it as a six-lane facility with a higher percentage of turns from exclusive lanes than indicated in the Generalized Tables.

Varying Volumes of Vehicles Within a Roadway Section

The volumes in the tables should be thought of as "median" or average volumes over the entire roadway sections being examined. The intent is to get the most typical situation for the roadway section. For example, if a four mile section of a roadway has annual average daily traffic counts of 23,000, 23,000, 22,000, 25,000 and 27,000 over its length, FDOT recommends the use of the median value 23,000 for comparison to the tables to determine the LOS. The median is obtained by ranking the values from highest to lowest and taking the middle value. Alternatively, the average (24,000) may be used. Generally, the median and average values are similar, but occasionally there may be an unusually high or low value distorting the most "typical" situation over the road section.

TABLE 5-10

Maximum Through Lane Standards for the State Highway System

Florida Intrastate Highway System (FIHS)	Urbanized Areas [1]	Non-Urbanized Area[5]
Turnpike Mainline[2]	n/a	4 lanes
Limited Access Highways[3]	10 lanes[4]	6 lanes
Controlled Access Highways	6 lanes (4 minimum)	6 lanes (4 minimum)
Non-Florida Intrastate Highway System	**Urbanized Areas [1]**	**Non-Urbanized Area[5]**
Limited Access Highways	10 lanes[4]	6 lanes
Other State Highways	6 lanes	4 lanes

Footnotes:

1 "Urbanized Areas" means areas of 50,000 or more persons expanded to include adjacent developed areas as provided by federal regulations.

2 "Turnpike Mainline" means Florida's Turnpike between the vicinity of the Palm Beach/Martin County line and Kissimmee.

3 "Limited Access" includes the Interstate System, Turnpike facilities not on the Turnpike Mainline, and additional limited access facilities on the State Highway System.

4 In urbanized areas with populations over 200,000, the ten lane maximum will include four physically separated, exclusive lanes (two in each direction) for through traffic, public transit vehicles, and other high occupancy vehicles. In urbanized areas with 50,000 to 200,000 population, the maximum initial construction will be six lanes and include provisions to add four exclusive lanes when needed to serve through traffic, public transit vehicles, and other high occupancy vehicles.

5 In non-urbanized areas, any needed capacity beyond four lanes in the following corridors will be provided by other transportation alternatives, with emphasis on intercity rail development: Tampa-Orlando, Orlando-Miami, Miami-Tampa, Orlando-Jacksonville. Additional corridors may be added based on favorable rail related market/ridership assessments.

Note: Exceptions to these standards will be addressed on a case-by-case basis, with final approval for inclusion in plans and programs resting with the Secretary of Transportation.

Source: Florida Department of Transportation, Office of Policy Planning, 1995.

Service Volumes Viewed as Capacities

Some people view the Generalized Tables as maximum capacity tables and point out that traffic volumes on some of the state's most congested roads actually exceed the LOS E volumes in the tables. This can occur for many reasons.

1. These are **not** in a strict sense **capacity tables**. They, instead, indicate threshold volumes at which levels of service move from one level to another. An arterial may have a greater volume than shown in the tables because rather than operating at an average travel speed of 13 mph during peak hour (LOS E criteria for a Class II arterial), the facility is simply operating at 5 mph. In this situation the service flow rate for LOS E is being exceeded, not the roadway's capacity.

2. As illustrated previously in Section 3.7 in the South Dixie Highway example, the roadway's signalization characteristics may vary substantially from state norms.

3. In many congested areas, roads experience extended peak hours of traffic. It must be remembered that the tables are based on the projected 100th highest volume hour of a year, not the conditions under which a road operates on a daily basis. Under extreme congested conditions traffic volumes higher than those in the daily tables occur because excess traffic demand will be dispersed over a period longer than an hour on which the tables are based.

The planning models from which the tables are derived can account for these differences and thus, can provide more site specific values.

Constant volumes across levels of service

With average travel speed being the measure of effectiveness for arterials, numerous other signalization characteristics, in addition to intersection capacity, became important. Intersection capacity remains significant; however, under many circumstances, the cumulative effect of other signalized intersection aspects dominates level of service determinations. Nevertheless, with low signal density intersection capacity virtually becomes the overriding issue. In any given hour only a certain volume of vehicles can pass through an intersection before a substantial queue begins to form and average travel speed drops dramatically. The critical intersection of a roadway section can virtually control the capacity of that arterial section.

FDOT's planning analysis tools allow volume to capacity ratios (v/c) for signalized intersections to exceed 1.0 for 15-minute periods; however, such v/c ratios can not be maintained for a full hour because of the substantial queues that would be formed. Essentially, for an hour, a volume no greater than the roadway's critical intersection capacity can use the facility. FDOT has incorporated an intersection check into its generalized tables and computer programs generating the tables. As soon as the v/c ratio reaches 1.0 for an hour, the service volumes remain constant across remaining lower quality levels of service.

This intersection constraint generally becomes applicable for Class I arterials (less than 2.0 signalized intersections per mile), and generally becomes an overriding constraint when signal spacing is less than a mile apart. Thus, for example, the Class I arterial volumes in Table 5-1 are constant for levels of service D and E. This constant volume across levels of service indicates that the intersection volume has reached the intersection capacity (v/c = 1.0 for a full hour) and physically, no additional vehicles could pass that intersection in that time period. For level of service reporting purposes, in this example, the higher quality level of service "D" should be used.

Unachievable Levels of Service

Unlike some previous generalized LOS tables based on the HCM, higher quality levels of service may not be achieved on interrupted flow facilities even with extremely low traffic volumes. These higher quality levels of service cannot be achieved primarily because the signalization characteristics simply will not allow vehicles to attain relatively high average travel speeds. The "cannot be achieved" entries in the Generalized Tables reflect this notion that a LOS cannot be achieved no matter how small the traffic volume, or that volumes are so low to give meaningless results (*e.g.*, a peak hour directional rate of 300 vehicles on a six-lane facility).

Transportation Planning Boundaries and Future Situations

Users of the tables are cautioned to use the appropriate tables that relate to the correct planning boundaries as established in the Department's MPO Administrative Manual (Topic No. 525-010-025-a). For example, Table 5-2 (the transitioning urbanized area table) represents an area in which land use changes are projected to occur and area type, traffic, roadway, and signalization characteristics are likely to change. This delineation covers the transition from a rural area to an urbanized area over the next 20 years.

A transportation analysis in an area designated as transitioning would use the transitioning table for the first 20 years and then use the urbanized table for the 20th year and beyond. If conditions in the area being reviewed as transitioning are more closely represented as an urbanized area and the area has been recognized as such by the MPO, the urbanized table may be used prior to the 20th year.

LOS Standards in Table 2-1 and the appropriate Corresponding Generalized Tables are to be applied throughout a 20 year planning horizon (See Section 2.2). Thus, the LOS Standards remain the same until boundaries are officially changed as described in the boundary procedure.

Review and Update of Generalized Tables

FDOT recognizes the need to monitor the effectiveness of the tables and to conduct on-going research regarding their use. Thus, the Generalized Tables will be updated and reissued as needed, based on new research and application results. FDOT welcomes comments and inputs to the tables.

Relationship with Urban Transportation Planning System Models

Long range transportation planning for urbanized areas is usually accomplished with the assistance of an urban transportation model. At the national level the U.S. Department of Transportation developed the Urban Transportation Planning System (UTPS) model. The Florida Standard Urban Transportation Model Structure (FSUTMS), based on UTPS, is used in Florida for urban area transportation modeling.

The FSUTMS travel demand model provides forecasts of average weekday traffic volumes for the peak season of the year. These peak season weekday average daily traffic (PSWADT) volumes **cannot** be used directly with the Generalized Tables without being adjusted. To calculate LOS using FSUTMS-generated future traffic volumes, a Model Output Conversion Factor (MOCF) must be applied. Analysts should contact FDOT to obtain the MOCFs specific to the area or facility being analyzed. After applying the MOCF, the derived AADT can then be used with the daily volumes found in the Generalized Tables to determine LOS.

Relationships with Freeway Access and Design Traffic

Although the planning analysis hour (K_{100}) is appropriate for planning purposes and determining system deficiencies, in Florida the design hour (K_{30}) is the proper analysis period for the development and review of new or modified access to freeways, or the preparation of design traffic.

5.16

SAMPLE PROBLEMS

Urbanized Freeway

A four-lane freeway is located in an urbanized area over 500,000. It is within 5 miles of a primary city central business district. The adopted LOS Standard for the facility is D. The 1998 AADT counts along the road were 81,900 vpd. The service volumes for this roadway will be found in the "Generalized Annual Average Daily Volumes for Florida's URBANIZED AREAS", in Group 1 of the Freeways section.

FREEWAYS

Group 1 (within urbanized area over 500,000 and leading to or passing within 5 miles of the primary city central business district)

	Level of Service				
Lanes	**A**	**B**	**C**	**D**	**E**
4	21,200	34,300	51,500	66,200	81,700
6	32,600	52,700	79,000	101,600	125,400
8	44,500	71,800	107,800	138,600	171,100
10	55,600	89,800	134,700	173,200	213,800
12	65,200	105,400	158,100	203,200	250,900

The maximum service volume for LOS E is 81,700. Therefore, since the 1998 count of 81,900 AADT exceeds the LOS E maximum volume, the level of service for this freeway section, using the Generalized Tables, is LOS F.

Urbanized Major City/County Road Arterial (Nonstate Road)

A local road which operates like an arterial is located in a city with a population of 130,000. The road is a two-lane undivided facility with three signalized intersections over 1.3 miles (or 2.3 signalized intersections per mile). There are turn

NON-STATE ROADWAYS
MAJOR CITY/COUNTY ROADWAYS

	Level of Service				
Lanes	**A****	**B****	**C**	**D**	**E**
2 Undivided	N/A	N/A	8,600	14,600	16,000
4 Divided	N/A	N/A	19,800	31,700	33,900
6 Divided	N/A	N/A	30,800	47,800	51,000

bays at all major intersections. The local comprehensive plan has adopted an LOS standard of E for facilities of this type.

Using the Major City/County section of the Generalized Tables (Daily Volumes), the maximum acceptable service volume for LOS E is 16,000 vpd. The median AADT in 1998 was 15,126 which correlates with LOS D, an acceptable LOS.

Urbanized Class II Arterial

A 2.3 mile section of an undivided four-lane arterial has 6 signalized intersections with left turn bays. The 1998 AADT is 31,500. The road is located in a metropolitan area of 430,000. The established LOS standard for the road is D.

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes/ Divided	A**	B**	C	D	E
	Level of Service				
2 Undivided	N/A	N/A	9,900	14,900	16,200
4 Divided	N/A	N/A	22,900	32,500	34,300
6 Divided	N/A	N/A	35,500	48,900	51,700
8 Divided	N/A	N/A	44,700	60,100	63,400

According to the Generalized Tables, the Class II maximum service volume for four lane divided facilities at LOS D is 32,500; however, the volume must be reduced by 5% since it is undivided, so the maximum service volume at LOS D is 30,900 vpd. Since the road's AADT exceeds the LOS D service volume the section is operating at LOS E and fails to meet the standard.

Rural Multilane Uninterrupted Highway Developed Area

A four-lane divided highway passes through a small town of 3500 people. There are no signalized intersections but there are turn bays at the median cuts. The 1998 AADT count along the road was 29,000 vpd. The maximum service volumes for this roadway may be found in the "Generalized Annual Average Daily Volumes for Florida's Rural Undeveloped Areas and Cities or Developed Areas Less Than 5,000 Population". The "Multilane Uninterrupted Highways"

MULTILANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Divided/Left Bays	A	B	C	D	E
	Level of Service				
4 Undiv/No Bays	14,300	23,900	33,100	39,600	46,000
4 Undiv/Bays	18,100	30,300	42,000	50,100	58,300
4 Div/Bays	19,000	31,900	44,200	52,800	61,400
6 Div/Bays	28,500	47,900	66,300	79,200	92,100

section is applicable.

The speed limit along this road is 55 mph. Since the AADT of 29,000 falls between the maximum service volumes of 19,000 (LOS A) and 31,900 (LOS B), the level of service for this highway section, using the Generalized Tables, is B.

Rural Multi-Lane Interrupted Flow Arterial in a City with less than 5000 Population

Suppose the same conditions exist as in the above sample except that there is 1 signalized intersection. The facility is analyzed using Class Ia portion of the "Interrupted Flow Arterials" section.

INTERRUPTED FLOW ARTERIALS

Class Ia (up to 1.50 signalized intersections per mile)

Lanes/Divided/ /Bays	Level of Service A	B	C	D***	E***
2 Undiv/No Bays	4,500	10,100	11,200	11,800	11,800
2 Undiv/Bays	5,700	12,800	14,200	15,000	15,000
2 Div/Bays	6,000	13,400	14,900	15,800	15,800
4 Undiv/No Bays	9,300	20,900	22,600	23,600	23,600
4 Undiv/Bays	11,800	26,400	28,600	29,900	29,900
4 Div/ Bays	12,400	27,800	30,100	31,500	31,500
6 Div/Bays	18,700	42,400	45,300	47,300	47,300

The AADT of 29,000 falls between the LOS B service volume of 27,800 and 30,100 for LOS C for four lane, divided, with bays so the LOS is C.

Rural Two-Lane Uninterrupted Flow Highway

A two-lane undivided highway is located in a largely unpopulated area. There are no signals or turn bays in the analysis section. It is 5.012 miles long and the speed limit is

TWO-LANE UNINTERRUPTED HIGHWAYS

55 MPH POSTED SPEED

Lanes/ Left Turn Bays	Level of Service A	B	C	D	E
2 No Bays	2,500	5,000	8,200	13,000	20,900
2 Bays	2,600	5,300	8,600	13,600	22,000

55 mph. The median 1998 AADT count was 8,350 vpd. In the "Two Lane Uninterrupted" section of the "Rural Undeveloped And Cities Or Developed Areas Less Than 5000 Population" table, the maximum service volume at LOS C is 8,200 vpd and 13,000 at LOS D, so this highway is operating at LOS D.

NOTES:

6

TABLE GENERATING SPREADSHEETS

All of the service volumes appearing in FDOT's Generalized Tables were generated by spreadsheets using statewide average input variables for specific facilities and/or area types. These spreadsheets extend the concept of the Generalized Tables in a very practical way because they allow analysts to work with a set of LOS tables that reflect local conditions more accurately. This section describes each spreadsheet and gives instructions for their application. All of the "TAB" spreadsheets are appropriate for planning applications.

6.1

SPREADSHEET MODELS

ART-TAB is the predominant spreadsheet model used in the Generalized Tables. It is available for the analysis of arterial roadways that are not adequately represented in the Generalized Tables. ART-TAB allows analysts to create a localized table showing service volumes for each level of service. The other "TAB" models which generate FDOT's Generalized LOS tables include:

- FREE-TAB
- RMUL-TAB
- UMUL-TAB
- R2LN-TAB
- U2LN-TAB
- SIG-TAB

An aggregate (or master) spreadsheet incorporating all of the above spreadsheets is also available for those agencies interested in creating localized tables. Use of the master spreadsheet results in a set of general LOS tables that emulates FDOT's Generalized Tables in function and appearance but uses locally-collected data.

ART-TAB for Arterial Level of Service Tables

This template uses the procedures from Chapter 11 of the Highway Capacity Manual (HCM) to develop generalized tables for arterials. This template is appropriate where individual link data is not available.

ART-TAB allows the analyst to enter traffic, roadway and signalization data that differ from the statewide averages used in Florida's generalized level of service tables; however, traffic roadway and signalization data are assumed to be the same for all links and signalized intersections. A detailed planning level of service analysis of a roadway is best handled by ART-PLAN. Whenever link-specific data are available, analysts are strongly encouraged to use ART-PLAN. ART-TAB can also be used to generate localized LOS tables for areas where the conditions differ from the statewide averages.

FREE-TAB - Freeway Level of Service Tables

This template uses the procedures from Chapter 3 of the HCM to develop generalized level of service tables for freeways.

RMUL-TAB - Rural Multilane Level of Service Tables

This template uses the procedures from Chapter 7 of the HCM to develop generalized level of service tables for *undeveloped* rural multilane uninterrupted flow highways. To analyze multilane uninterrupted flow highways in rural developed areas, UMUL-TAB should be used.

UMUL-TAB - Urban Multilane Level of Service Tables

This template uses the procedures from Chapter 7 of the HCM to help develop generalized level of service tables for multilane uninterrupted flow highways in urban, transitioning and rural developed areas. When analyzing these types of roadways, a supplementary analysis (SIG-TAB) must be performed to ensure that the capacity of the terminal and interface areas (*e.g.*, signalized intersections) will not be exceeded.

R2LN-TAB - Rural Two-lane Level of Service Tables

This template uses the procedures from Chapter 8 of the HCM to help develop generalized level of service tables for rural *undeveloped* two-lane uninterrupted flow highways. When analyzing these types of roadways, a supplementary analysis (SIG-TAB) must be performed to ensure that the capacity of the terminal and interface areas (*e.g.*, signalized intersections) will not be exceeded. To analyze two-lane uninterrupted flow highways in rural developed areas U2LN-TAB should be used.

U2LN-TAB - Urban Two-lane Level of Service Tables

This template helps develop generalized level of service tables for two-lane uninterrupted flow highways in urban, transitioning and rural developed areas. When analyzing these types of roadways, a supplementary analysis (SIG-TAB) must be performed to ensure that the capacity of the terminal and interface areas (*e.g.*, signalized intersections) will not be exceeded. This U2LN-TAB template is appropriate for a planning level of analysis.

SIG-TAB - Signalized Intersection Level of Service Tables

This template uses the procedures from Chapter 9 of the HCM to develop generalized level of service tables. This template may be appropriate for a planning level of analysis for an isolated intersection or where a local roadway (*e.g.*, collector) with a signalized intersection (s) should be analyzed based on an intersection analysis rather than an arterial analysis. The service volumes found in the rural "Isolated Intersections" and "Other Signalized Roadways" sections of the Generalized Tables are produced by SIG-TAB.

6.2

USING THE SPREADSHEETS

As supplied, the spreadsheets contain a statewide default value for each input variable. Subject to the minimum requirements outlined in Section 4.2, users may replace as many or as few of these defaults as their locally-collected data will support. Local data must be collected in conformance with generally accepted practices. Guidance for data collection is available in Section 4 of this manual and from FDOT personnel.

All spreadsheet documentation in this manual refers to the use of Lotus 1-2-3® Release 5.0 for Windows; however, more other releases of Lotus may be used. The use of other spreadsheet software is possible, but some formatting irregularities may exist. Use of other software should be approved by FDOT personnel. The remainder of this section describes generic operations more or less applicable to all spreadsheets.

Spreadsheet Settings

Each spreadsheet is protected so that the user may only make entries in certain unprotected locations. These locations are the blue entries on the spreadsheet. All other locations on the spreadsheets are not to be changed. If the user tries to change a protected location, "error" will flash in the upper right-hand corner, and the user must hit the <ESC> key to get out of the error.

To scan the results, the user must move the cursor to the right. This can be done by using the arrow keys or the <TAB> key. The spreadsheet was set up this way in order to have a one-page print out that includes all the inputs and outputs.

Description

The description section of the spreadsheet is for general identifying information about the facility to be analyzed. Analysts may enter any information they deem pertinent. Information in the Description section does not affect any spreadsheet calculation. Next to the Road Name, the user enters the name of the facilityl being analyzed. Directly below the name, the user is requested to enter a combination of the following:

limits (from/to)
analysis date
peak direction, *i.e.*, EB, WB, NB, or SB.
number of lanes
study time period
distance (length of analysis section)
user notes

Traffic, Roadway, and Signalization Characteristics

These sections contain the variables that may be replaced by local data when substantiated by field measurement. Below are descriptions of each characteristic with references to additional information. An example or range of inputs is provided for each characteristic in the spreadsheet. Not all spreadsheets use every characteristic (*e.g.,* signalization characteristics are not needed in FREE-TAB). The statewide default value for each characteristic is found at the bottom of every spreadsheet.

Traffic Characteristics

K Factor

The K factor gives the percent vehicles traveling in the peak hour, and has a value from 0.06 to 0.20. Based on statewide measurements, FDOT does not allow the use of K factors lower than .082. [Section 4.5]

Directional Distribution (D Factor)

The D factor gives the percent vehicles traveling in the peak direction, and has a value of 0.50 to 1.00. However, FDOT uses 0.52 as the minimum acceptable D factor. A D factor of 1.00 means that 100% of the traffic is in the peak direction, *i.e.*, one-way arterials. [Section 4.5]

Peak Hour Factor (PHF)

The peak hour factor or PHF is the hourly volume during the peak hour divided by the peak 15-minute rate of flow within the peak hour. The peak hour factor can have a value from 0.70 to 1.00. [Section 4.5]

Adjusted Saturation Flow Rate

This represents the maximum hourly service flow rate of vehicles per lane. The rate is subject to certain limitations specific to the facility type being analyzed. Detailed definitions follow. The adjusted saturation flow rate takes into account characteristics that vary from the ideal conditions, such as, trucks, narrow lane widths, grade, etc. [Section 4.5]

Interrupted Highways

This represents the maximum hourly service flow rate of vehicles per through or through-right lane that can be expected to discharge from an intersection under prevailing conditions, *i.e.*, maximum number of vehicles that can depart the intersection in a full hour of green time, with full demand, and prevailing conditions. The adjusted saturation flow rate can have a value from 1400 to 2100 vph.

This value is used later to determine the capacity of the through movement lane group. Capacity is estimated as the adjusted saturation flow rate x number of lanes x g/C, where g/C is the weighted through movement green-to-cycle length ratio (defined later).

Freeways and Uninterrupted Multilane Highways

This represents the maximum hourly service flow rate of vehicles in one lane in one hour. The adjusted saturation flow rate can have a value from 1600 to 2500 vph.

Uninterrupted Two-Lane Highways

Bi-Direction Adjusted Saturation Flow Rate (U2LN-TAB)-This represents the maximum hourly service flow rate of vehicles in both directions in one hour. The adjusted saturation flow rate can have a value from 2000 to 2800 vph.

One-Direction Adjusted Saturation Flow Rate (R2LN-TAB) - This represents the maximum hourly service flow rate of vehicles in one direction in one hour. The adjusted saturation flow rate can have a value from 1300 to 2000 vph.

Percent Turns from Exclusive Lanes

The percent turns (from 0 to 100%) made from left-turn-only lanes and/or right-turn- only lanes is entered here. When there is more than one intersection, enter the percent turns taken from the critical intersection, *i.e.*, the intersection with the lowest g/C ratio. Note that there is a maximum allowable percent of turns from exclusive lanes which relates to the g/C ratio. [Section 4.5]

The arterial LOS estimation methodology described in this document applies the HCM procedures to the through traffic at each signalized intersection. For planning purposes, it is assumed that the turning movements are accommodated by the signal timing plan. The service volumes computed by this technique do not include any turning movements made from exclusive lanes.

Turning volumes must therefore be added to the through volumes in determining the overall service volumes computed by the Generalized Tables and by ART-TAB. Conversely, the turning volumes must be subtracted from the overall demand volumes for purposes of computing arterial through-traffic delay by ART-PLAN. These operations are inherent in the techniques mentioned. The turning movement adjustments are made internally, based on the user-specified value of percent turns from exclusive lanes.

The accuracy of the results is understandably very sensitive to this variable. The Generalized Tables assume, for example, statewide averages of .44 g/C and 12 percent turns from exclusive lanes on state roads in urbanized and transitioning areas. These are user-specified items for ART-TAB and ART-PLAN. Proper use of these two programs requires some knowledge of field conditions.

Either of the two assumptions (g/C or percent turns) may be increased slightly without violating the requirement for a viable signal timing plan. There is generally no need for this supplemental check if the assumed values are close to the default values. However, when both of these assumptions are increased significantly at the same time, the results should be checked using Figure 4.1. **As a matter of practice, the check should be performed if the sum of the g/C and turns from exclusive lanes (both expressed in percent) exceeds 65%. Note that the default values of .44 (*i.e.*, 44%) for g/C and 12% for turns add up to 56%.**

This check is not necessary if the percent turns is based on field data (*i.e.*, intersection counts with turning movements and through movements) along with accurate signal timing. It should be considered appropriate when using the default value (12%) for turns in conjunction with high g/C ratios (>.53), especially on multilane roadways.

Roadway Characteristics

Area Type

There are three area types that can be entered here: Urban, Transitioning, or Rural, for which U, T, or R is entered, respectively. The urban and transitioning arterial types use the tabular lookup values from the HCM for determining LOS breakpoints. [Section 5.5]

Urbanized, Transitioning/Urban, or Rural Developed Area (U2LN-TAB and SIG-TAB)

Enter U, T, or R for the correct area type. The rural designation applies to cities or developed areas less than 5000 population. The LOS definitions are based on the area type entered here. [Section 5.5]

Arterial Class

There are four possible arterial classes for urban and transitioning arterials: I, II, III, and IV. The spreadsheet uses numbers 1, 2, 3, and 4 in place of the Roman numerals used in the HCM. Rural arterials must be Class I arterials. [Section 4.6]

Free Flow Speed

Each arterial class has a characteristics range of free flow speeds. The user must make sure that there are no inconsistencies between the arterial class entered and the free flow speed entered. Free flow speed is the desired speed most drivers would choose if they were alone on the roadway given the prevailing characteristics of that roadway. The posted speed limit may be used as a surrogate for free flow speed. It may be appropriate to use free flow speeds equal to the posted speed limit plus 5 mph on uninterrupted flow arterials and freeways. On the spreadsheet, the user is given a table of speeds that can be entered for each arterial class. [Section 4.6]

Total Length of the Arterial

The length of the arterial is entered in miles. [Section 4.10]

Medians

The default assumption is that medians exist. If medians do not exist, type 'N', for no medians. The effect of not having medians is to reduce the hourly volume by 5%. This factor for medians is not in the HCM, but was added specifically for Florida's planning program. [Section 4.6]

Left Turns Bays

The default assumption is that left turn bays do exist at signalized intersections along the entire length of the arterial. If there are no turn bays, ART-TAB is not considered to be an appropriate analysis technique. An ART-PLAN analysis should be used for the arterial using the shared lane methodology. [Sections 4.6 and 5.13]

Percent No Passing Zones

Enter the average percent of the highway having no passing zones (0 to 100%). [Section 4.6]

Percent Exclusive Passing Lanes

Enter the average percent of the highway that has exclusive passing lanes (0 to 100%). This factor does not exist in the Highway Capacity Manual and was added specifically for Florida's planning program. The default case is that there are 0% exclusive passing lanes. If passing lanes do exist, they will have the following multiplicative effects on hourly volumes:

Percent Exclusive Lanes Factor	
0	1.00
1- 4	1.05
5 - 19	1.10
20 - 59	1.20
60 - 100	1.30

For more information see Section 4.6.

Signalization Characteristics

Number of Signalized Intersections

The number of signalized intersections as determined using methodology from Section 4.7 and 5.10.

Arrival type

Arrival type is entered for the peak direction. Arrival type is a description of how the platoons of vehicles arrive at the intersection. The default arrival types is 4. The range is from 1 to 6. [Section 4.7]

The 1994 revision to the HCM introduced a sixth arrival type, AT-6, which represents truly ideal progression. This change was made in recognition of the fact that AT-5 did not give due credit to the beneficial effects of ideal progression. Very low delays are associated with AT-6, which suggests that nearly all of the vehicles are able to proceed through an intersection virtually unimpeded.

The conditions that identify favorable progression can only be applied on an intersection-by-intersection basis. AT-5 or 6 may well apply at specific intersections along a route, however it would be very rare to see these conditions apply to an entire route. Furthermore, the assumption of very good progression in one direction implies that a lower progression quality may prevail in the other direction. With a relatively even directional distribution, the off-peak direction speeds could be lower than the arterial LOS if very favorable progression has been established for the peak direction. **For these reasons, progression quality better than AT-4 should not be assigned in LOS analyses that use ART-TAB.**

Type Signal System

The type of control at the intersections can be either actuated, pretimed, or semiactuated. The user is cued to enter A for actuated, P for pretimed, or S for semiactuated. [Section 4.7]

System Cycle Length

The cycle length can have a value from 60 to 180 seconds. [Section 4.7]

Through Movement g/C ratio

(SIG-TAB) - The g/C ratio can have a value from 0.20 to 0.80. Effective green time at the intersection is the actual green time plus the amber time plus the allred time minus the start-up lost time minus the clearance lost time, *i.e.*,

$$g = G + \text{amber} + \text{all red} - l_1 - l_2,$$

where G is the actual green time; l_1 is the start-up lost time, the time lost while the beginning vehicles in a queue start moving after the light turns green; and l_2 is the clearance lost time, the time between the last vehicle from one approach entering the intersection and the initiation of the green signal for the conflicting approach. The total lost time ($l_1 + l_2$) is assumed to be 4 seconds. [Section 4.7]

Weighted Through Movement g/C ratio

(ART-TAB) - the weighted g/C ratio can have a value from 0.20 to 0.70. The weighted g/C is a modification to the effective g/C defined in the HCM. It is the average of the arterial's critical intersection effective through g/C (as defined above in "Through Movement g/C ratio") and the average of the non-critical intersection's effective through g/C. [Section 4.7]

Calculating

The user has now finished entering all the necessary information. The F9 function key should be pressed to recalculate the entire spreadsheet.

Before moving the cursor over to the results, the user should check to see if there are any 'ERROR' messages. If an input value is outside the permitted range, error messages will appear to the right of the value with a highlighted asterisk. If there are error messages, the user should go back and correct these values and then recalculate the spreadsheet by pressing the F9 function key.

Results

The user can use the arrows and/or the <TAB> key to look over the resulting tables, to the right of the data input.

Estimates of the breakpoint service volume for each level of service are given by number of lanes, expressed as:

- Peak hour peak directional volume
- Peak hour volume (both directions)
- Average annual daily traffic (AADT)
- Peak hour peak direction through/right v/c ratios, (these are the v/c ratios for the full hour, *i.e.*, the peak 15-minute v/c ratio * PHF).

'N/A' means that the LOS is not achievable, *e.g.*, under the given conditions, it would be impossible to achieve LOS A on a 2-lane arterial.

The volumes calculated are based on the v/c ratios given in the fourth section of the results. The determination was made that the maximum volume to capacity ratio allowed for the full hour for levels of service C, D, and E would be 1.0. Therefore, volumes given in the tables may be same across different levels of service.

6.3

EXAMPLE PROBLEMS

ART-TAB Example

From the example provided in Section 5.16, recall that:

> A 2.3 mile section of an undivided four-lane arterial has 6 signalized intersections with left turn bays. The 1998 AADT is 31,500. The road is located in a metropolitan area of 430,000. The established LOS standard for the road is D. According to the Generalized Tables, the Class II maximum service volume for four lane divided facilities at LOS D is 32,500; however, the volume must be reduced by 5% since it is undivided, so the maximum service volume at LOS D is 30,900 vpd. Since the road's AADT exceeds the LOS D service volume the section is operating at LOS E and fails to meet the standard.

Information gathered locally indicates the following variations to the statewide averages used in compiling the Generalized Tables:

- signal timing information was gathered and it was determined that the "weighted" g/C was 0.49 instead of the default of 0.44; and
- from directional counts gathered, it was found that the D factor was 0.55 instead of the 0.568 default value.
- turn movement counts show that there are 16 percent turns from exclusive lanes at the critical intersection not the average of 12% used in the tables.

With the new information, the Input section of the spreadsheet looks like this:

TRAFFIC CHARACTERISTICS		
		----Range----
K Factor	0.093	(0.06 - 0.20)
D Factor	0.55	(0.50 - 1.00)
Peak Hour Factor	0.925	(0.70 - 1.00)
Adj Saturation Flow Rate	1850	(1400 - 2000)
% Turns from Exclusive Lanes	16	(0 - 100)
ROADWAY CHARACTERISTICS		
Urban Transitioning, or Rural Area Type	U	(L, T, or R)
Arterial Class	2	(1,2,3, or 4)
Free Flow Speed(mph)	40	(45, 40, or 35)
Total Length of Arterial(mi)	2.3	
Medians(Y/N)	N	
Left Turn Bays (Y/N)	Y	
SIGNALIZATION CHARACTERISTICS		
No.Signalized Intersections	6	
Arrival Type,Peak Dir	4	(1,2,3,4,5 or 6)
Type Signal System	S	(P, S, or A)
System Cycle Length(sec)	120	(60 - 240 sec)
Weighted Thru Mvmt g/C	0.49	(0.20 - 0.80)

Results portion of the spreadsheet looks like this:

AVERAGE ANNUAL DAILY TRAFFIC (AADT)
(Includes vehicles in exclusive turn lanes)
2.6087 Intersections per mile

Level of Service

LANES	A	B	C	D	E
2	N/A	3,[illegible]00	14,600	18,700	20,000
4	N/A	7,[illegible]00	31,600	37,800	40,100
6	N/A	11,200	43,900	56,900	60,100
8	N/A	15,[illegible]00	63,400	76,000	80,200

The use of local data in the ART-TAB analysis results in a maximum service volume at LOS D of 37,800 AADT. The measured AADT is 31,500 so the section is operating at LOS C and meets the standard.

FREE-TAB Sample Calculation

From the example given in Section 5.16 recall:

> A four-lane freeway is located in an urbanized area over 500,000. It is within 5 miles of a primary city central business district. The adopted LOS Standard for the facility is D. The 1998 AADT counts along the road were 81,900 vpd. The service volumes for this roadway will be found in the "Generalized Annual Average Daily Volumes for Florida's URBANIZED AREAS", in Group 1 of the Freeways section. The maximum service volume for LOS E is 81,700. Therefore, since the 1998 count of 81,900 AADT exceeds the LOS D maximum volume and the LOS E maximum volume, the level of service for this freeway section, using the Generalized Tables, is LOS F.

A local study found the following differences from the statewide averages used in the Generalized Tables:

- The K_{100} is not .088 as used in the tables but is .082. This would be consistent with a roadway which has high traffic volumes throughout the day.
- The D-factor is not .568 as used in the tables but is .525. This would be consistent with a great deal of traffic in both directions without a really predominant peak direction.
- The Peak Hour Factor (PHF) is not .095 but is .098. This would be consistent with high traffic volumes uniformly over the peak hour.

After entering the calculated values for K_{100}, D and PHF into FREE-TAB, the input section looks like this:

TRAFFIC CHARACTERISTICS

		Range
K Factor	0.082	(0.06 - 0.20)
D Factor	0.525	(0.50 - [illegible])
Peak Hour Factor	0.900	(0.70 - [illegible])
Adjusted Saturation Flow Rate	2.150	(1300 - 2400)

ROADWAY CHARACTERISTICS

Free Flow Speed (mph)	60	(75 70 65 60 or 55)

As shown in the following partial printout from the completed FREE-TAB spreadsheet, the maximum service volume for LOS D, using local data, is 79,300 vpd.

AVERAGE ANNUAL DAILY TRAFFIC (AADT)

	Level of Service				
LANES	A	B	C	D	E
4	25,500	41,100	61,700	79,300	97,900
6	38,200	61,700	92,500	118,900	146,800
8	50,900	82,200	123,300	158,600	195,800
10	63,600	102,800	154,200	198,200	244,700
12	76,400	123,300	185,000	237,900	293,700
14	89,100	143,900	215,800	277,500	342,600

Since the measured volume was 81,900 AADT, the section fails to meet the standard; however, the FREE-TAB analysis using local data indicates the facility is operating at LOS E rather than F as shown by the Generalized Tables.

The other "TAB" spreadsheets follow the same format as the two examples above. For more information contact FDOT personnel.

7

ART-PLAN

Procedures and guidelines for conducting a level of service analysis using ART-PLAN are provided in this Chapter. ART-PLAN computes arterial level of service.

Because ART-TAB (see Section 6.1) and ART-PLAN both analyze arterials, they are closely linked. They vary in that all signalized intersections are assumed to have the same characteristics in ART-TAB, while ART-PLAN allows more precision by having the flexibility to treat each signalized intersection differently. Thus, ART-PLAN is more adept in evaluating the LOS for a specific roadway.

ART-PLAN is a spreadsheet template replicating the procedures from Chapter 11 of the HCM. Although it is considered a planning model, it approaches a traffic operations model in depth. It is fast, easy to use and allows for flexible application of the HCM procedure. It is recommended for use when an analyst is evaluating a specific interrupted flow facility. Many Florida analysts believe it is the most appropriate technique to analyze arterials in urbanized areas for local government comprehensive plans and for concurrency management systems. A detailed planning level of service analysis of a roadway is best handled by ART-PLAN. With ART-PLAN localized data can be entered for each segment and intersection to get a more accurate level of service estimate. It also provides an off-peak direction level of service analysis.

All spreadsheet documentation in this manual refers to the use of Lotus 1-2-3® Release 5.0 for Windows. Other releases of Lotus may be used. The use of other spreadsheet software is possible, but should be approved by FDOT personnel.

Summarization

ART-PLAN comprises:

- a general input page for aggregate arterial data,
- a peak direction specific inputs range for data pertaining to specific segments and intersections,
- peak direction results,
- an off-peak direction specific inputs range for data pertaining to specific segments and intersections,
- off-peak direction results

Information is first entered into the spreadsheet for data that apply to the arterial as a whole. Then, detailed data for segments and intersections in both the peak and off-peak directions of travel are entered. A maximum of ten intersections (nine segments) can be analyzed at one time. The spreadsheet is protected so that the user may only make entries in certain unprotected locations. All other locations on the spreadsheet may not be changed.

The spreadsheet is set for automatic recalculation. This means that when a number is changed, *e.g.*, the AADT is changed, the rest of the sheet will reflect this change automatically.

Following sections of this manual describe the operation of the spreadsheet in the order it is encountered by the user. The user should load the spreadsheet at this point, and follow along with the instructions. Once the spreadsheet is loaded, make sure you are at the beginning by pressing the <HOME> key. This brings you to the top left corner of the sheet.

The first information requested of the user is the Road Name, under the "Description" section of the spreadsheet. The cursor should be placed on this position to start.

This first page of entries are all in this same column; thus, the user can make an entry and press the down arrow as the "enter" key. The cursor, then, will be on the next position ready for entry by the user. Also, the spreadsheet is set up so that the user will never need to go further right than the existing screen, but only up and down.

7.1

DESCRIPTION

The description section of the spreadsheet is for general identifying information about the arterial to be analyzed. Information entered in this section does not affect the analysis. Next to the Road Name, the user enters the name of the arterial to be analyzed. Directly below the name, enter the limits of the arterial section being analyzed. The limits are often intersecting roads but users may choose to use other logical termini. Next, indicate the peak direction. This may be entered as a two-letter abbreviation, *i.e.*, EB, WB, NB, or SB, or spelled in full. Then the off-peak direction is entered in the same way.

Next, the study time period (*e.g.,* PM Peak) is entered, and, finally, the analysis data is entered. The analysis date is entered followed by "User Notes" made at the discretion of the analyst.

7.2

TRAFFIC CHARACTERISTICS

This section contains the following overall arterial volume data:

Average Annual Daily Traffic (AADT)

The median AADT count of the arterial is entered here. [Section 5.6] This value may be overridden by values entered later in the "Specific Inputs" range, if such information is available.

K Factor

The K factor identifies the percent vehicle traveling in the peak hour, and has a value from 0.06 to 0.20. Default values are 0.093 for Class I and II arterials. Default values for Class III and IV arterials are 0.092. FDOT does not allow a K Factor of less than .08 for calculations on state highways. [Section 4.5]

Directional Distribution (D Factor)

The D factor indicates the percent vehicles traveling in the peak direction, and has a value of 0.50 to 1.00. The default value in ART-PLAN is .568. FDOT does not allow a D Factor of less than .52 for calculations on state highways. [Section 4.5]

NOTE: A D factor of 1.00 means that 100% of the traffic is in the peak direction, *i.e.*, one-way arterials.

Peak Hour Factor (PHF)

The peak hour factor is the hourly volume during the peak hour divided by the 15-minute rate of flow within the peak hour. The default value in ART-PLAN is 0.925. [Section 4.5]

Adjusted Saturation Flow Rate

This represents the maximum hourly flow rate of vehicles per through or through-right lane that can be expected to discharge from an intersection under prevailing conditions, *i.e.*, maximum number of vehicles that can depart the intersection in a full hour of green time, with full demand, and prevailing roadway and traffic characteristics.

The adjusted saturation flow rate can have a value from 1400 to 2000 vph. Florida's default value for arterials in urbanized areas is 1850 vph. The adjusted saturation flow rate takes into account characteristics that vary from the ideal conditions, such as, trucks, narrow lane widths, grade, etc.

This value is used later to determine the capacity of the through movement lane group. Capacity is estimated as the adjusted saturation flow rate x number of lanes x g/C, where g/C is the through movement green-to-cycle length ratio. [Section 4.5]

Percent Turns from Exclusive Lanes

The percent turns from exclusive lanes is provided for the arterial as a whole. The default value is twelve percent (12%). [Section 4.5] This value may be overridden by values entered later in the "Specific Inputs" range, if such information is available.

In general, there is a trade off between the g/C ratio [Section 4.7] and the percent left turns from exclusive lanes, since both require longer green times. Furthermore, high g/C ratios imply heavy through traffic volumes which create a need for more green time for the associated left turns. If these variables are estimated without adequate field data, it is possible to create combinations of g/C ratio and percent left turns that exceed the parameters of a reasonable signal timing plan (*i.e.*, the timing plan will not be able to provide reasonable green times for the other movements that are assumed to be accommodated). This is especially true of six and eight lane arterials.

It is possible to verify the adequacy of the timing plan by a simple procedure illustrated in Figure 4-1. This procedure computes the maximum allowable percent turns from exclusive lanes. [Section 4.5]

Note: The analyst should be cautioned to review individual intersection characteristics carefully. There are many intersections where there are no left or right turning movements from exclusive lanes (when the arterial to the right is a T intersection or a one-way facility, for example). This is especially important on multilane highways since 12% of the trips can be a great number of vehicles and often, intersecting roadways do not attract a large number of trips (*i.e.*, the signalized intersection to a housing development). This data is highly sensitive to the peak direction when there can be turning movements for one peak period and none or few for the other peak.

7.3

ROADWAY CHARACTERISTICS

Number of Through Lanes

The number of through and shared through/right lanes is entered by direction. The peak direction is entered first, then the off-peak direction. [Section 4.6] Provisions for analyzing add/drop lane configurations and shared lanes are made below. This value may be overridden by values entered later in the "Specific Inputs" range, if such information is available.

Note: Turn bays are not to be included in the number of lanes. The AADT, however, will include left- and right-turning vehicles made from exclusive lanes, but the indicated turning percentage will be subtracted out when individual segment through volume is being calculated.

Area Type

There are three area types that can be entered here: Urbanized, Transitioning/Urban, and Rural, for which U, T, or R is entered, respectively. The urbanized and transitioning/urban arterial types use the tabular lookup values from the HCM for determining intersection and arterial level of service breakpoints. [Section 5.5]

Arterial Class

There are four possible arterial classes for urban arterials: I, II, III, and IV. (The spreadsheet uses numbers 1, 2, 3, and 4 in place of the Roman numerals used in the HCM.) Transitioning/Urban arterials may be I, II, or III. Rural arterials must be Class I arterials.

Arterial class is a categorization of arterials involving function, design, and free flow speed. In Florida, arterial class is primarily determined by the posted speed limit (a surrogate for free flow speed) and signal density. The level of development (*e.g.*, business districts) and the number of signalized intersections per mile are recommended as the primary determinants for arterials class when a facility's speed limit is 35 mph. [Section 4.6]

Note: In Florida's generalized tables, it is assumed that when there are 4.5 or more signalized intersections per mile, it is a class III or IV arterial. (Class IV arterials are assumed in the downtowns of core cities in urbanized areas over 500,000.)

Free Flow Speed

Each arterial class has a characteristic range of free flow speeds. The user must make sure that there are no inconsistencies between the arterial class entered and the free flow speed entered. Free flow speed is the average desired speed of all vehicles on the arterial. In Florida, the posted speed limit is often used as the free flow speed. On the spreadsheet, the user is given the table of speeds that can be entered for each arterial class. [Section 4.6]

7.4

SIGNALIZATION CHARACTERISTICS

Arrival Type

Arrival type is entered for the peak and off-peak directions. These can later be changed for individual segments. Arrival type is a general categorization of quality of signal progression.
Progression quality resulting from arterial signal coordination has always been expressed in the HCM in terms of an "arrival type" (AT).

There are six arrival types, with AT-1 representing the worst possible progression quality and AT-6 representing ideal progression. Uncoordinated operation (*i.e.*, random arrivals) is represented by AT-3. The HCM offers both a narrative and numerical description of the various arrival types. [Section 4.7]

Type Signal System

The type of control at the intersections can be either actuated, pretimed, or semiactuated. The user is cued to enter A for actuated, P for pretimed, or S for semiactuated. [Section 4.7]

System Cycle Length

The cycle length for the entire system is entered in seconds. [Section 4.7] This value may be overridden by values entered later in the "Specific Inputs" range, if such information is available.

Weighted g/C

The arterial's weighted through movement g/C may be entered. [Sections 4.7 and 6.2] This value may be overridden by values entered later in the "Specific Inputs" range, if such information is available.

7.5

SPECIFIC INPUTS

The following two sections allow the user to override values for individual segments in both directions. As used here, segments are road links between signalized intersections.

If there are less than 10 intersections (nine segments), a zero should be entered in the "Segment AADT" column for segments that do not exist. For example, if there is an arterial with six segments a "0" will be entered under "Segment AADT" for segments 7-8 through 9-10. There will be six segments appearing in the program.

Each segment in the peak direction, then, will have a peak hour volume equal to the AADT x K factor x D. Each segment in the off-peak direction will have an hourly volume equal to the AADT x K factor x (1 - D factor). This is the full-hour volume, not the fifteen minute flow rate expressed as an hourly volume. The program will later multiply this peak-hour volume by (1 - percent turns/1.00), which will remove turns made from exclusive lanes, and divide by the PHF, which will increase the hourly volume to account for the fifteen minute peak, thereby converting to a flow rate.

Changing Values

If segment data is available that justifies revising the characteristics of the analysis section, type over the value that is there. For example, if there are no turns from exclusive lanes at a given intersection, "0" should be entered. If the arrival type is different for that intersection, change the number.

Note that signal information is entered for the downstream intersection. For example, the first segment in the peak direction is segment 1-2; thus, the g/C ratio entered is the g/C ratio at intersection 2. In the off-peak direction, the last segment is segment 2-1, and the g/C ratio is entered for intersection 1. The bottom row marked "Formulas" contains the spreadsheet equations for each input column to ensure their longevity. They may be copied if the original is overwritten.

Entering Segment-specific Volumes

When traffic counts for individual segments are available, a more accurate analysis can be made by using the individual counts as opposed to the median or average count for the arterial. This is extremely important when analyzing arterials with a great deal of variation in the AADT counts.

> If the segment-specific volumes are **daily counts (AADT)**, simply enter the number in the column headed "Segment AADT". The spreadsheet will automatically convert the daily volumes into peak hour volumes.
>
> If the segment-specific volumes are **peak hour counts**, enter that number in the "Peak Hour Volume" column. This will overwrite the daily-to-peak conversion equation.

Treatment of Arterials Without Left Turn Bays

All of the planning level arterial analysis methods assume that left turns are accommodated by the geometric and signal operation design. Specifically, all methods assume that proper storage exists for all left turns. If this is not the case, then left turns will impede through traffic and intersection delays will suffer. [Section 4.6]

To estimate the effect of left turns on through traffic in shared lanes accurately, it is necessary to know the traffic volumes and signal timing parameters to a level of detail that far exceeds any planning requirements. For this reason, the use of ART-TAB has been restricted to facilities with adequate left turn storage at all locations. The Generalized Tables have more or less intuitive factors (approved by the Level of Service Task Team but not contained in the HCM) to adjust for the lack of left turn bays. ART-TAB calculates the level of service making those same assumptions. However, there was no method for making adjustments when the arterial characteristics differed from the assumptions when doing an ART-PLAN analysis.

Shared Lanes on Multi-lane Roadways

The HCM includes a planning level computational technique for estimating the degree to which a shared lane is blocked by left turning traffic. The methodology described in this handbook conforms with the HCM. **A fractional number of lanes reflecting the degree of left turn blockage should be used with ART-PLAN at intersections which do not have a left turn bay.** Table 4.5 indicates the appropriate fractional value as a function of the number of lanes on the facility, the left turn volume, and the volume of opposing traffic. Note that the fractional result always falls between the full number of lanes on the facility (indicating no interference from the left turns), and one lane less than the full number of lanes (indicating that the left turn has completely taken over the shared lane).

Shared-Lanes on Two-lane Roadways

The planning level shared lane model presented in the HCM treats the single lane case differently from the multilane cases. This is because the through traffic in a single shared lane is unable to divert to an alternate lane to avoid interference from the left turns. The multiple lane case (2,3 and 4 lanes in each direction) along with the single lane case is treated in Table 4-5.

Some care is necessary in dealing with the single lane case, because the methodology assumes that a left turning vehicle will block all of the following through vehicles while it waits for an opportunity to move. This will be true at some intersections, however, at others it may be possible for through vehicles to "squeeze by" a left turn using roadway capacity that does not theoretically exist. This treatment cannot be generalized for analysis purposes and field observations provide the only acceptable way to determine the level of service.

Treatment of Add/Drop Lanes

When lanes that carry through traffic are added before the intersection or dropped after the intersection, the added or dropped lanes will contribute to the intersection capacity, but probably not to the extent of a full lane. Where add/drop lanes are of sufficient length, a fractional lane may be assumed.[Section 4.6]

Through Movement g/C Ratio

The g/C ratio entered here should be the effective green time divided by the cycle length. Effective green time is the actual green time plus the amber time plus the allred time minus the start-up lost time minus the clearance lost time, *i.e.*,

$$g = G + \text{amber} + \text{all red} - l_1 - l_2$$

where G is the actual green time, l_1 is the start-up lost time, the time lost while the beginning vehicles in a queue start moving after the light turns green, and l_2 is the clearance lost time, the time between the last vehicle from one approach entering the intersection and the initiation of the green signal for the conflicting approach. If this information is not known, then in Florida the total lost time ($l_1 + l_2$) can be assumed to be equal to 4 seconds. [Section 4.7]

Treatment of Unsignalized Intersection Delay on an Arterial Route

On rare occasions, arterial routes will experience delay from unsignalized intersections. [Section 4.7] For two way stop control in which the arterial traffic is stopped, the equivalent cycle length should be assumed to be 30 seconds. The effective green time ratio, g/C should be computed as

$$g/C = 1 - (V_c/1400)$$

where V_c = The sum of the cross street hourly volumes.

For all-way stop control (both the arterial and cross street are stopped) the equivalent cycle length should be set at 15 seconds.

The effective g/C ratio should be estimated as

$$g/C = (15(V_{AH} / V_{CH}) - 3) / 15$$

where V_{AH} = The arterial volume in the heaviest direction

and V_{CH} = The cross street volume in the heaviest direction

These g/C values should be subject to minimum and maximum values of 0.3 and 0.7, respectively.

If the approximations suggested above indicate that the intersection in question would operate beyond its capacity, then a more detailed analysis should be conducted using the full HCM Chapter 10 methodology for analyzing two-way or all-way stop control.

Entering Segment Length

The distance between signals should be entered in the column entitled "Input Length". This number can be entered in either miles or feet; the spreadsheet will automatically convert miles to feet. Do not use metric measurements.

Off-Peak Considerations

If off-peak information is available, the user may then enter any changes to specific segments in the off-peak direction. Note the reverse order of the segments/intersections since the direction of travel being analyzed has reversed.

After entering the specific inputs for all the segments in both the peak and off-peak directions, the user has finished entering all the necessary information.

7.6

RESULTS

The user can use the down arrow to look over the through movement results for both directions. First are the peak direction's results, and then the off-peak direction.

Estimates are given for the following:

- Intersection Results
    - Stopped delay,
    - Intersection level of service
- Arterial Results
    - Segment travel speed (mph),
    - Segment level of service,
    - Overall arterial travel speed (mph),
    - Overall arterial level of service

NOTE: ART-PLAN does not allow the calculation of arterial speed when an intersection's volume to capacity ratio exceeds 1.0 for an entire hour. A warning message about the intersection appears in Column I of the spreadsheet and the user must be cautious of the calculated results when the message appears.

7.7

PRINTING

A print range encompassing the spreadsheet is incorporated. Lotus users should simply the push the button at the lower left of the Off-Peak Direction Results page with their mouse. The report will be printed on two pages, with the page break already built into the spreadsheet.

7.8

SAMPLE PROBLEM USING ART-PLAN

The following examples illustrate the use of ART-PLAN. Note that they relate to the examples used to illustrate the generalized tables and ART-TAB so that the user can see the changes that occur with the use of each application.

For an example of the use of ART-PLAN for a multi-lane urban arterial, recall the sample problem used in Sections 5.16 and 6.3:

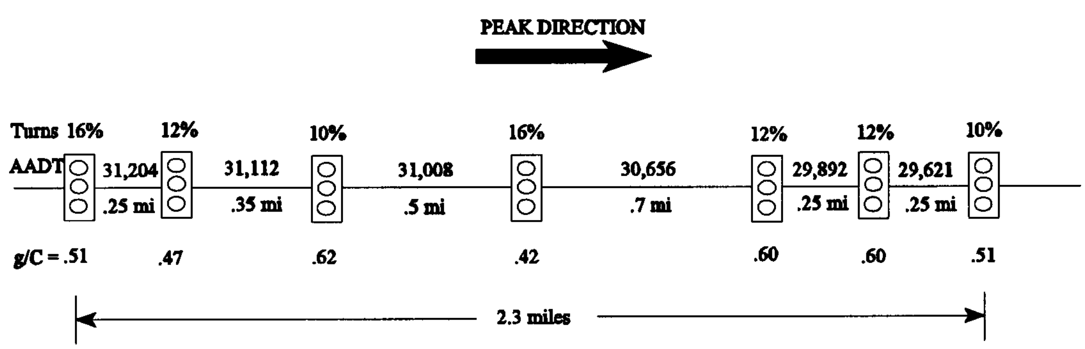
> A 2.3 mile section of an undivided four-lane arterial has 6 signalized intersections with left turn bays. The 1998 AADT is 31,500. The road is located in a metropolitan area of 430,000. The established LOS standard for the road is D. According to the Generalized Tables, the Class II maximum service volume for four lane divided facilities at LOS D is 32,500; however, the volume must be reduced by 5% since it is undivided, so the maximum service volume at LOS D is 30,900 vpd. Since the road's AADT exceeds the LOS D service volume the section is operating at LOS E and fails to meet the standard.

Information gathered locally indicated the following variations to the statewide averages used in compiling the Generalized Tables and were applied to ART-TAB:

- signal timing information was gathered and it was determined that the "weighted" g/C was 0.49 instead of the default of 0.44; and
- from directional counts gathered, it was found that the D factor was 0.55 instead of the 0.568 default value.
- turn movement counts show that there are 16 percent turns from exclusive lanes at the critical intersection not the average of 12% used in the tables.

Use of local data in the ART-TAB analysis, resulted in a maximum service volume at LOS D of 37,800 AADT. The measured AADT is 31,500 so according to ART-TAB, the section is operating at LOS C and meets the standard.

Assume additional data was collected regarding the signal spacing and g/C for each signal:



As shown in the following printout of the ART-PLAN analysis, The peak direction is operating at an average speed of 23.9 miles per hour which correlates to LOS 'C' so the section meets the standard.

ART-PLAN 3.0

Arterial Level of Service Estimating Software
Based on Chapter 11 of the 1997 Highway Capacity Manual Update

Florida Department of Transportation

September 1998

DESCRIPTION

Road Name	
From	
To	
Peak Direction	Eastbound
Off-Peak Direction	Westbound
Study Time Period	PM PEAK
Analysis Date	30-Oct-97
User Notes	Sample Problem 7.8

TRAFFIC CHARACTERISTICS

AADT	31,500
K Factor	0.093
D Factor	0.550
Peak Hour Factor	0.925
Adj. Saturation Flow Rate	1,850
% Turns from Exclusive Lanes	16

ROADWAY CHARACTERISTICS

# Through Lanes Peak Direction	2	
# Through Lanes Off-Peak Direction	2	
Urbanized, Transitioning/Urban, or Rural	U	(U, T, or R)
Arterial Class	2	(1, 2, 3 or 4)
Free Flow Speed (mph)	40	(55,50,45,40,35)

For Area Type and Class:	Use Free Flow Speed of:
Rural, Class 1	55, 50, 45, 40 or 35
Urbanized or Transitioning/Urban, Class 1 or 2	55, 50, 45, 40 or 35
Urbanized, Class 2	45, 40 or 35
Urbanized or Transitioning/Urban, Class 3	40, 35, 30 or 25
Urbanized, Class 4	35, 30 or 25

SIGNALIZATION CHARACTERISTICS

Arrival Type Peak Direction	4	(1,2,3,4,5,6)
Arrival Type Off-Peak Direction	2	
Type Signal System	S	P=Pretimed,A=Actuated,S=Semiactuated
System Cycle Length	120	
Weighted Through Movement g/C	0.49	

Eastbound PEAK DIRECTION SPECIFIC INPUTS

Segment	Segment AADT (Enter 1 if unavailable, 0 if segment is unused)	Peak Hour Volume (May be over-written if direct measure avail.)	% Turns from Exclusive Lanes	Number of Lanes	Cycle Length at Signals 2-20	Effective g/C at Signals 2-20	Distance between Signals (Enter in Miles or Feet)	Segment Length (FT)	Arrival Type
1-2	31204	**1,596**	12	2	120	0.47	0.25	1,320	4
2-3	31112	**1,591**	10	2	120	0.62	0.35	1,848	4
3-4	31008	**1,586**	16	2	120	0.42	0.50	2,640	4
4-5	30656	**1,568**	12	2	120	0.60	0.70	3,696	4
5-6	29892	**1,529**	12	2	120	0.60	0.25	1,320	4
6-7	29621	**1,515**	10	2	120	0.51	0.25	1,320	4
7-8	0								
8-9	0								
9-10	0								

Eastbound PEAK DIRECTION RESULTS

Segment	NOTES or From/To	Through Movement Flow Rate	v/c Ratio	Control Delay	Intersection Approach LOS	Speed (MPH)	Arterial Segment LOS
1-2		1518	0.87	29.6	C	**16.5**	**E**
2-3		1548	0.67	8.4	A	**28.8**	**B**
3-4		1440	0.93	36.9	D	**20.6**	**D**
4-5		1492	0.67	9.7	A	**31.3**	**B**
5-6		1455	0.66	10.2	B	**25.6**	**C**
6-7		1474	0.78	20.3	C	**19.9**	**D**
7-8							
8-9							
9-10							

Eastbound — **Arterial Speed: 23.9 mph**
LOS: C

Westbound OFF-PEAK DIRECTION'S SPECIFIC INPUTS

Segment	Peak Hour Volume	% Turns from Exclusive Lanes	Number of Lanes	Cycle Length at Signals 19-1	Effective g/C at Signals 19-1	Segment Length (FT)	Arrival Type
10-9							
9-8							
8-7							
7-6	1,240	12	2	120	0.60	1,320	2
6-5	1,251	12	2	120	0.60	1,320	2
5-4	1,283	16	2	120	0.42	3,696	2
4-3	1,298	10	2	120	0.62	2,640	2
3-2	1,302	12	2	120	0.47	1,848	2
2-1	1,306	16	2	120	0.51	1,320	2

Westbound OFF-PEAK DIRECTION RESULTS

Segment	NOTES or From/To	Through Movement Flow Rate	v/c Ratio	Control Delay	Intersection Approach LOS	Speed (MPH)	Arterial Segment LOS
10-9							
9-8							
8-7							
7-6		1,179	0.53	20.4	C	**20.1**	**D**
6-5		1,190	0.54	20.5	C	**20.0**	**D**
5-4		1,165	0.75	36.0	D	**24.0**	**C**
4-3		1,263	0.55	19.7	B	**26.2**	**C**
3-2		1,239	0.71	32.1	C	**19.0**	**D**
2-1		1,186	0.63	27.7	C	**17.2**	**D**

Westbound — **Arterial Speed = 21.7 mph**
LOS = D

7.9

Using ART-PLAN to Produce Service Volumes

ART-PLAN calculates service volumes for arterials on a separate worksheet. By clicking the "Service Volumes" tab in the upper left corner of the spreadsheet, the user is taken to a new worksheet incorporating the data entered on the previous worksheet. Users simply push the button labeled "Service Volumes" with the mouse to calculate the volumes. The service volumes represent the maximum volume for a given level of service on the arterial under the prevailing traffic, roadway, and signalization characteristics

Note that users may also adjust the volume profile of the arterial by entering a percentage in the column entitled "Volume Profile". For example, if the volume on segment 2 - 3 were expected to increase by 5 percent, then the user would enter 1.05 in the cell (J18) appropriate to that segment

CAUTIONARY NOTE: The service volumes produced using this method are very sensitive to signal timing since they are based on individual segment timing data. Any new development adding a large number of trips to one or more of the signals could require changes to the signal timing. At that time, the service volumes obtained using this method are no longer valid. New service volumes using the modified signal timing would be required. This is extremely important. For example, a developer is seeking to gain project approval along an arterial had been analyzed at an unacceptable level of service according to the generalized tables. However, due to a recent signal optimization project completed on that arterial, local officials develop more accurate service volumes using ART-PLAN and determine that the arterial is now operating at an acceptable level of service with an increased maximum service volume. The developer is seeking project approval which is anticipated to add a substantial number of vehicles from a side street turning left into an already critical intersection. This would require a change in signal time to accommodate the increased side street trips. This change in the signal timing would change the service volume and in fact would impact the entire arterial's progression. Local officials are warned to require that a consultant optimize any signal system which is being impacted by the development and develop service volumes based on the anticipated change in the signalization.

8

SOURCES FOR ADDITIONAL INFORMATION

FDOT welcomes questions, concerns, and comments on the level of service standards and generalized tables. FDOT personnel can provide assistance in interpreting the tables, answering questions on the tables and computer models, and advising in the development of local government comprehensive plans. **Initial contacts should be made with FDOT district planning personnel.**

District	Contact Person	Telephone	SunCom
Central Office	Kurt Eichin	850/922-0451	292-0451
1 (Ft. Myers)	Wayne Shelton	941/519-2353	557-2353
2 (Lake City)	Leah Gabbay	904/381-8606	824-8606
3 (Chipley)	Jerry Campbell	850/638-0250	767-1531
4 (Ft. Lauderdale)	Bill Cross	954/777-4076	436-4076
5 (Orlando)	Kacia Duhart	407/623-1085	334-1085
6 (Miami)	David Henderson	305/377-5910	452-5910
7 (Tampa)	Waddah Farah	813/975-6440	512-7797

Also, see the Florida Department of Transportation's planning website at:

http://www.dot.state.fl.us/planning

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GLOSSARY

Note: Italicized words and phrases are defined in this glossary.

Actuated control--Signal control of an intersection in which the occurrence and length of every signal *phase* is controlled by actuations of vehicle detectors placed on each approach to the intersection.

Adjusted saturation flow rate--The *saturation flow rate* adjusted for roadway and traffic characteristics such as lane widths, *driver population*, and heavy vehicles.

Adjustment factor--A multiplicative factor that adjusts a *service flow rate* from one representing an *ideal* or base *condition* to one representing a prevailing condition.

Annual average daily traffic (AADT)--The *volume* passing a point or *segment* of a highway in both directions for one year divided by the number of days in the year.

Approach--The set of lanes comprising one leg of an intersection.

Approach delay--The sum of stopped-time *delay* and the time lost in decelerating to a stop and accelerating to a steady speed.

Arrival type--A general categorization of the quality of signal progression.

Arterial--A signalized roadway that serves primarily through traffic and secondarily abutting properties and that generally has signal spacings of two miles or less.

Arterial classification--A categorization of arterials by function, design, and *free flow speed*.

Arterial section--A sequence of consecutive arterial *segments* considered together in the evaluation of an *arterial's* level of service.

Assumptions in generalized LOS volume tables--A set of input variables for *traffic*, *roadway*, and *signalization characteristics* used to determine the *volumes* in the *generalized tables*.

Average travel speed--The average speed of a traffic stream, computed as the length of a highway *section* divided by the *average travel time* of vehicles traversing it in miles per hour.

Average travel time--The average time spent by vehicles traversing a highway *segment* or *section* of given length, including all stopped-time *delay*, in seconds or minutes per vehicle.

Backlogged roadway--An *unconstrained road* on the *State Highway System* operating at a level of service below the minimum acceptable standard for such a road and not programmed for construction in the first three years of the FDOT's adopted work program or in the five year

schedule of improvements of the capital improvements element of a *local government*s *comprehensive plan*.

Capacity (c)--The maximum *rate of flow* at which vehicles reasonably can be expected to traverse a point on a lane or road during a specified period under prevailing *traffic*, *roadway*, and *signalization* conditions; usually expressed as vehicles per hour.

Capacity analysis--The study of a highway's ability to carry traffic, i.e., of its *operational characteristics* under a given *demand volume*.

Change interval--The yellow and, when used, all-red *interval*s at the end of a *phase* that allow the intersection to clear before conflicting *movement*s are allowed to proceed.

Classes--Categories of *arterial*s and *freeway*s appearing in Florida's *generalized level of service volume tables*; arterials are primarily grouped by their *signal density*, freeways in *urbanized areas* are primarily grouped by their orientation to a central business district.

Clearance lost time--The portion of the time between traffic signal *phase*s during which an intersection is not used by any traffic movement, in seconds.

Collector--A street providing land access and traffic circulation service to a residential, commercial, or industrial area.

Community--Outside of an *urban* or *urbanized area*, an incorporated place or a developed but unincorporated area with a population of 500 or more identified in the appropriate *local government*s *comprehensive plan*.

Congestion Management System (CMS)--A CMS is a systematic process that provides information on transportation system performance and alternative strategies to alleviate congestion and enhance the mobility of persons and goods. Florida's CMS is known as the Mobility Management Process.

Constrained roadway--A road on the *State Highway System* that FDOT will not expand by two or more through lanes because of physical, environmental, or policy constraints. Physical constraints include prohibitively expensive land immediately adjacent to a state highway. Environmental and policy constraints include ecological, historical, archaeological, aesthetic or social impacts that prevent the highway's expansion.

Continuous left turn lane--Same as *two-way left-turn lane*.

Controlled-access highway--A non-*limited-access highway* whose access connections, median openings, and traffic signals are highly regulated.

Critical signalized intersection--The signalized intersection of an *arterial section* with the lowest *effective green ratio* (g/C) for the *through movement*.

Cycle length (C)--The time it takes a traffic signal to go through one complete sequence of signal indications.

Delay--In this manual, generally used for stopped-time delay, the amount of time a vehicle spends stopped while traversing a given *segment* of roadway. Also see *percent time delay* and *approach delay*.

Demand flow rate--The traffic *flow rate* that now wants or at some future time is expected to want to travel over a point on or *section* of a highway for a 15-minute period, expressed in vehicles per hour.

Demand volume--The hourly traffic volume that now wants or at some future time is expected to want to travel over a point on or *section* of a highway.

Density--The number of vehicles, averaged over time, occupying a given length of lane or roadway; usually expressed as vehicles per mile or vehicles per mile per lane.

Design hour--The 30th highest *volume* hour of the year for a roadway *section*.

Design hour factor (K_{30})--The ratio of a highway *section's* *volume* in the year's 30th highest *volume* hour to its *annual average daily traffic* volume.

Design traffic--A method for projecting traffic *demand volumes* and equivalent single-axle loads (ESALs) for corridor analysis and project design.

Development of Regional Impact (DRI)--A development which, because of its character, magnitude, or location, would substantially affect the health, safety, or welfare of citizens of more than one county in Florida, as defined in section 380.06(1), Florida Statutes, implemented by Rule 9J-2, Florida Administrative Code, and coordinated by the regional planning agency.

Directional distribution factor (D)--The proportion of an hour's total volume occurring in the higher volume direction.

Driver population--The *traffic characteristic* that describes driver familiarity with a roadway and accounts for such differences in driving habits as those between commuters and recreation drivers.

Dual left-turn lanes--Two lanes designated exclusively for left turns at a signalized intersection.

Effective green ratio (g/C)--The ratio of the *effective green time* (g) for a *movement* at a signalized intersection to its *cycle length* (C).

Effective green time (g)--At a traffic signal, the time allocated to a traffic movement (green plus yellow plus all red), less the *start-up* and *clearance lost times* for the *movement*. In this manual, effective green times apply only to *through movements*.

Exclusive passing lane--An extra lane on a section of a two-lane, two-way highway along which vehicles are free to pass. *Two-way left-turn lanes* are not considered exclusive passing lanes.

Exclusive-through lane--Any *Intrastate highway* lane that is designated exclusively for intrastate travel, is physically separated from any *general-use lane*, and the access to which is highly regulated. These lanes may be used for *high occupancy vehicles* (HOVs) and express buses during peak travel hours if the level of service standards can be maintained.

Five-lane section--A roadway with four through lanes, two in each direction separated by a two-way left-turn lane; in the *generalized tables*, a five-lane section is treated as a roadway with four lanes and a *median*.

Florida Intrastate Highway System (FIHS)--A statewide network of *limited-access* and *controlled-access highways* designed with *general-use* and *exclusive-use lanes* to accommodate Florida's high speed and high volume highway traffic.

Flow rate--In this manual, the equivalent hourly rate at which vehicles pass over a given point or *section* of a lane or roadway during a given time interval less than one hour.

Flow ratio--The ratio of actual *flow rate* to the *saturation flow rate* for a given *lane group* at a signalized intersection.

Free-flow speed--(1) The theoretical speed of traffic when density is zero, i.e., when no vehicles are present; (2) the average speed of vehicles over an arterial *segment* not close to a signalized intersection during low demand (or low volume use);in this manual, the *posted speed limit* is often used as a surrogate for free flow speed..

Freeway--A multilane, divided highway with at least two lanes for exclusive use of traffic in each direction and full control of ingress and egress.

Fully actuated control--Same as *actuated control*.

Functional classification--The assignment of roads into systems according to the character of service they provide in relation to the total road network.

Generalized level of service volume tables--Maximum service volumes based on areawide average *traffic*, *roadway*, and *signalization characteristics* and presented in tabular form.

Generalized tables--Same as *generalized level of service volume tables*.

General-use lane--Any *Intrastate highway* lane not exclusively designated for long distance, high speed travel. In urbanized areas these lanes include *high occupancy vehicle* (HOV) *lanes* that are not physically separated from other travel lanes.

Green time (G)--The period of the green light for a given *movement* at a signalized intersection.

Growth management concepts--The ideas necessary for use in careful planning for urban growth so as to responsibly balance the growth of the infrastructure required to support a *community's* residential and commercial growth with the protection of its natural systems (land, air, water).

Guideline--A Florida Department of Transportation guideline is a recommended process intended to provide efficiency, uniformity, and economy to the implementation of policies, procedures, and standards. A guideline is intended to provide general program direction, but provides discretion to users.

Headway--The time between two sucessive vehicles in a traffic lane as they pass a point on the roadway, measured from front bumper to front bumper, in seconds.

Heavy vehicle--A vehicle with more than four wheels touching the pavement during normal operation.

High-occupancy vehicle (HOV) lane--A freeway lane reserved for the use of vehicles with a preset minimum number of occupants; such vehicles often include buses, taxis, and carpools.

Ideal conditions--The conditions assumed to determine a highway's greatest possible *capacity*, i.e., those which if further improved would not increase *capacity*, this term typically applies to roads having default values (e.g., 12- foot lane widths), which are not necessarily ideal.

Ideal saturation flow rate--The *saturation flow rate* under *ideal conditions*.

Interrupted flow--A category of traffic flow that occurs on highways having traffic signals, STOP or YIELD signs, or other fixed causes of periodic *delay* or interruption to the traffic stream.

Interval--A period in a signal *cycle* during which all signal indications remain constant.

Intrastate highways--Highways on the *Florida Intrastate Highway System* (FIHS).

Lane group--A set of lanes on an intersection approach which has been established for separate *capacity* and level-of-service analyses.

Left-turn bay or exclusive left-turn lane--Approaching a signalized intersection, a storage lane to accommodate left turning vehicles; as treated in this manual, a left-turn lane must be long enough to accommodate enough left turning vehicles to allow the free flow of the through traffic.

Level of Service (LOS)--A qualitative assessment of a road's operating conditions; an average driver's perception of the quality of traffic flow he or she is in. A LOS is represented by one of the letters A through F, A for the freest flow and F for the least free flow. Planners and engineers approximate these qualitative representations quantitatively with equations, now computer programmed.

Level terrain--Any combination of horizontal and vertical alignments which permits *heavy vehicles* to maintain approximately the same speed as passenger cars.

Limited-access highway--Same as *freeway*.

Link--Same as *segment*.

Local Government Comprehensive Plan (LGCP)--Any county or municipal plan that meets the requirements of subsections 163.3177 and 163.3178 of the Florida Statutes.

Lost time--Time during which a signalized intersection is not used by any movement; *clearance lost time* plus *start-up lost time*.

Maintain--Continuing operating conditions at a level that prevents significant degradation.

Major city/county roadway--A road not on the *State Highway System* whose *traffic*, *roadway*, and *signalization characteristics* (e.g., cross section , alignment, access control, trip lengths, speed limits, signalization) are similar to those of state roads classified as state minor *arterials*.

Maximum service flow rate--The highest 15-minute *rate of flow* that can be accommodated on a highway under *ideal conditions* while maintaining the *operational characteristics* for a stated level of service, expressed as passenger cars per hour per lane.

Maximum through lanes standards--The number of through lanes to which FDOT limits facilities under its jurisdiction, with a few exceptions.

Measures of effectiveness--Parameters describing the quality of a highway's service to drivers (or passengers), including *average travel speed*, *density*, *delay*, and others.

Medians--Areas at least ten feet wide, painted, raised, or grassed, that separate opposing-direction, mid-block traffic lanes and that, on arterials, contain turn lanes that allow left turning vehicles to exit from through traffic lanes.

Movement--A flow of vehicles in a given direction.

Multilane highway--A highway with at least two lanes for traffic in each direction, with no or partial control of access, and that may have occasional interruptions to flow at signalized intersections.

No passing zones--A segment of a two-lane, two-way road in which passing is prohibited in one or both directions.

Non-state roadway--A roadway not on the *State Highway System*.

Number of lanes--The number of lanes relevant to an analysis of a road's level of service, usually the through and shared-right-turn lanes; their number is determined by the primary factor limiting a road's traffic flow: regular interruptions, usually signalized intersections. Thus, a service-level

analysis is concerned with the number of such lanes (1) at the major intersections on an *arterial section*, (2) at the signalized intersection of any two roads; and (3) on the basic roadway segment of an uninterrupted-flow facility (e.g., a freeway or rural highway), i.e., those lanes unrelated to any interchange or intersection on such a highway.

Operational analysis--A detailed analysis of a road's present or future service level by highway capacity and quality-of-flow methods. As opposed to the generalized *planning analysis*, an operational analysis uses as nearly exact values as possible for the parameters representing a road's *traffic*, *roadway*, and *signalization characteristics*.

Operational characteristics--Parameters describing a highway's operation, including *speed* and *travel time*, *density*, freedom to maneuver, *delay*, traffic interruptions, comfort and convenience, and safety.

Other signalized roadway--A signalized road not on the *State highway system* and also considered by the local government of jurisdiction not to be a major city/county road.

Other state roads--Roads on the *State Highway System* which are not part of the *Florida Intrastate Highway System*.

Peak hour--In this manual, the 100th highest *demand volume* hour of the year for a roadway *section*.

Peak hour factor (PHF)--The ratio of the volume during the maximum volume hour of the day to the peak 15-minute flow rate for that hour.

Percent no passing--The percentage of a section of two-lane, two-way highway along which passing is prohibited in one or both directions.

Percent time delay--The average percent of time that a platoon of vehicles is delayed by its vehicles' inability to pass others.

Percent turns from exclusive-turn lanes--On a highway approaching a signalized intersection, the percent of vehicles traveling in one direction that turn left, right, or both left and right from dedicated turn lanes at that intersection. The *generalized tables* and the models from which they are derived assume that these turn lanes adequately accommodate turning demand, i.e., that turning traffic does not back into the through lanes.

Permitted turns--Same as *unprotected turns*.

Phase--The part of a traffic signal's *cycle* allocated to any combination of traffic *movements* receiving the right-of-way simultaneously during one or more *intervals*.

Planning analysis--A generalized analysis of a road's present or future service level by highway capacity and quality-of-flow methods. As opposed to the detailed *operational analysis*, a planning

analysis uses many default values for the parameters representing a road's *traffic*, *roadway*, and *signalization characteristics*.

Planning analysis hour factor (K_{100})--The ratio of a highway section's *volume* in the year's 100th highest volume hour to its *annual average traffic volume*. In developed areas the year's 100th highest volume hour represents a typical weekday peak traffic hour during the area's peak travel season, i.e., that area's peak season's "rush" hour, usually in the late afternoon. The K_{100} factor refers to a *demand volume*, not necessarily a measured volume.

Planning computer models--Based on the 1994 Update to the Highway Capacity Manual, computer models developed to analyze level of service at a *planning analysis* level.

Posted speed limit--The maximum speed at which vehicles are legally allowed to travel over a roadway segment.

Pretimed control--Traffic signal control in which the *cycle length*, phase plan, and phase times are preset and repeated continuously according to a preset plan.

Protected turns--At a signalized intersection, left or right turns allowed by the signal that simultaneously prohibits opposing or conflicting traffic movement.

Rate of flow--Same as *flow rate*.

Roadway characteristics--Parameters describing the geometric conditions of a roadway. In this manual, these are a road's *number of lanes*, *arterial classification*, *free flow speed*, *level terrain*, *percent*age of *no passing* length, and whether or not it has *medians*, *left turn bays/lanes*, or *exclusive passing lanes*.

Roadway parallel to an exclusive transit facility--A road generally parallel to and within one half mile of a physically separated rail or roadway that is reserved for multi-passenger use (rail cars or buses serving large volumes of home/work trips) during peak travel hours. Exclusive transit facilities do not include downtown people movers or *high occupancy vehicle lane*s unless those lanes are physically separated from other travel lanes.

Rural area--An area not included in a *transportation concurrency management area*, an *urbanized* area, a *transitioning urbanized area*, an *urban area*, or a *community*.

Saturation flow rate--The maximum hourly rate at which vehicles in through and through-right lanes can leave an intersection under prevailing conditions, assuming continuous green time and no *lost time*, expressed as vehicles per hour of green time per lane.

Saturation headway--The average *headway* between passsenger cars in a stable, moving queue as they pass through a signalized intersection, in seconds.

Section--A sequence of consecutive roadway *segment*s considered together in the evaluation of a roadway's level of service.

Segment--A length of roadway being evaluated, usually the distance from one signalized intersection to the next on an arterial; a series of arterial *segments* make up an *arterial section.*

Semi-actuated control--Signal control of an intersection in which the designated main road receives the green phase except when a vehicle approaching the intersection on the minor road activates a detector. Then, after a *change interval*, the signal provides a green phase for the side street until all vehicles on it are served or a preset maximum time for the side street passes.

Service flow rate--The maximum hourly rate at which vehicles can be reasonably expected to traverse a uniform section of a lane or roadway during a given period (usually 15 minutes) under prevailing traffic, roadway, and control conditions at a designated level of service, expressed as vehicles per hour or vehicles per hour per lane.

Seven-lane section--A roadway with six through lanes, three in each direction separated by a two-way left-turn lane; in the *generalized tables*, a seven-lane section is treated as a roadway with six lanes and a median.

Shared lane--A roadway lane shared by two or three traffic movements; in Florida a shared lane usually serves through and right turning traffic movements.

Signal density--The number of signalized intersections per mile of roadway.

Signal type--The kind of traffic signal with respect to the way its *cycle length*, *phase* plan, and phase times are operated; the signal's control may be *pretimed*, *actuated*, or *semi-actuated.*

Signalization characteristics--Parameters describing the signalization of a roadway. In this manual, these are the *number of signalized intersections per mile*, *arrival type*, *signal type*, *cycle length*, and *weighted effective green ratio*.

Signalized intersections per mile--The per-mile number of fixed interruptions (usually signalized intersections) that cause periods of delay or interruption to a traffic stream during the *peak hour.* These include flashing red signals and stop or yield signed intersections but not flashing yellow signals, draw bridges, or railroad crossings.

Speed--A rate of motion expressed as a distance per unit of time.

Speed limit--Same as *posted speed limit.*

Standard--A Florida Department of Transportation Standard is a formally established criterion for a specific or special activity to achieve a desired level of quality.

Start-up lost time--In a queue of vehicles at a signalized intersection, the time above and beyond the *saturation headway* that the first few vehicles take in reacting to the beginning of the green *interval* to accelerate to a steady speed, in seconds.

State Highway System (SHS)--All roads and highways that the Florida Department of Transportation operates and maintains. The SHS comprises the *Florida Intrastate Highway System*, which includes the *Interstate* highways within Florida, and all *other state-maintained roads*.

Three-lane section--A roadway with two through lanes separated by a *two-way left-turn lane*; in the *generalized tables*, a three-lane section is treated as a roadway with two lanes and a *median*.

Through movement--The direction of flow through an intersection of the predominance of vehicles; although the predominant flow of traffic occasionally is in a right or left turning direction, it is straight on most major roads.

Traffic characteristics--Parameters describing the distribution of vehicles in a traffic stream; in this manual, these are the *planning analysis hour factor*, *directional distribution factor*, *peak hour factor*, *adjusted saturation flow rate*, and *percent turns from exclusive turn lanes*.

Transitioning urbanized area--An area expected to be included in an adjacent *urbanized* area within 20 years because of its population's growth to the U.S. Bureau of Census's criterion for urbanization (at least 1000 people per square mile).

Transportation Concurrency Management Area (TCMA)--A geographically compact area designated in a *local government comprehensive plan* where intensive development exists or is planned so as to ensure adequate mobility and further the achievement of identified important state planning goals and policies, including discouraging the proliferation of urban sprawl, encouraging the revitalization of an existing downtown and any designated redevelopment area, protecting natural resources, protecting historic resources, maximizing the efficient use of existing public facilities, and promoting public transit, bicycling, walking, and other alternatives to the single-occupant automobile. A transportation concurrency management area may be established in a comprehensive plan in accordance with Rule 9J-5.0057, F.A.C.

Transportation planning system models--Computerized models of trip assignment in and distribution over *urban* and *urbanized areas* used in urban highway system planning.

Transportation planning boundaries--Precisely defined lines that delineate geographic areas. These boundaries are used throughout transportation planning in Florida; their mapping is described in FDOT's Procedure Topic Number 525-010-024-b.

Two-way left-turn lane--A lane that simultaneously serves left turning vehicles traveling in opposite directions.

Uninterrupted flow--The category of traffic flow that occurs on highways having no fixed cause of delay; examples of such highways include *freeways* and unsignalized sections of rural highways.

Unprotected turns--At an intersection, left or right turns through an opposing flow of vehicles or pedestrians not under the direction of a signal phase for *protected turns*.

Unsignalized intersection--An intersection not controlled by a traffic signal.

Urban area--A place with a population of between 5,000 and 50,000 and not in an *urbanized area*. The applicable boundary includes the 1990 Census's urban area and the surrounding geographical area agreed upon by the FDOT, the local government, and the Federal Highway Administration (FHWA). The boundaries are commonly called FHWA Urban Area Boundaries and include those areas expected to develop medium density before the next decennial census.

Urban Infill--A land development strategy aimed at directing higher density residential and mixed-use development to available sites in developed areas to maximize the use of adequate existing infrastructure; often considered an alternative to low density land development.

Urbanized area--Based on the 1990 census, any area the U.S. Bureau of Census designates as urbanized, together with any surrounding geographical area agreed upon by the FDOT, the relevant Metropolitan Planning Organization (MPO), and the Federal Highway Administration (FHWA), commonly called the FHWA Urbanized Area Boundary. The minimum population for an urbanized area is 50,000.

v/c ratio--The ratio of *demand flow rate* to *capacity* for a highway.

Volume--The number of vehicles passing a point on a lane or road during a specific period, often one hour, expressed in vehicles; a volume may be measured or estimated, either of which could be a constrained value, or a hypothetical *demand* value.

Weighted effective green ratio ($(g/C)_w$)--A ratio representing an *arterial section's* effective green ratio for all its signalized intersections; it is the section's average *effective green ratio* weighted by being averaged with the *effective green ratio* of the section's *critical signalized intersection*.

NOTES:

A

Appendix A: Ch. 14-94, F.A.C.

DEPARTMENT OF TRANSPORTATION

RULE CHAPTER TITLE RULE CHAPTER NO. 14-94

Statewide Minimum Level of Service Standards for State Highway System

14-94.001 Purpose.

(1) The purpose of this rule chapter is to establish statewide minimum level of service standards to be used in the planning and operation of the State Highway System. This rule chapter is intended to protect public safety and general welfare, ensure the mobility of people and goods, and preserve the facilities on the State Highway System. The minimum level of service standards for the State Highway System will be used by the Department to determine system deficiencies; assist in determining Department work program priorities; and review local government comprehensive plans and metropolitan planning organization comprehensive transportation plans, traffic circulation impacts related to developments of regional impact, and other developments affecting the State Highway System.

(2) This rule chapter does not supersede or negate the provisions of Chapter 9J-5, F.A.C., pertaining to the preparation and adoption of local comprehensive plans or plan amendments by local governments.

Specific Authority 334.044(2), (12), (21) FS.

Law Implemented 163.3184(4), 339.155(2),(5),(6) FS.

History - New

14-94.002 Definitions. As used in this rule chapter, the following definitions apply:

(1) "Backlogged Roadways" are roads on the State Highway System operating at a level of service below the minimum level of service standards, not programmed for construction in the first three years of FDOT's adopted work program or the five year schedule of improvements contained in a local government's capital improvements element, and not constrained.

(2) "Communities" are incorporated places outside urban or urbanized areas, or unincorporated developed areas having 500 population or more identified by local governments in their local government comprehensive plans and located outside of urban or urbanized areas.

(3) "Constrained Roadways" are roads on the State Highway System which FDOT has determined will not be expanded by the addition of two or more through-lanes because of physical, environmental or policy constraints. Physical constraints primarily occur when intensive land use development is immediately adjacent to roads, thus making expansion costs prohibitive. Environmental and policy constraints primarily occur when decisions are made not to expand a road based on environmental, historical, archaeological, aesthetic or social impact considerations.

(4) "Controlled Access Highways" are non-limited access arterial facilities where access connections, median openings and traffic signals are highly regulated.

(5) "Exclusive Through Lanes" are roadway lanes exclusively designated for intrastate travel, which are physically separated from general use lanes and to which access is highly regulated. These lanes may be used for high occupancy vehicles and express buses during peak hours if the level of service standards can be maintained.

(6) "General Use Lanes" are intrastate roadway lanes not exclusively designated for long distance high speed travel. In urbanized areas general use lanes include high occupancy vehicle lanes not physically separated from other travel lanes.

(7) "Intrastate" means the Florida Intrastate Highway System (FIHS) which comprises a statewide network of limited and controlled access highways. The primary function of the system is for high speed and high volume traffic movements within the state. Access to abutting land is subordinate to this function and such access must be prohibited or highly regulated. Highways included as part of this system are designated in the Florida Transportation Plan.

(8) "Level of Service" is a qualitative measure describing operational conditions within the traffic during the peak hour. The indicated "levels of service" designate lowest quality operating conditions for the 100th highest volume hour of the year in the predominant traffic flow direction from the present through a 20-year planning horizon. The 100th highest hour approximates the typical peak hour during the peak season. Definitions and measurement criteria used for minimum level of service standards are based on the 1985 National Transportation Research Board *Highway Capacity Manual Special Report 209*. All level of service evaluations are to be based on 1985 National Transportation Research Board *Highway Capacity Manual Special Report 209* or a methodology which has been accepted by FDOT as having comparable reliability. This manual is hereby incorporated by reference and made a part of these rules. The National Transportation Research Board's *Highway Capacity Manual Special Report 209*, is available from the Transportation Research Board, National Research Council, Washington, D.C.

(9) "Limited Access Highways (Freeways)" are multilane divided highways having a minimum of two lanes for exclusive use of traffic in each direction and full control of ingress and egress; this includes freeways and all fully controlled access roadways.

(10) "Maintain" means continuing operating conditions at a level such that significant degradation does not occur.

(a) For roadways in rural areas, transitioning urbanized areas, urban areas or communities, "significant degradation" means:

1. An average annual daily traffic increase in two-way traffic volume of five percent or

2. A reduction in operating speed for the peak direction in the 100th highest hour of five percent.

(b) For roadways in urbanized areas, for roadways parallel to exclusive transit facilities or for intrastate roadways in transportation concurrency management areas, "significant degradation" means:

1. An average annual daily traffic increase in two-way traffic volume of 10 percent or

2. A reduction in operating speed for the peak direction in the 100th highest hour of 10 percent.

(c) For other state roads in transportation concurrency management areas, "significant degradation" is defined in the transportation mobility element.

(d) For constrained roadways meeting or exceeding the level of service standards, "maintain" does not apply until the roadway is operating below the applicable minimum level of service standard.

(11) "Other State Roads" are roads on the State Highway System which are not part of the Florida Intrastate Highway System.

(12) "Peak Hour" means the 100th highest volume hour of the year in the predominant traffic flow direction from the present through a 20-year planning horizon. The 100th highest hour approximates the typical peak hour during the peak season.

(13) "Roadways Parallel to Exclusive Transit Facilities" are roads generally parallel to and within one-half mile of a physically separated rail or roadway lane reserved for multi-passenger use by rail cars or buses serving large volumes of home/work trips during peak travel hours. Exclusive transit facilities do not include downtown people movers, or high occupancy vehicle lanes unless physically separated from other travel lanes.

(14) "Rural Areas" are areas not included in an urbanized area, a transitioning urbanized area, an urban area or a community.

(15) "Transitioning Urbanized Areas" are the areas outside urbanized areas that are planned to be included within the urbanized areas within the next 20 years based primarily on the U.S. Bureau of Census urbanized criteria of a population density of at least 1000 people per square mile.

(16) "Transportation Concurrency Management Areas" are geographically compact areas designated in local government comprehensive plans where intensive development exists or is planned in a manner that will ensure an adequate level of mobility and further the achievement of identified important state planning goals and policies, including discouraging the proliferation of urban sprawl, encouraging the revitalization of existing downtowns and designated redevelopment areas, protecting natural resources, protecting historic resources, maximizing the efficient use of existing public facilities, and promoting public transit, bicycling, walking, and other alternatives to the single occupant automobile. Transportation concurrency management areas may be established in a comprehensive plan in accordance with Rule 9J-5.0057, Florida Administrative Code.

(17) "Transportation Mobility Elements" are integrated, multi-modal plans that meet the requirements of Rule 9J-5.0057.

(18) "Urban Areas" are places with a population of at least 5,000 and are not included in urbanized areas. The applicable boundary encompasses the 1990 urban area as well as the surrounding geographical area as agreed upon by FDOT, local government, and Federal Highway Administration (FHWA). The boundaries are commonly called FHWA Urban Area Boundaries and include areas expected to have medium density development before the next decennial census.

(19) "Urbanized Areas" are the 1990 urbanized areas, designated by the U.S. Bureau of Census as well as the surrounding geographical areas, as agreed upon by the FDOT, Metropolitan Planning Organization (MPO), and Federal Highway Administration (FHWA), commonly called FHWA Urbanized Area

Boundaries. The over or under 500,000 classifications distinguish urbanized areas with a population over or under 500,000 based on the 1990 U.S. Census.

Specific Authority 334.044(2), (12), (21) FS.

Law Implemented 339.155(2), (5), (6) FS.

History - New

14-94.003 Statewide Minimum Level of Service Standards.

(1) The Statewide Minimum Level of Service Standards for the State Highway System are as follows:

STATEWIDE MINIMUM LEVEL OF SERVICE STANDARDS FOR THE STATE HIGHWAY SYSTEM

	Rural Areas	Transitioning Urbanized Areas, Urban Areas, or Communities	Urbanized Areas Under 500,000	Urbanized Areas Over 500,000	Roadways Parallel to Exclusive Transit Facilities	Inside Transportation Concurrency Management Areas	Constrained and Backlogged Roadways
INTRASTATE							
Limited Access Highway (Freeway)	B	C	C(D)	D(E)	D(E)	D(E)	Maintain
Controlled Access Highway	B	C	C	D	E	E	Maintain
OTHER STATE ROADS							
Other Multilane	B	C	D	D	E	*	Maintain
Two-Lane	C	C	D	D	E	*	Maintain

Level of service standards inside of parentheses apply to general use lanes only when exclusive through lanes exist. * means the level of service standard will be set in a transportation mobility element that meets the requirements of Rule 9J-5.0057.

NOTE: Levels of service letter designations are defined in the Transportation Research Board's *Highway Capacity Manual Special Report 209*.

(2) Specific assumptions and restrictions that apply to these minimum level of service standards are:

(a) The minimum level of service standards designate lowest acceptable operating conditions in the peak hour (100th highest hour).

(b) Definitions and measurement criteria used for the minimum level of service standards can be found in the Transportation Research Board's *Highway Capacity Manual Special Report 209*.

(c) When calculating or evaluating level of service pursuant to this rule, all calculations and evaluations shall be based on the methodology contained in Transportation Research Board's *Highway Capacity Manual Special Report 209* or a methodology which has been accepted by the Department as having comparable reliability. Any methodology superseded by the 1985 *Highway Capacity Manual Special Report 209*, such as a methodology based on the 1965 *Highway Capacity Manual* or *Circular 212*, shall not be used.

(d) The standards shown for controlled access highways are the ultimate standards to be achieved for controlled access facilities on the FIHS within a 20 year period. Signalized intersections are to be minimized on these facilities within 20 years making an uninterrupted flow standard generally applicable. Controlled access facilities on the FIHS currently not meeting the ultimate standards shall be allowed to remain on the FIHS with a "maintain" status.

Specific Authority 334.044(2),(12),(21) FS.

Law Implemented 339.155(2),(5),(6) FS.

History - New

14-94.004 Implementation Schedule.

(1) Prior to January 1, 1993, the Department will review all local government comprehensive plans and amendments to these plans under the standards appearing in this rule chapter or under those that appeared in the Department's 1989 *Level of Service Manual*, according to which of those two standards is selected by the local government. However, subsequent to January 1, 1993, the Department will review all local government comprehensive plans and their amendments under the standards appearing in this rule chapter.

(2) Prior to July 1, 1992, the Department will review all developments of regional impact under the standards appearing in this rule chapter or under those that appeared in the Department's 1989 *Level of Service Manual*, according to which of those two standards is selected by the applicant. However, subsequent to July 1, 1992, the Department will review all developments of regional impact under the standards appearing in this rule chapter.

Specific Authority 163.3184(4), 334.044(2), (12), (21) FS.

Law Implemented 163.3184(4), 339.155(2), (5), (6) FS.

History - New

NOTES:

B

Appendix B: Guidelines on Constrained Roadways

PURPOSE:

To provide guidance to the District Offices on the identification of constrained roadways and consideration of constrained roadways in the local government planning process.

AUTHORITY:

Section 334.044, Florida Statutes
Secretary Policy Statement 000-525-005-b

DEFINITIONS:

1. Constrained Roadway

   A constrained roadway is one in which adding two or more through lanes to meet current or future traffic needs, is not possible because of physical or policy barriers.

   For a road segment to be considered as a constrained roadway it should be at least 0.2 miles in length.

2. Physical Barrier

   Physical barriers or constraints primarily occur when intensive land use development is immediately adjacent to highways making roadway expansion cost prohibitive, or a facility has reached the maximum through lane standards acceptable to the Department (see section 5.14 of the Level of Service Manual).

3. Policy Barrier

   Policy barriers or constraints are artificial barriers to roadway expansions based on environmental or political realities within a community. Unlike physical constraints, however, these barriers to roadway expansion can change over time, as needs and community goals change. As a consequence local governments which find a given roadway expansion as unacceptable and oppose construction today may, in later years, endorse and champion the project due to priority changes.

4. Maintain

Means continuing operating conditions at a level such that significant degradation does not occur.

(a) For roadways in rural areas, transitioning urbanized areas, urban areas or communities, "significant degradation" means:

1. An average annual daily traffic increase in two-way traffic volume of five percent or

2. A reduction in operating speed for the peak direction in the 100th highest hour of five percent.

(b) For roadways in urbanized areas, for roadways parallel to exclusive transit facilities or for intrastate roadways in transportation concurrency management areas, "significant degradation" means:

1. An average annual daily traffic increase in two-way traffic volume of 10 percent or

2. A reduction in operating speed for the peak direction in the 100th highest hour of 10 percent.

(c) For other state roads in transportation concurrency management areas, "significant degradation" means that amount defined in the transportation mobility element.

(d) For constrained roadways meeting or exceeding the level of service standards, "maintain" does not apply until the roadway is operating below the applicable minimum level of service standard.

GENERAL INFORMATION:

There are many state highways that are constrained from major expansion (adding lanes) due to the fact that it is physically impossible to build the facility without enormous costs or major disruption to a community and or public policy does not recommend the improvement at a particular point in time based on other community values.

GUIDELINES:

(1) Process for Determining a Constrained Roadway

The District is responsible for identifying constrained roadways. The method used to identify these facilities is at the District's discretion; however, the following method is suggested for consideration. The identification of construction constrained facilities should be completed after coordination with local governments.

The Department in determining constrained roadways should evaluate the use of maximum through lane roadway sections. In doing so it may be determined that the use of these maximum sections on constrained facilities may not be possible or desirable; however, their use in the evaluation to determine constrained roadways is essential.

(a) District Develops Initial Constrained List

The District identifies physically constrained roadways by a use of a study team headed by District planning which includes other District staff who are knowledgeable about the state highway system. The team evaluates the state highway system based on familiarity and knowledge of the roadways contained within. Study data consists of highway system knowledge, professional knowledge and judgments. Field review of specific roadway sites may be necessary. The study team should document their determination of a constrained facility by the development of a list of roadway segments with accompanying maps which identify construction constrained roadway limits. Coordination with MPOs should be maintained when developing the initial list.

(b) District Develops Revised Constrained List

After the first list is completed, the District begins to revise the list by adding to it those roadway segments that are considered to be policy constrained facilities. Again, this should be a team approach composed of the same team used to develop the initial list plus MPO personnel (e.g., MPO staff director) in urbanized areas and RPC personnel (e.g., RPC transportation manager) in rural areas. Also local government representatives should be invited to participate on the team as warranted. The study team should also reconsider any physically constrained roadway segments, which were questionable during development of the initial list. The team evaluates the State Highway System based on familiarity and knowledge of policy issues regarding the roadways under review. Study data consists of interviews and professional knowledge and judgments. Field review of specific sites may be necessary. The study team should document their determination of a policy constrained facility by adding these constrained roadways segments to the initial list of physically constrained roadway segments. All accompanying maps should be added to or revised to reflect identification of the policy constrained roadway limits. Coordination with MPOs, RPCs and local governments, as appropriate, should be maintained in the process of revising the initial list.

Policy constrained roadways are subject to review on a periodic basis.

(c) Determine Level of Service of Constrained Roadways

The District using data obtained from the Planning Data Base program file, or the Department's new generalized level of service tables or the level of service computer programs associated with the generalized tables, should determine at a planning level the roadway operating level of

service of each of these facilities. As appropriate, analysts are free to use roadway specific data and level of service analyses for a specific roadway section.

(d) Planning Data Base Update

Based on (a) and (b) above each District should enter the list of constrained facilities information into its data bases and modify, as appropriate, the 5-Year Work Program.

(e) District Recommendations for Maintaining and Improving Constrained Roadways

Once the list has been provided to local governments the District should consider forming a new team to evaluate the types of improvements which could be made to the constrained roadways or the corridor within which they are contained to maintain or improve their operational characteristics. This evaluation should be conducted by a District team headed by planning and possibly consisting of PD&E, design, right-of-way, traffic operations, and transit staff and MPO or RPC representatives depending on the location and nature of the constrained roadway. Study data should consist of professional knowledge and judgments. Documentation will consist of a list of roadway sections and appropriate improvement recommendations. District Planning should coordinate with local governments to ensure that the recommendations made by the Department for constrained roadways are included in the local government comprehensive plan and the Department's 5-Year Work Program, as appropriate.

(2) Constrained Roadways and the Local Government Comprehensive Planning Process

After the list has been revised and completed, District Planning should provide the list of physical and policy constrained roadways and associated maps to local governments for inclusion in their local government comprehensive plans. Each MPO should include the list and associated maps in their next update of the MPO transportation plan. The MPO plans should not show any expansion improvements to these facilities.

Local governments, in coordination with the District, should update their local government comprehensive plan to include constrained roadways. The decision regarding which facilities are construction constrained is the responsibility of the study teams. In addition to listing constrained roadways in their comprehensive plans, local governments, in cooperation with the District, should also include policies and strategies to ensure that the level of service on these roadways is maintained at the operating condition existing at time of adoption of the plan.

(a) Department Recommendations for Maintaining and Improving Constrained Roadways

During preliminary coordination on the local government comprehensive plan or at the time of draft plan review, the District should ensure that the types of improvements provided by the Department to local government during the identification process are included in the plan. This includes all improvement recommendations which could be made to the construction constrained

facility or the corridor within which it is contained that could maintain or improve its operational characteristics. In addition, planning should ensure that the recommended improvements are included in the Department's 5-Year Work Program, as appropriate.

It is the Department's responsibility to identify constrained roadways, update its data bases and prioritize its Work Program accordingly.

(3) Reevaluation Process for Constrained Roadways

District Planning should generally ensure that major expansion improvements to physically constrained roadways are not studied as a part of all long range urban area transportation study updates. For urban area transportation study updates physically constrained roadways will only be studied by District Planning and MPO staff for improvements requiring non-road expansion alternatives to maintain an acceptable operating level of service.

Since policy constrained roadways can change over time each of these roadways should be reevaluated at the start of each long range urban area transportation study (approximately every five years). If after restudy by MPO and District Planning staff they are still determined policy constrained, then no major expansion improvements to these roadways would be evaluated in the long range urban area transportation study. The study should only consider non-major improvements to policy constrained roadways to maintain an acceptable operating level of service. In non-urbanized areas policy constrained facilities should be restudied every five years.

(4) Suggested Improvements for Constrained Roadways

Although facilities on the State Highway System which are considered constrained are not subject to major roadway expansion (lane additions) certain other traffic flow improvements can still be made and are encouraged in order to maintain or improve the operating conditions of these roadways. Local governments, in cooperation with the Department, should identify in their local comprehensive plans both physical and policy constrained roadways and address improvements to these facilities to maintain their existing operating conditions at the level existing at the time of plan adoption by the local government.

Improvement strategies which should be studied and implemented by local government and/or the Department include the use of one way pairs in constrained corridors, traffic operation improvements (e.g., progressive signalization systems, intersection improvements), construction of or improvements to other state or local highways (usually parallel facilities), and/or alternative modal investments, such as local public transit.

Notes:

C

Appendix C: GUIDELINES FOR BACKLOGGED ROADWAYS

PURPOSE:

To provide guidance on identifying backlogged roadways and coordinating the enhancement of backlogged roadways in the local government comprehensive planning process.

AUTHORITY:

Section 334.044, Florida Statutes
Secretary Policy Statement 000-525-005-b

DEFINITIONS:

1. Backlogged Roadway

   A state roadway, at least 0.2 miles in length, operating at a level of service below the Department's statewide adopted minimum operating level of service standards and not programmed for construction in the first three years of FDOT's adopted work program or the five year schedule of improvements in a local government's capital improvements element.

2. Maintain

   Means continuing operating conditions at a level such that significant degradation does not occur.

   (a) For roadways in rural areas, transitioning urbanized areas, urban areas or communities, significant degradation" means

      1. An average annual daily traffic increase in two-way traffic volume of five percent or

      2. A reduction in operating speed for the peak direction in the 100th highest hour of five percent.

   (b) For roadways in urbanized areas, for roadways parallel to exclusive transit facilities or for intrastate roadways in transportation concurrency management areas, "significant degradation" means

1. An average annual daily traffic increase in two-way traffic volume of 10 percent or

2. A reduction in operating speed for the peak direction in the 100th highest hour of 10 percent.

(c) For other state roads in transportation concurrency management areas, "significant degradation" means that amount defined in the transportation mobility element.

GENERAL INFORMATION:

Throughout the State Highway System, some roadways are operating below the Department's minimum operating level of service standards. Many local governments are concerned that implementation of FDOT's minimum operating level of service standards is not possible because of the concurrency requirement of the Growth Management Act (Chapter 163, Florida Statutes). Local governments feel that the concurrency requirement would preclude them from issuing building permits, without first correcting the roadway deficiencies, whenever state roads are operating below FDOT's minimum operating level of service standards on the State Highway System. The Department, in coordination with the Department of Community Affairs, has established a special level of service category to ease the concern of local governments. It allows local governments to continue planned development under agreement to maintain the existing operating condition and to cooperate with the Department to improve the road facility over time.

GUIDELINES:

(1) Process for Determining Backlogged Roadways

The determination of backlogged facilities is a shared responsibility of the local governments and the District Planning Office. The method for determining backlogged roadways is left to the local government's and District's discretion; however, one suggested method is discussed below.

A. The State Highway System should be divided into sections to identify those roadway sections that are operating below the Department's standards. The roadway operating level of service for each roadway section can be determined at a planning level by using the Department's generalized level of service tables or level of service computer programs. As appropriate, analysts are free to use roadway specific data and level of service analyses for a specific roadway section.

From the above information, a list should be prepared showing all road sections that are operating below the Department's level of service standards.

B. Subtract from the list all roadway sections that are identified as constrained roadways.

C. The remaining roadway sections on the list should then be compared with the Department's Five Year Work Program. Any projects (sections on the list) with a construction phase in the first three years of the Work Program should also be subtracted from the list.

D. Those roadway sections remaining on the list are backlogged roadways.

(2) Backlogged Roadways and Local Government Comprehensive Plans

Upon a statutory update to a the local government's comprehensive plan, the Department should discuss the list of backlogged roadways with the local government to ensure that all parties agree and understand the expectations related to a backlog determination. The comprehensive plan should contain a list of all roadways that are backlogged when the plan is adopted.

The plan should address the local government's commitments, strategies and timetables to maintain the operating condition of backlogged roadways at the level of service that exists when the plan is adopted. Further, local governments in their comprehensive plans should adopt strategies, timetables and commitments acceptable to the Department to enhance the operating conditions of backlogged roadways over a reasonable period of time. Each strategy or method for improving the facility should have an accompanying commitment and timetable to finance and implement the strategy. All of the above should be coordinated with the District to ensure acceptability in maintaining the operating condition of the State Highway System.

NOTES:

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Appendix D: TRAVEL TIME STUDIES AND THEIR RELATIONSHIP WITH THE LOS HANDBOOK

Travel time studies have the advantage of being real world data, and therefore can have considerable importance in evaluating specific sites for both present and future traffic conditions.

Nonetheless, travel time studies must also be conducted with considerable care, to assure that the numbers which are produced are meaningful. Several cautions must be made:

a) There can be *considerable variability* from one run to another, so that the analyst must consider both the average travel time and the confidence bound on that average[1];

b) The data must be taken over a *relevant section of roadway*, generally including several arterial links. The number of runs required for reasonable confidence bound statements on a single link is generally excessive in practical terms;

c) The data must be taken in *time periods* which have significant volumes, relative to the volume for the reference period. While this allows for data to be taken in one time of year and corrected to another, the volume correction factor should not be excessive[2];

d) The *number of samples* depends upon the purpose for which the data is to be used. In general, it is easier to justify a refined value within an existing model than it is to justify an alternative model. This is addressed within this material;

e) While any careful data collection effort is acceptable, the analyst is advised that there are *automated data collection methods* which provide information on averages, variability, and confidence bounds. The same procedures also have graphical outputs.

In all cases, it is the responsibility of the analyst to document that the travel time studies justify an alternative value approach to that contained in the FDOT LOS Manual. The confidence bounds are critical in all cases, and must be presented as part of the analysis.

1. Reasons to Collect Travel Time Data

Travel time studies can be used for a number of purposes within the context of the FDOT LOS Manual:

a. Identify the Running Speed of Link(s) - It is recognized that the running times shown in HCM Table 11-4 are default values which can be easily superseded by local data. If such data is available, it can and should be used. The "running speed" value in both ART-TAB and ART-PLAN can be superseded.

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[1] In all cases in this material and in related submittals, the 95% confidence bounds are to be used.

[2] Pending further study, FDOT would not expect a volume factor of more than 1.3 to be used.

The running speed is best obtained from the segments of the arterial which are free of stopped delay. This is usually clear from plots of the speed as a function of position or time.

If an analyst can show that the observed running speed differs from the default value by more than 3 mph with 95% confidence, then the observed value should be used;

b. Quality Assurance - The analyst may simply wish to verify that the average travel time computed is plausible, compared to field observations.

Frequently, this can be done with a few samples. The confidence bounds can be so broad that the analyst obtains an answer that the field data implies that the true average travel speed is (say) 40 $\pm$ 5 mph (see Section 4, below), which contains the computed value. However, with

such a broad confidence bound, the analyst may wonder why it was worthwhile to collect any data, because so many computed values could fall inside the range.

If the computed value falls outside the confidence bounds, this does not automatically imply that the model is deficient. It is much more likely that the specific values put into the model need to be updated (g/C, progression factor, etc). The analyst might better allocate resources to update these values in the first place.

In a specific case, it is possible that the model is in need of calibration, or that a more detailed model needs to be used. However, the sample sizes needed to justify this need are higher than covered in this section. See the next situation (Refining the Existing Model) and those following;

c. Refining the Existing Model - The model which is imbedded into the arterial treatment of the FDOT LOS Manual (and ART-PLAN and ART-TAB) is that of the 1985 HCM, Chapter 11. It is of the form

$$\text{Average Travel Speed} = \frac{3600\ (\text{Length})}{(\text{RTPM})(\text{Length}) + 1.3\ (\text{Stopped Delay})}$$

where "RTPM" is "Running Time Per Mile" in seconds, "Length" is the relevant section length in miles, and "Stopped Delay" is the sum of all relevant intersection stopped delays in sec/veh. The "3600" assures that the units of Average Travel Speed is miles/hour.

Figure H depicts the situation in which the travel time data indicates that the model is not well suited to the case at hand. (Note that the model value must be obtained for the same volume as the travel time data. All other parameters [including g/C] must also be comparable).

If the analyst wishes to refine the standard model by adjusting one of its parameters, this may be done.

Adjusting the RTPM: This could have been done under Item 1, and should have been done by invoking that ability. If it has not been done, do it now. If the model still differs as indicated in Figure 1, proceed.

Adjusting the 1.3 Factor: This implies that multiplicative factor is inappropriate, or that the progression factor (which was already applied to the (d_1+d_2) to yield the stopped delay) was

inappropriate. In either case, the factor can be adjusted until the model goes through the observed mean.

What sample sizes are required? Notice that small sample sizes yield large confidence bounds, and that the real issue is whether the computed value lies outside the confidence bounds. *No adjustment to the model is justified unless the computed value falls outside the confidence bounds.* Therefore, the decision on sample size is in the hands of the analyst. If the analyst sees a 2.0 mph difference between the computed value and the observed average speed, and believes it to be significant, then the confidence bound must be less than 2.0 mph. This implies the required sample size (see Sections 3 and 4, below). However, the analyst must be cautioned: When this data is collected, both the assumed variance and the mean of the data can shift, defeating the case for adjusting the model[3];

d. Using an Alternative Model - The analyst may wish to use a more detailed model for the traffic situation, such as TRANSYT or NETSIM. This can be done, however, the analyst must document the fact that the alternative model provides reasonable estimates of the average travel speed over a relevant range of volumes. The model should be calibrated to field data which has $\pm$ 2 mph confidence bounds at the observed volumes. Analysts considering this approach should discuss the situation in detail with FDOT.

Some analysts may wish to calibrate a speed-flow curve solely from field data. This should be done with caution, and with great attention to the introductory remarks in this material and to Section 2 below. Prior discussion with FDOT is strongly recommended;

e. Critical Projects There are some projects in which the potential impacts (and the related mitigation costs) are so significant that the analyst may wish to use other models as outlined in Item 4 above.

Work is underway which may provide additional guidance on more precise models for traffic on arterial roads. Until such time as additional information is available from FDOT, it is the responsibility of the analyst proposing adjustments or alternative methods to document their suitability in accord with this material.

Note that this material addresses the use of travel time studies to establish the running time per mile, justify adjustments to the imbedded model, and justify alternative models. It does <u>not</u> suggest that travel time studies should be used to assign levels of service. As suggested by the computations in Section 4 below, the variability from run to run usually dictates sample sizes which would be very large.
If an analyst wished to assert that a particular LOS was observed based upon field data, the sample size should be such that the magnitude of the confidence bound limit is less than the difference between the observed mean and the nearest LOS boundary[4].

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[3] Consider that the first 10 travel time runs may show a mean speed of 43.0 mph and an estimated standard deviation of 4.5 mph. When the full set of samples is collected, the mean may shift to 41.2 mph and the estimated standard deviation to 5.7 mph.

[4] For example, consider an observed mean speed which is 1.0 mph away from the nearest LOS boundary, and the observed standard deviation is 4.2 mph. This would imply a sample size of $[(1.96)(4.2)]^2$ or 68 runs.

2. Basic Data Requirements

This material is not intended to provide instructions for a travel time study in the same detail as the standard references on traffic engineering studies. However, the analyst is reminded that:

a) volume data must be collected concurrently at representative point(s) along the section being studied;

b) other data used in the default traffic model (HCM Chapter 11) or in an approved alternative model must also be collected;

c) if the volume varies over the section under study, the collection plan must take this into account;

d) data should be collected in comparable periods, which can sometimes be done during one peak period with several test vehicles or over several comparable days with a fewer number of test vehicles;

e) there is an advantage in using data from two or more days which have comparable volume levels, in that the effect of (unknown) anomalous factors are mitigated.

The analyst is responsible for the data being collected and presented in accord with good professional practice.

3. Determining Sample Size Required

For present purposes, the confidence bound on the mean of a set of travel time data can be expressed as:

$$\text{Confidence Bound}_{TT} = \frac{1.96\ (\text{Standard Deviation})_{TT}}{\text{Square Root (N)}}$$

where "N" is the number of samples (i.e. the number of travel time runs),
"$(\text{Standard Deviation})_{TT}$" is simply the standard deviation of the travel time data as computed from the observations, and the confidence bound is in seconds.

Because the LOS definitions are in terms of speed, it is convenient to express the results in terms of speed. However, the basic data is in terms of *travel times* (seconds) and the averages and standard deviations are computed based upon the travel time data.

The following procedure is followed:

Step 1 The desired confidence bound is stated, preferably in terms of $\pm$ seconds over the test section.

If the confidence bound is expressed in terms of + mph, it is necessary to convert this to $\pm$ seconds over the test section by assuming the result, namely the average travel speed;
Step 2 Based upon previous knowledge, experience, or any other convenient means, the standard deviation of the travel time over the test section is assumed;

Step 3 The required sample size is computed. If it is excessive for the project budget, the confidence bound specification is changed (return to Step 1). If it is not excessive, collect the data;

Step 4 As the data is collected but before the field effort is over (i.e. the cars and drivers released), compute the estimated mean and standard deviation of the travel time data. Refine the sample size requirement based upon this new information (see Steps 1 and 2).

In some cases, fewer samples are required. It is therefore useful to compute the standard deviation more than once, as the data comes in;

Step 5 With the data in hand, compute the mean travel time and the confidence bounds (seconds). Knowing the section length, express these as speeds for convenience. Report the mean travel time divided into the length as the estimated average travel speed.

Depending upon the application, also reduce data on the estimated running speed and the estimated stopped delay.

In some cases, the number of samples is determined by available data (someone already collected it) or project resources (cost, cars available, etc). In such cases, simply execute Step 5.

Example 1 The estimate of the average travel speed over a link is desired, $\pm$ 2 mph. The link is 0.25 miles long. The estimated standard deviation of the travel time is 4.0 seconds.

Solution 1 The steps indicated above will be followed:

Step 1 Assume the result will be 40 mph (perhaps we know this facility). This implies 90 seconds to cover a mile, or 22.5 seconds to cover 0.25 miles. If the number were 42 mph or 38 mph, then the time would be 21.4 and 23.7 seconds respectively. This implies a desired confidence bound of $\pm$ 1.1 seconds, because (22.5 - 21.4) = 1.1 seconds is the more restrictive limit;

Step 2 The "estimated" standard deviation is simply the "assumed" standard deviation at this point. This was given as 4.0 seconds;

Step 3 Solving the equation provided for the number of samples, note that

$$\text{Square Root (N)} \geq \frac{1.96\ (\text{Standard Deviation})_{TT}}{\text{Confidence Bound}_{TT}}$$

or N $\geq$ $\{1.96(4.0)/1.1\}^2$ = 50.8 or 51 samples.

Although this is a demanding number, let us proceed for the purpose of this example;

Step 4 After N = 30 runs are collected, we compute the mean and standard deviation of the travel time, and obtain 24.7 seconds and 2.1 seconds respectively.

The estimated average travel speed is 3600/(24.7/0.25) = 36.4 mph.

The confidence bound on the travel time is computed at

$$\text{Confidence Bound}_{TT} = \frac{1.96\ (2.1)}{} = 0.75 \text{ seconds}$$

Square Root (30)

This implies bounds of 3600/(25.45/0.25) = 35.4 mph and 3600/(23.95/0.25) = 37.6 mph. This shows the outer bound at 1.2 mph whereas 1.0 mph is desired. Some more samples are needed, but far fewer than the initial estimate.

If all else remains the same, then the 37.6 mph can be reduced to the needed 37.4 mph by increasing the sample size to N = 42. This can be checked by substituting it into the confidence bound formula just above;

Step 5 Assume that the rest of the samples are collected and we compute the mean and standard deviation of the travel time, and obtain 24.9 seconds and 2.05 seconds respectively.

The estimated average travel speed is 3600/(24.9/0.25) = 36.1 mph.

The confidence bound on the travel time is computed at

$$\text{Confidence Bound}_{TT} = \frac{1.96\ (2.05)}{\text{Square Root}\ (42)} = 0.62 \text{ seconds}$$

This implies bounds of 3600/(25.52/0.25) = 35.3 mph and 3600/(24.28/0.25) = 37.1 mph. This shows the outer bound at 1.0 mph, which meets the initial specification.

Example 2 Travel time data are collected on a one-mile section covering five links. The mean travel time is computed at 115.0 seconds and the standard deviation at 12.0 seconds. There were N = 8 runs. Estimate the average travel speed.

Solution 2 This is a simple application of "Step 5" of the procedure outlined:

The average travel speed is estimated at 3600/115.0 = 31.3 mph.

The confidence bound on the travel time is computed at

$$\text{Confidence Bound}_{TT} = \frac{1.96\ (12.0)}{\text{Square Root}\ (8)} = 8.3 \text{ seconds}$$

This implies bounds of 3600/(123.3) = 29.2 mph and 3600/(106.7) = 33.7 mph.

It is therefore possible to state with 95% confidence that the average travel speed is between 29.2 and 33.7 mph, a spread of 4.5 mph.

4. Case Study: Confidence Bound on Speed

Consider a situation in which the true average travel speed is 40 mph over a one-mile section, but that this is unknown to us.

In order to estimate the average travel speed (which really is 40 mph, recall), we choose to do "N" travel time runs over this one-mile section. Show the range of the estimates, for N=10 to N=60. Use a standard deviation of 15.0 seconds for the travel time.

The familiar formula

$$\text{Confidence Bound}_{TT} = \frac{1.96\ (\text{Standard Deviation})_{TT}}{\text{Square Root (N)}}$$

can be used to generate travel time confidence bounds, which can be used to find corresponding speed bounds. Because it takes 3600/40 = 90 seconds to travel the mile, the bounds are $3600/(90 \pm CB_{TT})$ mph. These are tabulated below.

NUMBER OF RUNS	TRUE AVERAGE TRAVEL SPEED (MPH)	RANGE OF ESTIMATES (95%) FOR THE AVERAGE TRAVEL SPEED (MPH)
10	40 mph	36.2 to 44.6 mph
20	40 mph	37.3 to 43.1 mph
30	40 mph	37.7 to 42.5 mph
40	40 mph	38.0 to 42.2 mph
50	40 mph	38.2 to 41.9 mph
60	40 mph	38.4 to 41.8 mph

For "reasonable" numbers of travel time runs (10 or so), this table shows that two different studies of the same arterial (which has the same true average travel speed) could yield different estimates over the range 36.2 to 44.6 mph.

5. Case Study: The Advantage of Longer Sections

Consider an arterial with four consecutive links, each with a mean travel time of 30.0 seconds and a standard deviation of 5.0 seconds. Each section is 0.25 miles long.

For N=10 and N=20, compute the confidence bounds on the link travel time and the section travel time. Express the confidence bounds as a fraction of the mean travel time.
For the link, the confidence bound formula can be applied directly to yield $\pm$ 3.10 sec for N=10 and $\pm$ 2.19 sec for N=20.

For the section, it is first necessary to compute the section travel time standard deviation. Because the section travel time is the sum of the four link travel times,

$$TT = TT_1 + TT_2 + TT_3 + TT_4$$

then the variance is the sum of the variances, assuming that the travel time variation in one link is independent of the variation in the other links[5]. Therefore the combined variance is 25.0+25.0+25.0+25.0 = 100.0 and the link travel time standard deviation
is 10.0.

Applying the confidence bound formula yields ± 6.20 sec for N=10 and ± 4.38 sec for N=20. The table below summarizes the results, where "Std" is used to denote "standard deviation".

	True Mean TT	True Std TT	Travel Time Runs	Confidence Bounds on TT Estimate	Ratio, Confidence Bound to True Mean
Link	30.0 sec	5.0 sec	N = 10	± 3.10 sec	± 0.103
	30.0 sec	5.0 sec	N = 40	± 1.55 sec	± 0.052
Section	120.0 sec	10.0 sec	N = 10	± 6.20 sec	± 0.052
(4 links)	120.0 sec	10.0 sec	N = 40	± 3.10 sec	± 0.026

This table demonstrates that:

a) the sum of the link travel times grows faster than the standard deviation;

b) as a result, for the same "N", the relative stability of the section is greater than that of the link. This can be seen in the ratios of the last column, comparing the first and third lines, and the second and fourth lines;

c) to attain the same relative stability as the section with N=10 runs, it is necessary to have N=40 runs in the link.

This last point shows the great advantage of taking average travel time statistics (and average travel speed statistics) over a number of links and also shows why it is so challenging to make comparable confidence statements on a single link (many more runs are needed).

6. Case Study: Expanding the Volume

Consider a situation in which a study must be done in a time period other than the reference period specified by FDOT, because it is a significant burden to wait for seven months for the reference period. Fortunately, volumes on the facility are only 17% lower next week than the v = 1600 vph estimated by FDOT for the reference period. (This is based upon seasonal adjustment factors which yield a 1.20 factor.

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[5] This can be debated, but is plausible if the vehicle has already fallen into the progressive pattern (although one could then argue that the standard deviation should be smaller).

A travel time study is conducted to verify the running speed and as a quality assurance measure. The situation of Figure 2 is observed. The observed volume was v_1 = 1375 vph. For this case study, assume that the assumed running speed was within the confidence bounds of the observed running time.

Based upon the information in Figure 2 and that available from FDOT (the factor of 1.20), the following conclusions are reached:

a) the travel time confidence bounds yield a speed estimate which does not challenge the default model. Therefore it is used without adjustment;

b) the volume v_2 to be used for the future condition is 1.20(1375) = 1650 vph;
c) this volume may be specified in the spreadsheet available from FDOT (along with signalization and other information), and the future average travel speed and LOS estimated.

The "future" condition of interest was a seasonal peak seven months from now. It could also have been a future planning horizon five years hence. (The concern of what represents a reasonable upper bound on the multiplicative factor is being considered by FDOT.)

7. Case Study: Adjusting the HCM Model

The preceding case study found that no change to the basic model (the curve in Figure 2) was justified. This might have been different.

Consider a situation in which the observed running speed agrees with that used in the model (identifying this takes a bit of work), and is 33 mph for the 0.75 mile section of interest. Further assume a total stopped delay of 60 sec/veh along the arterial.

The running time per mile is 3600/33 = 109 sec/mile. The computed average travel speed is:

$$\text{Average Travel Speed} = \frac{3600(0.75)}{109\ (0.75) + 1.3\ (60)} = 16.9\ \text{mph}$$

Assume that the field observations show an average travel speed of 19.7 $\pm$ 1.2 mph, and also an average stopped delay of 50.0 sec/veh.

Clearly, the computed 16.9 mph of the model is outside the confidence bounds of the observations. Therefore, we will adjust to the better number, the field value. (Although not stated, a considerable number of travel time runs were needed to get the stated confidence bounds).

The adjusted model can be written as

$$\text{Average Travel Speed} = \frac{3600(0.75)}{109\ (0.75) + 1.3\ (FAC)(60)} = 19.7\ \text{mph}$$

Solving for FAC, we have FAC = 0.709.

This can be used to generate a curve which can be used in such applications as the previous case study. Does it have any meaning beyond that? The fact that stopped delay of 50.0 sec/veh was observed rather than 60.0

sec/veh as computed might imply an adjustment of (50/60) = 0.833 was needed, due to progression factor or calibration. This would still imply another factor: 0.709 = (?)(0.833) or (?) = 0.851, or a reduction in the 1.3 factor to (0.851)(1.3) = 1.11. Considering the simplicity of the 1.3 factor, this would not be surprising.

8. Technical Issues

In the course of developing this material, several issues arose which can be addressed in a question-and-answer format. Additional issues may arise in the future as this material is used, and they will addressed in later releases.

In travel time studies, the test vehicle tends to fit into the progression, and therefore has a better (lower) travel time than the "average" vehicle (including turning vehicles). Does this lead to an unacceptably high estimate of the average travel speed?

The function of an arterial is to move through traffic. Therefore, the LOS should reflect the through vehicles. The fact that the test vehicle acts like a through vehicle is all to the good, and not a deficiency.

Should the delay at the first signal be included or excluded in the travel time run?

This question is a common but poor wording. The real answer is that the "system" defined for the run should include all relevant links. If an intersection is obviously part of the system, then the travel time run should begin upstream of that intersection (and include it).

There is more to this answer: when the spreadsheet provided by FDOT is used for a comparable run, the definition of which links are in the system must be consistent. This is also true of any other model or computations used.