

ADAPTATION OF THE HCM2000 FOR PLANNING LEVEL ANALYSIS OF TWO-LANE AND MULTILANE HIGHWAYS IN FLORIDA

Scott S. Washburn

Department of Civil and Coastal Engineering
University of Florida
511 Weil Hall, PO Box 116588
Gainesville, FL 32611-6588
352-392-7575 (phone)
352-392-3394 (fax)
swash@ce.ufl.edu

Douglas S. McLeod

Florida State Department of Transportation
605 Suwannee Street, MS 19
Tallahassee, FL 32399-0450
850-414-4932 (phone)
850-921-6361 (fax)
douglas.mcleod@dot.state.fl.us

Kenneth G. Courage

Department of Civil and Coastal Engineering
University of Florida
511 Weil Hall, PO Box 116588
Gainesville, FL 32611-6588
352-392-7575 (phone)
352-392-3394 (fax)
kcour@ce.ufl.edu

Word Count: $5037 + 6 \text{ (figures and tables)} * 250 = 6537$

**Submitted for Presentation at the 81st Annual Meeting of the
Transportation Research Board, Washington, D.C., 2002**

ABSTRACT

This paper describes a planning level adaptation of the Highway Capacity Manual 2000 (HCM2000) procedure for estimating the level of service (LOS) on two-lane and multilane highways in Florida. The paper identifies the problems associated with planning level adaptations in general and with uninterrupted-flow highways in particular. While much of the adaptation was achieved through the use of default values for data items, some departures from the HCM procedures were required, which are explained in detail in this paper. The most significant deviation was the creation of a third class of two-lane highway to supplement the two classes currently defined by the HCM. The paper makes a case for the existence of this class and argues that it should be included in a future edition of the HCM. FDOT's planning level methodology, termed HIGHPLAN, is well suited to its intended application, which is planning level analysis of two-lane and multilane highways in Florida. It maintains fidelity to the HCM procedures to the extent that Florida conditions will allow, and that Florida users will accept. As long as they are understood, the departures from the HCM should not pose significant problems for users outside of Florida. The planning level methodology has also been implemented in a software program that produces LOS estimates and service volume tables covering site-specific conditions.

INTRODUCTION

Florida has been a leader in the adoption and implementation of the Highway Capacity Manual (HCM) [1], especially at the planning level. The Florida Department of Transportation's (FDOT) commitment to the HCM has been further advanced by the development of software tools that implement various planning level procedures from the HCM2000.

Planning level analysis is characterized by the use of assumptions, approximations and default values to reduce the need for the detailed field data upon which operational level analyses are based. Procedures have been developed based on the HCM2000 for application at two levels:

- Generalized planning, which typically makes use of statewide service volume tables, and
- Conceptual planning, which applies user-specified parameter values. The conceptual planning level procedure includes features that estimate the level of service (LOS) for site-specific conditions and features that generate service-volume tables.

The focus of this paper is on HIGHPLAN, the FDOT's implementation of the HCM2000 multilane and two-lane highway methodologies (chapters 20 and 21) at a planning level. Due to some unique characteristics in the State of Florida, and some philosophical differences of opinion by the FDOT, HIGHPLAN incorporates a number of concepts and calculations that differ significantly from the basic procedures in chapter 20 and 21, particularly the two-lane methodology (chapter 20). The topics covered in this paper include an overview of FDOT concerns with the HCM2000 highway analysis methodologies, a detailed discussion on HIGHPLAN's methodological and computational deviations from the HCM2000, and a brief overview of the software implementation of the HIGHPLAN procedures.

PROBLEM STATEMENT

The basic problem is how to maintain fidelity with the HCM and create a methodology that will be accepted by a broad constituency of users, some of which have no particular allegiance to the HCM. The product must be able to stand the scrutiny of state-level administrators, quasi-judicial proceedings, developers, etc. Specific problems encountered in the development of planning applications of the HCM2000 two-lane and multilane methodologies include:

- Reconciling abrupt changes in performance measures brought about by the transition to the HCM2000.
 - There has been an approximately one level of service letter grade shift for LOS A-D between the two-lane methodologies of the HCM1997 and HCM2000.
 - A large proportion of the state highway system that was previously considered adequate cannot suddenly be declared deficient because of the appearance of a new manual; using a LOS C criterion, the amount of two-lane highway deficiencies would change from about 25% to 60%, without any change in the actual operating conditions.
 - Reconciling LOS assessments with established minimum LOS standards, and with the administrator-perceived meaning of the various levels of service.
-

- Agencies can change LOS standard letter grades, but there is at least some common understanding of the meaning of LOS across facility types and by transportation professionals.
- Applying the two-lane and multilane chapter methodologies to a broad range of applications, especially in meeting the analysis expectations of “rural interests”.
 - There is wide concern in Florida and apparently elsewhere in the U.S. that the new two-lane chapter methodology does not adequately address quality of service in small communities.
 - The chapters essentially remain “segment” chapters instead of “facility” chapters by not addressing how to treat isolated intersections on roadways that generally feature uninterrupted flow.
- Balancing the need for site-specific data with planning level interests and resources.
 - Planning applications feature greater use of default values and there is a need to determine which are the most important input values.
- Maintaining parity with other facility analyses in the estimation of capacity, other performance measures, and inputs.
 - Multilane capacity values must be lower than freeway values, yet straight application of multilane inputs would yield higher values than Florida is experiencing on its freeways; this occurs because Florida is experiencing capacity reductions in freeway interchange areas, but no particular treatment is available in the multilane methodology.
 - If a driver population factor is applicable to freeway commuters, than a driver population factor less than 1.0 should probably routinely be applied to drivers on two-lane and multilane highways outside urbanized areas.
 - If signalized arterials experience reductions in capacity or service volumes because of the lack of medians and left turn lanes at major intersections, similar results should also be anticipated on two-lane and multilane highways.

FDOT’s problems with the planning level implementation of the two-lane highway procedure date back to the 1985 HCM. The main difficulty in implementing the 1985 HCM two-lane chapter was its perceived inaccurate level of service results in developed areas. Florida has many two-lane uninterrupted flow roads that are in developed areas, such as roads passing through communities, along beaches or rivers, and on causeways.

The problem came to the forefront with the analysis of US-1 (the Overseas Highway), a predominantly two-lane highway serving well over 100,000 people in the Florida Keys [2]. To Florida’s Level of Service Task Team¹, the primary objective of travelers on these facilities was to travel at a reasonable speed, and percent time delayed (i.e., percent time spent following) was of secondary concern. Furthermore, capacities were higher in more urban situations. Thus, FDOT adopted a hybrid of the 1985 HCM two-lane (based on percent time delayed) and arterial (based on average travel speed) methodologies for applications on two-lane uninterrupted flow highways in developed areas.

In developing HIGHPLAN, the intent was to incorporate the new HCM2000 two-lane and multilane procedures, yet also tailor the procedures to meet the special needs of the FDOT

¹ FDOT has coordinated a statewide Level of Service (LOS) Task Team composed of approximately 20 representatives since 1988, and it has addressed many highway capacity issues that have arisen in the state since that time.

and address common roadway environments encountered in the state that do not fit well with current HCM classifications.

HIGHPLAN METHODOLOGICAL DESCRIPTION

This section will describe the inputs, assumptions, approximations and deviations from the HCM2000 that went into the methodology development of HIGHPLAN.

Summary of Data Requirements

A summary of the input data items required for the HIGHPLAN computations, along with their choices, ranges and initial default values, is presented in Table 1. The initial defaults reflect the most common conditions and facilities that are encountered in the State of Florida. User-specified values may be substituted for all of the defaulted items.

Methodological and Computational Deviations from the HCM2000

From the inception of FDOT's level of service planning program, FDOT has committed to the maximum feasible extent to rely on the HCM methodologies to address the automobile mode. Because HIGHPLAN is a planning level methodology, some simplifying assumptions and/or extensions have been made and documented in FDOT's Quality/Level of Service Handbook [3]. The deviations in the HIGHPLAN methodology from the HCM methodology are summarized below.

Facility and Segment Level Analysis

HIGHPLAN includes an adjustment to account for whether the analysis is at the segment level or the facility level. If a segment level analysis is performed, it is assumed that the highway section under consideration is short enough that it does not include any capacity reducing effects due to the presence of intersecting driveways or cross streets. If a facility level analysis is chosen, a 10% reduction is applied to the base capacity to account for driveway and cross street friction. This value is consistent with the capacity reducing effects of interchanges experienced on Florida freeways.

Free-Flow Speed

Since HIGHPLAN is used for conceptual planning purposes, the determination of free-flow speed (FFS) by direct measurement is generally not an option. The HCM offers a method for estimating FFS when a direct measurement is not available. This method is based on applying reductions to the ideal FFS (i.e., FFS under ideal geometric conditions) for fixed site conditions that are less than ideal (e.g., narrow lanes, reduced lateral clearances, etc.). The FDOT has found that the posted speed for a highway serves as a reasonable surrogate for FFS, and therefore sets FFS equal to the posted speed plus 8 km/h (5 mph).

Furthermore, for the multilane procedure, the HCM's default upper limit of free flow speeds has been extended from 97 km/h (60 mph) to 113 km/h (70 mph). This allows the full range of multilane highways present in the State of Florida to be covered by the analysis procedure.

Medians and Left Turn Lanes

A primary simplifying analytical technique used by FDOT was the concentration on the through movement—side road and left turning movements are accommodated with their impacts handled generically. One of the earliest issues addressed was how to treat left turn lanes at intersections and mid-block medians at a planning level. In 1991, FDOT's Level of Service Task Team adopted a 5 percent reduction in service volumes if a roadway was undivided and a further 20 percent reduction if the roadway did not have left turn lanes at major intersections. Although most applicable to arterials, those adjustments have also been applied to two-lane and multilane highways. Essentially, the concept is to get left turning vehicles out of the through traffic stream and reflect some level of detriment if they cannot readily do so. In Florida, most multilane roadways are divided and have left turn lanes at major intersections. Two-lane highways are usually undivided (e.g., do not contain a two-way left turn lane) and have left turn lanes at major intersections, so the statewide default is somewhat different between two-lane and multilane highways. In the case of two-lane divided highways, which may occur in developed situations, service volumes are increased 5 percent; however, consideration would also be given to the effect of having 100 percent no passing. The LOS Task Team also adopted some passing lane adjustments, but these are now superseded by the values in HCM2000.

Local Adjustment Factor

Whereas historically the HCM only included a driver population factor, f_p , to account for potential capacity reducing effects on freeways due to a traffic stream not composed primarily of commuters, and the recommended default value continues to be 1.0, FDOT has for the last 10 years made extensive use of gradations of the driver population concept for all facility types. Research conducted by the University of South Florida [4, 5] indicated that base saturation flow rates are reduced up to 15% on freeways and 19% on arterials because of non-local drivers. Furthermore, limited research [6] in south Florida indicated higher base saturation flow rates occur in larger urbanized areas than in smaller urbanized areas.

Rather than using the HCM's CBD factor (but no recognition of non-CBD driver population factors) for signalized intersections and arterials, a driver population factor for freeways and multilane highways, and no adjustment factor for two-lane highways, FDOT uses the term "local adjustment factor" (LAF) to help obtain adjusted saturation flow rates for all facility types in all area types. The LAF is intended to primarily capture the effects of driver population, but allows the analyst to also capture capacity reducing effects that are not explicitly addressed at the planning level, but that the analyst may still consider important.

The LAF values primarily reflect the location of facilities, whether they are in rural undeveloped areas, small communities, small cities, metropolitan areas, large metropolitan areas or central business districts. Using gradations of the LAF has resulted in favorable matches with actual capacities on freeways throughout the state and on arterials in urbanized areas. Furthermore, FDOT believes that if a LAF is applicable to those facilities they should also be applicable to two-lane and multilane highways in similar areas.

Base Capacity and Adjusted Capacity Terms

The HIGHPLAN methodology incorporates a base capacity term and an adjusted capacity term, while the HCM uses just a single capacity term. These terms were introduced for consistency with FDOT's other facility planning methodologies.

In the HCM procedure, fixed site effects, such as geometry and access frequency are applied to the free-flow speed estimate (in lieu of a direct measurement), which in turn determines the capacity value. Temporal site conditions, such as percentage of heavy vehicles and the peak hour factor, are applied to the analysis flow rate. However, in HIGHPLAN, the FFS is based on the posted speed, as previously discussed, and the base capacity is based on FDOT recommended values², but can also be directly specified by the user. The fixed and temporal effects (e.g., median presence, percent heavy vehicles) get applied to the base capacity, which then results in an adjusted capacity. This adjusted capacity value is used in the calculations for the maximum service volume tables. However, for consistency with HCM level of service calculations, the adjustments (e.g., LAF) get applied to the analysis flow rate, and the base capacity value is used.

Passing Lane Implementation (Two-Lane Only)

The HCM procedure deals with a specific passing lane segment with three user-specified length parameters:

1. Length upstream of the passing lane,
2. Length of the passing lane itself, including taper, and
3. Length downstream of the passing lane.

The procedure divides the downstream segment computationally into two subsegments. The first segment is considered to be within the effective length of the passing lane. The second segment is beyond the influence of the passing lane.

For planning level analyses, the roadway is treated as a series of segments, each of which has its own passing lane. Using this approach, the only user-specified variable is the passing lane spacing in miles. The roadway is then modeled as a series of segments, each of which begins with a passing lane exactly one mile long. The HCM computations are then performed to determine what proportion of the downstream segment is within the influence of the passing lane. An example of the results of the HIGHPLAN passing lane computation is illustrated in Figure 1. This figure shows the effect of the passing lane spacing (8 km (5 mi) to 48 km (30 mi)) on the 'percent time spent following' (PTSF) for annual average daily traffic (AADT) values of 5000, 15000, and 25000. All other input data were kept at the HIGHPLAN defaults for two-lane roadways.

Class III Roadways (Two-Lane Only)

In 1990 a major issue arose over the adequacy of the HCM in addressing level of service on two-lane roads over a broad range of conditions and area types. A LOS Task Team subcommittee was formed to directly address those concerns that primarily centered on the analysis of such facilities in developed areas (e.g., small towns) and along coastal roads. In addition to FDOT members, the subcommittee included a transportation representative of the state's most rural regional planning council, and a representative of the state's land planning agency.

² For the two-lane analysis, the default base capacity values are the HCM values of 1700 pc/hr (one-way) and 3200 pc/hr (two-way). For multilane analysis, the values also correspond with HCM values, with additional values of 2250 and 2300 for free-flow speeds of 105 km/h (65 mph) and 113 km/h (70 mph), respectively.

As a result of this subcommittee's efforts, FDOT implemented a hybrid approach for two-lane uninterrupted flow facilities in developed areas in its 1991 LOS Handbook. Since that time, no serious questioning of the results has occurred from local governments, developers, preservationists, or others. It was anticipated that the HCM2000 would better address the aforementioned concerns, but the feeling in Florida is that it has not succeeded. The following discussion describes the rationale of the LOS Task Team in arriving at the recommendation to implement a third class for two-lane highways and the use of 'percent of free flow speed' as its primary performance measure.

Chapter 12 of the HCM2000 offers the following definitions for Class I and Class II highways:

- Class I—These are two-lane highways on which motorists expect to travel at relatively high speeds. Two-lane highways that are major intercity routes, primary arterials connecting major traffic generators, daily commuter routes, or primary links in state or national highway networks generally are assigned to Class I. Class I facilities most often serve long-distance trips or provide connecting links between facilities that serve long-distance trips.
- Class II—These are two-lane highways on which motorists do not necessarily expect to travel at high speeds. Two-lane highways that function as access routes to Class I facilities, serve as scenic or recreational routes that are not primary arterials, or pass through rugged terrain generally are assigned to Class II. Class II facilities most often serve relatively short trips, the beginning and ending portions of longer trips, or trips for which sightseeing plays a significant role.

Based on these definitions, the HCM uses two measures of effectiveness (MOE) for Class I LOS—percent time spent following (PTSF), and average travel speed (ATS), and just one measure for Class II—percent time spent following.

Many of the state's two-lane highways are in areas that would be considered scenic in nature (e.g., along the coasts, the Florida Keys route), implying a Class II classification, yet many of these highways also serve well-developed areas, which would imply a Class I classification. Quoting from Chapter 12 of the HCM, it is stated, "*...the primary determinant of a facility's classification in an operational analysis is the motorist's expectations, which might not agree with the functional classification.*" This statement sums up very well the crux of the issue for the FDOT. Thus, the LOS Task Team had to decide if either one of these classifications would be appropriate for these types of highways, or if a new classification needed to be developed. From the US-1 (Florida Keys) analysis experience, the LOS Task Team concluded that the most important LOS measure for motorists on these types of highways was the ability to maintain a "reasonable" speed. Drivers in a small, developed, area which is posted for 89 km/h (55 mph) would primarily like to travel near that speed. Similarly, along a beach road posted at 72 km/h (45 mph) or in a community posted at 64 km/h (40 mph), drivers probably accept that they need to slow down and are quite satisfied to proceed through these areas close to those speeds. From this conclusion, PTSF was removed from consideration as an MOE applicable for these types of roadways. Consequently, the Class II definition was then removed from consideration, as PTSF is the only MOE for this Class. That left Class I for consideration, which included a speed-based MOE, as well as PTSF.

On Class I highways, the LOS is determined by the most critical of the two performance measures (ATS or PTSF). This raises the question of which measure dominates and under what conditions. The ATS is heavily influenced by the free flow speed and the PTSF is not. On the other hand, PTSF is much more sensitive to the traffic volume than ATS, whose relationship to the demand volume is fairly flat. So, it should be expected that the PTSF will govern at high speed and high volume while the ATS will govern at low speed and low volume. An experiment was conducted to test this premise. Keeping all parameters except free flow speed and AADT at their default values for two lane highways, a “crossover volume” was determined for each free flow speed. The crossover volume represents the point at which PTSF becomes the critical determinant of the LOS. The results of this experiment are presented in Figure 2. The volume is represented by the v/c ratio to give a normalized perspective on the numbers. It can be seen that ATS never governs at v/c ratios above 0.3, or at free flow speeds above 89 km/h (55 mph).

While free-flow speeds at or below 89 km/h (55 mph) are the condition on a very large percentage of these two-lane highways, the volumes can encompass a large range, with v/c ratios frequently exceeding 0.3. However, even for facilities in which the ATS would govern, the LOS Task Team had difficulty with the concept that a facility that had an average travel speed the same as a posted speed of 80 km/h (50 mph), for example, would only have a level of service of C (see Table 2). They felt these ATS LOS thresholds were unreasonably pessimistic for these types of roadways in developed areas.

In light of these results, and the DOT’s philosophy about ATS LOS thresholds, it was decided that for two-lane highways in developed areas there should also be a Class III classification, with percent of free flow speed being the primary performance measure. Working with average speed criteria in Exhibit 20-2 (also shown in Table 2) of the HCM2000, a percent of free flow speed criteria based on 97 km/h (60 mph) was easily derived.

Under this scheme, the resulting service volumes appear much more in line with previous FDOT findings. For example, based on statewide default roadway and traffic data, a two-lane uninterrupted flow roadway posted at 72 km/h (45 mph) with a 10,000 AADT would be LOS E using the HCM2000 criteria and LOS C using the proposed criteria (compare results shown in Figure 3a with the LOS criteria shown in Table 2). Given that vehicles are still averaging about 64 km/h (40 mph) in an urban situation, do not need to come to a stop, and are not trying to pass, the LOS C result appears more reasonable. FDOT’s position since the early 1990’s is that drivers primarily want to go at a reasonable speed on two-lane uninterrupted flow facilities in developed areas. Although originally presented as ‘average travel speed’ in the Florida Keys study, ‘percent of free flow speed’ best represents that concept of “reasonable” speed. Furthermore, the use of a Class III uninterrupted flow two-lane facility classification based on ‘percent of free flow speed’ is appropriate and needed.

SOFTWARE IMPLEMENTATION

This section discusses the software implementation of the HIGHPLAN two-lane and multilane level of service planning methodologies. HIGHPLAN is a stand-alone Windows™ application. For reference, the user interface is shown in Figure 3, where it can be seen that the inputs correlate with those shown in Table 1. At this point, HIGHPLAN deals only in US customary units, and a metric version does not exist.

Features

HIGHPLAN has two major level of service calculating features. First, it calculates the level of service for the facility being analyzed and also shows the calculated performance and service measures. Second, it calculates three service volume tables: hourly volumes in the peak direction, hourly volumes in both directions, and annual average daily traffic volumes. The program can be used at a generalized planning level with numerous defaults or at a conceptual planning level with specific roadway and traffic variable inputs.

HIGHPLAN uses the Traffic Model Markup Language (TMML) format (based on XML) for data interchange [7]. This facilitates direct results comparison to other TMML compliant programs that deal with highway analysis, such as the HCS. A companion utility program, TMRC (for Traffic Model Results Comparison), has been developed to compare the output of two TMML files generated by different programs for the same facility type. Furthermore, consultants that prefer to develop their own user interface for the input data can interface directly with the computational engine of HIGHPLAN by using TMML formatted data. This will ensure that third party developed programs maintain fidelity with FDOT's analysis procedures by utilizing the data validation capabilities and computational engine of HIGHPLAN.

CONCLUSIONS AND RECOMMENDATIONS

HIGHPLAN is well suited to its intended application, which is planning level analysis of two-lane and multilane highways. It maintains fidelity to the HCM procedures to the extent that Florida conditions will allow, and that Florida users will accept.

It is also important to recognize the limitations of a planning application, in which the input data requirements have been simplified to facilitate productive application. For example, the HCM provides a procedure for computing free-flow speed as a function of site-specific factors. HIGHPLAN assumes the free-flow speed to be 8 km/h (5 mph) above the posted speed. If more accurate estimates of free flow speed are required, then software that implements the full procedure may be a better choice than HIGHPLAN. This would also be the case if strict adherence to the HCM procedure were required.

The most significant deviation from the HCM is the introduction of a third highway class for analysis of two lane roadways in developed areas. The HCM now recognizes two classes of highways and prescribes two performance measures (PTSF and ATS) that could determine the level of service on a given highway. For Class I highways, the most critical of PTSF or ATS determines the LOS. For Class II highways, PTSF is the sole determinant, and the ATS is ignored. This paper argues that there exists, especially in developed areas, a third highway class in which the average travel speed, in relation to the free-flow speed is the sole determinant of LOS. The HCM2000 two-lane highway analysis methodology would be more useful and relevant if it recognized such a class.

Historically, Florida has been in the lead in applying HCM concepts at a planning level and developing corresponding guidance and software. Applying the HCM procedures in the second largest state in the eastern U.S. with major population centers and totally rural areas provides an excellent test case not only of the two-lane and multilane chapter methodologies, but the entire HCM. Perhaps naturally, when implementing the new HCM2000 procedures for two-lane and multilane facilities and applying them to roadways in urbanized areas (e.g., five-mile long causeways), in numerous small towns, and in totally undeveloped areas and in conjunction with freeway and arterial analyses, anomalies arise. The findings and recommendations in this

paper should be applicable throughout the U.S. at the local, regional, state and national levels, whether applying the techniques to analyze a specific roadway or to conduct system-wide analyses.

REFERENCES

1. Transportation Research Board. Highway Capacity Manual. Washington D.C., USA. 2000.
2. DeAraza, Rafael E. and McLeod, Douglas S. Methodology to Assess Level of Service on US-1 in the Florida Keys, In *Transportation Research Record 1398*, TRB, National Research Council, Washington, D.C., 1993.
3. Florida Department of Transportation. Draft Quality/Level of Service Handbook. Tallahassee, FL, 2001.
4. Lu, John J., Huang, Weimin, and Mierzejewski, Edward A. Driver Population Factors in Freeway Capacity. Center for Urban Transportation Research (CUTR), Tampa, FL, 1997.
5. Zhou, Yanhu, et. al., Development of Driver Population Factors for Capacity Analysis of Signalized Intersections. Center for Urban Transportation Research (CUTR), Tampa, FL, 1999.
6. McMahon Associates, Inc. for Florida Department of Transportation District Four. District Four Area-wide Saturation Flow Study. Ft. Lauderdale, FL, 1995.
7. Courage, Kenneth G., Washburn, Scott S., and Kim, Jin-Tae. Development of an XML-Based Specification for Traffic Software Data Interchange. Submitted for presentation at the 81st meeting of the Transportation Research Board, 2002.

List of Tables and Figures

Table 1. Data Input Variable Summary	11
Table 2. LOS Criteria for the Three Classes of Two-Lane Highways	12
Figure 1. Effect of Passing Lane Spacing on PTSF in HIGHPLAN.....	13
Figure 2. Effect of Free-Flow Speed on Crossover Volume.....	14
Figure 3. HIGHPLAN user interface showing input data and results.....	15

Table 1. Data Input Variable Summary

Data Item	Choice or Range	Initial Default
Roadway Variables		
Area Type	Rural undeveloped Rural developed Transitioning urban Urbanized	Rural undeveloped
Number of Thru Lanes	2,4, or 6	2
Posted Speed	35-65 mph	Depends on area and highway type
Median Presence	Yes or No	Depends on area and highway type
Left Turn Lane Presence	Yes or No	Depends on area and highway type
Terrain	Level or Rolling	Level
No Passing Zone %	0 - 100	20 (Two-lane only)
Passing Lane Spacing	0 - 30	None (Two-lane only)
Highway Class	I, II or III	I (Two-lane only)
Analysis Type	Segment or Facility	Segment
Traffic Variables		
AADT	1,000 - 100,000	10,000
K Factor	0.06 - 0.20	0.095
D Factor	0.5 - 1.0	0.55
PHF	0.75 - 1.0	0.925
% Heavy Vehicles	0 - 25	Depends on area and highway type
Local Adjustment Factor	0.8 - 1.0	1.0
Base Capacity	1700 (2-lane)	1700
	1900 – 2300 (multilane)	Depends on Free Flow Speed
Adjusted Capacity	Calculated Only	

Table 2. LOS Criteria for the Three Classes of Two-Lane Highways

	Class I¹		Class II¹	Class III
LOS	PTSF²	ATS³	PTSF	% of FFS⁴
A	≤ 35	> 55	≤ 40	> 0.917
B	$> 35-50$	$> 50-55$	$> 40-55$	> 0.833
C	$> 50-65$	$> 45-50$	$> 55-70$	> 0.750
D	$> 65-80$	$> 40-45$	$> 70-85$	> 0.667
E	> 80	≤ 40	> 85	> 0.583

¹ Values are directly from the HCM

² PTS – Percent Time Spent Following

³ ATS – Average Travel Speed

⁴ FFS – Free Flow Speed

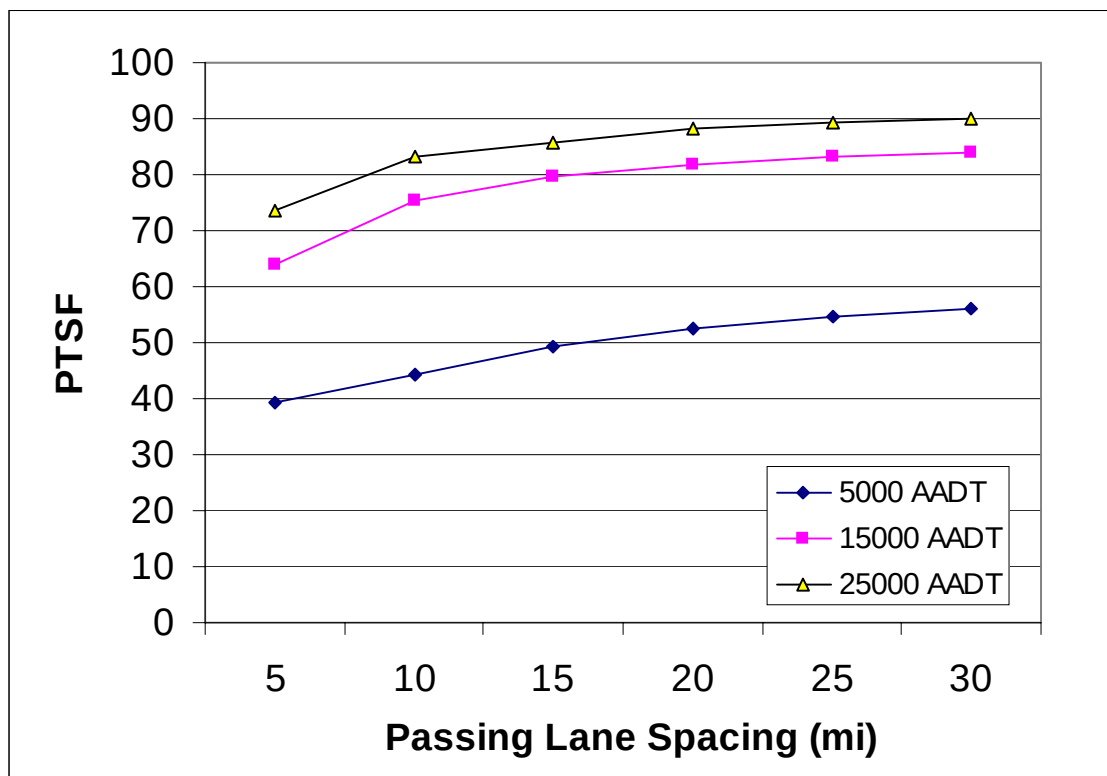


Figure 1. Effect of Passing Lane Spacing on PTSF in HIGHPLAN

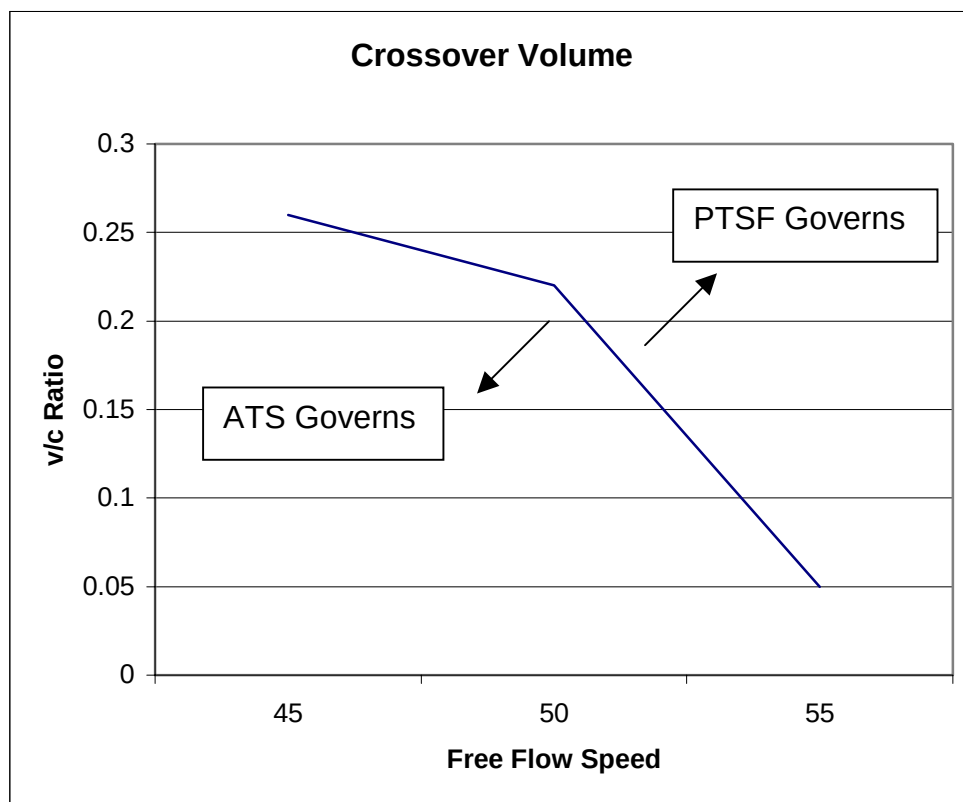


Figure 2. Effect of Free-Flow Speed on Crossover Volume

HIGHPLAN: Two-Lane Urban Roadway - [Highplan]

File Highway Type View Help

Facility Data and LOS

Roadway Variables

Area Type: Number of Lanes (Both directions):

Class: ☐ Medians % No Passing Zone

Posted Speed: ☒ Left Turn Lanes ☒ Passing Lanes Spacing (miles):

Free Flow Speed: Terrain:

Traffic Variables

AADT: PHF: Base Capacity:

K factor: % Heavy Vehicles: Local Adj. Factor:

D factor: Adj. Capacity:

Results

v/c Ratio: % Time Spent Following: Average Speed: % Free Flow Speed: LOS:

Service Volume Tables

Description

Road Name: From/To:

Peak Direction: Study Period:

File Information

Analyst: District:

Date: Agency:

User Notes:

User Notes: Valid Range:

(a) Facility input data and site-specific results

HIGHPLAN: Multi-Lane Urban Roadway - [Highplan]

File Highway Type View Help

Facility Data and LOS

Hourly Volume in Peak Direction

Service Volumes

Lanes	LOS A	LOS B	LOS C	LOS D	LOS E
2	1090	1750	2520	3340	3880
3	1630	2620	3790	5010	5830
4	2180	3500	5050	6680	7770

Maximum v/c Ratio

Lanes	LOS A	LOS B	LOS C	LOS D	LOS E
2	0.28	0.45	0.65	0.86	1.00
3	0.28	0.45	0.65	0.86	1.00
4	0.28	0.45	0.65	0.86	1.00

Service Volume Tables

Hourly Volume in Both Directions

Peak-Hour Bidirectional Service Volumes

Lanes	LOS A	LOS B	LOS C	LOS D	LOS E
4	1980	3180	4590	6070	7060
6	2960	4770	6880	9110	10590
8	3950	6360	9180	12140	14120

Annual Average Daily Traffic

Lanes	LOS A	LOS B	LOS C	LOS D	LOS E
4	20800	33500	48300	63900	74300
6	31200	50200	72500	95900	111500
8	41600	66900	96600	127800	148700

Area Type: Valid Range:

(b) Service volume tables

Figure 3. HIGHPLAN user interface showing input data and results