GEORGIA DOT RESEARCH PROJECT 18-33

FINAL REPORT

VISSIM SIMULATION GUIDANCE

Georgia Department of Transportation

OFFICE OF PERFORMANCE-BASED MANAGEMENT AND RESEARCH

600 WEST PEACHTREE STREET NW
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16. Abstract

Where analytical tools such as the Highway Capacity Software™ (HCS), SYNCHRO®, etc. do not adequately represent traffic operations within a study area, or do not provide the necessary performance metric(s) required for the analysis, detailed simulation or similar approaches may be required. In such cases, the Georgia Department of Transportation (GDOT) typically employs PTV VISSIM™ 11 as the preferred transportation modeling tool. This project has developed guidance material that enhances GDOT's ability to review and utilize VISSIM™ models.

To aid in the development of the necessary skills for VISSIM™ model review, a series of eight modules has been developed. The first four modules provide a basic introduction to arterial corridor and freeway model development, walking the reader step-by-step through the development of a small model containing unsignalized and signalized (fixed-time and actuated) control and a freeway segment and diamond interchange. The final four modules cover broader modeling issues, such as working with VISSIM™ results and direct output; underlying VISSIM™ model parameters and distributions; alternative model layouts and features; verification, calibration, and validation; and other issues critical to a thorough model review. These four modules culminate with reviewer checklists. After completion of all eight modules the GDOT reviewer will have been exposed to the knowledge and skills necessary to review and utilize a VISSIM™ model.

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GDOT Research Project 18-33

Final Report

VISSIM SIMULATION GUIDANCE

By

Michael Hunter
Professor

Georgia Tech Research Corporation

Contract with
Georgia Department of Transportation

In cooperation with
U.S. Department of Transportation
Federal Highway Administration

June 2021

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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EXECUTIVE SUMMARY

Where analytical tools such as the Highway Capacity Software™ (HCS), SYNCHRO®, etc. do not adequately represent traffic operations within a study area, or do not provide the necessary performance metric(s) required for the analysis, detailed simulation or similar approaches may be required. In such cases the Georgia Department of Transportation (GDOT) typically employs VISSIM™ 11 as the preferred transportation modeling tool. This project has developed guidance material that enhances GDOT's ability to review and utilize VISSIM™ 11 models.

The developed guidance is based on several assumptions. First, it is recognized that several public agency and private industry VISSIM™ user documents exist. This effort does not seek to replace or replicate these documents and will draw from and/or reference them frequently. Second, the developed guidance documents do not address analysis tool selection, scope, scenario development, etc. The documents are limited to the skills and knowledge needed to conduct a thorough model review. Third, while the effort provides extensive discussion on how to review model validation and calibration, it does not recommend a specific calibration methodology. Fourth, the user/reviewer is assumed to have basic traffic engineering knowledge, typical of that found in a standard traffic engineering course. Lastly, an approach has been adopted in the development of the guidance documents that requires a GDOT staff member or consultant to have some basic experience in model development in order to review a model.

Thus, to aid in building the necessary skills for VISSIM™ model review, a series of eight modules has been developed. The first four modules provide a basic introduction to arterial corridor and freeway model development, walking the reader step by step through the development of a small model containing unsignalized and signalized (fixed-time and actuated) control and a freeway segment and diamond interchange. The final four modules cover broader modeling issues, such as working with VISSIM™ results and direct output; underlying VISSIM™ model parameters and distributions; alternative model layouts and features; verification, calibration, and validation; and other issues critical to a thorough model review. These four modules culminate with reviewer checklists. After completion of all eight modules, the GDOT reviewer will have been exposed to the knowledge and skills necessary to review and utilize a VISSIM™ model.

The eight modules developed in this effort are as follows:

MODULE 1: BASIC THREE INTERSECTION MODEL SETUP – This module guides the user through the creation of a corridor that consists of three 4-approach intersections. The module steps through six basic components of network creation: links and connectors, traffic controllers, traffic volumes and routing decisions, conflict zones, performance measures and output files, and running the model.

MODULE 2: ACTUATED SIGNAL – This module familiarizes the user with basic actuated controller setup in VISSIM™. It steps the user through renaming controller files, placing stop bar and upstream detectors, ring-barrier control (RBC), and signal coordination.

MODULE 3: UNSIGNALIZED INTERSECTION – Module 3 adds a two-way stop-controlled intersection to the network constructed in Modules 1 and 2. This module provides additional guidance on vehicle input, routing decisions, and links and connectors, as well as stop signs and conflict zones.

MODLUE 4: DIAMOND INTERCHANGE – Module 4 adds a diamond interchange to the network. This includes creating the interchange geometry and signal control, creating the on- and off-ramps, and introducing several additional VISSIM™ vehicle and driver behavior parameters.

MODULE 5: CONCEPTS AND TIPS – Module 5 provides guidance on the vehicle fleet and composition, underlying vehicle performance and driver behavior distributions, and several methods to set vehicle speeds. In addition, alternate layouts are introduced for an intersection link configuration, a left-turn bay configuration, and an on-ramp link-connector layout.

MODULE 6: DATA AND PERFORMANCE METRICS – Module 6 demonstrates how to collect, view, and save various performance metrics and signal control measures. The module shows how to collect both aggregate data and raw data. Potential challenges and best practices are discussed relative to each performance metric.

MODULE 7: START-UP & REPLICATE TRAILS, AND VERIFICATION, VALIDATION, & CALIBRATION – Module 7 fills in many of the concepts required for a simulation study. It provides guidance on starting a model, the length of a data collection period (e.g., accounting for over-capacity conditions), and replicate trials, as well as a discussion on verification, calibration, and validation.

MODULE 8: REVIEW CHECKLIST – This module is the capstone to the previous seven modules. Module 8 provides several checklists for use by GDOT for the verification and review of a VISSIM™ model.

A brief summary of each of these modules may be found in chapter 3, and the modules are posted on the GDOT website.

Finally, it is critical to recall that VISSIM™ is a highly flexibly tool. While there are clearly many potential modeling errors or invalid approaches, there are often multiple modeling approaches that could be utilized to model a given area; different "experts" may select different approaches. Where questions arise on alternative implementations, VISSIM™ reviewers are encouraged to interact with the model developers to determine the adequacy of an approach.

CHAPTER 1. INTRODUCTION

OVERVIEW

GDOT is committed to maintaining safety on Georgia's roadways and providing an efficient, cost-effective transportation system. Often, this requires the analysis of transportation facilities, such as a single intersection, an arterial corridor, a freeway interchange, etc. Where analytical tools such as the Highway Capacity Software™ (HCS), SYNCHRO®, etc. do not adequately represent traffic operations within a study area, or do not provide the necessary performance metric(s) required for the analysis, detailed simulation or similar approaches may be required. In such cases the Georgia Department of Transportation (GDOT) typically employs VISSIM™ 11 as the preferred transportation modeling tool. VISSIM™, a microscopic simulation tool, can be a powerful resource for project analysis; however, with its use comes many complexities and challenges not found in analytic modeling tools. As such, GDOT sought to develop guidance material that enhances its ability to review and utilize VISSIM™ 11 models.

RESEARCH SCOPE

To aid in the review and utilization of microscopic simulation (e.g., VISSIM™) for operational analysis, this research project sought to:

1. Understand prior state of the practice and state of the art in VISSIM™ 11 model development.
2. Understand key issues related to VISSIM™ 11 use by GDOT and its consultants.

3. Develop a guidance document suitable for use by GDOT personnel in the review of GDOT VISSIM™ 11 models, as well as GDOT consultants in model development.

In the development of the guidance document, it was recognized that several public agency and private industry VISSIM™ user documents already exist. This effort does not seek to replace or replicate these documents but rather draws from and/or references them frequently. In addition, this project does not address analysis tool selection. It is assumed that the choice to use VISSIM™ is made outside the guidance developed within this effort. Finally, while the effort provides extensive discussion on how to review model validation and calibration, it does not recommend a specific calibration methodology, as this is out of the scope of the project effort.

RESEARCH APPROACH

To accomplish the stated objectives, an approach was adopted that requires a GDOT staff member or GDOT consultant who will review a model to have some basic experience in model development. That is, the most thorough and thoughtful reviews will be provided by individuals with familiarity in VISSIM™ development. Thus, to aid in the development of the necessary skills for VISSIM™ model review, a series of eight modules have been created. The first four modules provide a basic introduction to arterial corridor and freeway model development, walking the reader step by step through the development of a small model containing unsignalized and signalized (fixed-time and actuated) control and a freeway segment and diamond interchange. The final four modules cover broader modeling issues, such as working with VISSIM™ results and direct output; underlying VISSIM™

model parameters and distributions; alternative model layouts and features; verification, calibration, and validation; and other issues critical to a thorough model review. These four modules culminate with reviewer checklists. After completion of all eight modules, the GDOT reviewer will have been exposed to the knowledge and skills necessary to review and utilize a VISSIM™ 11 model.

The developed eight modules are the following:

- Module 1: Basic Three Intersection Model Setup
- Module 2: Actuated Signal
- Module 3: Unsignalized Intersection

MODULE 4: DIAMOND INTERCHANGE

- Module 5: Concepts and Tips
- Module 6: Data and Performance Metrics
- Module 7: Start-Up & Replicate Trials, and Verification, Validation, & Calibration
- Module 8: Review Checklist

Chapter 3 provides a brief summary of each module.

USER EXPECTATIONS

There are several important expectations on the part of the user of the developed modules. First, the user is assumed to have basic traffic engineering knowledge, typical of that found in a standard traffic engineering course. Concepts such as dual ring signal control, actuated control and detector settings, geometric design, etc. will be utilized without detailed explanation. For questions in these areas, readers are referred to guides such as the American Association of State Highway and Transportation Officials' *A Policy on Geometric Design of Highways and Streets* (AASHTO 2018), the Transportation Research Board's *Highway Capacity Manual* (TRB 2010), the Federal Highway Administration's (FHWA) *Traffic Signal Timing Manual* (Koonce et al. 2008), etc.

Second, through the use of these modules the user will become experienced with many of the fundamental principles of VISSIM™ and simulation. Although within the limited number of modules it is not possible to cover all (or even most) VISSIM™ features, through the completion of the modules, users should gain a considerable comfort in their ability to use the VISSIM™ manual and interfaces to learn about new topics as needed, allowing them to tackle simulation models with features not covered in this guidance. As such, users are highly encouraged to explore beyond the step by step instructions when completing the modules, trying different settings than those recommended, reviewing metrics and attributes not directly included in the steps, etc.

Finally, it is critical to recognize that VISSIM™ is a highly flexible tool. While there are many potential modeling errors or invalid approaches, there are similarly often multiple approaches that could be utilized to model a given area, and different "experts" select different approaches. Where questions arise on alternative implementations, VISSIM™ reviewers are encouraged to interact with the model developers to determine the adequacy of an approach.

PROJECT TASKS

To develop the guidance modules, the following tasks were undertaken.

Task 1. Conduct VISSIM™ Simulation Model Development Literature Review

In this task, the research team collected and reviewed literature relevant to VISSIM™ simulation model development, calibration, and validation. The lessons from the key literature are woven throughout the guidance documents, and background information is provided in chapter 2. Key literature includes existing VISSIM™ simulation development guidance and training documents that have been developed by other public agencies and private industry. Additionally, published peer-reviewed literature that highlights potential VISSIM™ model development, calibration, and validation challenges and insights were examined.

Task 2. Review Prior GDOT VISSIM™ Projects and Interview GDOT and Consultant Users

Current model users are one of the most important resources for understanding VISSIM™ development, calibration, and validation challenges. Thus, the research team interviewed a group of current GDOT and consultant users, as identified by GDOT staff and the research team. The survey enabled an improved understanding of the current state of the practice for model development in Georgia, as well as known questions, issues and concerns, and areas of inconsistency. Survey responses were particularly helpful in identifying issues to be included in the last four modules.

Task 3. Develop Outline of VISSIM™ Guidance Document

This task outlined the VISSIM™ guidance document. Key issues were identified, such as basic model development (arterial and freeway), modeling concepts, data input and output, performance metrics, start-up and fill-period, data collection period, considerations related to under- and over-capacity conditions, and calibration and validation. The outline was coordinated with GDOT through project meetings and email. The ordering of topics was adjusted during the project with the final module list as provided previously in Research Approach.

Task 4. Development of Guidance Document

In this task the content for individual modules, as listed in Research Approach, was finalized. A summary of each module is provided in chapter 3.

Task 5: Draft Guidance Document

In this task each module was drafted. Draft text for each module was submitted to GDOT for review as it was completed.

Task 6: Final Report

This final report contains a summary of the work completed and the final modules.

SUMMARY

This project has developed a series of guidance documents suitable for use by GDOT personnel for training in how to review VISSIM™ 11 models, as well as by GDOT consultants for model development. Through the completion of the eight developed modules, the GDOT reviewer should possess the knowledge and skills to conduct a thorough review of a VISSIM™ 11 simulation. The remainder of this report provides background material (chapter 2), an overview of the modules developed (chapter 3), and a summary and conclusions (chapter 4). The full modules may be found on the GDOT website.

CHAPTER 2. BACKGROUND

VISSIM™ OVERVIEW

VISSIM™ is a discrete, stochastic time-step microscopic simulation model (PTV Group 2019) that incorporates a behavior-based traffic simulation approach capable of modeling a wide range of traffic conditions, including point facilities (i.e., intersections, interchanges, etc.), freeway and arterial corridors, roadway networks, and public transit operations. VISSIM™ utilizes psychophysical perception models to capture car-following behavior: the Weideman 74 and Wiedemann 99 models. The Wiedemann models categorize the car-following behavior of a vehicle into different states. These states are:

(1) *free driving*, where the following vehicle behavior is not influenced by the lead vehicle (i.e., the lead vehicle, if any, is sufficiently far away that the following vehicle ignores it);

(2) *approaching*, where a faster following vehicle must decelerate and adapt its speed to a slower leading vehicle;

(3) *following*, where the following vehicle maintains a safe distance from the leading vehicle (allowing for some variability in the following behavior); and

(4) *braking*, where the following vehicle decelerates to maintain a safe following distance, typically in response to the lead vehicle slowing or stopping (PTV Group 2019).

Each simulated vehicle in a VISSIM™ model is assigned to one of these four states at each time step, switching between states based on parameter thresholds, including desired speed, required safety distance, and others. These thresholds vary from one simulated vehicle to another, providing one of the ways in which VISSIM™ introduces stochasticity into its modeling framework. When near its threshold a vehicle may oscillate between driving modes, simulating a human driver's limitations in exactly perceiving a lead vehicle's speed and acceleration. Figure 1 is an example of how the current driving state of a following vehicle is determined by its relative difference in speed (ΔV) and distance (ΔX) with the lead vehicle. In this figure, the zones labeled "no reaction," "reaction," "unconscious reaction," and "deceleration" correspond to the driving states of free driving, approaching, following, and braking, respectively (Hunter et al. 2017, PTV Group 2019).

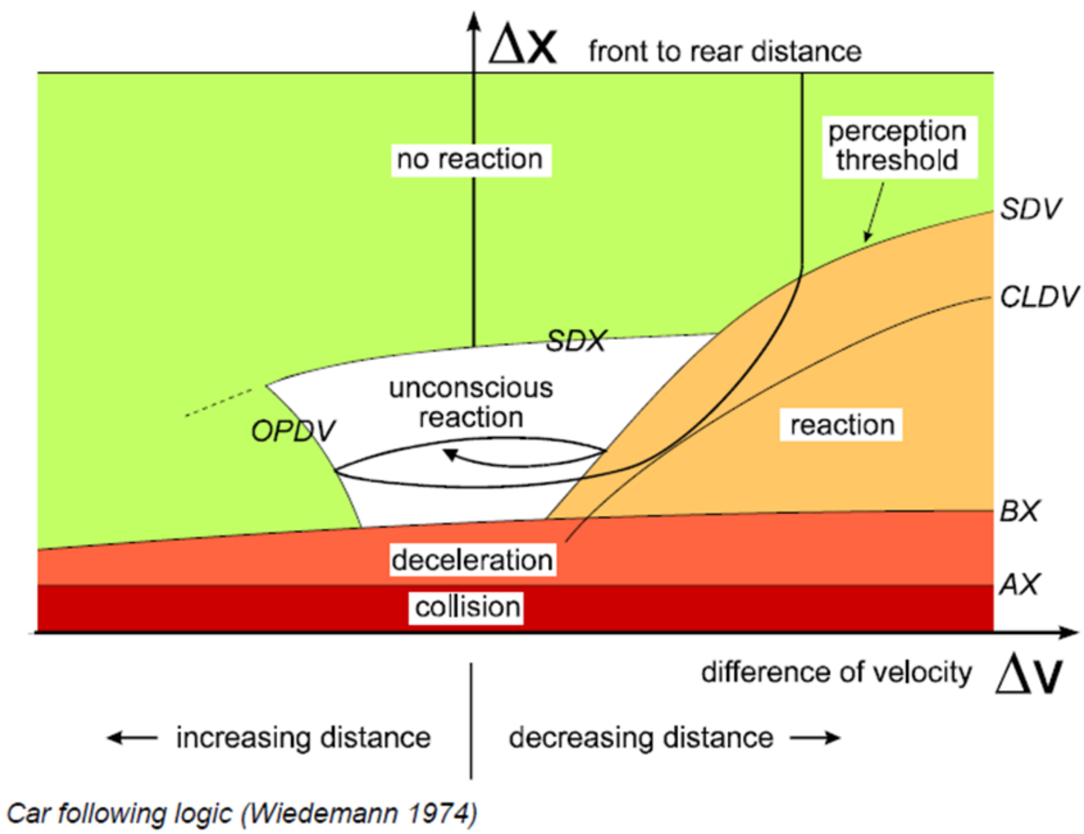


Figure 1. Graph. Psychophysical car-following model.
(Source: Kia Ova, PTV 2010)

As seen, when ΔX is large a vehicle is in free driving, and its behavior is not influenced by downstream (lead) vehicles. As ΔX becomes smaller the vehicle behavior will begin to respond to the lead vehicle, maintaining a safe following distance with some minimal variation. Should ΔX become smaller than some set safety distance, the vehicle will decelerate in an effort to restore its headway. Similarly, it may be observed that as ΔV changes, the response of the lagging vehicle to the lead vehicle may change. While the exact form of these zones is not critical to the use of a VISSIM™ simulation, it is important that a model developer or reviewer intuitively understand these underlying behaviors. For example, in an undersaturated demand scenario, a change in an underlying VISSIM™ parameter that is highly correlated with headways may have minimal impact on performance metrics, as most vehicles are operating in free driving. However, under higher demand scenarios, that same parameter change may significantly impact the model behavior given the reduced headways in the scenario. That is, in a modeling project a VISSIM™ parameter may be found to not influence model results in the "before" scenario while results are highly sensitive to the parameter in the "after" scenario or vice versa.

As general guidance, Wiedemann 74 is used for lower speed roadway sections and Wiedemann 99 is utilized for higher speed roadway sections. In practice, Wiedemann 74 is typically applied to signalized and low-speed corridors, while Wiedemann 99 is utilized for freeways. However, the application of Wiedemann models by facility type is not a hard and fast rule. The Wiedemann models directly influence a roadway segment capacity, saturation flow, density, etc. Thus, it may be necessary to calibrate the model parameters to reflect field conditions. In addition to the Wiedemann models, lane changing, speed reduction, and other parameters are also incorporated into VISSIM™. One focus of the proposed guidance document will be on understanding the influence of these models and parameters on VISSIM™ results. Prior to calibrating the Wiedemann parameters, a thorough calibration should be made of these location-specific elements. Additional detail may be found on the Wiedemann models and other features in the VISSIM™ User Manual (PTV Group 2019). In addition, these models receive extensive coverage throughout the developed eight modules.

EXISTING GUIDANCE

There are a number of guidance documents available that were drawn from for this effort. Several examples are discussed in the following section.

The *Protocol for VISSIM™ Simulation* (Mai et al. 2011) developed for the Oregon Department of Transportation (ODOT) is a well-developed example of a VISSIM™ guidance document. It has the stated purpose of "…promoting consistency among VISSIM™ applications from one project to the next and between modelers." Three important chapters (relative to the current GDOT effort) within this protocol are Chapter 4: Model Development, Chapter 6: Calibration, and Chapter 10: Reviewing. Chapter 4 discusses in depth such items as vehicle fleet, various network coding issues (e.g., freeway access and egress), signal control, speed zones, vehicle routing, etc. Chapter 6 provides a brief introduction to calibration, generally limited to very high-level guidance rather than significant detail regarding the implementation of a calibration protocol. Chapter 10 provides several useful checklists for a model reviewer. These discussions, along with the VISSIM™ manual and other guidance documents, helped to inform the content of the developed VISSIM™ modules. While outside the scope of the current GDOT project, this protocol also includes information on tool selection, project scoping, staffing, etc.

The Florida Department of Transportation's *Traffic Analysis Handbook* (FDOT 2014) is a general operations and planning reference, covering a range of topics; however, it contains a chapter dedicated to microscopic simulation analysis, covering topics related to both CORSIM™ and VISSIM™. While not intended as a "how-to" guide, the handbook provides a number of useful tips and general guidelines for model development that helped inform the current effort. This included classical model calibration targets and statistical analyses that are referenced directly in Module 7. It also provides a "checklist" approach to model development that was applicable to the development of the Module 8 reviewer checklists.

Another highly useful discussion of simulation is found in the *Traffic Engineering, Operations & Safety Manual*, developed by the Wisconsin Department of Transportation (WISDOT 2018). Of relevance to this study is Chapter 16: Traffic Analysis and Modeling, and Chapter 20: Microscopic Simulation and Traffic Analysis. This manual provides several useful simulation definitions and concepts, including a presentation of a number of measures of effectiveness. The Wisconsin guide arguably provides more detail on calibration than the previously discussed guides. However, as with the previous documents, without additional examples and VISSIM™-specific guidance there will likely exist a disconnect between the guidance document and implementation when applied by many readers.

Other state guidance documents specific to VISSIM™ also exist, such as the Maryland Department of Transportation's *VISSIM™ Modeling Guidance* (MDOT 2017), the Washington State Department of Transportation's *Protocol for VISSIM™ Simulation* (WSDOT 2014), and the Virginia Department of Transportation's *VDOT VISSIM™ User*

Guide, Version 2.0 (VDOT 2020). Manuals such as these provided additional valuable input into the current effort. Each of these documents seeks to provide guidance for specific geometric modeling elements, such as modeling acceleration and deceleration lanes with links and connectors, suggested driver behavior parameter ranges, signal controller settings, vehicle routing, reduced speed zones, etc. These manuals, as well as previously described documents, provide multiple sources that helped inform the GDOT guidance documents. For instance, several results from the WSDOT manual are directly referenced in the Module 7 calibration discussion.

Another more general document is the *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software* (Dowling et al. 2004, Wunderlick et al. 2019). The toolbox provides a high-level discussion of a seven-step model development process: "1) Identification of Study Purpose, Scope, and Approach, 2) Data Collection and Preparation, 3) Base Model Development, 4) Error Checking, 5) Calibration, 6) Alternatives Analysis, and 7) Final Report and Technical Documentation." The toolbox provides useful guidance and insight. Though it seeks to be model neutral, it does use model examples in a link-node scheme, which lessens some of its usefulness when considering VISSIM™. As with Mai et al., it provides calibration guidance, although the outlined procedures would be difficult to directly apply to a VISSIM™ model.

The *Microscopic Simulation Model Calibration and Validation Handbook* (Park and Won 2006) was developed for VDOT. This handbook focuses exclusively on simulation calibration, avoiding discussion of base model development except as it may pertain to model calibration. It provides a useful high-level discussion of many of the underlying concepts within many calibration efforts, such as calibration parameter selection, use of performance metric distributions and standard deviation, number of replicate trials, X–Y plots for testing feasibility, Latin hypercube design, etc. The handbook recommends a specific genetic algorithm (GenA) approach to calibration. While a potentially useful calibration approach, it has several drawbacks. The most critical of these being: (1) the GenA approach will be a "black-box" to many potential users, and (2) it is dependent on a previously developed calibration utility program. Thus, while some underlying concepts discussed in this handbook will help inform the current effort, it is unlikely that the method it developed will be applied to the proposed work.

Finally, two other highly useful resources in the development of the guidance documents were two PTV Group training courses, both with Training Manager Levi Button: *Freeway Modeling* (PTV Group 2020a) and *VISSIM™ for Reviewers* (PTV Group 2020b). These courses had the advantage of providing insights not found in many of the guidance documents, as well as allowing attendees to ask questions. For instance, the alternative on-ramp link connector layout in Module 5 is discussed in detail in the *Freeway Modeling* course. In addition, Mr. Button and other PTV staff were helpful in answering emails regarding specific questions as the modules in this effort were being developed.

GDOT AND CONSULTANT SURVEY

As seen, task 2 of the project included a survey of existing GDOT personnel and GDOT consultants regarding the use and review of VISSIM™ models. The survey consisted of an informal conversation between the project researchers and the survey participant. While stated as a condition of the survey that specific comments are not attributed to individual survey respondents, a number of interesting insights from the survey were found and influenced the modules' development. The following items summarize key insights.

- *Review process:* Based on the discussions with both the GDOT personnel and GDOT consultants, it was determined that there was not a clearly identified review process or set of expectations. The level of detail undertaken in a model review was highly dependent on the assigned reviewer and that reviewer's VISSIM™ knowledge and skill level. Model reviewers (and model developers) tended to use visual inspection of the model animation for the initial review, utilizing this inspection to determine which aspects of the model required a deeper review of model inputs, parameters, etc.
- *Review documentation:* The survey revealed a wide variety in the documentation that would be provided with a model as part of the review process. Documentation ranged from detailed model development and calibration reports, to minimal documentation in the overall project report. One instance was even noted where the model developer resisted providing the model files to the reviewer (the files were provided upon insistence by the reviewer). GDOT personnel highlighted the need for documentation to identify where model parameters differed from default values and to justify why changes were made.
- *Model developers:* Each model developer (e.g., consultant) tended to have their own in-house model development process, calibration procedures, and verification/reviewer checklists. Although there was generally significant overlap in the documents between consultants, each had their own unique

approach. Several of the consultants provided example reports or checklists to the project researchers. These significantly influenced the checklists developed in Module 8 as well as highlighting topics included in Module 1 through Module 7.

However, it is noted, that the survey respondents were identified for their expertise in VISSIM™ simulation and active participation in the advancement of simulation in Georgia. It should not be expected that all model developers will have these same levels of in-house VISSIM™ development procedures.

- *Calibration:* GDOT personnel did not express a preferred approach to model calibration. Each consultant had their own calibration method(s), which parameters they considered important, which distributions they would adjust, how to identify critical locations, etc. For determining the adequacy of a calibration effort and the validity of a model, most consultants utilized, at least in part, the thresholds as described in several of the other state guides, with the ODOT, FDOT, and VDOT guidance being particularly highlighted. Module 7 seeks to provide the guidance necessary to enable a reviewer to knowledgably review such calibration efforts.
- *Performance metrics:* Variation was seen in the performance metrics reported and the methods adopted to collect measures. For instance, some consultants utilized link- and node-based performance metrics while others relied on setting up measurement sections and data collection points. Both approaches may provide reasonable performance measures and are covered in Module 6. While beyond the scope of this research effort, GDOT may wish in the future to

provide additional guidance on formalizing a subset of expected measures and collection methods.

- *Other:* A number of other items were raised during the survey that were out of the scope of the current effort. For example, tips on developing roundabout models, use of origin–destination matrices, importing a VISSIM™ network from another modeling tool, ramp meter coding, simulating pedestrians, bikes, and transit, modeling two-way left-turn lanes, etc. In the future GDOT may wish to prioritize some of these modeling issues for development of specific guidance (e.g., additional modules) on these topics.
- *Flexibility:* While a more consistent review process is desirable, the need for flexibility in model development was highlighted by several consultants. VISSIM™ is a highly flexible model and as such often multiple methods can be used to simulate a given situation. In addition, there are many unique and complex traffic and geometric scenarios. Several survey participants expressed concern that model development could become overly prescriptive. They emphasized the need to maintain a balance between a checklist approach to modeling and flexibility in making modeling choices as Georgia advances its simulation efforts.

Recommendations Based on the Survey

The survey both confirmed the approach taken in the guidance document as well as offered insights into material that needed to be provided. First, it was clear that to conduct a review, a reviewer (GDOT or consultant personnel) needed to have hands-on experience with VISSIM™. While Module 1 through Module 4 seek to provide this experience, GDOT may also wish to consider increasing its in-house development of models. This will aid in building and maintaining the skills and expertise necessary to review models developed outside of GDOT.

Second, both the GDOT personnel and consultant staff highlighted the importance of model documentation. Providing explanations of the underlying modeling assumptions, justification for parameters settings different from VISSIM™ defaults, tables, and figures for evaluating model calibration and validation, etc., will create a more reliable and efficient review process. Module 8 provides checklists that will help inform this documentation.

Third, while most state departments of transportation do not have specific calibration guidance, GDOT may wish to explore additional guidance for calibration methods, calibration objectives, and acceptable performance as a potential means to improve the consistency and quality of the model development and review process.

Fourth, neither GDOT nor the consultant developers sought an entirely prescriptive approach to VISSIM™ model development and review. The need for flexibility in the process was clear. Where possible, modeling development processes and choices should be discussed between GDOT and the model developer prior to expending significant effort on the model development. In addition, as stated above, documentation of the model development should include justifications for variations from defaults.

In summary, the survey proved highly informative for the development of the modules. In addition to the overarching themes of the survey presented in the preceding discussion, many specific VISSIM™ elements were also discussed. For example, when to utilize

Wiedemann 74 vs. Wiedemann 99. While each of these details is not addressed in this section, they helped inform the topics and discussion included throughout the modules.

CHAPTER 3. GUIDANCE MODULES SUMMARY

As stated, eight modules have been developed to provide the knowledge and skills necessary to review VISSIM™ models. These modules are:

Module 1: Basic Three Intersection Model Setup

Module 2: Actuated Signal

Module 3: Unsignalized Intersection

Module 4: Diamond Interchange

Module 5: Concepts and Tips

Module 6: Data and Performance Metrics

Module 7: Start-Up & Replicate Trials, and Verification, Validation, & Calibration

Module 8: Review Checklist

The first four modules provide a basic introduction to arterial corridor and freeway model development, walking the reader step by step through the development of a small model containing unsignalized and signalized (fixed-time and actuated) control and a freeway segment and diamond interchange. The final four modules cover broader modeling issues critical to a thorough model review, such as working with VISSIM™ results and direct output; underlying VISSIM™ model parameters and distributions; alternative model layouts and features; verification, calibration, and validation; and other issues. The following sections provide a brief overview of common module elements as well as a description of each module.

COMMON MODULE ELEMENTS

Each module seeks to provide the user with a certain VISSIM™ skill set and knowledge base. Each module builds upon the previous modules, assuming the user has acquired the skills previously presented. Each module contains various components, such as step-by-step instructions, example VISSIM™ interfaces, helpful hints, and critical concepts. Examples of each are given in the following subsections. Significant discussion on the various steps and concepts are provided throughout each module.

Step-by-Step Instructions

To guide the user, the modules use step-by-step instructions. For example, figure 2 shows the first five steps utilized to create the east–west main roadway centerline.

step i. Left Click the *links* icon: 

in the *Network Objects* toolbar (This should be to the left of the *Network Editor* window.)

step ii. With the right mouse button, click at the desired position of the *link* (roughly halfway down the network editor screen, near the left edge)

step iii. Drag the mouse in the **direction of flow** (we will do eastbound first, left-to-right) to the destination point and release the button (See helpful hints on the next page.). Don't worry about getting exactly 2000', we can adjust later.

step iv. When you reach the end of the *link* and release the mouse button, the *Link Window* containing the *link* data will pop-up, Figure 4.

- Set the *number of lanes* equal to 2.
- Type in the roadway name (Let's use "Buzz Blvd EB") in the *Name* box.
- We will leave the other parameters at the default values for now but take a few moments to review the other possible link inputs.

step v. Select *OK* to close the *Link Window*

Figure 2. Screen capture. Example step-by-step module guidance.

VISSIM™ Interfaces

To support the step-by-step instructions, screen captures of VISSIM™ pop-up windows are also provided. For example, figure 3 is the VISSIM™ Link window. These windows provide one of the primary interfaces utilized during model development.

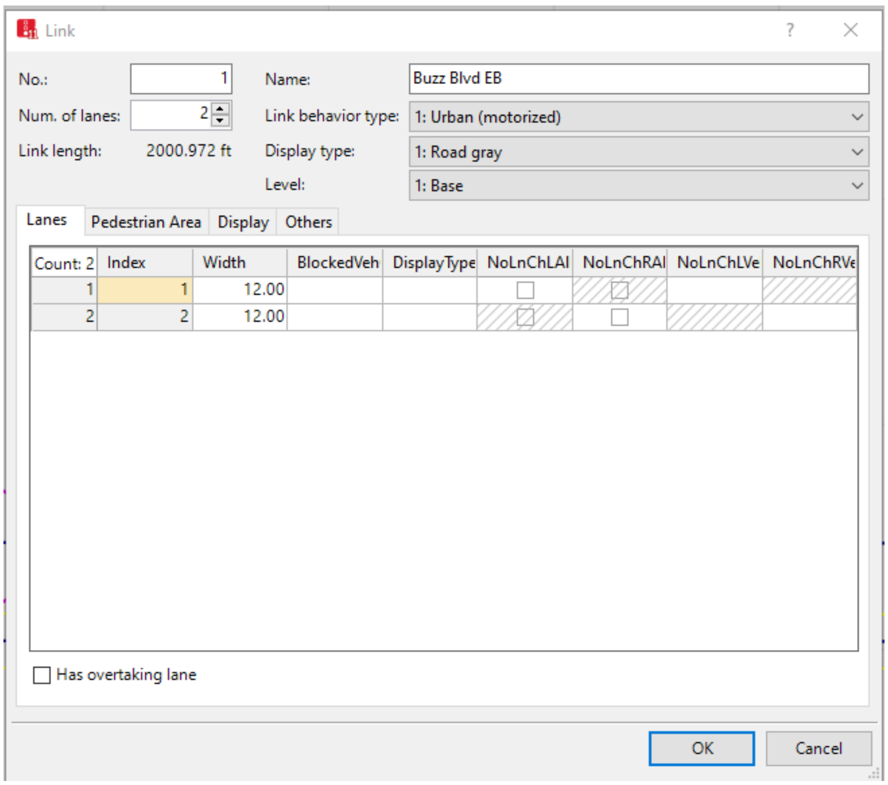
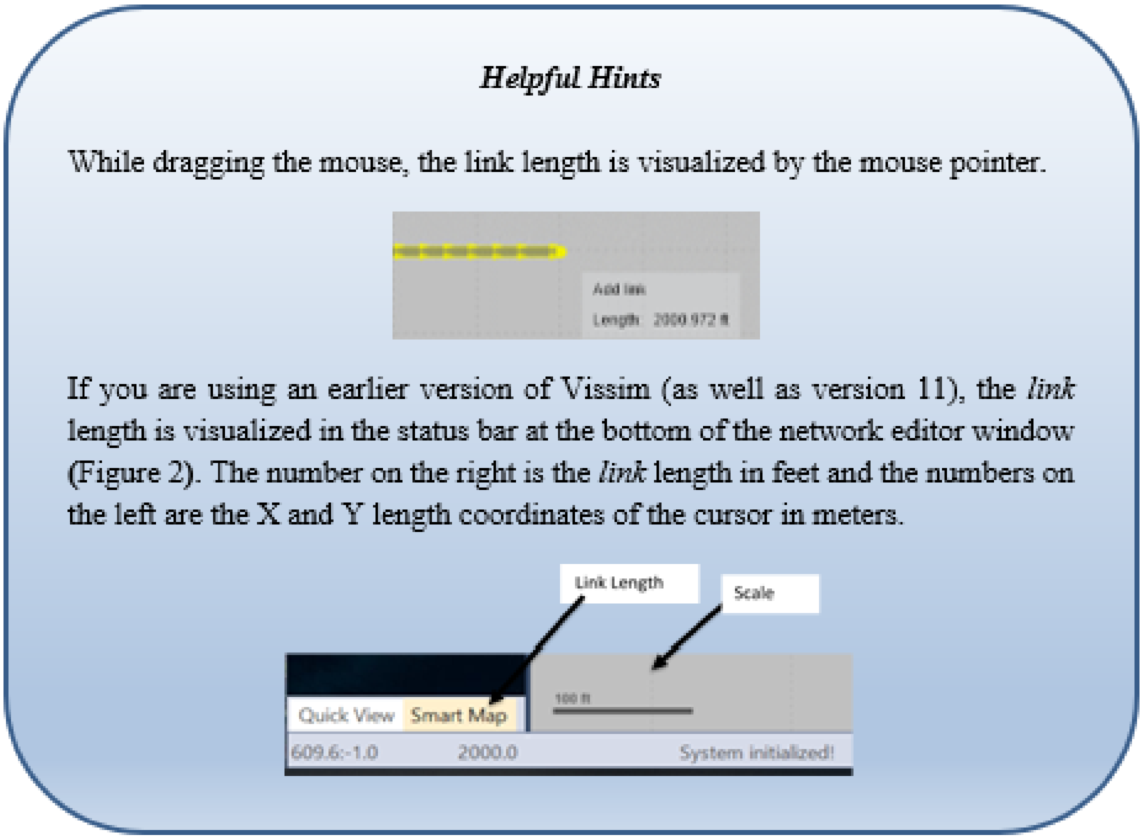


Figure 3. Screen capture. Example VISSIM™ pop-up window.

Helpful Hints

Throughout the modules “helpful hints” are provided. These helpful hints may be related to guidance on building a model, tips on the VISSIM™ interface, key issues to consider when reviewing a model, etc. Figure 4 provides an example helpful hint.


Helpful Hints

While dragging the mouse, the link length is visualized by the mouse pointer.

If you are using an earlier version of Vissim (as well as version 11), the *link* length is visualized in the status bar at the bottom of the network editor window (Figure 2). The number on the right is the *link* length in feet and the numbers on the left are the X and Y length coordinates of the cursor in meters.

Figure 4. Screen capture. Example helpful hint.

Critical Concepts

Finally, throughout the modules, brief discussions related to critical concepts are provided; for example, figure 5 discusses concepts related to the placement of a signal head (SH). Critical concept text seeks to address the "why" rather than the "how-to" for model setup. Often these critical concepts will highlight issues important to model review.

CRITICAL CONCEPT:

When placing a SH it will only apply to those vehicles on the associated link and lane. That is, if an SH is placed downstream of a link-connector join location the vehicles that utilize that connector will NOT be influenced by the SH. This is true even though on the Vissim network map it may look like the SH is covering the connector. When reviewing a model, it is sometimes seen that turning movements appear to ignore the SH. This typically due to a signal head being placed downstream (often very slightly) of the connector join location on the link. Similarly, a signal head may be placed on a connector, in such a case that signal will not influence vehicles that remain on the link.

Figure 5. Screen Capture. Example critical concept.

MODULE 1: BASIC THREE INTERSECTION MODEL SETUP

This is the first in the series of VISSIM™ modules. This module guides the user through the creation of a corridor that consists of three 4-approach intersections, as seen in figure 6. The network is regulated by fixed-time traffic signals using ring-barrier control (RBC).

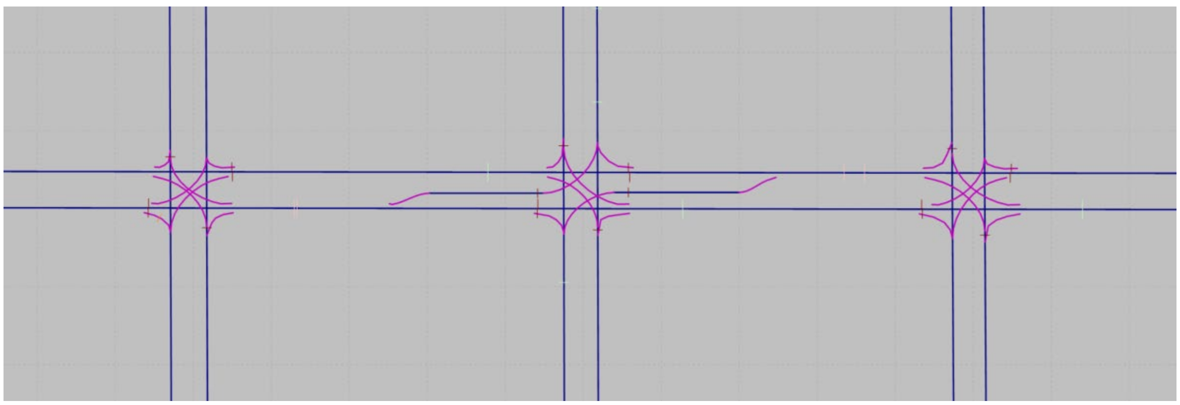


Figure 6. Network diagram. Link–connector layout of Module 1.

The module begins with the assumption that the user has no VISSIM™ experience. Thus, it starts with a basic introduction to the VISSIM™ graphical user interface (GUI), describing how to start the model, navigate the view screen, view the background map, display settings, pan and zoom, save a model, etc. The module then steps through six basic components of network creation:

1. *Links and connectors.* These are the "roads and intersections" of the network. This includes roadway geometric layout, i.e., roadway alignment, number of lanes, turn bays, allowable intersection turn movements, etc.
2. *Traffic controllers*, i.e., the signals controlling intersection traffic. This includes adding signal controllers, signal heads, and stop bars; dual ring signal control,

e.g., allowable phases, phase lengths and order, yellow and red time, etc.; and other timing parameters, such as recall, max green, right-turn-on-red, etc.

3. *Traffic volumes and routing decisions.* This task covers settings that control the entering of traffic volume and vehicle paths. This includes defining vehicle input locations and volume, setting routing decisions (i.e., implementing turn percentages at intersections), understanding routing constraints, etc.
4. *Conflict zones.* Conflict zones specify the right of way where vehicle movements conflict. Conflict zones define, at a potential conflict point, which vehicle has the right of way and the expected behavior of conflicting vehicles.
5. *Setting up performance measures and creating output files.* This is the initial introduction into defining potential performance metrics provided by the model, limited to basic travel time and delay measurements. Module 6 provides a significantly more comprehensive review of performance metrics.
6. *Running the model.* This includes initial concepts on how to review the model run for reasonableness and errors.

Module 5 through Module 8 provide significantly more depth in these topics.

MODULE 2: ACTUATED SIGNAL

Module 2 builds on the arterial corridor developed in Module 1. The module familiarizes the user with basic actuated controller setup in VISSIM™. It is assumed that the user already understands actuated signal control concepts. The network in Module 1 is updated to include actuated control and detection (see figure 7).

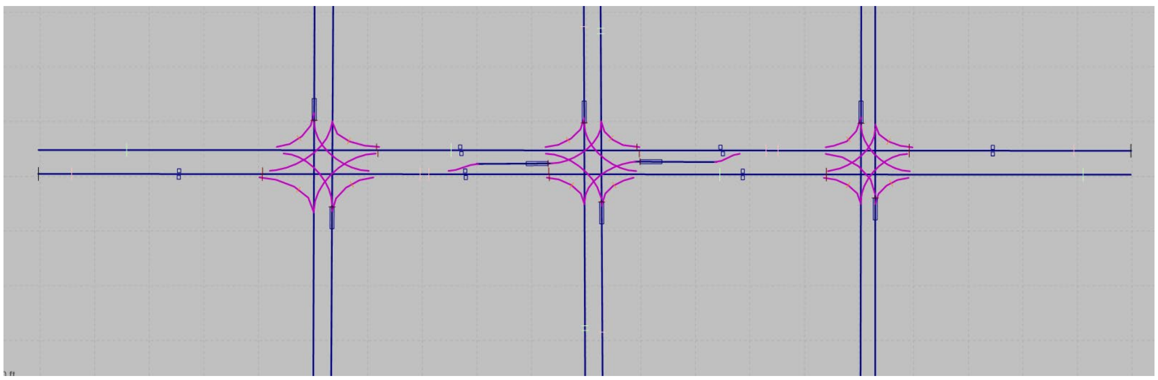


Figure 7. Network diagram. Module 2 corridor, includes actuated control and vehicle detection.

This module steps through seven primary tasks:

1. *Saving a VISSIM™ file under a new name and renaming controller files*. This section covers critical concepts in file saving and how to ensure that prior controller files are not overwritten.
2. *Placing stop bar detectors*. This section demonstrates how to place detectors at the stop bars of the left-turn mainline and side streets and assign the detectors to the appropriate signal controller and signal head.
3. *RBC parameters for stop bar detection*. This section presents actuated signal ring-barrier control using stop bar detection, including min and max green,

vehicle extension, and min and max recall. Also shown is assigning detector calls to a phase.

4. *Placing upstream detection*. This task further expands the detection placement at the intersection to include mainline upstream 6-ft × 6-ft detectors.
5. *RBC parameters for upstream detection*. This task provides the linkage of the upstream detection to the actuated signal control, highlighting changes in recall settings, min and max greens, etc.
6. *Signal coordination.* This task introduces coordination along the mainline, introducing concepts such as splits, coordination settings, time-of-day pattern, cycle length, offset, offset reference, max inhibit, transitioning, etc.
7. *Reviewing controller operations*. In this task the user is introduced to several resources for viewing the implemented signal control at a 10 Hz resolution, allowing for a detailed review of signal controller operation. This material is significantly extended in Module 6.

Throughout the module the user is provided extensive interim opportunities for running the model and detailed discussions on how to review the simulation for reasonableness, inconsistencies, and errors.

MODULE 3: UNSIGNALIZED INTERSECTION

Module 3 adds an unsignalized intersection to the network constructed in Module 1 and Module 2, adding a two-way stop-controlled intersection to the south of the westmost intersection, as shown in figure 8. Module 3 advances the user's ability to handle conflicts between vehicles.

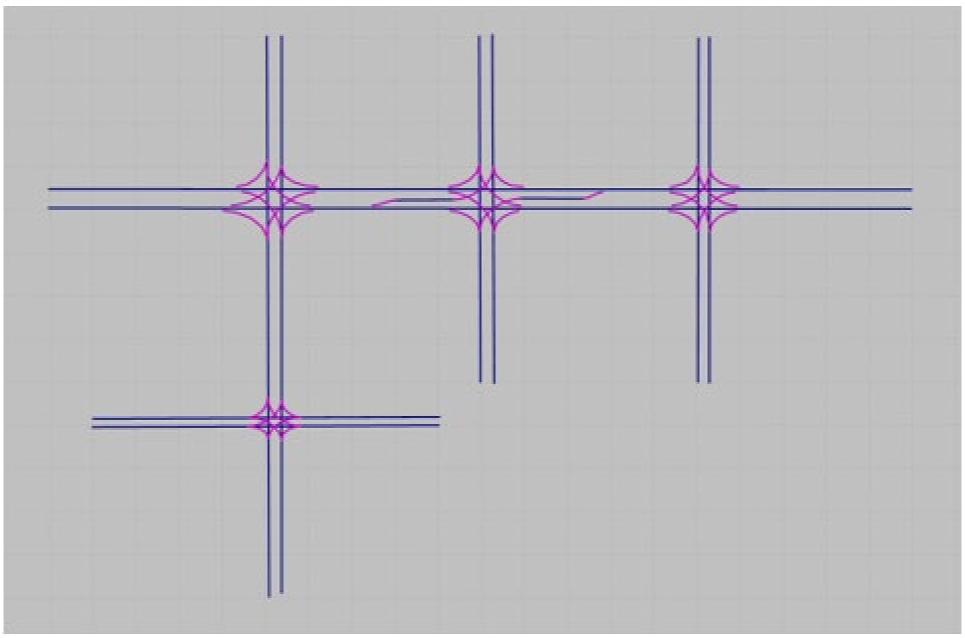


Figure 8. Network diagram. Module 3 network.

This module covers four primary tasks:

1. *Links and connectors*. This section expands on the geometric layout introduced in Module 1, demonstrating adding an intersection to an existing model.
2. *Traffic volumes and routing decisions*. The section extends the traffic volumes and routes as defined in Module 1, demonstrating how to add new vehicles and routes to the model, reinforcing critical concepts for the development and review of any VISSIM™ model.

3. *Stop signs.* Module 1 and Module 2 utilized signal control to control traffic. In this task stop sign control is added to the new intersection.
4. *Conflict zones.* Conflict zones are a critical concept in VISSIM™, utilized to avoid collisions at crossing and merge points. At each conflict or merge point (not controlled by a signal) it is necessary to define the right of way among the permitted vehicle movements. Every merge, diverge, and crossing conflict in VISSIM™ may be defined using conflict zones. Figure 9 provides an example set of conflicts defined by the user, where green is the vehicle path with priority.

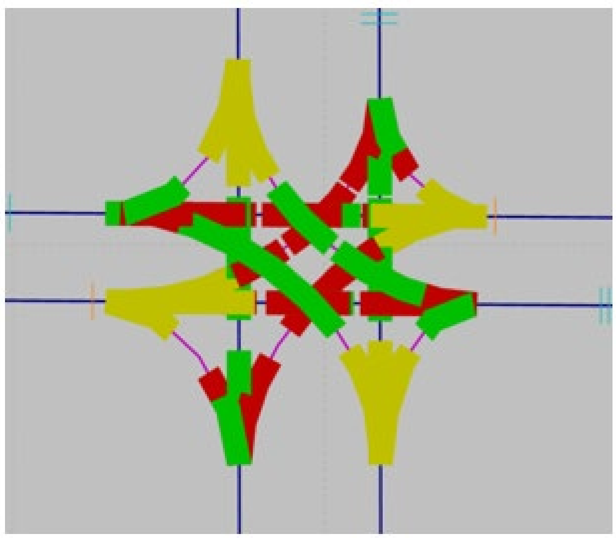


Figure 9. Network diagram. Example conflict zones for unsignalized intersection.

MODULE 4: DIAMOND INTERCHANGE

Module 4 adds a diamond interchange to the network developed in Module 1 through Module 3, as in figure 10. Module 4 familiarizes the user with the basics of designing freeway segments, on-ramps, and off-ramps.

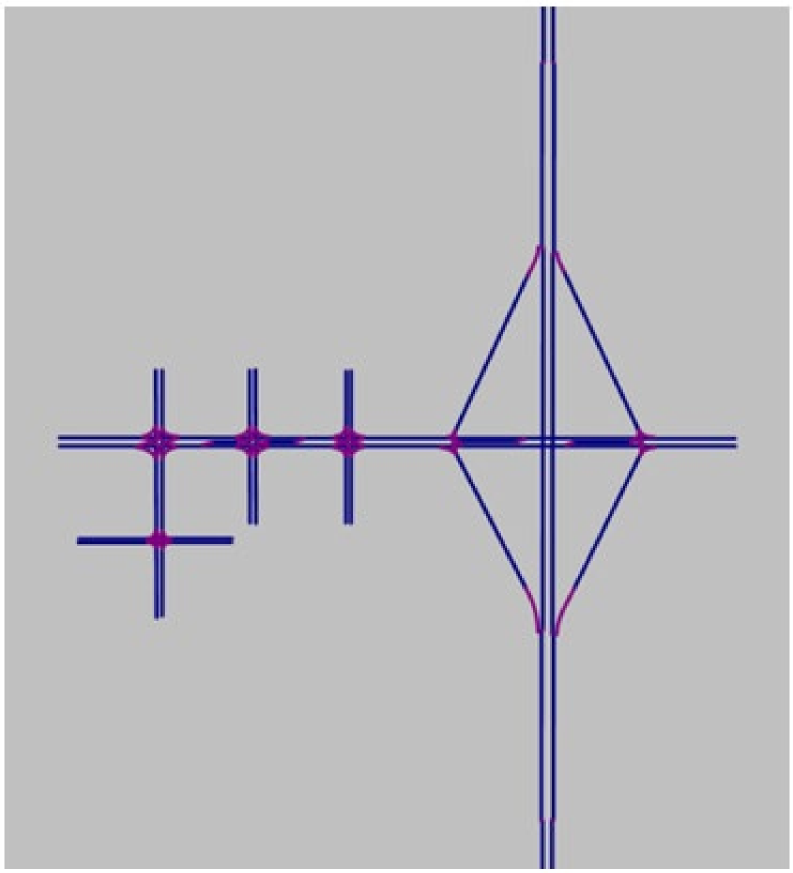


Figure 10. Network diagram. Module 4 network incorporating an interchange.

Module 4 covers four primary tasks:

1. *Creating the diamond interchange network geometry*. The first task is adding the interchange geometry. This involves extending the arterial to add the corridor diamond intersections, adding the freeway segments, and adding on- and off-ramp lanes. This effort reinforces the skills developed in the first three

modules, highlighting properties of links and connectors not yet covered, such as the assignment of the underlying driver behavior type.

2. *Adding RBC parameters at the interchange on-ramp and off-ramp intersections*. In this task the at-grade intersection signal control is added to the arterial corridor, demonstrating signal control for the intersection of a two-way street with a one-way street (i.e., ramp).
3. *Developing the on-ramp and off-ramp freeway geometry.* This task develops the diverge and merge sections of the freeway, introducing several key VISSIM™ parameters, such as link- and connector-specific emergency stop distance and lane-change distance. Ramp junctions provide a number of unique challenges in model development. Settings such as location-specific parameters are shown to be critical to model development, calibration, and review.
4. *Providing vehicle routes, inputs, and speeds*. The existing routes and vehicle inputs are extended and augmented to incorporate the interchange in this task. In addition, the user is shown how to change desired vehicle speeds for different areas of the model; that is, the arterial vehicle speeds will be lower than that of the vehicles on freeway segments. Discussions of vehicle classes are also included.

MODULE 5: CONCEPTS AND TIPS

Module 5 introduces additional concepts and tips for building and reviewing a VISSIM™ model, providing depth to topics covered quickly or skipped in the prior modules. Module 5 utilizes the model developed in Module 4. Topics covered in Module 5 are areas commonly calibrated during model development, and, thus, understanding of these topics is critical to conducting a thorough model review. The general topics covered include:

1. *Vehicle fleet characteristics and composition.* The prior modules utilized VISSIM™ default vehicle characteristics. Module 5 shows the user how to select different fleets (e.g., U.S. vs. European) or manually adjust the fleet composition. Vehicle characteristics related to category, type, and class are discussed, as well as selecting and adjusting the underlying driver behavior.
2. *Acceleration, deceleration, and desired speed distributions*. Each vehicle is assigned min and max acceleration and deceleration values and a desired speed during a model run. These values are drawn from distributions within VISSIM™. This module shows the user how to review and change these underlying distributions.
3. *Driver behavior: lane changing and emergency stop distance*. Lane change distance and emergency stop distance are key attributes of a VISSIM™ connector. Understanding their use and calibration enables robust model development, providing more realistic vehicle behavior and avoiding unnecessary calibration of global parameters. These are primary points in the review of any VISSIM™ model and, as such, extensive descriptions of how to use these features is provided.

4. *Reduced-speed zones and desired-speed decision.* Reduced-speed zones allow a user to set a lower (or higher) speed over a segment of roadway, for instance reducing speed due to horizontal curvature. At the end of a reduced-speed zone the vehicle will seek to return to its initial desired speed. Desired-speed decision points represent a permanent change in a vehicle's desired speed, for instance, the speed change that would occur when transitioning from a freeway to arterial. How and when to utilize each of these is demonstrated, as well as the difference in speed behavior for a given implementation.
5. *Alternative intersection link configuration*. The default intersection link layout in Module 1 through Module 4 assumes a continuous link for intersection through movements. This module demonstrates the use of connectors for all movements, discussing the difference between these modeling approaches.
6. *Alternative intersection left-turn bay configuration*. The left-turn implementation in Module 1 utilized a separate link for left-turn bays. This task demonstrates how to add a left-turn bay to an existing link. The pros and cons of both approaches are discussed, providing a model reviewer with the insight necessary to evaluate each method in a model.
7. *Alternative ramp merge section*. One of the largest challenges in a VISSIM™ model can be an on-ramp merge section. This task presents an alternative design of these sections that seeks to address the drawbacks found in the commonly utilized default layout demonstrated in Module 3. While it is a more complicated layout, this alternative method can overcome issues with unrealistic behavior that may be observed in the traditional layout.

MODULE 6: DATA AND PERFORMANCE METRICS

Module 6 demonstrates how to collect, view, and save various performance measures, such as travel time, speed, delay, queues, etc., including many of the numerous VISSIM™ data elements for each of these metrics. The module shows how to collect both aggregate data (e.g., average travel time over a roadway segment every 15 minutes) as well as raw data (e.g., individual vehicle travel time over a roadway segment). Potential challenges and best practices are discussed relative to each performance metric. In addition, several useful data outputs and visualization for traffic signal control are presented. Understanding these features will enable a reviewer to knowledgably ask the model developer for specific metrics, as well as work with a model personally to review various performance metrics. The following performance metric features and types are discussed.

1. *Results list and direct output.* Prior to presenting specific metrics, users are introduced to the two primary options for collecting data in VISSIM™. The first is a results list, which may be reviewed while a model is running, as well as be saved to a file. The results list data are aggregated by user-selected intervals. The second is direct output of individual vehicle-performance metric raw data to a file. For results lists, VISSIM™ performs many of the various potential data aggregations for the user; in direct output, the raw performance measure data are written to a file that may then be utilized for post hoc analysis.
2. *Travel time.* The module starts with travel time, one of the most commonly utilized performance metrics. To collect travel times, there are several tasks necessary: (1) define the travel time measurements, that is, the roadway segments over which travel time data will be collected; (2) define data

collection times and intervals for results; (3) select the desired metrics for the results list; and (4) set if direct output of travel time data to a file is desired. This is shown to be the general set of tasks that must be completed for most performance metrics. The user will see how to collect numerous travel time metrics, such as standard deviation, minimum, maximum, interval-specific metrics, distance traveled, etc. Figure 11 show the travel time measurement sections that the user defines in Module 6. An example of processing direct output data in Excel is also provided.

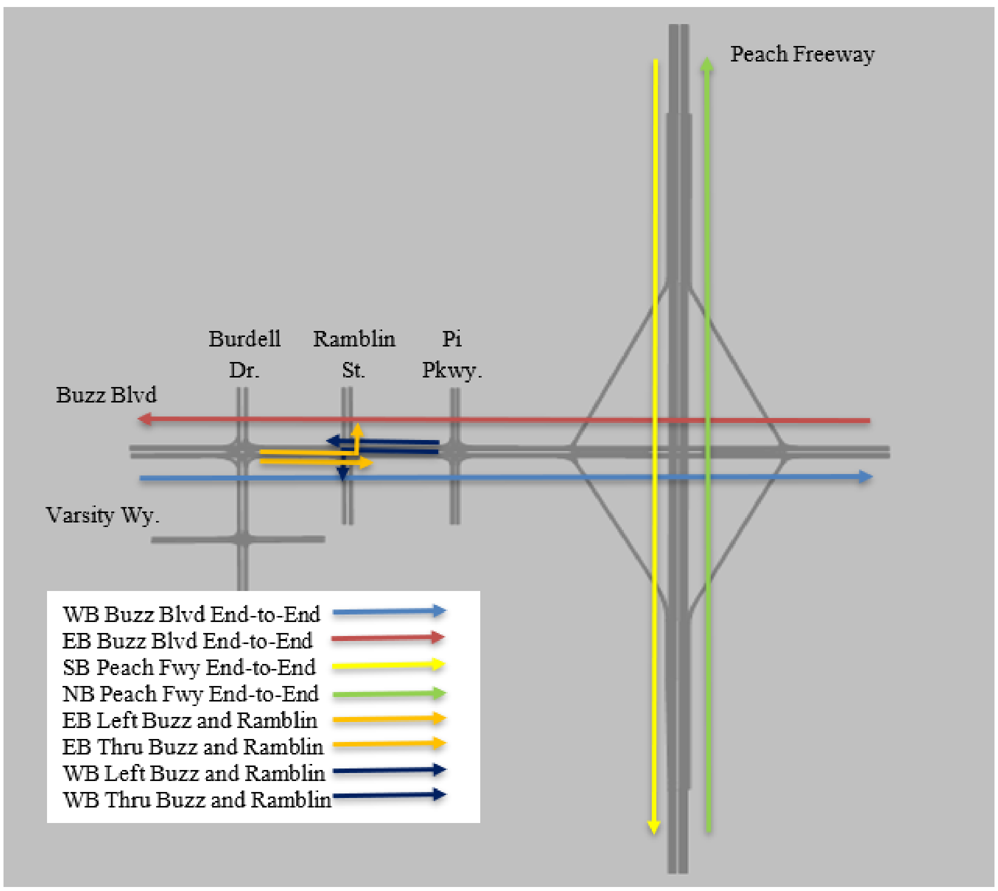


Figure 11. Network diagram. Location of travel time measurements.

3. *Delay.* Delay represents the time difference between the travel time at a vehicle's actual speed and its desired speed. Similar to travel time, this task shows for delay how to define data collection times and intervals for the results list; select the desired metrics for the results list; and set direct output of the delay data to a file. This task also shows that delay utilizes the same measurement zones as travel time.
4. *Volume and speed (data collection points).* While travel time and delay are based on segment measures, volume and speed utilize point detectors, referred to as "data collection points." This task shows the user how to place the desired data collection points in the network (data collection points are placed per lane). Next, data collection point measurements are defined, utilizing individual and groups of data collection points. Then the user sets the data collection interval and selects the desired data collection point attributes for the results list. VISSIM™ is shown to offer a significant variety of data aggregation and attribute metrics. Finally, direct output of raw data is set. As part of this section, methods to provide graphical presentations of the data that can be highly useful for model review are also discussed. Figure 12 is an example heat map for network speeds.

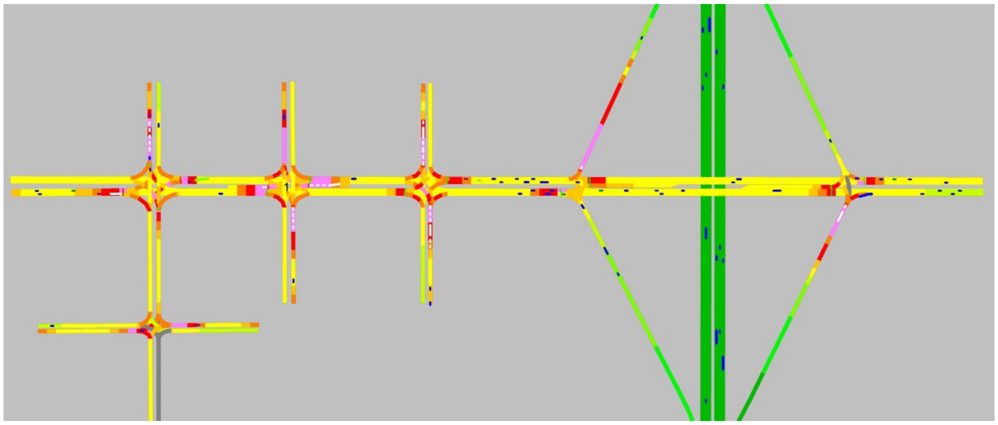


Figure 12. Network diagram. Example speed heat map.

5. *Queues.* To obtain queue data, the user will place queue counters. Queue length is measured in distance, not number of vehicles. Queue counters are placed at the start of the queue; generally, this will be at signal heads or conflict zones. How to set parameters for defining queues (e.g., headway between vehicles, vehicle speed, etc.) is demonstrated.
6. *Node- and link-based metrics*. Nodes and links provide an additional method to obtain performance metrics. VISSIM™ enables the collection of numerous attributes on a link basis, including density, relative delay, speed, volume, and a multitude of emissions metrics. A user may also place a node (select area of the model) for the collection of performance metrics. Nodes provide a method to quickly collect data over a limited area of interest, such as an intersection or ramp junction. This section of the module steps the user through the setup of nodes, interaction of neighboring nodes, and defining of node performance measures. In addition, visualization techniques are demonstrated that can be highly useful for model review.

7. *Signal control and detector data*. Methods are demonstrated for writing signal control data to a file, as well as several highly useful visualizations. For writing data to a file, there is not a results attributes list. There are, however, two direct outputs: signal control detector data and signal changes. A number of signal controller data elements may be written out and visualized, such as gaps in effect, local cycle, master cycle, active phase, preempt call, etc. These visualizations and outputs are particularly useful when reviewing complex signal systems, such as actuated coordinated control, as developed in Module 3.

MODULE 7: START-UP & REPLICATE TRIALS, AND VERIFICATION, VALIDATION, & CALIBRATION

Module 7 fills in many of the concepts required for a simulation study. It provides guidance on starting a model, the length of a data collection period (e.g., accounting for overcapacity conditions), and replicate trials, as well as a discussion on verification, calibration, and validation. Module 7 covers the following primary topics.

1. *Start-up fill period*. At the very beginning of a model run, no vehicles are in the model. Thus, the first vehicles to enter the model will experience empty roads and high levels of service. The performance data for these initial vehicles will likely be better than the conditions under study. To counter this, a “fill” period is utilized at the beginning of a simulation run. Intuitively, the fill time allows for the distribution of vehicles into the model, such that traffic conditions at the start of data collection reflect those that would be expected at the beginning of an analogous field data collection effort. This section demonstrates several methods to set and check the fill period duration. Included in this section are critical concepts related to steady state and non-steady state assumptions.
2. *Data collection period length*. Next, the length of time data should be collected for analysis is considered. When a model remains uncongested throughout the run, data collection will be based on typically accepted analysis periods. However, more flexibility in selecting the data collection period may be required where *congestion* exists. To model such scenarios, Module 7 shows that it is critical to simulate from before any breakdown or congestion occurs to after the traffic returns to uncongested conditions. If the model data collection

fails to capture this entire time period, then delays, emissions, queuing, or other critical performance metrics impacted by the high demands will not be fully captured in the model performance metrics.

3. *Replicate trials.* All results in Module 1 through Module 6 have been based on a single model run. However, VISSIM™ is a stochastic model, meaning it seeks to incorporate randomness. For instance, in Module 5 it was seen that driver behaviors, such as acceleration, desired speed, and route choice, are based on distributions. For each individual vehicle, parameter values are assigned from these distributions. Changing these assignments will change model results. This is analogous to seeing day-to-day variability in a corridor's operation. Users will see how to reflect this variability due to randomness using replicate trials.
4. *Model verification, validation, and calibration*. Verification is the confirmation that a model has been constructed as intended (e.g., a roadway that is 3 lanes in the field is 3 lanes in the model). Validation confirms that the performance of the model satisfies expectations (e.g., the model approximately matches field conditions). Calibration is the process of adjusting the parameters of a verified model to achieve a valid model. This section provides additional detail on each of these areas, including tables for potential parameter thresholds in VISSIM™.

While a specific calibration method is not recommended in this module, extensive discussion is provided on the attributes of a calibration method and guidance on reviewing a calibration effort. This includes both calibration of local parameters (e.g., lane change distance, emergency stop distance, etc.), and global parameters (e.g., Wiedemann car-following model parameters).

MODULE 8: REVIEW CHECKLIST

Module 8 is the capstone to the previous seven modules. Module 8 provides several checklists for use by GDOT for the verification and review of a VISSIM™ model. The checklists cover the various features of a VISSIM™ model, such as simulation run settings, VISSIM™ defaults, network development (e.g., geometry, speed, etc.), signal control (e.g., layout, timing parameters, detection, coordination, etc.), vehicle demand and routes, underlying driver and vehicle parameters, validation and calibration, evaluation output, etc. Additionally, guidance on viewing simulation animation is provided.

Given the guidance provided through the completion of the first seven modules, a reviewer will be able to confidently step through the reviewer checklist. To aid in this review, documentation of the model development, calibration, and validation process should be provided by the model developer, particularly highlighting areas that diverge from expected or VISSIM™ parameters that have been changed from default values. Finally, as VISSIM™ is a complex and highly flexible modeling tool, a review will likely require interaction between the model developer and reviewer where questions arise regarding modeling choices.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

Where analytical tools such as the Highway Capacity Software™, SYNCHRO®, etc. do not adequately represent traffic operations within a study area, or do not provide the necessary performance metric(s) required for the analysis, detailed simulation or similar approaches may be required. In such cases, the Georgia Department of Transportation typically employs VISSIM™ 11 as the preferred transportation modeling tool. This project has developed guidance material that enhances GDOT's ability to review and utilize VISSIM™ 11 models.

The developed guidance is based on several assumptions. First, it is recognized that several public agency and private industry VISSIM™ user documents exist. This effort does not seek to replace or replicate these documents. Second, the developed documents do not address analysis tool selection, model area scope, scenario development, etc. The documents are limited to developing the skills and knowledge needed to conduct a thorough model review. Third, while the effort provides extensive discussion on how to review model validation and calibration (see Module 7), it does not recommend a specific calibration methodology. Fourth, the user/reviewer is assumed to have basic traffic engineering knowledge, typical of that found in a standard traffic engineering course Lastly, an approach has been adopted in the development of the guidance documents that requires a GDOT staff member or GDOT consultant to have some basic experience in model development in order to review a model.

Thus, to aid in the development of the necessary skills for VISSIM™ 11 model review, a series of eight modules has been developed. The first four modules provide a basic introduction to arterial corridor and freeway model development, walking the reader step-by-step through the development of a small model containing unsignalized and signalized (fixed-time and actuated) control and a freeway segment and diamond interchange. The final four modules cover broader modeling issues, such as working with VISSIM™ results and direct output; underlying VISSIM™ model parameters and distributions; alternative model layouts and features; verification, calibration, and validation; and other issues critical to a thorough model review. These four modules culminate with reviewer checklists. After completion of all eight modules, the GODT reviewer will have been exposed to the knowledge and skills necessary to review and utilize a VISSIM™ 11 model.

The developed eight modules are as follows:

- Module 1: Basic Three Intersection Model Setup
- Module 2: Actuated Signal
- Module 3: Unsignalized Intersection
- Module 4: Diamond Interchange
- Module 5: Concepts and Tips
- Module 6: Data and Performance Metrics
- Module 7: Start-Up & Replicate Trials, and Verification, Validation, & Calibration
- Module 8: Review Checklist

A brief summary of each of these modules may be found in chapter 3, with the modules posted on the GDOT website.

Finally, it is critical to recall that VISSIM™ is a highly flexible tool. While there are clearly many potential modeling errors or invalid approaches, there are often multiple modeling approaches that could be utilized to model a given area, with different "experts" selecting different approaches. Where questions arise on alternative implementations, VISSIM™ reviewers are encouraged to interact with the model developers to determine the adequacy of an approach.

Of the areas covered in the developed modules, validation and calibration represent some of the more challenging topics. While providing specific recommendations for calibration procedures was out of scope of this effort, it is recommended that future GDOT efforts consider the development of calibration guidance for use by model developers. In addition, as part of that effort, it may be useful to develop potential calibrated parameter sets that could be adopted by model developers that represent the varying traffic conditions found in the State of Georgia.

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