PURPOSE OF ISSUE PAPERS

1. Implement 2005 growth management legislation.

Many changes have been made to FDOT and Florida Department of Community Affairs (DCA) processes with regard to concurrency, development review and level of service (LOS) standards resulting from the passage of sweeping growth management reform in 2005. These issue papers have been developed to execute changes in process and/or implementation until FDOT's 2002 Quality/Level of Service (QLOS) Handbook is updated to reflect these changes and other LOS updates. The issue papers reflect input from FDOT's Level of Service Task Team which has statewide and local representation.

> *Background:* though these papers represent the most up to date guidance on LOS issues, there has been much discussion in the 2007 Florida legislature on this topic. Many possible changes in the growth management area have been considered. The guidance in these papers should not be considered final until the legislature has concluded their debate on this topic.

2. Address new issues in the application of QLOS Handbook and software.

These issue papers accompany a new release of FDOT's LOSPLAN software and provide guidance for both the government and private sectors regarding technical analysis and review. New emphasis on local concurrency management systems, proportionate fair-share options, and the requirement for comprehensive plans to be consistent with Capital Improvement Elements will require more consistent review practices and mitigation measures.

3. Provide guidance in the following new areas and applications

> *Updated Rule 14-94, F.A.C., Minimum LOS Standards*
> Rule 14-94, F.A.C. governing minimum roadway LOS standards has been updated to reflect the changes in Section 163.180 Florida Statutes.
>
> *FDOT's 2002 QLOS Handbook*
> The issue papers represent an official update of FDOT's 2002 QLOS Handbook which is regarded as the nation's leading planning application of the Highway Capacity Manual (HCM). The guidance contained within the issue papers supersedes any conflicting guidance in FDOT's key planning documents prepared prior to July of 2006 such as the 2002 QLOS Handbook and Site Impact Handbook. Though specific issues and requirements may differ, the philosophy and detailed explanations in these prior and more complete documents are essential in growth management and highway capacity/LOS analysis. Because Rule 14-94, F.A.C. specifically references these documents, the issue papers govern the application of the state's minimum LOS standards. Within FDOT district and central office planning units, they are to serve as guidance for general planning and preliminary engineering applications of highway capacity and LOS analyses. The concepts in these papers will be incorporated in the next update of the QLOS Handbook (estimated April of 2008).

Address inconsistencies in approach across the state
Though the State of Florida has a diverse collection of roadways and area types, consistent application of growth management rules, LOS standards and measurement techniques is essential. The issue papers provide a foundation for high quality, consistent capacity/LOS analyses and review.

Intended for FDOT, FDCA, MPOs, local governments, and the private sector
The issue papers are written to serve FDOT planners, engineers and reviewers, as well as other agencies, local governments and the private sector. Analyses prepared in accordance with the issue papers can be quickly and fairly reviewed.

4. Implementation schedule

The guidance in these issue papers should be implemented immediately for new projects. Projects currently in development or review will continue under the current review requirements. All projects will be subject to these issue papers on October 1, 2007. These papers remain in effect until the release of the next QLOS Handbook or other official action by FDOT.

Organization of Issue Papers

Titles of the issue papers contained herein are:

1. Purpose of Issue Papers
2. Impact of Growth Management Act of 2005
3. Overview of Capacity and LOS Tools
4. Guidance on Applying Capacity and LOS Tools in Planning Stages
5. Highway System Structure Terminology Related to Highway Capacity and LOS analyses
6. Partitioning of Roadways for LOS Analysis (Segmentation)
7. Area Types
8. Applicability of FDOT's Statewide Minimum LOS Standards for Roadway LOS analyses
9. LOS Analyses for Strategic Intermodal System Connectors
10. Maximum Acceptable Capacity Volumes
11. Minimum/Maximum Acceptable Input Values
12. Obtaining and Determining Key Highway Capacity/LOS Input Data
13. Technical Processes for LOS Analyses for Comprehensive Plan Amendments, Proportionate Fair-Share and Developments of Regional Impact *(to be developed)*
14. Future Year Capacity and LOS Analyses (Draft)
15. What Is New in LOSPLAN and Generalized Tables
16. Training Requirements for FDOT/Consultant Use of LOSPLAN

Each of the issue papers was developed as stand alone issue documents, so there is some redundancy and cross referencing among them. This redundancy and cross referencing will be addressed in the update of the QLOS Handbook.

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ISSUE #2 - IMPACT OF GROWTH MANAGEMENT ACT OF 2005

Overview

The Growth Management Act of 2005 (Act) was the most significant growth management legislation since 1985. From a transportation perspective, the new growth management legislation had major implications regarding the implementation of concurrency and capital improvement planning at the local level.

The Act requires local governments, beginning December 1, 2008, to submit annually to DCA as an amendment to their Capital Improvement Element, a five year financially feasible schedule of capital improvements. The schedule of improvements should be coordinated with and support other elements of the comprehensive plan (i.e., land use) and contain projects to ensure that adopted transportation level of service (LOS) standards are achieved and maintained.

The Act defines "financial feasibility" as funding available now or from committed funding sources in the first three years of the Capital Improvement Program (CIP), or funds that will be available from committed or planned funding sources in the fourth and fifth years of a five-year CIP. Funding sources include ad valorem taxes, bonds, state and federal funds, tax revenues, impact fees, and developer contributions which are adequate to fund the projected costs of the capital improvement identified in the Plan. The capital improvement schedule should ensure the adopted LOS standards are achieved and maintained within the time period covered by the five-year CIP. The requirement that LOS standards be achieved and maintained shall not apply if the proportionate fair-share process allowed under the Act and set forth in Chapter 163.3180, F.S. is utilized.

The legislation *further encouraged new partnerships and potential increased funding sources for transportation projects* by providing for proportionate fair share mitigation options. Proportionate fair-share mitigation options are intended for use by developers whose projects have been stopped due to a failure to meet transportation concurrency. In this instance, a developer may satisfy concurrency by making a proportionate fair-share contribution to a project contained within the local government's adopted cost feasible five-year CIP or ten-year or in some instances fifteen-year long term concurrency management plan. Adoption of a long term concurrency management plan is at the option of a local government, but is still required to be financially feasible.

Florida concurrency law, 163.3180 (2) (c), FS requires transportation facilities needed to serve new development to be in place or under actual construction within three years after the local government approves a building permit or its functional equivalent that results in traffic generation. Prior to the Act, transportation concurrency was tied to certificates of occupancy. Local governments are allowed to adopt more stringent requirements (i.e., facilities required to be in place or under construction within one or two years from the time of permitting). Transportation facilities funded in the fourth and fifth years of an adopted CIP are eligible for proportionate fair-share agreements with developers. The option to enter into agreements for these projects is controlled by the developer per statute.

In the case where an impacted road causing a proposed development to fail concurrency is not contained within a cost feasible CIP or long term concurrency management plan, the Act allows the developer and local government to negotiate a transportation improvement to satisfy concurrency. Local governments are required to concur and coordinate with FDOT in instances where proportionate-fair-share agreements are negotiated to mitigate impacts to Strategic Intermodal System (SIS) facilities and/or where exceptions to concurrency such as Transportation Concurrency Exception Areas impact SIS facilities.

The Act also addressed Transportation Concurrency Exception Areas (TCEAs)by adding specific criteria for new and existing TCEAs. From a transportation perspective, the local government must now adopt mitigation strategies into their comprehensive plan and implement them to support and fund mobility within the designated exception area. Mitigation strategies must include alternate modes of transportation and urban design standards. The strategies must also address the mix and density or intensity of land uses, as well as network connectivity.

Impact on FDOT

FDOT is expected to assist DCA in implementing the new growth management legislation in matters involving transportation. FDOT is also expected to coordinate with local governments and assist them in developing appropriate transportation analysis tools and mitigation strategies for the SIS facilities traversing their jurisdiction. FDOT has recently published several guidance documents related to FDOT's review and technical assistance in the development of concurrency management systems, transportation concurrency exception areas and proportionate fair-share ordinances. As a result, FDOT Districts will be required to perform new tasks which may involve shifting or reprioritizing of planning resources.

Capital Improvement Planning

Local governments are required to submit a financially feasible five-year CIP for review by DCA and FDOT on an annual basis. The statutes require that the CIP contain projects from the Metropolitan Planning Organization's(MPO) adopted Transportation Improvement Program(TIP) and Long Range Transportation Plan (LRTP), to the extent that projects are relied upon for concurrency and financial feasibility (S. 163.3177 (6)). While verification of financial feasibility falls within the responsibility of DCA, FDOT should be prepared to provide technical assistance to DCA regarding projects contained within the CIP as they relate to the adopted LOS standards for roadways on the state highway system, including designated Florida Intrastate Highway System (FIHS) and SIS facilities. To provide the necessary technical assistance and guidance to DCA in determining the LOS, each FDOT District will be responsible for reviewing the CIPs for consistency with the MPO's TIP and LRTP, and will also need to develop some basic knowledge regarding the local government's concurrency management systems. Programs found to be inconsistent with the local government's land use strategy, TIP or LRTP or that are not related to attaining or maintaining adopted LOS standards should be noted and referred to DCA for their annual review.

Comprehensive Plan Amendment Review

The main focus of FDOT District comprehensive plan amendment reviews will still be on the analysis of impacts to the SIS. However, under the new legislation the reviewer will also need to analyze the amendment in relation to the local government's Concurrency Management System, long-term corridor development and management strategies and the current CIP. For example, plan amendment activity in corridors operating below or near adopted LOS standards should be reviewed in conjunction with the local government's adopted CIP. Capacity delineated for non-SIS facilities will need to be the basis for the issuance of future development orders by the local government in these instances. Amendments that correspond to adopted corridor plans, especially those involving proportionate fair-share agreements, should be noted along with capacity projects within the CIP that may address impacts from the amendment. Expanded responsibilities dealing with comprehensive plan reviews may require FDOT Districts to prioritize reviews in relation to size and location.

FDOT should also encourage long-term strategies for the development of local government transportation networks to accommodate future growth, address and eliminate transportation concurrency backlogs, and provide technical support to local governments on appropriate network development strategies. Facilitating the expansion of local government transportation networks will help reduce reliance on SIS facilities for local trips, and may encourage more compact growth patterns that can support alternative modes of travel in urban areas. For example, the City of Newberry is currently developing a transportation network development plan to aid in long term concurrency management on SR 26, a SIS facility, and is establishing an agreement with a number of developers to advance the plan and mitigate transportation impacts to SR 26.

Proportionate Fair-Share

The intent of the proportionate fair-share option required by the Act is to provide applicants for a development failing transportation concurrency an opportunity to proceed by contributing their share of the cost of improving the impacted transportation facility. Proportionate fair-share agreements present an opportunity for FDOT, along with the respective local government(s), to bring new partners to the table that can potentially provide new or expanded sources of revenues for transportation improvements needed to mitigate impacts of new development. FDOT should provide technical assistance to local governments interested in entering into proportionate fair share agreements, especially for state roads that are not on the SIS and on strategic corridors that might positively impact the operation of a SIS facility. Another potential FDOT role is to work with local governments to identify generalized construction and right-of-way costs for proportionate fair-share contributions toward improvement projects on the State Highway System, FIHS and SIS.

A key FDOT function will be to provide the local government with an assessment of FDOT's capability to provide capacity projects over a ten-year period. In some instances, FDOT may enter into a non-binding development agreement with the local government outlining responsibilities and funding levels associated with the development of a project over a ten-year period. Funds brought to the table by the local government would likely be made available through impact fees and proportionate fair-share agreements with developers.

Proportionate fair-share agreements involving SIS facilities, supporting network improvements or alternative modes require concurrence of FDOT and should remain a top priority in this area.

Transportation Concurrency Exception Areas (TCEAs)

The new legislation significantly tightened the criteria for approving TCEAs. In addition it required TCEAs existing prior to July 1, 2005 to meet the new provisions by July 1, 2006 or at the time of the comprehensive plan update pursuant to the evaluation and appraisal report, whichever occurs last. Prior to the designation of a TCEA, FDOT will be consulted by the local government to assess the impact that the proposed exception area is expected to have on SIS facilities. A plan to mitigate these impacts must be incorporated into any TCEA prior to its approval. Planning staff should evaluate any existing TCEAs within the FDOT District and work with the local government and DCA to correct any deficiencies in regard to the new criteria within the allotted time frame. These TCEAs shall also be updated to reflect the new requirements promulgated by the Act regarding strategies for the funding and support of mobility, alternative modes of travel, urban design, land use mix, density, intensity and network connectivity. Data and analyses to support these strategies must be included.

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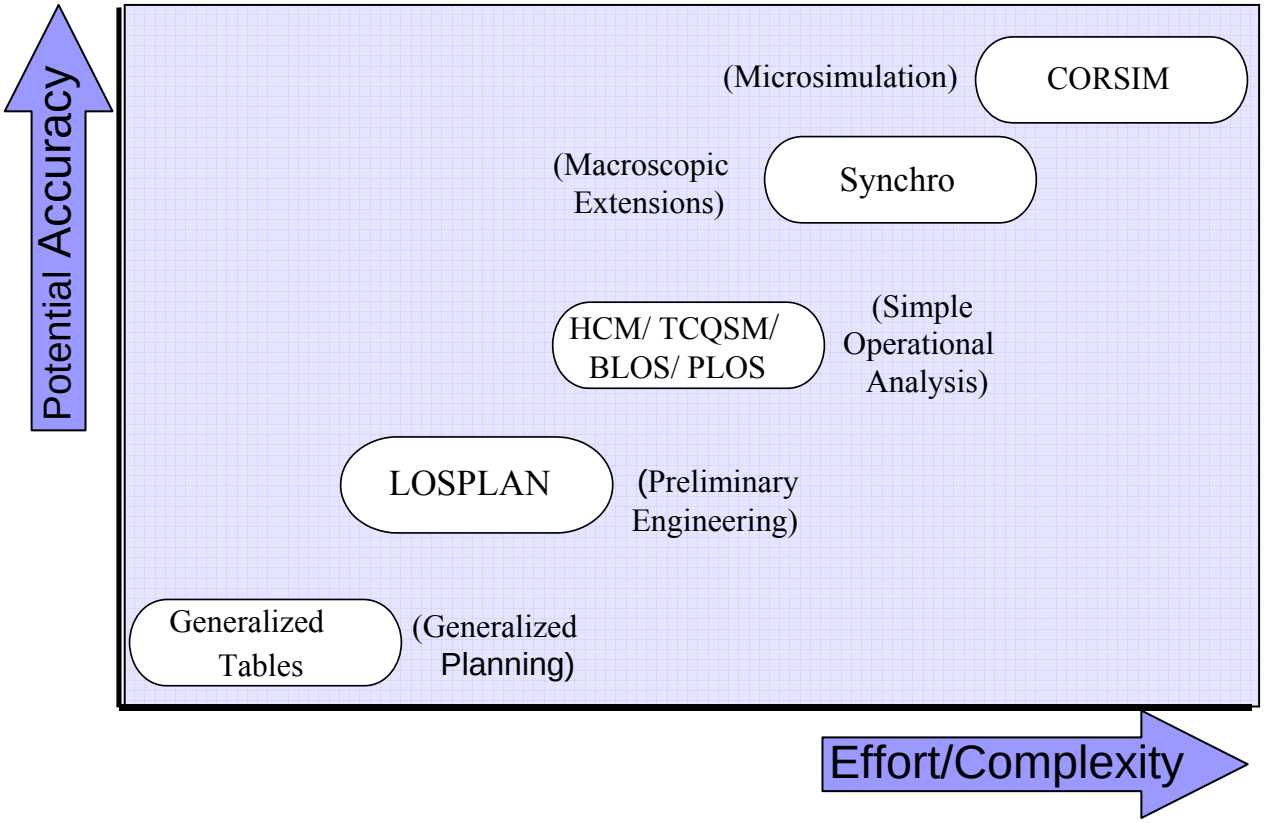
ISSUE #3 - OVERVIEW OF CAPACITY AND LOS TOOLS

There are many methods for computing highway capacity and level of service (LOS), which form a hierarchy ranging from Generalized Level of Service Volume Tables (the simplest to use, but least accurate) to complex operational analysis tools (very precise, but in most cases, too time consuming and costly). Figure 1 below provides an overview of analysis levels and sample evaluation tools for each level. In selecting the appropriate tools, tradeoffs among study purposes (e.g., generalized planning application, signal timing application), accuracy and precision of results (e.g., variability in data for current year analyses, variability in future year analyses), and data preparation effort (e.g., use of existing statewide traffic data, use of direct field measurements) should be considered. No one tool is appropriate for all applications.

Figure 1 – Capacity/LOS Analyses and Sample Evaluation Tools



This paper will discuss the appropriate analysis tool to use for specific applications, but the detailed discussion on the actual use of each tool will be discussed in issue papers #4 and #10: *Guidance on Applying Capacity and LOS Tools in Planning Stages,* and *Maximum Acceptable Capacity Volumes*.

While operational analyses, such as intersection signal timing and interchange justification reports, are sometimes conducted in planning stages, two levels of analysis are more representative of planning studies: (1) "generalized planning", and (2) "preliminary engineering"

(also known as "conceptual planning"). Generalized planning makes extensive use of statewide default values and is intended for broad applications such as initial problem identification (e.g., deficiency and needs analyses, geographic influence areas), statewide analyses (e.g., statewide calculation of delay), and future year analyses (e.g., ten-year planning horizon). Preliminary engineering is increasingly more detailed than generalized planning, but generally does not involve comprehensive operational analyses.

Generalized planning is most appropriate when a quick, "in the ball park" determination of capacity or LOS is needed. Florida's Generalized Tables are the primary tools for conducting this type of planning analysis. The tables are the most extensively researched in the nation and provide the most representative statewide service volumes and capacities for the State of Florida.

Preliminary engineering is best suited for obtaining a solid determination of the capacity and LOS of a facility. Preliminary engineering analyses are performed to support decisions related to roadway design concept and scope (e.g., 4 through lanes with a raised median and bicycle lane), conducting alternatives analyses (e.g., 4 through lanes undivided versus 2 through lanes with a two-way left turn lane), assessing development impacts, and determining needs when a generalized planning approach is simply not accurate enough. The tools in Florida's LOS planning software (LOSPLAN), including ARTPLAN, FREEPLAN, and HIGHPLAN, are appropriate tools for this type of planning analysis. They are specifically developed to address preliminary engineering issues in Florida, are easy to use, and are based on the nation's leading operational tools. These are the Highway Capacity Manual (HCM), Transit Capacity and Quality of Service Manual (TCQSM), Bicycle LOS Model (BLOS), and Pedestrian LOS Model (PLOS).

Operational tools range from "simple" to "complex". The analytical methods found in the Highway Capacity Manual (HCM) methodology chapters and the Highway Capacity Software (HCS), which replicates the HCM methodologies, are representative of "simple" operational tools. They are deterministic (i.e., provide a single, consistent answer), macroscopic (i.e., addresses vehicles as a group, not individually), and descriptive (e.g., replicates system behavior given the inputs – does not optimize). Traffic engineering practitioners typically work at this level. Simulation techniques are typically even more complex requiring specialists, but can overcome some of the limitations of simple operational tools (e.g., evaluate LOS F conditions).

The intermixing of generalized planning tools, preliminary engineering tools and operational tools should be avoided whether developing and implementing a concurrency management system, applying them to other planning applications, or conducting a traffic operations analysis. Using very precise data appropriate for a more detailed analysis as input to a less detailed analysis does not necessarily make the less detailed analysis more accurate. The precision of the inputs should be appropriate for the precision of the output. Similarly, the precision of the output is usually no better than the worst of the inputs. For example, the generalized service volume tables were structured to yield reasonable service volumes for typical roadways in the state. Typical roadway, traffic, and control (signalization) inputs from the state of Florida were used. Inserting specific traffic inputs for a preliminary engineering analysis (e.g., K and D factors) without simultaneously addressing key roadway and control inputs (e.g., effective green time ratios) is inappropriate, and also potentially leads to misuse of the tools as analysts can "cherry

pick" which variables to alter for a desired result. "Typical" values for roadways are the most appropriate inputs when the generalized tables are applied to analyze roadways.

FDOT's planning tools were designed to provide the most accurate results for the appropriate application. For example, a statewide summary of LOSPLAN results should have about the same service volumes as the generalized service volume tables. Many analysts believe the generalized tables were constructed to be conservative in terms of service volumes; however, that is not the case. An analyst should expect more accurate roadway specific values, but not necessarily higher or lower values when performing a detailed analysis for a typical state road.

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ISSUE #4 - GUIDANCE ON APPLYING CAPACITY AND LOS TOOLS IN PLANNING STAGES

There are two FDOT supported and statewide acceptable highway capacity and LOS analysis tools for planning and preliminary engineering (conceptual planning): FDOT's Generalized Service Volume Tables and FDOT's LOSPLAN software which includes ARTPLAN, FREEPLAN and HIGHPLAN. These two tools form the core for all FDOT's highway capacity and LOS analyses and reviews in planning stages. Through detailed research and review these planning and preliminary engineering tools can frequently result in more accurate analyses than more detailed unadjusted national operational tools. Each may be supplemented by other analyses, but they form the basis for all highway capacity and LOS analyses and determinations in Florida. To ensure that an analysis is consistent with Florida conditions and research, the inputs and volumes must be within the ranges specified in issue papers #10 and #11: *Maximum Acceptable Capacity Volumes* and *Minimum/Maximum Acceptable Input Values.*

More detail on the use of these tools for future conditions analyses is addressed in draft issue paper #14 *Future Year Capacity/LOS Analyses.*

Specific applications of the Generalized Service Volume Tables include:

- Generalized comprehensive plan amendment analyses;
- Statewide highway system deficiencies and needs;
- Statewide mobility performance measure (e.g., delay) reporting;
- Areawide (e.g., MPO boundaries) baseline capacity and service volume values for travel demand forecasting models;
- Areawide (e.g., impact areas) influence areas for major developments;
- Future year analyses (e.g., 10 year planning horizon);
- Threshold evaluations for roadway concurrency management programs (e.g., 85% of a roadway's applicable LOS standard service volume) and;
- Baseline capacity and service volumes for concurrency management systems

Generalized Tables must be appropriately applied (e.g., using the right area type and facility type designations) and interpreted (e.g., selecting the right values from the tables). Depending upon the application, such generalized analyses may be appropriately supplemented with documentation by an LOSPLAN analysis. For example, in Gainesville, roadways where 85% or more of a roadway's LOS standard service volume is exceeded based on the Generalized Tables, those roadways are analyzed with a supplemental LOSPLAN analysis. However, no operational tool (e.g., HCM) should be used as part of a generalized planning analysis because of falsely implied precision and to avoid "cherry picking" of desired input or output values.

FDOT's LOSPLAN software contains the core tools for site and project specific analyses in planning stages. Input and output documentation must be verifiable and approved by Districts and reviewing agencies. Guidance on obtaining acceptable data for AADT, K, D, g/C and percent turns from exclusive lanes is provided in issue paper #12 on *Obtaining and Determining Key Highway Capacity/LOS Input Data*.

Specific applications of the LOSPLAN software include:

- Assessing capacity and LOS impacts from a development along a specific roadway;
- Assessing the existing LOS, deficiencies, and needs for the highway component of the Strategic Intermodal System (or other roadways);
- Assessing the existing LOS, deficiencies, and needs for multimodal facilities (e.g., routes leading to elementary schools);
- Conducting alternatives analysis for a specific roadway; and
- Conducting project development and environmental studies (e.g., LOS, vehicular operating speeds) for location and preliminary design approval.

To support these applications:

- Appropriate traffic, roadway and control (i.e., signalization) variables must be entered in the LOSPLAN software. The key software input variables are highlighted in blue, while many other inputs are defaulted to statewide values;
- The software must be appropriately applied (e.g., applying the right area type and facility type); and
- The analysis must be appropriately interpreted (i.e., using the results correctly).

FDOT generally will accept outside analyses that utilize these accepted practices. Only at the discretion of the FDOT reviewer, will supplemental methods be allowed and only on a case by case basis. Reasons for such exceptions must be fully documented and justified.

Intermixing of generalized planning tools, preliminary engineering tools and operational tools in a single analysis should be avoided. This also applies to congestion management systems. The level of analysis for a specific application (e.g., conceptual planning) should be determined and then the appropriate tool (e.g., ARTPLAN) should be applied. However, depending upon the application it may be appropriate to supplement a level of analysis tool with another type of tool. For example, in assessing the impact of a proposed development along an arterial, ARTPLAN is usually the most appropriate tool; however, if it is desired to also analyze the signalized intersection leading directly into the development, it may be appropriate to use an operational tool (e.g., HCM/HCS). In this case, an HCS analysis may be provided for the signalized intersection leading into the development; however, it cannot substitute for or be used as input to the overall ARTPLAN analysis.

Rule 14-94 F.A.C. regarding Statewide Minimum Level of Service Standards states that when calculating LOS, all calculations and evaluations are to be based on those included in FDOT's Quality/Level of Service Handbook, the HCM, or a methodology determined by FDOT as having comparable reliability. The only tools FDOT will officially accept and support for roadway analysis (auto) are the Generalized Service Volume Tables, LOSPLAN, and the HCM/HCS, each applied at the proper level of analysis. Operational analyses based on other tools (e.g., Synchro, CORSIM) may be submitted to FDOT for consideration, but FDOT reviewers are under no obligation to consider, review, or comment on such analyses. For transit, pedestrian, and bicycle capacity and LOS

analyses, the only operational tools FDOT fully recognizes for planning applications are, respectively, the:

- Transit Capacity and Quality of Service Manual;
- Pedestrian Level of Service Model; and
- Bicycle Level of Service Model.

The Department also recognizes software applications which support these tools.

If there is conflicting guidance on the application of highway capacity or LOS analyses in other FDOT planning handbooks (e.g., Site Impact Handbook), the guidance above takes precedence while these other handbooks are being updated.

FDOT's Statewide Minimum Level of Service Standards apply to Strategic Intermodal System (SIS) connectors. From a highway system structure these connectors cover the full range of facility types including points (e.g., ramps, intersection movements), segments, and facilities, and frequently involve more than one roadway. FDOT does not routinely monitor or report LOS for SIS connectors when they are off the State Highway System. HCS is recommended to evaluate the LOS of a SIS connector at a point level. For more detail, see issue paper #9 on *LOS Analysis for Strategic Intermodal System Connectors.*

The misuse of level of analysis tools and the intermixing of level of analysis tools, especially at a conceptual planning level, has increased in Florida in recent years. According to Rule 14-94 F.A.C., FDOT's roadway (auto) LOS analyses must be based on the HCM methodologies or a methodology determined by FDOT as having comparable reliability. If an operational tool is needed to supplement an LOSPLAN analysis, that tool should be the HCM/HCS. There are numerous reasons for this position including:

- State and national recognition of the HCM as the nation's leading resource on highway capacity and LOS analysis;
- The HCS is a faithful replication of the HCM methodology chapters and is the leading software implementing the HCM in Florida and the nation;
- FDOT staff cannot be responsible for acquiring and reviewing all of the currently available software programs in the market;
- Although other methodologies may be more accurate than the HCM in specific applications, they have not received the international acceptance based on national research conducted through the National Academies of Science Transportation Research Board; and,
- Requiring operational analyses be based on the HCM/HCS offers statewide consistency in approach for the benefit of both the reviewers and analysts submitting analyses.

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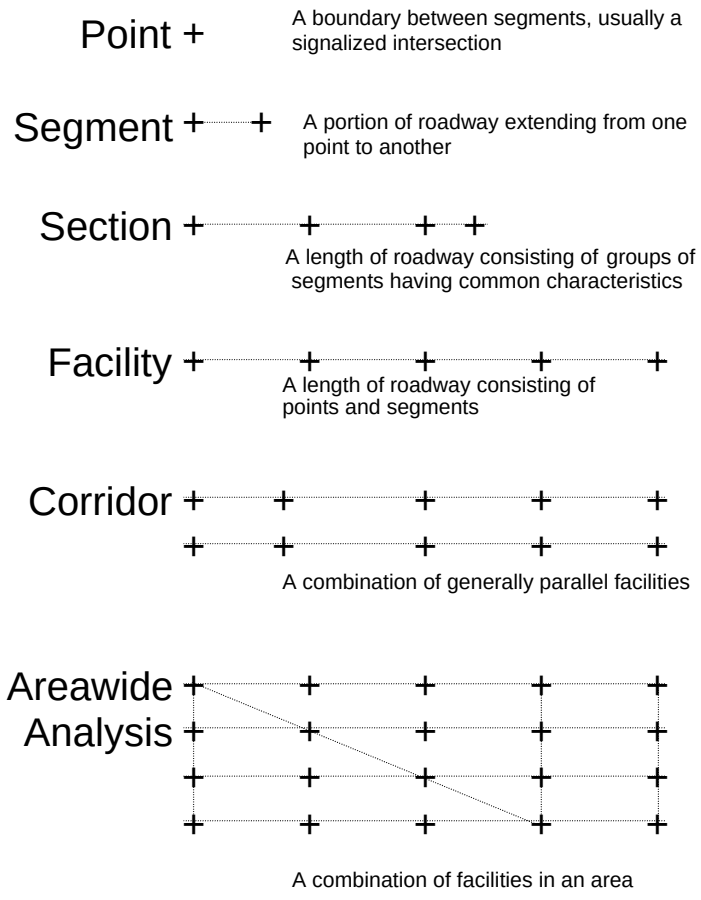
ISSUE #5 - HIGHWAY SYSTEM STRUCTURE TERMINOLOGY RELATED TO HIGHWAY CAPACITY AND LOS ANALYSES

FDOT's quality/level of service (Q/LOS) techniques generally incorporate the primary highway system structure of the HCM, consisting of points, segments, sections, facilities, corridors and areas. A generalized characterization of the HCM structure is shown in Figure 1.

Figure 1
GENERALIZED HCM2000 HIGHWAY SYSTEM STRUCTURE



The analysis techniques contained in the Q/LOS Handbook and accompanying software are focused at the HCM "facility" level. Points and segments are the primary building blocks of facilities. It is useful to use roadway sections (groups of segments having common characteristics) as the analysis unit depending on the mode or facility-type being analyzed.

In fact, when analyzing impacts to specific roadways, it is commonplace to evaluate them at point and section levels. Point analyses are primarily used for capacity analyses such as analyzing signalized intersections so traffic volumes can be handled.

Section analyses

When determining roadway LOS, most FDOT districts partition roadways at points where volumes significantly change or the number of through lanes change. The HCM term for these groupings of segments is "section." For LOS analysis purposes, individual segments (point to point) are usually grouped together as long as traffic and roadway characteristics do not vary appreciably.

For LOS analysis, the term "section" is used to describe or encompass the following:

- A segment or group of segments that have similar traffic and roadway characteristics, and
- "Links" as used in travel demand forecasting models.

Typical section lengths are:

- Freeways : interchange to interchange,
- Arterials: 0.25 mi. to 2.0 mi. and,
- Highways: highly variable in length and may include
    - uninterrupted flow two-lane segments,
    - uninterrupted flow multilane segments, and
    - isolated intersection influence areas.

Highway analyses

The HCM does not contain a "facility" level analysis for generally uninterrupted flow facilities (highways). The HCM two-lane and multilane highway chapters are "segment" chapters. They deal with uninterrupted flow segments, but there is no guidance on how to combine segments, how to deal with isolated signalized intersections, or a combination of two-lane and multilane segments. FDOT is in the process of developing such LOS techniques; however, in the interim FDOT will follow the HCM and analyze such roadways on a "segment" basis.

To perform a specific roadway analysis, FDOT recommends breaking the "highway" into uninterrupted and interrupted flow segments. For example, if a two-lane highway facility in a rural area extends 15 miles with an isolated intersection at the 10-mile point: (1) the LOS for the first 9.75 miles would be based on the two-lane highway segment LOS, (2) the 0.5 mile intersection influence area would be based on the LOS for that intersection, and (3) the last 4.75 miles would be based on the two-lane highway segment LOS.

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ISSUE #6 - PARTITIONING OF ROADWAYS FOR LOS ANALYSIS (SEGMENTATION)

In order to properly apply the Generalized Tables or the LOSPLAN software, it is necessary to partition roadways into appropriate lengths for analysis. Setting lengths too short may not adequately capture traffic flow characteristics. Vehicles will not achieve the same average running speed on a segment as over a longer facility length. Short lengths would also be subject to bias caused by signal control delay. Furthermore, analysis results would not conform to the concept of level of service that is based on driver perception of the operation of roadways and may not show where the most significant impact of proposed development traffic will occur. Conversely, setting lengths too long may dilute the impact of "hot spots" by averaging them into other portions that operate better. The guidance below is based on roadway partitioning or segmentation needed to adequately assess the appropriate service measure by facility type in the HCM.

The HCM identifies three primary facility types:

- Arterials (signalized roadways that primarily serve through traffic),
- Freeways (multilane roadways with full control of ingress and egress), and
- Highways (uninterrupted flow roadways that are not freeways).

Four key highway system structure terms (using HCM nomenclature) apply: point, segment, section and facility. A brief description of each using an arterial as an example follows (for a more complete discussion see the Q/LOS Handbook pages 10-11).

- Point – a signalized intersection,
- Segment – a portion of a facility from one signalized intersection to another,
- Section – a group of consecutive segments that have similar characteristics, and
- Facility – a group of consecutive segments or sections that form logical roadway lengths from a driver's perspective and/or from a highway system structure.

Continuing the use of an arterial example, the HCM2000 provides level of service performance measures and thresholds only at the point (i.e., signalized intersection) and facility levels, but not at the segment or section levels. Capacity is typically measured at the point level with control delay serving as the LOS performance measure for the intersection. Average travel speed is the performance measure for an arterial's LOS at a facility level, with the concept that the roadway length must be long enough that average travel speed serves as a reasonable performance measure. Transportation professionals in Florida typically apply average travel speed at both the smaller segment and section levels as well. For conceptual planning analyses, analysts frequently find it more useful to evaluate roadways at point and section levels than at segment and facility levels. Concurrency Management Systems analysis is frequently based on existing conditions at point and section levels.

FDOT District LOS Coordinators have primary responsibility for segmentation of the State Highway System for LOS purposes. FDOT Central Office may combine smaller segmentation lengths of a facility for statewide reporting and other purposes.

Section lengths and typical termini

Typical section lengths are:`

- Arterials: 0.25 mi. to 2.0 mi.,
- Freeways : interchange to interchange,
- Highways (generally uninterrupted flow non-freeways): highly variable in length and may include:
    - uninterrupted flow two-lane segments,
    - uninterrupted flow multilane segments, and
    - isolated intersection influence areas.

Typical termini are:

- Changes in the number of through lanes,
- Significantly varying traffic volumes,
- Freeway interchanges,
- Intersecting functionally classified principal arterials,
- A signalized intersection no more than 2 miles away from for the following area boundaries (see section below on signalized intersection as termini for arterial analyses):
    - Urbanized area boundaries
    - Transitioning area boundaries.
- Area boundaries if no nearby signalized intersection exists:
    - Urbanized area boundaries
    - Transitioning area boundaries
- Urban boundaries.
  (See section below on Signalized intersections as termini for arterial analyses)

Facility lengths and typical termini

In general, the partitioning of roadways for facility analyses should be based on the following considerations, ranked in order:

- highway system structure
- lengths
- area boundaries

At times, section termini may also aid in the delineation of facility termini and lengths. In all cases, the beginning and ending points for a facility analysis should coincide with the beginning and ending points of sections that make up the facility.

Arterial facility lengths and typical termini:

Appropriate lengths

- 0.75-2.0 (typically 1) miles in urbanized downtown areas, and
- 1.5-5.0 (typically 3) miles in other areas

Typical termini

- Large urbanized areas – intersecting freeways and arterials that connect to at least 2 freeways,
- Other areas – intersecting freeways and intersecting functionally classified principal arterials,
- A signalized intersection less than 2 miles away from for the following area boundaries (see section below on signalized intersection as termini for arterial analyses):
    - Urbanized area boundaries
    - Transitioning area boundaries
    - Urban boundaries
- City boundary to city boundary in cities under 5,000 population.

Freeway facility lengths and typical termini

Appropriate lengths

- 2-5 (typically 3) miles in large urbanized area central city downtown areas,
- 4-15 (typically 8) miles in other parts of urbanized areas,
- 4-15 miles in transitioning areas,
- 10-50 miles in rural areas,

Typical termini

- Intersecting Florida Intrastate Highway System (FIHS), SIS and TRIP funded routes,
- Urbanized area boundaries for nearby jurisdictions, and
- Transitioning area boundaries.

Highway lengths and typical termini

Lengths

- At least 3 miles,

Typical termini

- Large urbanized areas – intersecting freeways and arterials that connect to at least 2 freeways,
- Other areas - intersecting functionally classified principal arterials,
- Urbanized area boundaries for nearby jurisdictions,
- Transitioning area boundaries,
- Urban boundaries, and
- City boundary to city boundary in cities under 5,000 population

(Nuances exist for analyzing generally uninterrupted flow highways. For a more in depth discussion, see issue paper #5 on *Highway System Structure Terminology Related to Highway Capacity and LOS Analyses*.)

Local government segmentation of roadways

At the local level, government agencies frequently make highway capacity and LOS termini at their own jurisdictional boundaries, regardless of the appropriate facility length and termini considerations described above. Jurisdictional boundaries by themselves are usually not appropriate termini for capacity and LOS analyses. Local governments are encouraged to consult with FDOT District LOS coordinators for applicable segmentation within their jurisdictional boundaries.

Signalized intersections as termini for arterial analyses

When evaluating arterial section or facility LOS at a conceptual planning level, the roadway should begin and end at a signalized intersection. The following guidance is provided for some special cases:

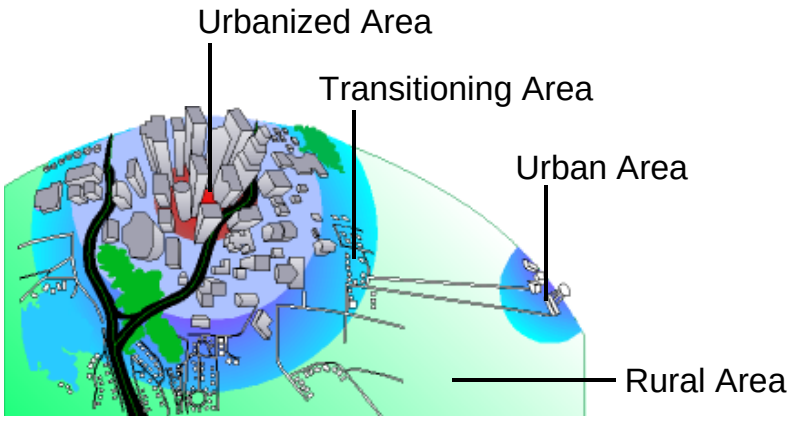
(1) Interchanges along an arterial - Although at a generalized planning level it is typically appropriate to make a break at an interchange (highway system structure criterion) that does not include a signalized intersection, at a conceptual planning level it is appropriate to extend the analysis to the next signalized intersection if within 2 miles of the interchange; and

(2) Boundaries, especially urbanized area boundaries - When a signalized intersection lies just outside the boundary, it is proper to extend an analysis to the next signalized intersection if within 2 miles of a boundary for a conceptual planning analysis. For example, if a signalized intersection lies 1 mile beyond the existing urbanized boundary in a transitioning area, it is appropriate to include that signalized intersection and the 1 mile of transitioning area as part of an urbanized area analysis.

Contacts on topic:
FDOT District LOS Coordinators
FDOT Central Office – Gina Bonyani

ISSUE #7 - AREA TYPE

Three broad area type groups are used in the Q/LOS Handbook and accompanying software:



- Urbanized areas (areas over 50,000 population);
- Transitioning/Urban areas (transitioning into urbanized areas or areas over 5,000 population not in urbanized areas); and
- Rural areas (rural undeveloped areas and cities or developed areas less than 5,000 population).

The area types in the Generalized Tables (Tables 4-1 through 4-9 of FDOT's Q/LOS Handbook) and software match well with FDOT's LOS standards as designated in Rule 14-94, F.A.C.; however, a few points should be noted. FDOT District LOS Coordinators should be consulted for applicable boundaries within their districts.

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). The minimum population for an urbanized area is 50,000.

All urbanized areas are combined in the Generalized Tables, regardless of size. However, in the software, area types are distinguished by whether an urbanized area is greater than or less than 1,000,000 population. Currently, the over 1,000,000 grouping applies to the MPO areas that include central cities: Ft. Lauderdale, Jacksonville, Miami, Orlando, St. Petersburg, Tampa, and West Palm Beach. In the software, these are referred to as "Large Urbanized." The urbanized areas less than 1,000,000 population are referred to as "Other Urbanized". Florida research has shown that drivers are more aggressive the larger the population of the area. This increases the saturation flow rate, yielding higher service volumes.

Note: The LOS standards in Rule 14-94, F.A.C. use a breakpoint of 500,000 population. Thus, the LOS standards for urbanized areas between 500,000 and 1,000,000 are the same as those over 1,000,000; however, for analyses using the LOSPLAN software the "Other Urbanized" category should be used.

Transitioning/urban areas

Transitioning/urban areas consist of two distinct areas. However, because their traffic characteristics are similar, they are treated as one group in the Generalized Tables.

Transitioning areas

Transitioning areas are "fringe" areas that exhibit characteristics between rural and urbanized/urban. Transitioning areas are intended to include areas that, based on their growth characteristics, are anticipated to become urbanized or urban in the next 20 years.

Frequently the "Metropolitan Planning Area" is used for the transitioning area adjacent to an "FHWA Urbanized Area" (Adjusted Census Urbanized Area Boundary) (see FDOT's MPO Handbook coordinated by the Office of Policy Planning). The definition of Metropolitan Planning Area specifically mentions the "contiguous area expected to become urbanized with the 20-year forecast period." It is that "contiguous area" that should be considered the "transitioning area". However, in practice, most MPOs have not specifically delineated those "contiguous" or "transitioning" areas and many of the Metropolitan Planning Areas extend to remote rural areas of counties. In situations where the MPO does not identify these "transitioning areas", or areas adjacent to urban (but not urbanized) areas, FDOT Districts, in cooperation with local governments, may delineate transitioning areas for level of service purposes.

There is no established statewide process for designating transitioning areas. For example, some districts may prefer having signatures of approval for the boundaries while other districts may designate the areas less formally. For understanding by all potential parties involved, keeping the boundaries relatively consistent over time is desirable. The transitioning boundary should be reviewed and adjusted as a part of the census cycle update consistent with the setting of the "FHWA Urbanized Area boundaries". It may also be appropriate to review the transitioning boundary in conjunction with a Long Range Transportation Plan update. Regardless, short time frame updates to respond to individual development projects or political desires should be avoided. For these reasons FDOT District LOS coordinators should be consulted for transitioning boundaries within their districts. It is recommended boundaries for transitioning areas be based on the location of major roadways or at interchanges. This avoids portions of a freeway changing from transitioning to urbanized or rural between interchanges. It is desirable for an arterial to have the same designation between major roadways and not change mid-block. In cases where aligning the boundary with major roads is impractical see the section below on treatment of small lengths of roadways.

Urban areas

An urban area is a place with a population between 5,000 and 50,000 and not within an urbanized area. Boundaries for cities over 5,000 population and not within 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 classification in the Generalized Tables and "urban" classification in the software.

Other situations exist where an area has over 5,000 population (e.g., 10,000) and yet, the area is more characteristic of a "rural developed area." In this situation, it is reasonable to use the developed area less than 5,000 population sections of Generalized Tables 4-3, 4-6, and 4-9, and the "rural developed" classification in the software. In both of these situations, FDOT district planning offices, after consultation with the central office, should make a determination as to the appropriate area type designation to use.

Rural areas

Rural areas consist of two types:

- "Rural undeveloped" – areas in which there is minimal development
- "Rural developed" – areas with small populations.

Generally, the cities or developed areas portion of the Generalized Tables should be applied to areas with a population between 500 and 5,000, and not immediately adjacent to urbanized, urban or transitioning areas. This portion of the tables also should be generally applied to coastal roads not in urbanized, urban or transitioning areas.

Note: the "rural undeveloped area" in Tables 4-3, 4-6, and 4-9 corresponds to the "rural area" in the LOS standards. The "cities or developed areas less than 5,000 population" portion of Tables 4-3, 4-6, and 4-9 corresponds to different LOS standards under the "communities" category in the standards.

Treatment of small lengths of roadways

There may be small lengths of roadways (e.g., approximately 6 miles for freeways, 3 miles for non-freeways) between area types or adjacent to an area type which from a logical and analytical sense should be combined into one area type or another. These situations typically occur with adjacent interchanges or in transitioning areas, but may also occur elsewhere. FDOT districts have the flexibility to adjust the area type boundaries or designate a roadway with a certain area type under these circumstances. FHWA guidance on Urban Area boundaries may be helpful in this regard: http://www.fhwa.dot.gov/planning/census/faqa2cdt.htm#q60

Future year LOS analyses

Under general circumstances FDOT's LOS standards and analytical assumptions and techniques (Generalized Service Volume Tables) apply for the various area types apply throughout the planning period. For a conceptual planning analysis of a roadway see Issue Paper #15 on *Future Year Capacity/LOS Analyses*.

Contacts on topic:

Because of the many nuances associated with area type designations, FDOT's LOS Rule 14-94, and Generalized Service Volume Tables, analysts are encouraged to contact FDOT's District LOS Coordinators with any questions. The FDOT Central Office contact is Martin Guttenplan.

ISSUE #8 - APPLICABILITY OF FDOT'S STATEWIDE MINIMUM LOS STANDARDS FOR ROADWAY LOS ANALYSES

FDOT has adopted statewide minimum LOS standards for roadway facilities in Rule 14-94, F.A.C. These standards apply on the Strategic Intermodal System (SIS), SIS connectors, the Florida Intrastate Highway System (FIHS) and Transportation Regional Incentive Program (TRIP) roadways. Rule 14-94, F.A.C. requires that all LOS determinations are to be based on the Highway Capacity Manual (HCM) or FDOT's Quality/Level of Service (Q/LOS) Handbook or a methodology determined by FDOT as having comparable reliability. There are only two FDOT supported highway capacity and LOS analysis tools for planning and preliminary engineering: FDOT's Generalized Service Volume Tables and FDOT's LOSPLAN software. (For a more in depth discussion, see Issue Paper #4 on *Guidance on Applying Capacity and LOS Tools in Planning Stages.*) These two tools form the core for all FDOT's highway capacity and LOS analyses and reviews in planning stages.

Three primary types of facilities are identified in the HCM and the Q/LOS Handbook, including their implementation software:

- Freeways (multilane, divided roadways with at least two lanes for exclusive use of traffic in each direction and full control of ingress and egress),
- Highways (generally uninterrupted flow roadways which may be further categorized as two-lane or multilane), and
- Arterials (signalized roadways that primarily serve through traffic).

While the determination of the applicable LOS standards for these facilities is a relatively straightforward process, there is a need for further guidance for point (signalized intersection) analyses and section analyses. (For a more in depth discussion on point, segment, section, and facility analyses, see Issue Paper #5 on *Highway System Structure Terminology Related to Highway Capacity and LOS Analyses.*).

Section LOS analyses

All FDOT districts have segmented their freeways, highways and arterials for highway capacity and LOS analysis purposes. (For a more in depth discussion on roadway segmentation see Issue Paper #6 on *Partitioning Roadways for LOS Analyses.*) In practice, most districts and others have found it more useful to conduct section-level analyses than facility-level analyses to address vehicular traffic. Because of typically shorter travel distances by the bus, pedestrian, and bicycle modes on individual roadways, a section level analysis is more appropriate for those modes than a facility-level analysis.

Although FDOT's LOS standards and the HCM and Q/LOS Handbook evaluation techniques emphasize freeway, highway, and arterial facility analyses, extending those standards and techniques to section analyses is logical, provided the segments are not too short. FDOT District LOS Coordinators should be contacted for the applicable LOS segmentation used in their districts.

Point LOS analyses

Point analyses, such as at signalized intersections or freeway ramp terminals, are largely operational in nature, not planning. For site impact evaluations, point analyses are frequently limited to entrances/exits to a specific development.

From planning and roadway LOS viewpoints, the usual intent of point analyses is to get traffic adequately moved through the point so the roadway as a whole operates adequately. On the other hand, in order for the roadway as a whole to work effectively, "hot spots" must be addressed. Usually operational tools are needed to analyze these critical points. In the case of arterials, a further analytical complication arises because the facility level "average speed" LOS service measure changes to "control delay" at a signalized intersection. Furthermore, although typically there is a direct relationship between the two, it is quite possible that the LOS for many signalized intersections is good, yet the arterial operates poorly, or vice versa.

For preliminary engineering studies of a specific roadway, basic capacity and LOS analyses should be conducted at the point level over the roadway's length. FDOT's ARTPLAN and FREEPLAN software feature some point highway capacity and LOS features; however, they are not operational enough to yield detailed results. If an operational tool is needed to supplement an LOSPLAN analysis, that tool should be the HCM/HCS. (For a more in depth discussion of applying operational tools, see Issue Paper #4 on *Guidance on Applying Capacity and LOS Tools in Planning Stages.*)

Signalized intersection analyses

The logical extension of applying the LOS standards to point analyses is to apply the applicable standards to the through movement of the roadway. For example, for a site impact analysis if the LOS standard for an arterial is "D", then the through movement at the intersection should also be "D". However, while sound in concept, it is virtually always possible to obtain a desired LOS for an intersection approach if the other approaches are ignored. Therefore, if an operational analysis of a signalized intersection is part of a planning study, the operational analysis should be conducted with HCS for the entire intersection with appropriate traffic volumes and other inputs for each approach. No intersection approach should fall below its established LOS standard. If there is no LOS standard, the approach should not have a volume to capacity ratio in excess of 1.0 for the full hour. The section and the relevant intersection approaches must operate at acceptable levels of service. Other techniques exist for analyzing signalized intersections in planning studies, so District LOS Coordinators should be consulted for specific techniques and acceptable values in their districts.

If a detailed point analysis is performed, the applicant must demonstrate ample left turn storage. Any actual turning movement counts can only be used to determine the

percentage of the approach turning left, not the actual number of turning vehicles as this number can be constrained and not representative of a demand volume.

TRIP Funded Roadway LOS Standards

FDOT LOS standards apply to a Transportation Regional Incentive Program (TRIP) funded facility when the following occurs:

- If the project being funded is a Project Development and Environmental (PD&E) Study, the local entity must agree to use the FDOT adopted LOS throughout the study.
- For all other projects, the local entity agrees that once the additional capacity from the project is available for purposes of concurrency under Chapter §163.3180, F.S. it will officially adopt the FDOT LOS standard for the TRIP funded facility project. In other words, the local government must adopt the FDOT LOS standard no later than when the construction phase reaches Year 3 of the FDOT Five-Year Work Program.

More information about TRIP facilities can be found at www.dot.state.fl.us/planning/trip

Contacts on topic:
FDOT District LOS Coordinators
FDOT Central Office – Martin Guttenplan

ISSUE #9 - LOS ANALYSES FOR STRATEGIC INTERMODAL SYSTEM (SIS) CONNECTORS

FDOT's Rule 14-94, F.A.C. on Statewide Minimum Level of Service Standards, establishes a LOS D standard for SIS connectors. From a highway system structure these connectors cover a full range of roadway types varying from points (intersection movements), individual sub-segments (ramps), segments, sections, and facilities, and frequently involve more than one roadway. FDOT does not routinely monitor or report LOS for SIS connectors unless they conform to appropriate facility or section length criteria for a roadway. In these cases LOSPLAN is an appropriate measurement tool. To evaluate the LOS of a SIS connector at a point level, HCS is the recommended tool. If a signalized intersection of a SIS connector is being evaluated, the LOS D standard applies to the applicable movement, with the recommendation that all other movements are adequately addressed for the operation of the intersection as described in Issue Paper #8 *Applicability of FDOT's Statewide Minimum LOS Standards for Roadway LOS Analyses*.

Contacts on topic:
FDOT District LOS Coordinators
FDOT Central Office – Martin Guttenplan

ISSUE # 10 - MAXIMUM ACCEPTABLE CAPACITY VOLUMES

"Highway capacity analysis" and "LOS analysis" are two distinct, although closely related, analyses. "Capacity" is the maximum number of vehicles or persons that can reasonably be expected to pass a point on a roadway during a specified time period under prevailing roadway, traffic, and control conditions. "Level of service" is a quantitative stratification of the quality of service to a typical traveler of a service or facility into 6 letter grades with "A" being the best and "F" the worst. To fully evaluate the impacts of site developments both capacity and LOS analyses should be conducted. To help insure that maximum service volumes for a given level of service are appropriate, checks on the capacity values are usually desirable.

Use of highway capacity and LOS tools, whether applied appropriately or not, has resulted in projected traffic volumes beyond normal capacity ranges found on Florida facilities. The causes are many-fold, but to aid analysts and reviewers on what capacity values will normally be acceptable, FDOT provides the guidance below. These values are based on site specific freeway studies and counts, and arterial maximum acceptable through movement effective green ratios (g/C) (see Issue Paper #11 on *Minimum/Maximum Input Values*). For the benefit of users conducting LOS analyses, FDOT's updated LOSPLAN programs will automatically check capacity and provide warnings and messages if acceptable capacities are exceeded. (Note: Under most circumstances the maximum service volume for LOS E equals capacity.)

Maximum acceptable capacity volumes for facilities

For arterial facilities the maximum generally acceptable per lane approach volumes are as follows:

- Large urbanized – 1000 vehicles per hour per lane (vphpl)
- Other urbanized – 950 vphpl
- Transitioning – 920 vphpl
- Urban – 920 vphpl
- Rural – 850 vphpl

Note: arterial segments and sections may have higher values.

For freeway facilities and sections, the maximum generally acceptable volumes are as follows:

- Large urbanized – 2100 vphpl
- Other urbanized – 2000 vphpl
- Transitioning – 1900 vphpl
- Urban – 1800 vphpl
- Rural – 1800 vphpl

For highway (generally uninterrupted flow highways) segments, the maximum generally acceptable per lane approach volumes are as follows:

- Two-lane
    - Developed – 1600 vphpl

    - Undeveloped – 1500 vphpl
- Multilane
    - Developed – 1850 vphpl
    - Undeveloped – 1600 vphpl

(For area type determinations, see Issue Paper #7 on *Area Types*; for definitions of facilities, sections and segments, see Issue Paper #5 on *Highway System Structure Terminology Related to Highway Capacity and LOS Analyses*.)

Special arterial and highway considerations

Maximum volumes for arterial and highway segments may vary due to widely varying effective green to cycle length ratios (g/C), turning movements at intersections, and the segmentation of roadways.

For arterials, the maximum volumes shown represent a weighted g/C of approximately 0.50, which is the average of the critical g/C and the average of all other g/Cs along an arterial facility. Typically there will be at least one principal arterial intersecting an arterial being analyzed. Such intersections are usually the critical intersections ("hot spots") for an arterial analysis and g/C ratios for the through movements are in the range of about 0.40. Although these intersections are frequently flared out to achieve greater capacity, the through movement g/C ratios cannot increase appreciably if all intersection movements are included. Therefore, the use of a 0.50 g/C ratio for determining the capacity of an arterial should represent the upper bounds of what can be reasonably expected.

Arterial facility analyses typically involve intersecting principal arterials, but section analyses may not. Under these circumstances, arterial through movements during peak travel hours may feature g/C ratios in the 0.50 to 0.60 range. Such values may be appropriate for segment or section analyses; however, use of such high g/C ratios is not normally acceptable for a facility analysis and may represent inappropriate segmentation of roadways. (For segmentation guidance, see Issue Paper #6 on *Partitioning of Roadways for LOS Analyses*.)

Another situation in which g/C ratios may be above 0.50 is in the outlying parts of urbanized areas or in transitioning areas for both arterials and generally uninterrupted flow highways. Typically signals have been recently installed and side traffic hasn't reached the high levels that it will in future years. Therefore, although current maximum volumes per lane may be higher than those shown above, in the future such values will likely not be sustained and should be avoided in the arterial analysis. (For a more in depth discussion on future year analyses, see Issue Paper #15 on *Future Year Highway Capacity and LOS Analyses*.)

Special freeway considerations

FDOT's conceptual planning (preliminary engineering) software for freeway analyses (FREEPLAN) features 3 new operational freeway characteristics that may result in volumes slightly higher than those shown above: ramp metering, extension of acceleration/deceleration lanes, and auxiliary lanes. In general, implementation of ramp metering and extension of acceleration/deceleration lanes will have a 5% or less improvement on capacity. No special consideration is given to those two types of possible improvements in the maximum generally acceptable volume per lane values shown above.

Auxiliary lanes (lanes connecting on ramps and off ramps) can have significant capacity benefits for freeways. The benefit largely depends upon the length of these lanes and volumes entering/exiting the freeway facility. The values shown above apply only to the through lanes. The capacity of the auxiliary lanes and their volumes should be treated separately. (For a more in depth understanding of auxiliary lanes, see the "help file" for auxiliary lanes in FREEPLAN.)

Compatibility of software results with maximum acceptable capacity volumes

The FDOT supported and statewide acceptable highway capacity and LOS analysis tool for conceptual planning (preliminary engineering) is FDOT's LOSPLAN software (ARTPLAN, FREEPLAN, HIGHPLAN). (For a more in depth discussion on LOS tools and their application, see Issue Paper #4 on *Guidance on Applying Capacity and LOS Tools in Planning Stages*.) Reflecting the importance of Florida's capacity volumes, the 2007 LOSPLAN programs have been updated to feature warnings and messages about exceeding these volumes.

FDOT will accept HCS operational analyses if they are appropriate to supplement LOSPLAN analyses. However, a separate check of HCS results to insure they do not exceed the maximum volumes must be conducted. The HCS capacity results and other LOS threshold values should be adjusted to meet Florida's maximum acceptable capacity volumes. Of special note, is the HCS's analysis of freeways. Applying the HCM directly results in higher volumes than typically seen on Florida and other U.S. freeways. If FDOT allows a different analytical tool to supplement LOSPLAN analyses, the results of those tools also should be checked to insure they do not exceed the Florida maximum acceptable capacity volumes.

Approval of volumes higher than typical Florida maximum acceptable capacity volumes

FDOT Districts and Central Office are expected to routinely reject analyses with higher facility volumes than shown above. Nevertheless, properly conducted highway capacity and LOS analyses may occasionally indicate capacities higher than the maximum acceptable capacity values. Under such circumstances the following approval processes apply.

If the facility being analyzed is not part of the Strategic Intermodal System (SIS), a SIS connector, part of the Florida Intrastate Highway System (FIHS) or a Transportation Regional Incentive Program (TRIP) roadway, FDOT District LOS Coordinators have the authority to approve higher volumes if they believe such volumes are representative of specific roadway conditions. However, they are under no obligation to do so, and may routinely submit these analyses to the FDOT's Central Office LOS Unit for review. If the analysis is for a SIS or other facility listed above, FDOT districts are expected to seek concurrence with the Central Office LOS Unit before approving such high capacity volumes. Only an FDOT district may submit a request to the Central Office LOS unit for approval of higher volumes.

Inappropriate Use of Volume to Capacity (v/c) Ratios for LOS

As discussed in Issue Paper #12 (*Obtaining and Determining Key Highway Capacity/LOS Input Data*) demand volumes should be used, not necessarily measured volumes, to determine v/c ratios for LOS calculation for concurrency and other growth management topics. Furthermore, capacity analysis is based on hourly or sub-hourly time periods, such that "daily volume to capacity ratios" are meaningless. Volume to capacity ratios are only appropriate during hourly or sub-hourly periods. Issue Paper #11 (*Minimum/Maximum Acceptable Input Values*) contains FDOT's minimum K factors to convert hourly demand volumes so that volumes can be presented in daily terms which are more familiar to the general public.

Contacts on topic:
FDOT District LOS Coordinators
FDOT Central Office – Gina Bonyani

ISSUE #11 - MINIMUM/MAXIMUM ACCEPTABLE INPUT VALUES

This paper is intended to provide clear guidance on the limits of acceptable input values. It is intended to be applied in tandem with Issue Paper #10 on *Maximum Acceptable Capacity Volumes* to help insure LOS analyses are appropriate.

Ten variables have a significant impact on calculated volumes in capacity and LOS analyses along an urban arterial and are presented on page 41 of the Q/LOS Handbook. Although statewide default values may be reasonable to use in a conceptual planning analysis, site specific values for all 10 key variables should be used for specific segment analyses. Based on the importance of those 10 variables, the updated ARTPLAN program highlights the variables and requires analysts to provide specific values before the program calculates capacity and LOS. Four key variables affect freeways and seven key variables affect generally uninterrupted flow highways and are highlighted in FREEPLAN and HIGHPLAN, respectively.

Based on statewide applications of LOSPLAN, inappropriate input values appear most frequently for the following 3 variables:

- Planning analysis hour factor (K),
- Directional distribution factor (D), and
- Effective green ratio (g/C).

In order to help analysts avoid input mistakes and to help reviewers of LOS analyses, the updated LOSPLAN programs now provide warnings and messages if values for these variables lie outside the normally acceptable ranges that occur using FDOT's K_{100} study period analysis option.

FDOT continues to recommend the use of demand K_{100} and D_{100} values (see Issue Paper #12 on *Obtaining and Determining Key Highway Capacity/LOS Input Data* for a more detailed discussion). (**Minimum K_{100} and D_{100} factors are not default values. They should only be used in an LOS analysis if adequate justification is provided for the specific roadway**).

Minimum acceptable K_{100} input values

- Large urbanized and other urbanized areas
    - Freeways – 0.085
    - Arterials – 0.09
    - Highways – 0.09
- Transitioning and urban areas (all facility types) – 0.09
- Rural developed and rural undeveloped areas (all facility types) – 0.095

Minimum acceptable D_{100} input value

- D_{100} (all area and facility types) – 0.52

Joint K_{100} and D_{100} considerations

The above K_{100} and D_{100} values reflect only a slight change to the values found on page 67 of the Q/LOS Handbook. In developing the values, FDOT's data base of unconstrained traffic permanent count stations were used for the years 2001-2003.

It is considered an acceptable practice to obtain measured K_{100} and D_{100} factors from FDOT's traffic information DVD as long as the above minimums are met. If they are not met, the respective K_{100} and D_{100} values must be raised to the minimum acceptable values.

The use of both the minimum K_{100} and D_{100} values in a single analysis is not an acceptable practice and should raise a "red flag" to reviewers about the reasonableness of a study.

Maximum acceptable through movement g/C input values

The maximum acceptable "facility" through movement effective green ratios (g/C) during the peak hour typically should not exceed:

- State principal arterials
    - Current year – 0.50
    - Long term (>= 10 years out) – 0.47
- Other roadways– 0.44

Under most circumstances arterial "facility" lengths are 1.5-5.0 miles and include principal arterials as termini (see Issue Paper #6 on *Partitioning of Roadways for LOS Analysis* for a more complete description). The g/C value of 0.50 approximates FDOT's maximum allowable arterial capacity volumes of 1000 vphpl and 950 vphpl in large urbanized areas and other urbanized areas, respectively (see Issue paper on *Maximum Acceptable Capacity Volumes*).

Through movement g/Cs vary widely for individual intersections and different hours of the day. Therefore, ARTPLAN's acceptable g/C range for individual intersections is 0.1 to 1.0. Along principal arterials it is not unusual for the arterial to have g/C ratios in the 0.5 to 0.7 range at many intersections. However, as the analysis length is increased from an individual intersection, to a segment, to a section, and on to a facility (see Issue Paper #5 on *Highway System Structure Terminology Related to Highway Capacity and LOS Analyses*), the probability that the arterial intersects other arterials increases. Furthermore, when two principal arterials intersect, the g/Cs for the through movements are in the range of about 0.40. To reflect these wide ranges in g/C values and upper limits of a "facility" g/C ratio, the updated ARTPLAN allows individual intersections to have a g/C ratio of up to a 1.0, but it provides warnings and messages if the 0.50 facility g/C ratio is exceeded.

Verification of g/C values should be provided by the applicant. For detailed information on the collection and verification of g/C values, see Issue Paper #12 on *Obtaining and Determining Key Highway Capacity/LOS Input Data.*

Contacts on topic:
FDOT District LOS Coordinators
FDOT Central Office – Gina Bonyani

ISSUE # 12 - OBTAINING AND DETERMINING KEY HIGHWAY CAPACITY/LOS INPUT DATA (USE OF FIELD DATA AND OTHER DATA SOURCES) (SPECIFIC VARIABLE INPUT GUIDANCE)

Ten variables have a significant impact on capacity calculations and LOS analyses along an urban arterial. These variables are listed on page 41 of the Q/LOS Handbook. Four key variables affect freeways and seven key variables affect generally uninterrupted flow highways. Statewide default values for the other roadway, traffic and control variables may be reasonable to use in a conceptual planning analysis; however, roadway specific values should be used for these ten variables. Since there are concerns with the use of four of these inputs (AADT, K, D, g/C), this issue paper provides supplemental discussion and guidance on obtaining and determining the data for these inputs. Updated guidance is also provided on percent turns from exclusive lanes.

Traffic volume data

Traffic volume is the most basic of all traffic inputs. It is generally defined as the number of vehicles passing a point on a highway during a specified time period. Traffic volumes typically are developed separately from capacity/LOS analyses and provide input to that analysis. Various sources include:

- FDOT's Project Traffic Forecasting Handbook,
- Extrapolation of historical growth trends
- FDOT's travel demand forecasting models, and
- ITE's Trip Generation Handbook.

Traffic demand volumes

Volume is the parameter most often used to quantify traffic demand. Traffic demand is the number of vehicles that desire to traverse a particular highway during a specified time period. While traffic demand expresses a desire, volume typically represents actual measurement.

Misuse of measured volumes often occurs in capacity/LOS analyses. Traffic studies result in the observation and measurement of conditions as they presently exist. Current observations do not reflect constraints in the existing highway system that may prevent vehicles from accessing a desired segment of the system at any given point in time. Observed volumes on congested facilities are more a reflection of capacity constraints than of true demand.

Traffic volume cannot theoretically exceed roadway capacity, but traffic demand can. An example of a common misinterpretation of these two distinct terms typically occurs while collecting traffic turning movement data at an oversaturated intersection. The traffic volume that can physically be processed through a traffic signal is a measure of the capacity (or supply). When traffic volumes approach roadway capacity, the transportation system may experience abnormally long vehicle queues and excess vehicular delay. The length of the vehicle queue upstream of a traffic signal is a more accurate measure of the traffic demand that cannot be processed in the on-hour analysis period.

The impact of bottlenecks, alternative routes, latent demand, and future growth further complicate the relationship between measured traffic volume (V) and traffic demand (v). If questions arise as to the appropriateness of using "measured volumes" or "demand volumes" for capacity and LOS analyses, it is clear "demand volumes" should be used. Deriving demand volumes is discussed in the following sections in conjunction with Issue Paper #11 on *Minimum/Maximum Acceptable Input Values.*

Annual average daily traffic (AADT)

Annual average daily traffic (AADT) is the total volume on a highway segment/section for one year divided by the number of days in the year. Most planning and preliminary applications begin with AADT volumes. As stated above, determining AADT values is a separate process and distinct from capacity/LOS analyses.

Planning analysis hour factor (K_{100})

FDOT's LOS Rule 14-94, F.A.C., specifies the use of the 100th highest traffic hour of the year for planning purposes. In developed areas, the 100th highest volume hour of the year is representative of a typical weekday peak hour traffic hour during the peak travel season. To convert AADT values to the 100th highest hour, the K_{100} factor is used. It is the ratio of the 100th highest traffic volume hour of the year to the AADT.

Whether intentional or not, the K_{100} is probably the most frequently misused parameter in capacity/LOS analyses in Florida. Misapplication of K_{100} can make huge differences in capacity/LOS analyses. 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 the peak hour by the measured daily volume. In the Florida professional community, peak to daily ratios are frequently misapplied as K factors. Another source of misunderstanding is that FDOT's statewide typical and minimum acceptable K_{100} values represent "demand volumes" during the 100th highest hour, not necessarily measured volumes. FDOT's minimum acceptable K_{100} values are presented in Issue Paper #11 on *Minimum/Maximum Acceptable Input Values*.

The preferred approach is to obtain K_{100} data from the Florida Traffic DVD and to adjust them upward if they do not meet the statewide minimum acceptable values (see Issue Paper #11 on *Minimum/Maximum Acceptable Input Values*). If a K_{100} value from Florida Traffic DVD is above the minimum acceptable value it may be used. If the value is below the minimum acceptable value, then it is accepted practice to use the statewide minimum acceptable value. This check helps to insure that traffic volumes reasonably reflect demand conditions.

Alternatively, 3-day (i.e., 72-hour Tuesday through Thursday) on-site field traffic data counts may be used to estimate K_{100}. That process is found in FDOT's Q/LOS Handbook (pages 65-66). It requires 3-day counts in urbanized, transitioning, and urban areas, and 7-day counts in rural areas. Calculation of K_{100} based on 1-day or 2-day counts is not acceptable.

(**Notes** – (1) The K_{100} calculation process in the Q/LOS Handbook makes use of peak season factors. FDOT's peak season factors are now presented as less than 1.0. Therefore following the

procedure in the Q/LOS Handbook, the factor should be divided by instead of multiplied by the adjusted peak season factor. (2) Some confusion has recently surfaced about these 3-day counts being used as described above and 3-day counts to determine AADT. The process in the Handbook is for the determination of K_{100} and is independent of the calculation of AADT.)

Directional Distribution Factor (D)

The directional distributional factor (D) is used to convert AADT to directional peak traffic. The peak hour D factor is the proportion of an hour's total volume occurring in the higher volume direction.

The preferred approach is to obtain D_{100} data from the Florida Traffic DVD and to adjust them upward if they do not meet the statewide minimum acceptable values (see Issue Paper #11 on *Minimum/Maximum Acceptable Input Values*). If a D_{100} value from Florida Traffic DVD is above the minimum acceptable value it may be used. If the value is below the minimum acceptable value, then it is accepted practice to use the statewide minimum acceptable value.

Alternatively, 3-day (i.e., 72-hour Tuesday through Thursday) on-site field traffic data counts may be used to estimate D_{100}. That process is found in FDOT's Q/LOS Handbook (pages 67-68). It requires 3-day counts in urbanized, transitioning, and urban areas, and 7-day counts in rural areas. Calculation of D_{100} based on 1-day or 2-day counts is not acceptable.

Peak hour directional volumes

Although for planning and preliminary engineering purposes AADT is usually used, actual capacity and LOS analyses are conducted on an hourly or subhourly directional basis. For example, all FDOT's generalized LOS tables are based on peak hour (100th highest) directional roadway, traffic, and control characteristics. FDOT's "daily" tables are probably the most widely used in the U.S. Nevertheless, it should be recognized that they are based on hourly directional analyses. FDOT's hourly directional tables may be viewed as the most fundamental of the tables because the daily tables are created by dividing the peak hour directional values by the directional distribution factor (D) and the planning analysis hour factor (K). Although determination of AADTs is outside the capacity/LOS analyses, determination of K and D is a fundamental part of capacity/LOS analyses in planning and preliminary engineering stages because of the need to convert AADT to peak hour directional volumes.

Field traffic data collection

If FDOT's preferred processes for determining K_{100}, D_{100}, and g/C values are followed, there will be no need for extensive field data collection for conceptual planning capacity/LOS analyses. Nevertheless, consideration should be given to the collection of turning movement counts at key intersections.

Percent turns from exclusive turn lanes

The accuracy of capacity/LOS calculations may be highly dependent on the percent turns from exclusive turn lanes. In most cases, it is of moderate importance, but at some key intersections it may be one of the most significant variables. These are used to obtain percentage of turns only to be applied to demand volumes. FDOT's accepted process is shown on page 73 of the Q/LOS Handbook. Capacity/LOS analysts and reviewers should agree at which intersections turning counts will be collected.

Through movement effective green to cycle length ratio (g/C)

One of the most critical inputs to calculating highway capacity and LOS on a signalized roadway is the through movement's effective green time to signal cycle length ratio (g/C). It is typically the most important factor for determining the capacity of a roadway's through movement at any given intersection, and for the roadway as a whole, at its critical intersection. Yet, for planning and preliminary engineering analyses g/C is seldom addressed. There are many good reasons for this lack of consideration:

- g/Cs typically vary from intersection to intersection along an arterial;
- g/Cs typically vary by time of day;
- Planning staff typically are not knowledgeable in signal operations (signal phasing, treatment of "lost time") and choose to avoid it.

However, ignoring g/C makes any arterial LOS analysis at a generalized planning or preliminary engineering level suspect. Essentially, guidance is needed providing default g/Cs for generalized planning arterial analyses and for determining g/Cs at a conceptual planning/preliminary engineering level.

Three approaches are acceptable for determining an arterial's existing through movement g/C for a conceptual planning capacity/LOS analysis. The approach to be used for capacity/LOS analysis should be agreed upon early in the process so that the determination of g/C is not performed to the benefit of any one party. (**Note**: all three approaches presented below are different from what appears in the Q/LOS Handbook, page 79.)

In the discussions below, for the through movement phase, "G" is the green displayed time, "Y" the yellow displayed time (typically 3 seconds), and "R" the "all red" indication (typically 1 second). "C" is the cycle length. The most representative situation in Florida is for cycles to consist of 4 phases and 12 indications: a phase to accommodate the main road through movement, the side road left movement, the side road through movement, and the main road left movement, with G, Y and R indications for each phase. "g" refers to the effective green time which includes consideration vehicular start up and clearance lost times.

The preferred, most accurate, consistent, and verifiable method is to obtain from the traffic operations agency the actual signal timings (i.e., G/C for the through movement) for the 5-6 p.m. weekday time period for each signalized intersection. Signal timing plans showing the maximum times for each signal indication are typically available, the actual signal timings may not be. Every reasonable effort should be used to obtain these actual signal timings. (Use Worksheet 1 for submittal of required data.)

The second alternative offers the potential for high accuracy, but is subject to less consistency and greater potential misuse by an affected party. This process consists of obtaining the through movement G/C in the field at each signalized intersection during the 5-6 p.m. weekday time period. For major intersections, 9 consecutive G/Cs are to be collected and the median is to be used for analytical purposes. For other signalized intersections 5 consecutive G/Cs are to be collected and the median is to be used for analytical purposes. (Use Worksheet 2 for submittal of required data.)

The third alternative is to use the actual signal timing plans from the traffic operations agency for the 5-6 p.m. weekday time period for each signalized intersection. This approach offers outstanding consistency in the determination of g/C values, but probably yields less accuracy than the second approach. If the signal is semi-actuated or actuated, use the (G+Y+R)/C for the through movement. By doing so, this assumes the Y+R time (usually 4 seconds) equals additional time allocated to the through movement as a result of unused time from the other movements. If the signal is pretimed, then use the G/C for the through movement. (Use Worksheet 3 for submittal of required data.)

Notations in signal timing plans and actual signal timings vary throughout the state. When submitting g/C information for review to FDOT, the information should be placed in the following attached applicable format for each of the 3 alternatives presented above.

FDOT's maximum acceptable "facility" g/C values are presented in Issue Paper #11 on *Minimum/Maximum Acceptable Input Values*.

Contacts on topic:
FDOT District LOS Coordinators
FDOT Central Office – Gina Bonyani

Worksheet 1

g/C Documentation (Actual Signal Timing Alternative[1])

Date_____ (Time of analysis: Circle yes if exactly 5-6 p.m. weekday; if not, indicate time _____)

Road Name	Intersection Name	Primary Road Through			Side Road Left			Side Road Through			Primary Road Left			Cycle Length	Control Type	Primary Road Through	Primary Road Left
		G	Y	R_{pa}	G	Y	R_{pa}	G	Y	R_{pa}	**G**	Y	R_{pa}	**C**	(a,s,p)	G/C	G/C

1. Note: these are the actual, recorded signal timings, not the timings from a signal timing plan. Signal indications in bold are the only ones used to determine applicable effective green ratios (g/Cs). The other indications are for documentation purposes.

Signal indications:
G = The duration in seconds of the green indication for a given movement at a signalized intersection
Y = The duration in seconds of the yellow indication for a given movement at a signalized intersection
R_{pa} = The duration in seconds of the "all red" indication for a given movement phase at a signalized intersection (typically 1 second)

Control types:
a = Actuated control
s = Semiactuated control
p = Pretimed control

Source: Florida Department of Transportation, Systems Planning Office, August 21, 2007

Worksheet 2

g/C Documentation (Field Data Alternative)

Primary Road Name _____ Intersecting Road Name _____
Date_____ (Time of analysis: Circle yes if between 5 – 6 pm weekday; if not, indicate time _____)

Cycle Number	Primary Road Through			Cycle Length	Primary Road	Control Type	Primary Road	
	G	Y	R_C	C	Left G	(a,s,p)	Through G/C	Left G/C
1								
2								
3								
4								
5								
6								
7								
8								
9								

Signal indications:
G = The duration in seconds of the green indication for a given movement at a signalized intersection
Y = The duration in seconds of the yellow indication for the primary road through movement
R_C = The duration in seconds of the red indication for the primary through movement during the cycle

Control types:
a = Actuated control
s = Semiactuated control
p = Pretimed control

Source: Florida Department of Transportation, Systems Planning Office, 2007.

Worksheet 3

g/C Documentation (Signal Timing Plan Alternative)

(Time of analysis: Circle yes if exactly 5-6 p.m. weekday; if not, indicate time _____)

Road Name	Intersection Name	Primary Road Through			Side Road Left			Side Road Through			Primary Road Left			Cycle Length	Control Type	Primary Road Through	Primary Road Left
		G	**Y**	**R_{pa}**	G	Y	R_{pa}	G	Y	R_{pa}	**G**	Y	R_{pa}	**C**	(a,s,p)	$(G+Y+R_{pa})/C$	G/C

Signal indications in bold are the only ones used to determine applicable effective green ratios (g/Cs). The other indications are for documentation purposes.

Signal indications:
G = The duration in seconds of the green indication for a given movement at a signalized intersection
Y = The duration in seconds of the yellow indication for a given movement at a signalized intersection
R_{pa} = The duration in seconds of the "all red" indication for a given movement phase at a signalized intersection (typically 1 second)

Control types:
a = Actuated control
s = Semiactuated control
p = Pretimed control

Source: Florida Department of Transportation, Systems Planning Office, August 21, 2007

ISSUE #14 - FUTURE YEAR CAPACITY/LOS ANALYSES (Draft)

This paper is currently under review by FDOT. Districts have flexibility on its implementation.

Traffic and development conditions change on roadways over time. This raises questions as to what LOS standards, input values, and analysis tools should be used for capacity/LOS analyses in future years. Under general circumstances FDOT's LOS standards apply throughout the planning period. This paper will address five input values for future years as well as appropriate analysis tools.

Planning years and horizons

Analysis years and planning horizons vary appreciably in transportation planning. Frequently cited years are:

- Most recent year with traffic data;
- Current year;
- 3 years from the current year;
- 5 years from the current year;
- 10 years from the current year;
- 20 years from the current year;
- 25 years from the current year; and,
- 50 years from the current year.

For this issue paper the terms "long term" means 10 or more years from the current year and "short term" means less than 10 years from the current year. Recommendations and conclusions can be interpolated between the current year and 10 years in the future, and extrapolated after 10 years.

Annual average daily traffic (AADT)

For conducting generalized planning, conceptual planning, or operational analyses, annual average daily traffic (AADT) is usually a fundamental input. AADT is the total volume on a highway segment for one year divided by the number of days in the year. AADT and other traffic volume data are typically developed independently and provided for capacity/LOS analyses. For example, historical growth trends and the state's travel demand forecasting models are typically used for long term traffic projections. Analysts and reviewers of capacity and LOS analyses need to agree on what future AADT values to use.

GENERALIZED PLANNING ANALYSIS

For generalized analyses, FDOT's LOS standards and Generalized Service Volume Tables apply for the various area types throughout the planning period. With projected AADT and the generalized tables, an approximate LOS can be determined for any roadway in future years

CONCEPTUAL PLANNING ANALYSIS – Key Input Values for Future Years

For site specific applications five key input variables are at the forefront: AADT, planning analysis hour factor (K), directional distribution factor (D), effective green to cycle length ratio (g/C) and signal density. Obtaining current year data on the first four of those inputs is addressed in Issue Paper #12 on *Obtaining and Determining Key Highway Capacity and LOS Input Data*. The following provides guidance on the latter four variables for future years.

Planning analysis hour factor (K_{100})

FDOT's LOS rule specifies the use of the 100th highest traffic hour of the year for planning purposes. In developed areas, the 100th highest volume hour of the year is representative of a typical weekday peak hour traffic hour during the peak travel season. To convert AADT values to the 100th highest hour, the K_{100} factor is used. It is the ratio of the 100th highest traffic volume hour of the year to the AADT.

As areas become more developed (see Issue Paper #7 on "*Area Types*") and/or development occurs along roadways, measured K_{100} values drop primarily for two reasons. The first is that more urban situations typically are not subject to highly volatile volumes like holiday traffic in rural areas. Generally, more developed areas are subject to frequent recurring volumes such as weekday commuter traffic. The second is that as congestion develops, spreading of the peak travel hour traffic also occurs. For future year capacity/LOS analyses the first consideration is appropriate to include while the second is not. The second consideration should not be included because capacity/LOS analyses make use of traffic demand volumes (see Issue Paper #12 on *Obtaining and Determining Key Highway Capacity/LOS Input Data*).

Presently, typical demand K_{100} values for various area and facility types are found on the back of FDOT's generalized tables in the 2002 Q/LOS Handbook (pages 85-102). In the short term, demand K_{100} values can be estimated by FDOT's procedure involving 3-day counts (see Issue Papers #12 and #11 on *Obtaining and Determining Key Highway Capacity/LOS Input Data* and on *Minimum/Maximum Acceptable Input Values*). In the long term, if a current K_{100} value is

- below the statewide typical value, the calculated value is appropriate for continued use as long as it is above the minimum acceptable K_{100} value; or
- above the statewide typical value, the statewide typical value is appropriate for use.

Directional Distribution Factor (D)

The directional distributional factor (D) is used in converting AADT to directional peak traffic. The peak hour D factor is the proportion of an hour's total volume occurring in the higher volume direction.

In the short term, D values as determined by a current 3-day analysis should be used (see Issue Papers #11 and #11 on *Obtaining and Determining Key Highway Capacity/LOS*

Input Data and on *Minimum/Maximum Acceptable Input Values*). Under demand traffic conditions, typical statewide D values hover around 0.55 for all area types and facility types. In the long term, if a current D value is

- below the statewide typical value, the calculated value is appropriate for continued use as long as it is above the minimum acceptable D value; or
- above the statewide typical value, the statewide typical value of 0.55 is appropriate for use.

General discussion on control variables

In general, control variables refer to roadway traffic controls including traffic signals timing and density. To determine a signalized roadway's capacity and LOS, control data is essential. Yet, for many planning studies they are either not addressed or treated so generally as to be nearly meaningless. For reasonable planning and preliminary engineering analyses of signalized roadways, control variables must be addressed both in the short term and in the long term. In most cases, the two most important control variables are the through movement effective green to cycle length ratio (g/C) and signal density, which are discussed below.

Through movement effective green to cycle length ratio (g/C)

A roadway's through movement effective green time to signal cycle length ratio (g/C) is typically the most important factor for determining the capacity of a roadway's through movement at any given intersection and for the roadway as a whole at its critical intersection. Determining current and future g/Cs for a roadway is complicated and judgments must be made.

Determining current g/Cs is discussed in Issue Paper #12 on *Obtaining and Determining Key Highway Capacity/LOS Input Data*. A roadway's current year and long term maximum acceptable g/Cs are presented in Issue Paper #11 on *Minimum/Maximum Acceptable Input Values*.

In the short term:

- For arterial Classes II, III, and IV, continued use of existing g/Cs is appropriate,
- For Class I arterials with low speeds in small towns or Class I arterials not subject to significant development pressure, continued use of existing g/Cs is appropriate,
- For relatively high speed (posted 45 mph) Class I arterials incurring significant new development pressure, it is appropriate to lower through movement g/Cs,
- For new signals, through movement g/Cs will vary greatly; however, for planning purposes none should be assumed to be higher than 0.55.

In the long term:

- For arterial Classes II, III, and IV, continued use of existing g/Cs is appropriate,
- For Class I arterials with low speeds in small towns or Class I arterials subject to minimal development pressure, continued use of existing g/Cs is appropriate,
- For relatively high speed (posted 45 mph) Class I arterials incurring more than minimal development pressure, it is appropriate to lower through movement g/Cs,

- For new signals, through movement g/Cs will vary greatly; however, for planning purposes none should be assumed to be higher than 0.55.

Using ARTPLAN an acceptable way to project g/C ratios in the long term is by assuming a through g/C of 0.40 at all major intersections (typically state arterials) and 0.55 at other intersections. This is based on an assumption that each of the major arterial facilities gets an equal amount of green time for their approaches, minus the green time for accommodating left turning vehicles. Corresponding left and right turn percentages for each are 15% at major intersections, and 5% at other intersections.

Using HCS an acceptable way to estimate future g/C ratios is by conducting intersection capacity analyses. HCS will determine the required g/C ratios to progress through traffic movements on the major street, while simultaneously minimizing delay to the minor street approaches.

Signal density

As areas grow in population, additional traffic signals are frequently installed. Usually these new signals do not significantly affect the capacity of roadways unless they are in a previously undeveloped area or are so closely spaced that queue spillback blockage occurs. They can play a major role in the determination of LOS if stops occur more frequently and average travel speeds drop.

In both short and long term analyses, it is appropriate to consider the probability of new traffic signals, especially based on proposed new developments. In the absence of specific development plans or intersecting traffic volume cross-product signalization criteria, the following offers generalized guidance for use in developed areas.

In short term:

- For arterial Classes II, III, and IV, continued use of existing signalized intersection locations is appropriate,
- For Class I arterials with low speeds in small towns or not subject to significant development pressure, continued use of existing signalized intersection locations is appropriate,
- For relatively high speed (posted 45 mph) Class I arterials incurring significant new development pressure, one additional signalized intersection per mile may be assumed.

In the long term:

- For arterial Classes III and IV, continued use of existing signalized intersections is appropriate,
- For Class II, one additional signalized intersection per mile may be assumed,
- For Class I arterials with low speeds in small towns one additional signalized intersection per mile may be assumed,
- For relatively high speed (posted 45 mph) Class I arterials incurring more than minimal development pressure, it is appropriate to assume they become Class II arterials with at least 2 signalized intersections per mile.

Because of the wide variety of circumstances along generally uninterrupted flow highways in rural areas, no specific guidance can be given on future signal locations. However, for capacity/LOS purposes the possibility of new signalized intersections should be considered.

Because of the importance of signal density on LOS on state roadways, for site impact applications the number of new signals should be reviewed and approved by the FDOT district prior to use in an analysis.

Other roadway, traffic, and control input data

Typically, other roadway, traffic and control variables do not have as large of an effect on capacity/LOS as the ones addressed above. If some of these other inputs (i.e., turning movement counts) were determined in a current year analysis, they can usually be applied to future year analyses. If these other variables were not determined for a current year analysis, the statewide default values appearing on the back of FDOT's Generalized LOS Volume Tables in the Q/LOS Handbook (pages 85-102) may be assumed.

APPROPRIATE ANALYTICAL TOOLS FOR FUTURE YEAR ANALYSES

Travel demand forecasting models, the HCM and accompanying HCS software, and simulation tools are appropriate tools for future years. FDOT's LOSPLAN software programs were also developed to address LOS in future years. Recent discussions have occurred in Florida about the use or misuse of capacity/LOS software for planning applications in future years. In most situations the basis for concern is not the tools themselves, but the assumptions and subsequent input values used in application of the tools.

In Florida, FDOT's generalized LOS volume tables are almost universally accepted for generalized planning purposes (see Issue Paper #4 on *Guidance on Applying Capacity and LOS Tools in Planning Stages*). Because of uncertainty in traffic and signal control conditions in future years they become more applicable as they do not imply a great deal of numerical precision.

FDOT's LOSPLAN software programs are specifically applicable and are typically the most appropriate tool to conduct conceptual planning capacity/LOS analyses in future years. It is imperative that appropriate assumptions and input values be used in the programs (as it is for travel demand forecasting models, the HCS, and simulation programs), and should comply with the guidance provided in the previous sections of this issue paper and in other issue papers (#12 on *Obtaining and Determining Key Highway Capacity/LOS Input Data*, and #11 on *Minimum/Maximum Acceptable Input Values*).

Contacts on topic:
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ISSUE #15 – WHAT IS NEW IN LOSPLAN AND THE GENERALIZED SERVICE VOLUME TABLES

Introduction

The last major revision of the LOSPLAN suite of software packages was in 2003, concurrent with the release of the 2002 Quality/Level of Service Handbook. Since that time:

- Some issues with the HCM 2000 have been identified in recently released errata, most notably the two-lane highway analysis methodology;
- FDOT's Systems Planning Office and contracted researchers have carried out several research projects that impact the LOS analysis methodologies for the handbook and software; and
- FDOT updated its LOS Rule Chapter 14-94 (FAC) on Statewide Minimum Level of Service Standards.

Overview

The first section of this paper outlines general changes to each of the LOSPLAN programs. The second section lists the specific data input fields that have changed between the LOSPLAN 2002 and LOSPLAN 2007 program versions. The last section addresses FDOT's generalized service volume tables.

General Changes:

ARTPLAN

ARTPLAN 2007 maintains much of the same look and feel of ARTPLAN 2002. All of the previous features, such as input validation, dynamic field value updating, separately formatted reports for printing, context sensitive help, and data exchange capability with other XML compliant transportation software applications, are all maintained in this version. Major new features include the capability to analyze the off-peak direction and to analyze up to 14 segments. The multimodal input screens have also been changed such that the data for all active segments can be viewed at the same time. Many other user interface (UI) enhancements have been made to this version, particularly with respect to screen navigation, such as 'Back' and 'Next' buttons and tabs at the bottom of the screen, in addition to the toolbar buttons and menu elections.

Major changes to the analysis methodology include a revised calculation procedure for adjusted saturation flow rate (based on FDOT final report DO2319, "Guidelines for Quantifying the Influence of Area Type and Other Factors on Saturation Flow Rate"), additional performance measures, such as free-flow delay and LOS threshold delay, and inclusion of a left-turn queue spillover calculation. In addition, input data validation has been enhanced with respect to critical variables, such as AADT/hourly volume and weighted g/C ratio. Critical input variables are now highlighted in blue and require the user to input facility specific values as they no longer appear with statewide default values.

HIGHPLAN

HIGHPLAN 2007 maintains much of the same look and feel of HIGHPLAN 2002. All of the previous features, such as input validation, dynamic field value updating, separately formatted reports for printing, context sensitive help, and data exchange capability with other XML compliant transportation software applications, are maintained in this version.

Major changes to the analysis methodology include revisions to the calculation of percent time spent following (PTSF) for two-lane highways (based on NCHRP Report 20-7(160). As a result of implementing the PTSF calculation revisions, HIGHPLAN now uses PTSF (or average travel speed [ATS]) under certain conditions) as the service measure for 'rural undeveloped' highways instead of v/c ratio (as was used in HIGHPLAN 2002). Additional performance measures have been added as well, namely free-flow delay and LOS threshold delay. Input data validation has also been enhanced with respect to critical variables, such as AADT/hourly volume.

FREEPLAN
FREEPLAN 2007 maintains much of the same look and feel of FREEPLAN 2002. All of the previous features, such as input validation, dynamic field value updating, separately formatted reports for printing, context sensitive help, and data exchange capability with other XML compliant transportation software applications, are maintained in this version. The analysis methodology has been expanded to incorporate the effects of ramp metering, acceleration/deceleration lane extensions, auxiliary lanes, off-ramp queuing, and oversaturation. Additional performance measures have been added as well, namely free-flow delay and LOS threshold delay. Input data validation has also been enhanced with respect to critical variables, such as AADT/hourly volume. In addition a warning alerts the user if an off-ramp backs up onto the mainline.

Data Input Field Changes
This section identifies the differences between the data input fields of the LOSPLAN 2002 and LOSPLAN 2007 programs.

ARTPLAN
Project Properties Screen

Changed
- Area Type (list of choices)
- Study Period (list of choices)

Added
- Modal Analysis
- Type of Analysis

Facility Data Screen

Changed
- % Turns Excl. Lanes → % Left Turns, % Right Turns
- Left Turn Lanes → Exclusive Left Turn Lane(s), Exclusive Right Turn Lane(s)

Added
- Left turn bay storage length
- Left g/C

- Signals/Mile → # of Signals, Arterial Length
- Peak Dir. Hourly Volume (input for 'Dir Hr Demand Vol' study period)

Off Peak inputs for:

- Off Peak Dir. Hourly Volume (input for 'Dir Hr Demand Vol' study period)
- % Heavy Vehicles
- % Left Turns
- % Right Turns
- Arrival Type

Removed
Local Adj. Factor

Intersection Data

Changed
- % Turns Excl. Lanes → % Left Turns, % Right Turns

Added
- Left g/C
- Excl. Lanes—Right

Off Peak inputs for all inputs available for Peak direction

Segment Data Screen
Added
- # Thru Lanes

Off Peak inputs for all inputs available for Peak direction

HIGHPLAN

Changed
- Area Type (list of choices)
- Study Period (list of choices)

Added
- Segment Length
- Peak Dir. Hr. Vol. (input for 'Dir Hr Demand Vol' study period)
- Segment Length

Off Peak inputs for:
- Off-peak Dir. Hr. Vol. (input for 'Dir Hr Demand Vol' study period)

FREEPLAN

Added
- Freeway Length
- Aux Lanes (Y/N)
- Accel/Decel Lanes to 1500 feet (Y/N)

Ramp analysis features added
- Ramp Analysis (Y/N)
- Off ramp length
- Signal Location (at end of ramp, downstream from off ramp, no signal)

- Ramp Metering (Y/N)
- Aux Lanes number per segment

- Signal Type (actuated or pretimed?)
- g/C Ratio
- Cycle Length
- Percent off ramp volume moving on right turn on red
- Distance to signal from off ramp's end
- Arrival flow rate to signal not from ramp
- Arrival type of vehicles on arterial
- Number of lanes on arterial at signal
- Percent off ramp volume moving on right turn on red

Generalized Service Volume Tables

- The maximum service volume tables are identical to those in the 2002 QLOS Handbook except for
  - Volume changes to the two-lane highway methodology reflecting the corrections to the HCM2000.
  - Due to methodological changes in the LOSPLAN software, no default values are printed on the back. Several methodologies have been updated and there are new input values which were not in the 2002 LOSPLAN software. If the default values were inserted into LOSPLAN 2007, and reasonable planning assumptions made for the new inputs, the results would be similar but not be identical to the 2002 tables in most cases.
  - Minor editorial changes.

ISSUE #16 - MINIMUM TRAINING REQUIREMENTS FOR FDOT CONSULTANTS USING LOSPLAN

In order to assure consistent application and review of LOSPLAN analyses across the state, the following guidance is provided:

Consultants working for FDOT, who perform LOSPLAN analyses or reviews for the Department, must attend a FDOT training class on the use of LOSPLAN. In extenuating circumstances, these consultants can be trained in-house on a one-to-one basis, but their work must be carefully checked to ensure that they have mastered the program. Those trained in this manner should attend a training class at the earliest possible opportunity.

If consultants are working with LOSPLAN for non-FDOT clients, it is highly recommended their firms have at least one person in each office attend an FDOT training class. They in turn can make sure that those in their office are trained in its use. These additional users can either attend a training class or be taught in house.

Training schedules can be found on the FDOT Systems Planning LOS website:
http://www.dot.state.fl.us/planning/systems/sm/los/default.htm
In addition anyone who downloads LOSPLAN is entered into the FDOT Contact Database. Training announcements will be periodically e-mailed to those who download the software.

Although no certification process is proposed, FDOT District LOS Coordinators have the authority to determine whether consultants have met this training requirement.

Contacts on topic:
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