VISSIM STANDARDS PROJECT

Summary of Year One Findings

July 2012

DELAWARE VALLEY
dvrpc
REGIONAL PLANNING COMMISSION

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The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's

Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for the findings and conclusions herein, which may not represent the official views or policies of the funding agencies.

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Figures and Tables

I. Introduction

The *VISSIM Standards Project* originated as an idea due to issues related to unknown variables encountered during a large VISSIM modeling project completed by Delaware Valley Regional Planning Commission (DVRPC). VISSIM is a microscopic-scale traffic flow modeling software program. During the creation and calibration of the VISSIM model, several variables proved unknown particularly for secondary and intersecting roads. Issues included the following.

- Undue congestion at intersections controlled by stop signs was prevalent;
- Free-flow speeds on secondary roads were unknown;
- Traffic signal throughput was unknown;
- The proportion of heavy vehicles on secondary roads was unknown; and
- Average following distances were unknown.

While each of the variables had an impact on the VISSIM model and its calibration, determining the appropriate values at each location would be a major undertaking, and well beyond the scope of most projects. These issues led to this project. The project team felt that determining a set of DVRPC region defaults would be beneficial to future micro simulation modeling. To best capitalize on DVRPC's efforts in this project, many of the region's VISSIM users were invited to participate as study advisors. All findings were to be made available to the advisory committee and any other micro simulation modelers that would find them beneficial. The advisory committee was tasked with assisting in prioritizing measurements and reviewing findings.

There are several sources for traffic engineering default values (*Highway Capacity Manual, NCHRP Report 599*, VISSIM defaults, etc.); however, they often cover large geographic areas and may or may not be reflective of the Delaware Valley region, or directly applicable to micro simulation modeling. Measurements conducted for this project were from samples collected throughout the DVRPC region, and if relevant to a particular measurement, categorized into context-driven subcategories. For example, free-flow speeds were subcategorized similarly to the classification system shown in the *Smart Transportation Guidebook* (2008, DVRPC Pub. No. 08030A). These classifications are context driven, and those used in this study include: suburban centers, suburban corridors, suburban freeways, urban freeways, and urban roads.

The project received funding for two fiscal years. This technical memorandum summarizes the first year's work. During the second year work will continue on quantifying parameters, preparing a VISSIM input (.inp) file with preloaded findings, and will result in a final technical memorandum summarizing both years' work.

This project was conducted with a focus on the VISSIM micro simulation software program. The results may be useful to users of other micro simulation software programs.

II. Study Process

DVRPC has been using VISSIM since 2008, and several projects utilizing the software have been completed since then. Many of the region's consulting firms also use VISSIM and may have significant levels of experience. Assembling a team of study advisors representing the region's VISSIM users was essential to ensure the most important parameters could be measured and the methodology and findings validated. The project team solicited a list of the region's VISSIM users from the software vendor, PTV America. Invitations were sent to each listed user and an advisory committee was formed. Participants included the following individuals.

- Trevor Booz, EIT, Pennoni Associates, Inc.;
- Christopher Burke, PE, Urban Engineers;
- Michael Howard, Delaware River Port Authority;
- Troy Illig, PE, PTOE, Parsons Brinkerhoff;
- Randy Johnson, PE, PTV America;
- Jonathan Kugel, Delaware Valley Regional Planning Commission;
- Regan Miller, PE, Michael Baker Corporation;
- Raj Paradkar, PE, Michael Baker Corporation;
- Dave Petrucci, PE, PTOE, Petrucci Engineering;
- Emily Scholl, EI, McCormick Taylor;
- Fang Yuan, Delaware Valley Regional Planning Commission; and
- Jason Zhang, PE, Orth-Rodgers and Associates.

The DVRPC study team prepared a memorandum describing the project and potential parameters for measurement. Feedback from the advisory committee was received and an initial set of parameters for measurement was determined. For the first year, the study team measured free-flow speed, signal throughput, and speeds through stop-sign-controlled intersections. The remainder of this technical memorandum presents the findings of these measurements.

These findings, and the ultimate purpose of this project, are to provide default values for use when direct measurement at a study location is not feasible or practical.

III. Free-Flow Speed

Free-flow speed corresponds with the Desired Speed Distribution attribute in VISSIM. Free-flow speed can be defined as the speed at which a vehicle will travel when uninfluenced by externalities, such as other vehicles, pedestrians, or cyclists. Measurements for each road context were conducted. Results are presented relative to the posted speed limit, with statistics including: number of measurement locations, sample size, base speed, mean, median, 5^{th} percentile, 20^{th} percentile, 80^{th} percentile, 85^{th} percentile, 95^{th} percentile, and the standard deviation.

Methodology

Locations were selected from roadways throughout the DVRPC region based on the following characteristics.

- Flat areas, or areas with subtle grades;
- Locations that were representative of the respective road context category;
- Freeway locations that were accessible via a pedestrian-friendly overpass; and
- Locations where speed data could be collected without allowing the measuring equipment to influence driver behavior.

Data was only recorded for vehicles deemed to be unimpeded. For example, only the lead vehicle of a platoon would be eligible. Also, vehicles needed to proceed through the prior downstream traffic signal when green so as not to be accelerating when the data was captured. Judgment was exercised during the data collection effort.

Results

All results are given with the posted speed limit subtracted so that they may be applied to a range of posted speed limits.

A sample speed distribution is shown for each road type. The end points were defined by the 5th and 95th percentile to eliminate outliers, and the 20th and 80th percentiles were used to create the s-shaped distribution.

Suburban Center

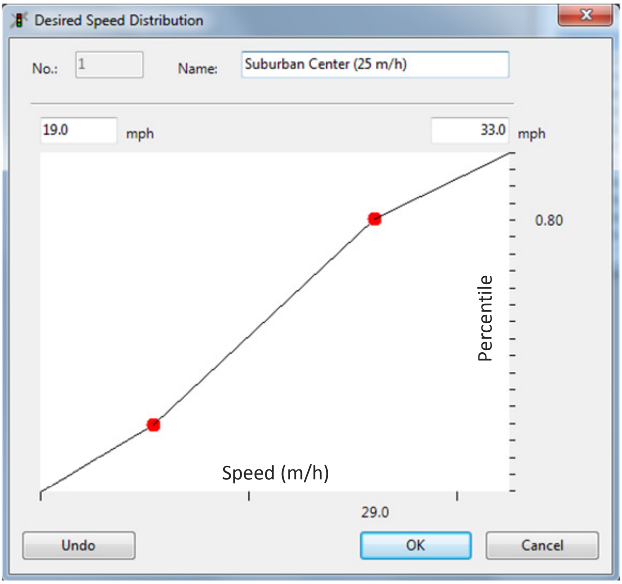
A suburban center location is often a "Main Street." Surrounding land uses are defined as follows. Table 1 provides the results and Figure 1 provides a sample speed distribution.

> Often a mixed-use, cohesive collection of land uses that may include residential, office, retail, and restaurant uses where commercial uses serve surrounding neighborhoods. These areas are typically designed to be accessible by car, and may include large parking areas and garages. (Guidebook, 2008)

Table 1: Suburban Center Free-Flow Speed

SUBURBAN CENTER	
Measurement Locations	11
Sample Size	1,588
Base Speed	25
Mean Speed	0.7
Median Speed	1.0
5th Percentile Speed	-6.0
20th Percentile Speed	-3.6
80th Percentile Speed	4.0
85th Percentile Speed	5.0
95th Percentile Speed	8.0
Standard Deviation	4.58
speed = m/h	DVRPC, 2012

Figure 1: Suburban Center Sample Speed Distribution



DVRPC, 2012

All measurement locations had a posted speed limit of 25 miles per hour.

Suburban Corridor

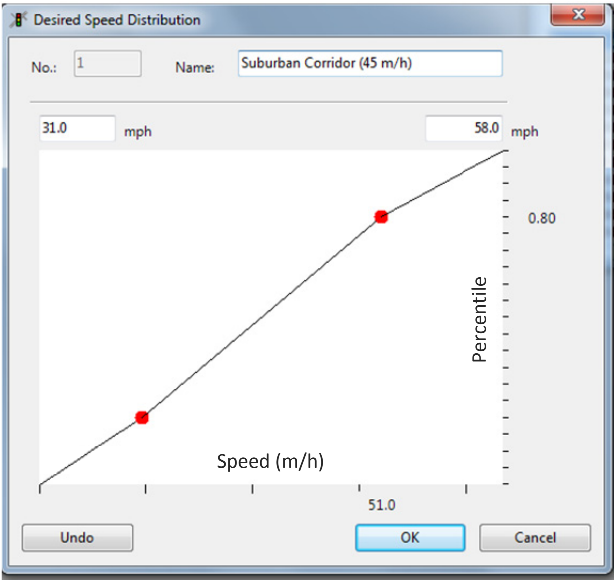
Suburban corridors are often regional arterials serving both local and regional traffic. Surrounding land uses are summarized as follows. Table 2 provides the results and Figure 2 provides a sample speed distribution.

> Typically characterized by commercial strip development, sometimes interspersed with natural areas and occasional clusters of homes. Such areas consist primarily of big box stores, commercial strip centers, restaurants, auto dealerships, office parks, and gas stations. (Guidebook, 2008)

Table 2: Suburban Corridor Free-Flow Speed

SUBURBAN CORRIDOR	
Measurement Locations	10
Sample Size	1,500
Base Speed	35 - 55
Mean Speed	-0.5
Median Speed	1.0
5th Percentile Speed	-14.0
20th Percentile Speed	-8.0
80th Percentile Speed	6.0
85th Percentile Speed	7.0
95th Percentile Speed	13.0
Standard Deviation	8.24
speed = m/h	DVRPC, 2012

Figure 2: Suburban Corridor Sample Speed Distribution



DVRPC, 2012

Posted speed limits for measurement locations ranged from 35 to 55 miles per hour (Figure 2 represents an example for 45 miles per hour). Due to the variation in posted speed limits at the measurement locations, an assessment to determine how the posted speed limit impacts the results was conducted. In general, the results found the difference to be between the low speed and the mean. Greater than the mean, there was little difference. The mean speed above the posted speed limit was 3.0, 1.7, and 1.2 miles per hour for 35, 45, and 55 miles per hour speed limits, respectively. The raw data is available and can be formulated based on user preference.

Suburban Freeway

A suburban freeway is a limited-access expressway in a suburban context. Typical characteristics include: several miles between interchanges, heavy volumes focused on the peak periods, and serving suburban locations. Table 3 provides the results and Figure 3 provides a sample speed distribution.

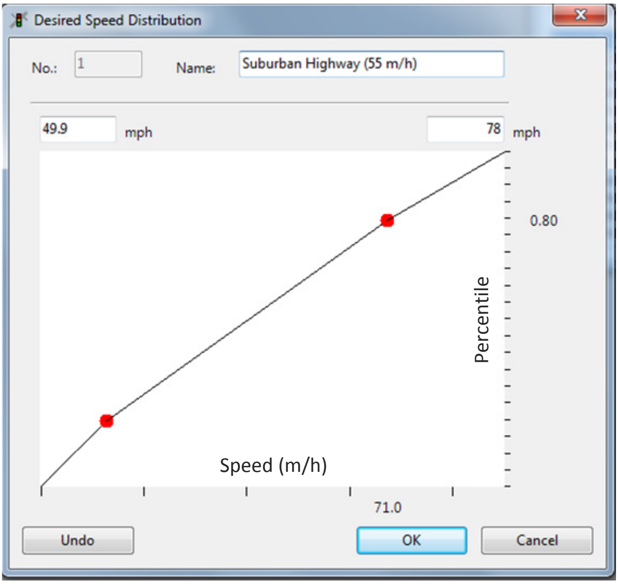
Measurement locations had posted speed limits ranging from 45 to 55 miles per hour.

Table 3: Suburban Freeway Free-Flow Speed

SUBURBAN FREEWAY	
Measurement Locations	8
Sample Size	1,200
Base Speed	45 - 55
Mean Speed	8.5
Median Speed	8.0
5th Percentile Speed	-5.1
20th Percentile Speed	1.0
80th Percentile Speed	16.0
85th Percentile Speed	18.0
95th Percentile Speed	23.0
Standard Deviation	8.86

speed = m/h — DVRPC, 2012

Figure 3: Suburban Freeway Sample Speed Distribution



DVRPC, 2012

Urban Freeway

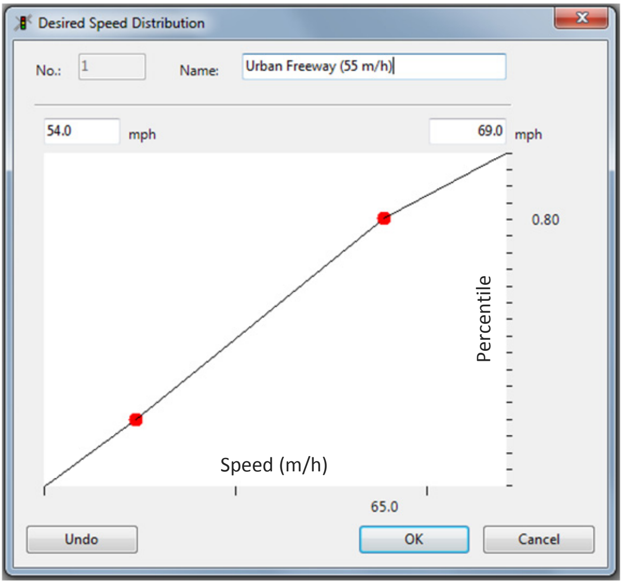
An urban freeway is a limited-access expressway in an urban context. Typical characteristics include: a high density of interchanges, heavy volumes throughout the day, and serving urban locations. Table 4 provides the results and Figure 4 provides a sample speed distribution.

Measurement locations had posted speed limits ranging from 50 to 55 miles per hour.

Table 4: Urban Freeway Free-Flow Speed

URBAN FREEWAY	
Measurement Locations	7
Sample Size	1,054
Base Speed	50 - 55
Mean Speed	6.0
Median Speed	6.0
5th Percentile Speed	-1.0
20th Percentile Speed	2.0
80th Percentile Speed	10.0
85th Percentile Speed	11.0
95th Percentile Speed	14.0
Standard Deviation	4.99
speed = m/h	DVRPC, 2012

Figure 4: Urban Freeway Sample Speed Distribution



DVRPC, 2012

Urban Road

Surrounding land use can be described as the following:

> Downtown areas consisting of blocks of higher density, mixed-use buildings. Across the region, buildings vary in height from 1 to 60+ stories tall with most buildings dating from an era when elevators were new technology – so five to twelve stories were the standard. (Guidebook, 2008)

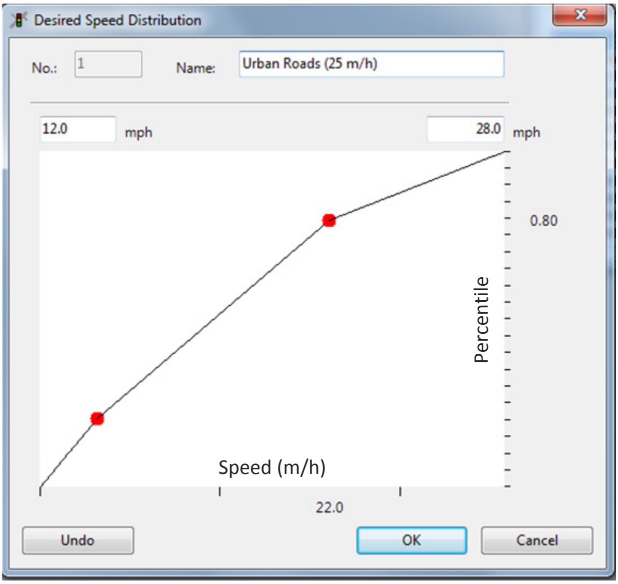
Table 5 provides the results and Figure 5 provides a sample speed distribution.

Measurement locations all had a posted speed limit of 25 miles per hour.

Table 5: Urban Road Free-Flow Speed

URBAN ROAD	
Measurement Locations	15
Sample Size	1,650
Base Speed	25
Mean Speed	-6.4
Median Speed	-7.5
5th Percentile Speed	-13.0
20th Percentile Speed	-11.0
80th Percentile Speed	-3.0
85th Percentile Speed	-1.0
95th Percentile Speed	3.0
Standard Deviation	6.29
speed = m/h	DVRPC, 2012

Figure 5: Urban Roads Sample Speed Distribution



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Incorporation into VISSIM

Desired speed distributions are formulated in VISSIM through the following path: Base Data – Distributions – Desired Speed. Selecting 'new' will bring up an empty desired speed distribution. The low and high ends of the range are inputted above the graph (5^{th} and 95^{th} percentile for this study). Right clicking on the graphed line will introduce a mid-point. The mid-point can be moved to the desired location. Additional mid-points can also be added.

After the desired speed distribution is complete, a desired speed decision is placed on the respective link in the VISSIM network. The newly constructed distribution is assigned to the decision. This study did not distinguish between vehicle types, and therefore the same distribution may be assigned to all vehicle types.

Observations

A few observations were noted during data collection and analysis.

- Observed operating speed variations from posted speed limits were relatively minor. Only on suburban freeways was the 95th percentile subjectively excessive;
- Urban freeways were difficult to measure due to high volumes during off-peak periods; and
- The urban road context is effective at traffic calming.

In summary, 6,992 individual samples were collected from 51 locations. The mean speed across all contexts and posted speed limits was found to be 1.3 miles per hour over the posted speed limit.

Distribution curves can be reformulated based on user preference.

IV. Signal Throughput

Signal throughput refers to the number of vehicles that clear a stop bar during the respective approach's progression phase. The analyses resulted in a series of headway values that models may be calibrated to achieve. Measurements for through movements and protected left turns were conducted. For most through movement measurements, vehicles had the ability to turn right. Results are given both by context and general movement.

Methodology

Locations were selected from roadways throughout the DVRPC region.

- Intersections with significant grade changes were avoided;
- Through-movement measurement locations could not share a lane with left-turning vehicles;
- Left-turn measurements were only conducted at locations with a protected signal phase, and only during the protected signal phase;
- Ideally, measured phases would have demand exceed capacity. Not all vehicles could clear one green phase. When not possible, timing was stopped as the final queued vehicle reached the stop bar;
- The measured green phase was timed. If not fixed, the green time was measured for each captured cycle; and
- The number of vehicles that completed the respective movement was noted even if they crossed the stop bar on yellow or red.

Results

The results are presented as seconds of green time per vehicle completing the movement. The following statistics are given for both protected left turns and through movements: mean, minimum, maximum, 85th percentile, 15th percentile, number of observations, standard deviation, and measurement locations. Measurement locations that include both single and dual lanes are included. Dual-lane movements were factored to match single lanes.

This data was collected solely for the purpose of creating default values for calibrating traffic signals in VISSIM. Vehicles were counted during each cycle, though only the green time was considered when calculating headway values. This was to create values relevant to traffic signals in VISSIM, where yellow may not be fully utilized and no vehicles run red lights. In practice, models may need to be calibrated more aggressively to achieve observed results.

Suburban Center

The results are presented in Table 6 below.

Table 6: Suburban Center Signal Throughput Results

SUBURBAN CENTER	Left	Through
Mean (seconds/vehicle/lane)	1.85	2.52
Minimum (seconds/vehicle/lane)	1.00	1.88
Maxium (seconds/vehicle/lane)	3.90	3.50
85th Percentile (seconds/vehicle/lane)	2.45	2.87
15th Percentile (seconds/vehicle/lane)	1.40	2.17
Number of Observations	94	130
Standard Deviation	0.55	0.33
Measurement Locations	4	6

DVRPC, 2012

Suburban Corridor

The results are presented in Table 7 below.

Table 7: Suburban Corridor Signal Throughput Results

SUBURBAN CORRIDOR	Left	Through
Mean (seconds/vehicle/lane)	2.37	2.27
Minimum (seconds/vehicle/lane)	1.17	1.39
Maxium (seconds/vehicle/lane)	5.00	3.33
85th Percentile (seconds/vehicle/lane)	3.03	2.67
15th Percentile (seconds/vehicle/lane)	1.52	1.95
Number of Observations	127	130
Standard Deviation	0.86	0.40
Measurement Locations	6	7

DVRPC, 2012

Urban Road

The results are presented in Table 8 below.

Table 8: Urban Road Signal Throughput Results

URBAN	Left	Through
Mean (seconds/vehicle/lane)	2.21	3.07
Minimum (seconds/vehicle/lane)	1.25	1.89
Maxium (seconds/vehicle/lane)	3.40	7.17
85th Percentile (seconds/vehicle/lane)	2.67	3.93
15th Percentile (seconds/vehicle/lane)	1.75	2.21
Number of Observations	65	105
Standard Deviation	0.48	1.07
Measurement Locations	3	5

DVRPC, 2012

Aggregated Results

Results aggregated by movement, and further by single- and dual-lane configurations, are shown in Table 9. Note that dual-lane mean, minimum, maximum, percentile, and standard deviation results have been factored to show average per lane.

Table 9: Aggregated Signal Throughput Results

	All		Single-Lane		Dual-Lane*	
AGGRETATED RESULTS	Left	Through	Left	Through	Left	Through
Mean (seconds/vehicle/lane)	2.02	2.59	1.95	2.41	2.39	2.83
Minimum (seconds/vehicle/lane)	1.00	1.39	1.00	1.39	1.71	1.79
Maxium (seconds/vehicle/lane)	3.90	7.17	3.90	3.50	3.40	7.17
85th Percentile (seconds/vehicle/lane)	2.50	3.00	2.50	2.85	3.00	3.58
15th Percentile (seconds/vehicle/lane)	1.50	2.08	1.43	2.06	2.00	2.14
Number of Observations	259	355	218	200	41	155
Standard Deviation	0.51	0.73	0.49	0.38	0.43	0.97
Measurement Locations	13	18	10	11	3	7

*Dual-lane statistics are factored to show 'per lane' DVRPC, 2012

Incorporation into VISSIM

The intent of measuring traffic-signal throughput is to accurately code a simulation in the absence of detailed traffic-count data. Once the green time for a particular approach is known, this value can be multiplied by a factor according to the roadway classification. However, this only establishes a target throughput desired in the simulation. Several parameters in VISSIM can affect driver behavior applied to throughput at signalized intersections, including turning speeds, headway times, standstill distance, and the safety distance reduction factor. At a minimum, a visual calibration check should be performed to measure the throughput during the simulation. For higher volume approaches or multi-lane cross-sections, inserting a data collection point is preferred. This parameter would be most applicable for intersections and approaches that experience at or near capacity conditions.

It should be noted that vehicles were frequently observed entering the intersection during the clearance phase (essentially running the light). This condition does not occur in VISSIM. Therefore, when modeling conditions above capacity, rather than force unrealistic driver behavior parameters to reach throughput, it may be necessary to extend the green time by a couple of seconds. Any added time would ideally be taken from the respective approach's yellow or all-red time.

Observations

A few observations were noted during data collection and analysis.

- Left-turning vehicles utilize green time more efficiently than through-movement vehicles, except in the suburban corridor context;
- One or more vehicles crossing the stop bar after a signal has turned yellow is the norm. At least one vehicle crossing the stop bar after the signal has turned red is a common occurrence, particularly for left-turning vehicles;
- Distracted drivers at the beginning of green phases were fairly common;
- Measurement locations for suburban center protected left turns were difficult to find. Locations with a protected left-turn signal phase, dedicated lane, and sufficient demand were rare;
- Single-lane movements are more efficient on a per-lane basis than comparable dual-lane movements; and
- Urban through movements suffer from pedestrians conflicting with right-turning vehicles.

Related Work

Jacobs Engineering and Petrucci Consulting are currently conducting a project for PennDOT to complete Publication 46, Traffic Engineering Manual, Chapter 10, Traffic Study Parameters and Analysis Guidelines. Chapter 10 is currently a reserved chapter in Publication 46. In the course of completing their work, the consultants collected and analyzed data for saturation flow rate, start-up lost time, number of left-turn sneakers, and extension of effective green time from locations throughout the commonwealth. A series of 'Pennsylvania Default Values' were developed that can be used to replace HCM2010 default values. The results of their work should be reflected in the next update to Publication 46.

V. Rolling Stop Speed

Intersections controlled by stop signs may often function more in line with yield-controlled intersections. Few vehicles come to a complete stop when there are no conflicts present. Modeling stop-sign-control in VISSIM produces results in which every vehicle approaching a stop sign comes to a complete stop. The dwell time can be adjusted to minimize time stopped, but any complete stop can result in slower speeds through the intersection. Congested stop-sign-controlled intersections may perform vastly differently between reality and a modeled environment. For this reason, the study team has modeled stop signs with a combination of reduced speed areas and conflict zones. The conflict zone forces a vehicle to come to a complete stop if a conflict is present; otherwise the vehicle will proceed through the stop sign at the speed designated by the reduced speed area. The purpose of this analysis was to identify the speed to assign to these reduced speed areas.

Methodology

A diverse (surrounding land use context and traffic volumes) set of measurement locations was selected.

- A 15-foot segment was denoted on the pavement with chalk. The center of the segment was the average vehicle's slowest point, usually five feet before to 10 feet after the stop bar;
- Vehicles approaching a stop sign when no conflicts were present at the intersection were timed across the marked segment; and
- At most measurement locations, 25 samples were collected.

Results

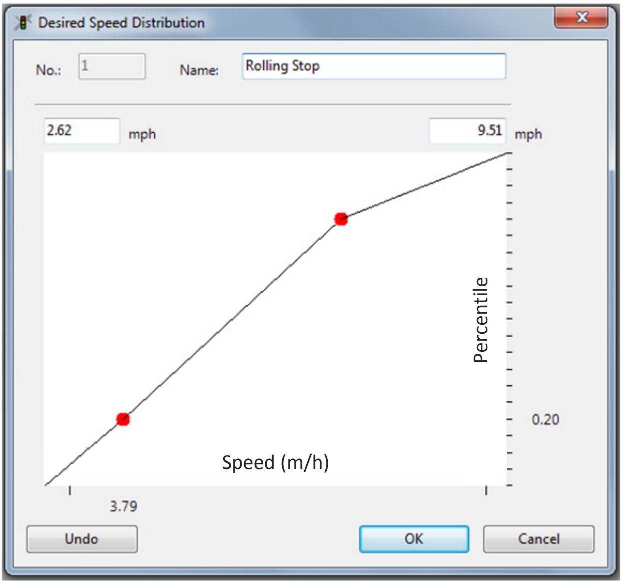
The results are presented in Table 10. Additionally, a sample speed distribution curve is shown as Figure 6.

Table 10: Rolling Stop Results

ROLLING STOP		
Measurement Locations		17
Sample Size		456
	Seconds	**m/h**
Mean	2.19	4.67
Median	2.00	5.11
5th Percentile	3.90	2.62
20th Percentile	2.70	3.79
80th Percentile	1.45	7.05
85th Percentile	1.33	7.72
95th Percentile	1.08	9.51
Standard Deviation	0.92	0.18

DVRPC, 2012

Figure 6: Rolling Stop Sample Speed Distribution



DVRPC, 2012

Incorporation into VISSIM

To model a stop sign using the findings of this work, a multistep process must be undertaken. First, a desired speed distribution must be constructed to reflect the found values. A 15-foot reduced speed area must be placed on the link or connector where the stop sign would be, ideally five feet prior to ten feet after the stop bar if one is present. The desired speed distribution needs to be applied to the reduced speed area. The default values for the conflict zone should be sufficient. An actual stop sign is not used.

Note that when modeling a congested stop-sign-controlled intersection the conflict zone parameters may need to be adjusted to achieve a desired throughput. Throughput for this type of intersection was not quantified for this study.

Observations

A few observations were noted during data collection and analysis.

- Though not quantified, it was estimated that less than five percent of vehicles completely stop when no conflicts are present;
- When conflicts are present, most vehicles slow down significantly until the conflict clears, without ever fully stopping. This may affect their rate of acceleration when departing the intersection; and
- While results varied by location, there were no recognizable patterns regarding differences in context or demand on the intersection.

VI. Conclusion and Lessons Learned

Conclusion

The results will be beneficial to future modeling projects of the study team, and hopefully for those of the region's other VISSIM and other micro-simulation platform users as well.

With the end of Year One complete, the study team will move on to Year Two efforts. As was the process with Year One, Year Two will begin by identifying three useful measurements for quantification. Year Two will conclude with the preparation of a VISSIM .inp file preloaded with the findings of both years' work, and a final technical memorandum.

Lessons Learned

Several lessons were learned during the course of this study.

- The most useful measurements with purposes similar to those conducted for this study do not have academic counterparts from which to borrow methodology;
- Three driver behaviors/calibration factors is a good number for one year, based on the scope and budget of this project;
- Pre-screening locations for data analysis is desirable since many locations are inaccessible for the purpose of observation; and

- It is impossible to determine an ideal sample size due to the variable nature of traffic flow patterns and the diversity of measurement locations. To compensate, data was collected and analyzed for this project until the standard deviation remained stable; i.e., until newly collected data had little to no impact on the resulting statistics.

Going forward, the study team will incorporate the lessons learned into future data collection.

Raw data is available by request.

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Abstract: This report presents the results of the first year's analyses for the VISSIM Standards Project. Three VISSIM model calibration factors were quantified in the project's first year; free-flow speed, signal throughput, and rolling stop speed. The results can be used to improve micro simulation modeling conducted by DVRPC staff and the region's traffic engineers.

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