Traffic Analysis Toolbox Volume I:

Traffic Analysis Tools Primer

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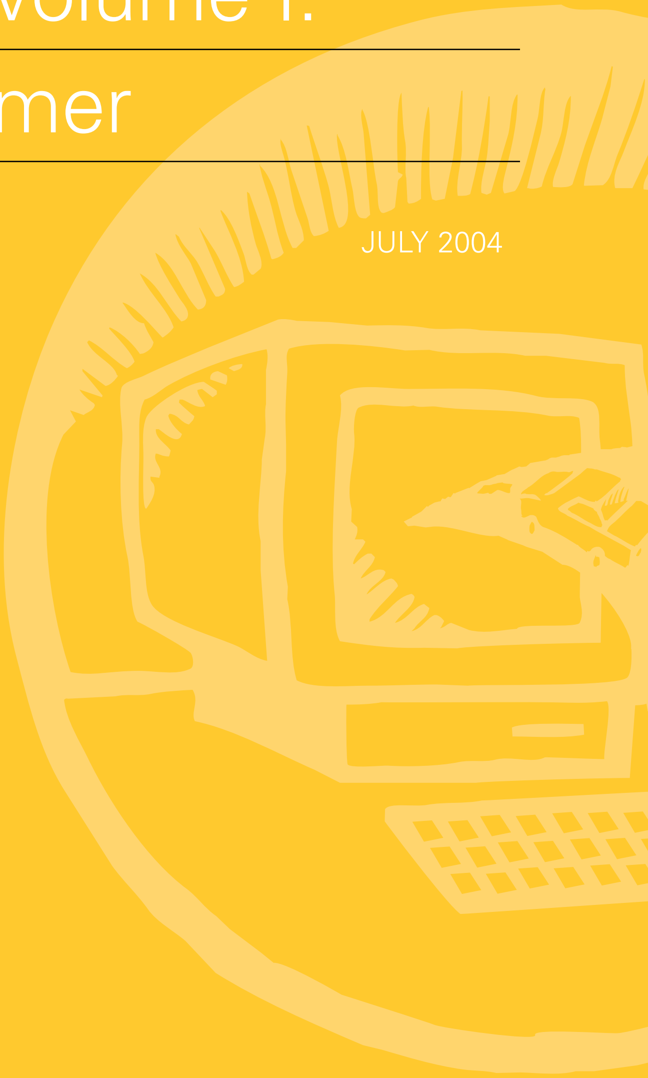

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Foreword

"Traffic analysis tools" is a collective term used to describe a variety of software-based analytical procedures and methodologies that support different aspects of traffic and transportation analyses. Traffic analysis tools include methodologies such as sketch-planning, travel demand modeling, traffic signal optimization, and traffic simulation. The purpose of this *Traffic Analysis Tools Primer* is to give the reader an overview of the different types of traffic analysis tools and to describe their role in transportation analyses.

This document serves as Volume I in the Traffic Analysis Toolbox. Other volumes currently in the toolbox include: Volume II: *Decision Support Methodology for Selecting Traffic Analysis Tools* and Volume III: *Guidelines for Applying Traffic Microsimulation Modeling Software.*

The intended audience for this report is the transportation professional or manager who needs a high-level introduction into the role of traffic analysis tools in the transportation analysis process.

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Technical Report Documentation Page

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16. Abstract

This primer provides an overview of traffic analysis tools in the transportation analysis process. Different categories of traffic analysis tools are defined, and the challenges and limitations of using traffic analysis tools is presented. A specific comparison between *Highway Capacity Manual* (HCM) analysis and traffic simulation-based analysis is provided. Criteria for selecting the appropriate type of traffic analysis tool are described. A list of traffic analysis tools within each category and their corresponding website links is provided in an appendix.

This is the first volume in a series of volumes in the Traffic Analysis Toolbox. The other volumes currently in the Traffic Analysis Toolbox are:
Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools (FHWA-HRT-04-039)
Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software (FHWA-HRT-04-040)

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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)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		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)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		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

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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1.0 Introduction

Entering the 21st century, the Nation's transportation system has matured; it only expands its infrastructure by a fraction of a percentage each year. However, congestion continues to grow at an alarming rate, adversely impacting our quality of life and increasing the potential for accidents and long delays. These are expected to escalate, calling for transportation professionals to increase the productivity of existing transportation systems through the use of operational improvements. In order to assess the potential effectiveness of a particular strategy, it must be analyzed using traffic analysis tools or methodologies.

There are several traffic analysis methodologies and tools available for use; however, there is little or no guidance on which tool should be used. These tools vary in their scope, capabilities, methodology, input requirements, and output. In addition, there is no one tool that can address all of the analytical needs of a particular agency.

The objective of *Traffic Analysis Tools Primer (Volume I)* and *Decision Support Methodology for Selecting Traffic Analysis Tools (Volume II)* is to assist traffic engineers, planners, and traffic operations professionals in the selection of the correct type of traffic analysis tool for operational improvements. These documents are intended to assist practitioners in selecting the c*ategory* of tool for use. Another objective of these documents is to assist in creating analytical consistency and uniformity across State departments of transportation (DOTs) and Federal/regional/local transportation agencies.

Decision Support Methodology for Selecting Traffic Analysis Tools identifies the criteria that should be considered in the selection of an appropriate traffic analysis tool and helps identify the circumstances when a particular type of tool should be used. A methodology is also presented to guide users in the selection of the appropriate tool category. This document includes worksheets that transportation professionals can use to select the appropriate tool category and provides assistance in identifying the most appropriate tool within the selected category. An automated tool that implements this methodology can be found at the Federal Highway Administration (FHWA) Traffic Analysis Tools Web site at: http://ops.fhwa.dot.gov/Travel/Traffic_Analysis_Tools/traffic_analysis_tools.htm.

2.0 Overview of the Transportation Analysis Process

The Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21), and the Federal/State Clean Air legislation have reinforced the importance of traffic management and control of existing highway capacity. As transportation agencies deploy more sophisticated hardware and software system management technologies, there is an increased need to respond to recurring and nonrecurring congestion in a proactive fashion, and to predict and evaluate the outcome of various improvement plans without the inconvenience of a field experiment.

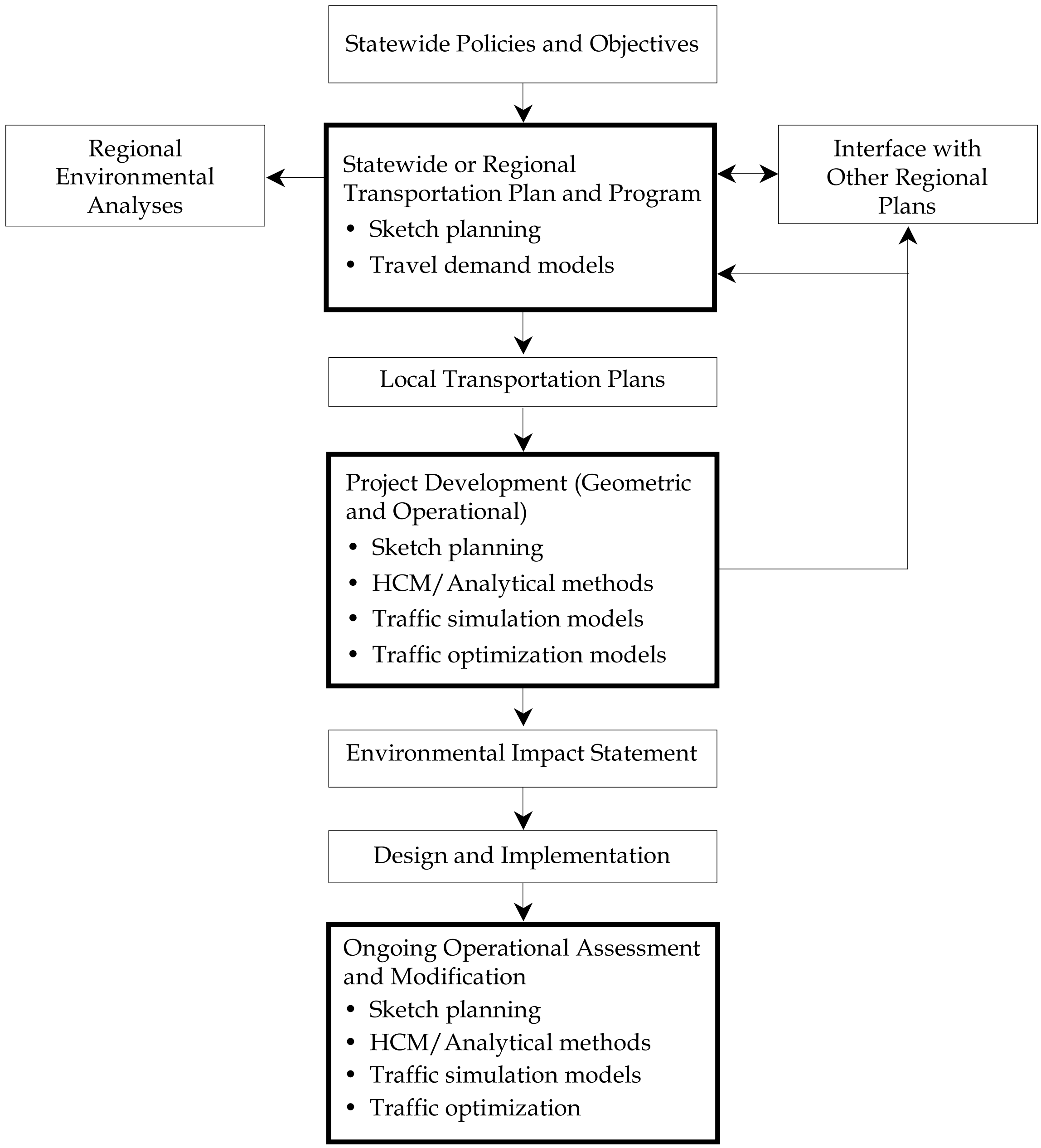
Out of these needs, traffic analysis tools emerge as one of the most efficient methods to evaluate transportation improvement projects. This document addresses quantifiable *traffic operations* analysis tools categories, but does not include real-time or predictive models. Traffic analysis tools may include software packages, methodologies, and procedures, and are defined as those typically used for the following tasks:

- Evaluating, simulating, or optimizing the operations of transportation facilities and systems.

- Modeling existing operations and predicting probable outcomes for proposed design alternatives.

- Evaluating various analytical contexts, including planning, design, and operations/construction projects.

Figure 1 presents an overview of the transportation analysis process, along with its various evaluation contexts and the types of traffic analysis tools that are typically used in each context. Typically, transportation analysis needs result from the policies and objectives of State/regional/local transportation plans and programs. A transportation improvement (project) goes through several phases, including planning, project development, design, implementation, and post-implementation operational assessment and modification. As shown in figure 1, each of these phases requires different analytical methodologies and tools. A project's early planning stage usually involves the application of sketch planning or travel demand modeling techniques. These methodologies help agencies screen the different transportation improvements, resulting in the selection of a few candidate transportation improvements. Later stages (such as project development or post-implementation modifications) usually involve the application of more rigorous and detailed techniques, such as traffic simulation and/or optimization. The role of traffic analysis tools is further explained in the following chapter.



Note: Boxes outlined by a bold line represent the primary realm of application of traffic analysis tools.

Figure 1. Overview of the transportation analysis process.

3.0 Role of Traffic Analysis Tools

Traffic analysis tools are designed to assist transportation professionals in evaluating the strategies that best address the transportation needs of their jurisdiction. Specifically, traffic analysis tools can help practitioners:

- **Improve the decisionmaking process.** Traffic analysis tools help practitioners arrive at better planning/engineering decisions for complex transportation problems. They are used to estimate the impact of the deployment of traffic management and other strategies, and to help set priorities among competing projects. In addition, they can provide a consistent approach for comparing potential improvements or alternatives.

- **Evaluate and prioritize planning/operational alternatives.** This typically involves comparing "no build" conditions with alternatives, which include various types of potential improvements. The impacts are reported as performance measures and are defined as the difference between the no-build and alternative scenarios. The results can be used to select the best alternative or prioritize improvements, increasing the odds of having a successful deployment.

- **Improve design and evaluation time and costs.** Traffic analysis tools are relatively less costly when compared to pilot studies, field experiments, or full implementation costs. Furthermore, analytical tools can be used to assess multiple deployment combinations or other complex scenarios in a relatively short time.

- **Reduce disruptions to traffic.** Traffic management and control strategies come in many forms and options, and analytical tools provide a way to cheaply estimate the effects prior to full deployment of the management strategy. They may be used to initially test new transportation management systems concepts without the inconvenience of a field experiment.

- **Present/market strategies to the public/stakeholders.** Some traffic analysis tools have excellent graphical and animation displays, which could be used as tools to show "what if" scenarios to the public and/or stakeholders.

- **Operate and manage existing roadway capacity.** Some tools provide optimization capabilities, recommending the best design or control strategies to maximize the performance of a transportation facility.

- **Monitor performance.** Analytical tools can also be used to evaluate and monitor the performance of existing transportation facilities. In the future, it is hoped that monitoring systems can be directly linked to analytical tools for a more direct and real-time analysis process.

4.0 Categories of Traffic Analysis Tools

To date, numerous traffic analysis methodologies and tools have been developed by public agencies, research organizations, and consultants. Traffic analysis tools can be grouped into the following categories:

- **Sketch-planning tools:** Sketch-planning methodologies and tools produce general order-of-magnitude estimates of travel demand and traffic operations in response to transportation improvements. They allow for the evaluation of specific projects or alternatives without conducting an indepth engineering analysis. Such techniques are primarily used to prepare preliminary budgets and proposals, and are not considered to be a substitute for the detailed engineering analysis often needed later in the project implementation process. Sketch-planning approaches are typically the simplest and least costly of the traffic analysis techniques. Sketch-planning tools perform some or all of the functions of other analytical tool types, using simplified analyses techniques and highly aggregated data. However, sketch-planning techniques are usually limited in scope, analytical robustness, and presentation capabilities.

- **Travel demand models:** Travel demand models have specific analytical capabilities, such as the prediction of travel demand and the consideration of destination choice, mode choice, time-of-day travel choice, and route choice, and the representation of traffic flow in the highway network. These are mathematical models that forecast future travel demand based on current conditions, and future projections of household and employment characteristics. Travel demand models were originally developed to determine the benefits and impact of major highway improvements in metropolitan areas. However, they were not designed to evaluate travel management strategies, such as intelligent transportation systems (ITS)/operational strategies. Travel demand models only have limited capabilities to accurately estimate changes in operational characteristics (such as speed, delay, and queuing) resulting from implementation of ITS/operational strategies. These inadequacies generally occur because of the poor representation of the dynamic nature of traffic in travel demand models.

- **Analytical/deterministic tools (HCM-based):** Most analytical/deterministic tools implement the procedures of the *Highway Capacity Manual* (HCM). These tools quickly predict capacity, density, speed, delay, and queuing on a variety of transportation facilities and are validated with field data, laboratory test beds, or small-scale experiments. Analytical/deterministic tools are good for analyzing the performance of isolated or small-scale transportation facilities; however, they are limited in their ability to analyze network or system effects. HCM procedures and their strengths and limitations are discussed in more detail in section 6.1.

- **Traffic signal optimization tools:** Traffic signal optimization tools are primarily designed to develop optimal signal-phasing and timing plans for isolated signal intersections, arterial streets, or signal networks. This may include capacity calculations; cycle length; splits optimization, including left turns; and coordination/offset plans. Some optimization tools can also be used for optimizing ramp metering rates for freeway ramp control.

- **Macroscopic simulation models:** Macroscopic simulation models are based on the deterministic relationships of the flow, speed, and density of the traffic stream. The simulation in a macroscopic model takes place on a section-by-section basis rather than by tracking individual vehicles. Macroscopic models have considerably fewer demanding computer requirements than microscopic models. They do not, however, have the ability to analyze transportation improvements in as much detail as the microscopic models.

- **Mesoscopic simulation models:** Mesoscopic simulation models combine the properties of both microscopic (discussed below) and macroscopic simulation models. As in microscopic models, the mesoscopic models' unit of traffic flow is the individual vehicle. Their movement, however, follows the approach of the macroscopic models and is governed by the average speed on the travel link. Mesoscopic model travel simulation takes place on an aggregate level and does not consider dynamic speed/volume relationships. As such, mesoscopic models provide less fidelity than the microsimulation tools, but are superior to the typical planning analysis techniques.

- **Microscopic simulation models:** Microscopic models simulate the movement of individual vehicles based on car-following and lane-changing theories. Typically, vehicles enter a transportation network using a statistical distribution of arrivals (a stochastic process) and are tracked through the network over small time intervals (e.g., 1 second or a fraction of a second). Typically, upon entry, each vehicle is assigned a destination, a vehicle type, and a driver type. Computer time and storage requirements for microscopic models are large, usually limiting the network size and the number of simulation runs that can be completed.

5.0 Challenges and Limitations in the Use of Traffic Analysis Tools

As discussed in sections 2.0 and 3.0, traffic analysis tools are useful and effective in helping transportation professionals best address their transportation needs (as long as they are used correctly). Each tool and tool category is designed to perform a different traffic analysis function, and there is no one analytical tool that can do everything or solve every problem. This section addresses some of the challenges and limitations that should be considered when selecting traffic analysis tools:

- **Availability of quality data.** If good data are not available, the user should consider a less data-intensive tool category, such as a sketch-planning tool rather than microsimulation. However, the results of the simpler tool categories are usually more generalized, so the user should carefully balance the needs of a more detailed analysis with the amount of data required.

- **Limited empirical data.** Data collection can often be the most costly component of a study. The best approach is to look at the ultimate goals and objectives of the task and focus data collection on the data that are crucial to the study.

- **Limited funding.** Limited funding for conducting the study, purchasing tools, running analytical scenarios, and training the users is often a consideration in transportation studies. Traffic analysis tools can require a significant capital investment. Software licensing and training fees can make up a large portion of the budget. Also, the analysis of more scenarios costs money. When faced with funding limitations, focus on the project's goals and objectives, and try to identify the point of diminishing returns for the investment.

- **Training limitations.** Traffic simulation tools usually have steep learning curves and, as a result, some transportation professionals do not receive adequate modeling and simulation training.

- **Limited resources.** Limitations in staffing, capabilities, and funding for building the network and conducting the analysis should be considered. The implementation of most traffic analysis tools is a resource-intensive process, especially in the model construction and calibration (front-end) phases for simulation analyses. Careful scheduling and pre-agreed-upon acceptance criteria are necessary to keep the project focused and on target.

- **Data input and the diversity and inconsistency of data.** Each tool uses unique analytical methodologies, so the data requirements for analysis can vary greatly from tool to tool and by tool category. In many cases, data from previous projects contribute very little to a new analytical effort. Adequate resources must be budgeted for data collection.

- **Lack of understanding of the limitations of analytical tools.** Often, limitations and "bugs" are not discovered until the project is underway. It is important to learn from experiences with past projects or to communicate with fellow users of a particular tool or tool category in order to assess the tool's capabilities and limitations. By researching the experiences of others, users can gain a better understanding of what they may encounter as the project progresses.

- **Tool may not be designed to evaluate all types of impacts produced by transportation strategies/applications**. The output measures produced by each tool vary, so the process of matching the project's desired performance measures with the tool's output is important. In addition, there are very few tools that directly analyze ITS strategies and the impacts associated with them (e.g., reduction in incident duration, agency cost savings, etc.).

- **Lack of features.** Some analytical tools are not designed to evaluate the specific strategies that the users would like to implement. This is more prevalent in modeling ITS strategies or other advanced traffic operations strategies. Often, "tricking" the tool into mimicking a certain strategy is a short-term solution; however, there should be flexibility so that advanced users may customize the tools.

- **Desire to run real-time solutions**. Many tools require a significant amount of time for setup, modeling, and analysis. There is hope that future tools would be able to be linked to Traffic Management Centers and detectors, so that the analysis can be implemented directly and in real time. This would allow transportation professionals to respond to recurring and nonrecurring congestion using real-time solutions.

- **Tendency to use simpler analytical tools and those available in house, although they might not be the best tools for the job.** Because of lack of resources, past experiences, or lack of familiarity with other available tools, many agencies prefer to use a tool currently in their possession, even if it is not the most appropriate tool for the project.

- **Biases against models and traffic analysis tools.** These biases are not only because of the challenges listed above, but also because models are not always reliable and are often considered to be "black boxes." Some transportation professionals prefer to use back-of-the-envelope calculations, charts, or nomographs to estimate the results. This may be adequate for simpler tasks; however, more complex projects require more advanced tools.

- **Long computer run times.** Depending on the computer hardware and the scope of the study (i.e., area size, data requirements, duration, analysis time periods, etc.), an analytical model run may range from a few seconds to several hours. The most effective approaches to addressing this issue involve using the most robust computer equipment available and/or carefully limiting the study scope to conform to the analytical needs.

6.0 Comparison of *Highway Capacity Manual* (HCM) and Simulation

The intent of this section is to compare the capabilities of HCM and traffic simulation tools and to provide additional guidance on assessing when traffic simulation may be more appropriate than HCM-based methods or tools.

6.1 HCM Strengths and Limitations

For many applications, HCM is the most widely used and accepted traffic analysis technique in the United States. The HCM procedures are good for analyzing the performance of isolated facilities with relatively moderate congestion problems. These procedures are quick and reliable for predicting whether a facility will be operating above or below capacity, and they have been well tested through significant field-validation efforts. However, the HCM procedures are generally limited in their ability to evaluate system effects.

Most of the HCM methods and models assume that the operation of one intersection or road segment is not adversely affected by conditions on the adjacent roadway. Long queues at one location that interfere with another location would violate this assumption. The HCM procedures are of limited value in analyzing queues and the effects of the queues.

There are also several gaps in the HCM procedures. HCM is a constantly evolving and expanding set of analytical tools and, consequently, there are still many real-world situations for which HCM does not yet have a recommended analytical procedure. The following list identifies some of these gaps:

- Multilane or two-lane rural roads where traffic signals or stop signs significantly impact capacity and/or operations.
- Climbing lanes for trucks.
- Short through-lane is added or dropped at a signal.
- Two-way left-turn lanes.
- Roundabouts of more than a single lane.
- Tight diamond interchanges.

6.2 Simulation Strengths and Limitations

Simulation tools are effective in evaluating the dynamic evolution of traffic congestion problems on transportation systems. By dividing the analysis period into time slices, a simulation model can evaluate the buildup, dissipation, and duration of traffic congestion. By evaluating systems of facilities, simulation models can evaluate the interference that occurs when congestion builds up at one location and impacts the capacity of another location. Also, traffic simulators can model the variability in driver/vehicle characteristics. Simulation tools, however, require a plethora of input data, considerable error checking of the data, and manipulation of a large amount of potential calibration parameters. Simulation models cannot be applied to a specific facility without the calibration of those parameters to the actual conditions in the field. Calibration can be a complex and time-consuming process.

The algorithms of simulation models are mostly developed independently and are not subject to peer review and acceptance in the professional community. There is no national consensus on the appropriateness of a simulation approach.

Simulation models, for all their complexity, also have limitations. Commercially available simulation models are not designed to model the following:

- Two-way left-turn lanes.

- Impact of driveway access: Major driveways can be modeled as unsignalized T-intersections. However, models cannot address the impact of numerous minor driveways along a street segment (link). They can only be approximately modeled as a midblock sink or node.

- Impact of onstreet parking, commercial vehicle loading, and double parking (although such conditions may be approximately modeled as short-term incidents).

- Interferences that can occur between bicycles, pedestrians, and vehicles sharing the same roadway.

Simulation models also assume "100-percent safe driving," so they will not be effective in predicting how changes in design might influence the probability of collisions. In addition, simulation models do not take into consideration how changes in the roadside environment (outside of the traveled way) affect driver behavior within the traveled way (e.g., obstruction of visibility, roadside distractions such as a stalled vehicle, etc.).

6.3 Traffic Performance Measures: Differences Between HCM and Simulation

The HCM methodologies and tool procedures take a static approach to predicting traffic performance; simulation models take a dynamic approach. HCM estimates the average density, speed, or delay over the peak 15 minutes of an hour, while simulation models predict density, speed, and delay for each time slice within the analysis period (which can be longer than an hour).

Not only are there differences in approach, there are differences in the definitions of the performance measures produced by the simulation models and the HCM tools. Some of the most notable differences include:

- Simulation models report density for actual vehicles, while HCM reports density in terms of equivalent passenger cars (trucks and other heavy vehicles are counted more than once in the computation of density).

- Simulation models report vehicle flows in terms of actual vehicles, while HCM reports capacity for freeways and highways in terms of passenger-car equivalents.

- Simulation models report delay only on the street segment where vehicles are slowed down, while HCM reports all delay caused by a given bottleneck (regardless of the actual physical location of the vehicles).

- Simulation models report queues only on the street segment where vehicles are actually queued, while HCM reports all queued vehicles caused by a given bottleneck (regardless of the actual physical location of the vehicles).

- Simulation models do not necessarily report control delay at signalized intersections. The reported values include midblock delays for vehicles traveling along the link, or only stopped delay at the traffic signal.

6.4 Strategy for Overcoming the Limitations of HCM

After a transportation professional has decided that the HCM procedures do not meet the needs of the analysis, the next step is to determine whether microscopic, mesoscopic, or macroscopic simulation is required. There are several simulation programs available for evaluating a variety of transportation improvements, facilities, modes, traveler responses, and performance measures. These analytical tools vary in their data requirements, capabilities, methodology, and output. In addition, the performance measures for the simulation models and the HCM procedures may differ in definition and/or methodology (e.g., the number of stops may be estimated at speeds of less than 8 kilometers per hour (km/h) (5 miles per hour (mi/h)) for one tool, but 0 km/h for another).

If it is not necessary to microscopically trace individual vehicle movements, then the analyst can take advantage of the simpler data entry and control optimization features available in many macroscopic simulation models. However, macroscopic models often have to make certain assumptions regarding regularity in order to be able to apply macroscopic vehicle behavior relationships. If these assumptions are not valid for the situation being studied, then the analyst must resort to mesoscopic or microscopic simulation.

Simulation models require a considerable amount of detailed data for input, calibration, and validation. In general, microscopic simulation models have more demanding data requirements than mesoscopic and macroscopic models. Simulation models are also more complicated and require a considerable amount of effort to gain an understanding of the assumptions, parameters, and methodologies involved in the analysis. The lack of understanding of these tools often makes credibility and past performance (use/popularity) a major factor in the selection of a particular simulation tool. More information on this issue may be found in *Guidelines for Applying Traffic Microsimulation Modeling Software (Volume III)*.

7.0 Criteria for Selecting the Appropriate Type of Traffic Analysis Tool

This section identifies criteria that can be considered in the selection of an appropriate traffic analysis tool type and helps identify under what circumstances a particular type of tool should be used. *Decision Support Methodology for Selecting Traffic Analysis Tools (Volume II)* provides a detailed assessment of criteria to be considered when selecting a type of traffic analysis tool.

The first step is identification of the analytical context for the task—planning, design, or operations/construction. Seven additional criteria are necessary to help identify the analytical tools that are most appropriate for a particular project. Depending on the analytical context and the project's goals and objectives, the relevance of each criterion may differ. The criteria include the following:

1. Ability to analyze the appropriate **geographic scope** or study area for the analysis, including an isolated intersection, single roadway, corridor, or network.

2. Capability of modeling various **facility types**, such as freeways, high-occupancy vehicle (HOV) lanes, ramps, arterials, toll plazas, etc.

3. Ability to analyze various **travel modes**, such as single-occupancy vehicle (SOV), HOV, bus, train, truck, bicycle, and pedestrian traffic.

4. Ability to analyze various **traffic management strategies and applications**, such as ramp metering, signal coordination, incident management, etc.

5. Capability of estimating **traveler responses** to traffic management strategies, including route diversion, departure time choice, mode shift, destination choice, and induced/foregone demand.

6. Ability to directly produce and output **performance measures**, such as safety measures (crashes, fatalities), efficiency (throughput, volumes, vehicle-miles of travel (VMT)), mobility (travel time, speed, vehicle-hours of travel (VHT)), productivity (cost savings), and environmental measures (emissions, fuel consumption, noise).

7. **Tool/Cost-Effectiveness** for the task, mainly from a management or operational perspective. Parameters influencing cost-effectiveness include tool capital cost, level of effort required, ease of use, hardware requirements, data requirements, animation, etc.

In *Decision Support Methodology for Selecting Traffic Analysis Tools*, each analytical tool category is evaluated against each criterion to identify whether or not a category of analytical tool is appropriate for use. Figure 2 below summarizes the criteria that may be considered in the selection of a tool category.

The steps for selecting the appropriate type of analysis tool are:

1. Users should begin by identifying the project's analytical context (discussed in Section 2.1 of *Decision Support Methodology for Selecting Traffic Analysis Tools*).

2. Next, users should filter through criteria 1 through 6 to limit the appropriate tool categories to one or two options.

3. Finally, criterion 7 (tool/cost effectiveness) should be used to select the final tool category based on parameters outside of the technical context of the analysis, such as tool cost, training, hardware requirements, etc.

Decision Support Methodology for Selecting Traffic Analysis Tools presents step-by-step guidance for the tool selection process, along with a list of recommended readings. An automated tool that implements the guidance can be found at the FHWA Traffic Analysis Tools Web site at:

http://ops.fhwa.dot.gov/Travel/Traffic_Analysis_Tools/traffic_analysis_tools.htm

The first step in selecting the appropriate type of traffic analysis tool is the identification of the analytical context of the project. Figure 2 illustrates a typical transportation analysis process, which contains several analytical phases, including:

- **Planning:** This phase includes short- or long-range studies or other State, regional, or local transportation plans (e.g., master plans, congestion management plans, ITS strategic plans, etc.).

- **Design:** This phase includes approved and funded projects that are going through analysis of the alternatives or preliminary design to determine the best option for implementation. This phase also includes the analysis of roadway features needed to operate at a desired level of service (LOS). Full design projects (i.e., horizontal/vertical alignments, pavement design, etc.) are not included in this category.

- **Operations/Construction:** These projects share many similar characteristics with design projects, but are performed to determine the best approach for optimizing or evaluating *existing* systems.

Table 1 presents the general relevance of each tool category for each analytical context, including planning, design, and operations/construction.

Analysis Context:
Planning, Design, or Operations/Construction

1 Geographic Scope	2 Facility Type	3 Travel Mode	4 Management Strategy	5 Traveler Response	6 Performance Measures	7 Tool/Cost-Effectiveness
What is your study area?	**Which facility types do you want to include?**	**Which travel modes do you want to include?**	**Which management strategies should be analyzed?**	**Which traveler responses should be analyzed?**	**What performance measures are needed?**	**What operational characteristics are necessary?**
• Isolated Location • Segment • Corridor/ Small Network • Region	• Isolated Intersection • Roundabout • Arterial • Highway • Freeway • HOV Lane • HOV Bypass Lane • Ramp • Auxiliary Lane • Reversible Lane • Truck Lane • Bus Lane • Toll Plaza • Light Rail Line	• SOV • HOV (2, 3, 3+) • Bus • Rail • Truck • Motorcycle • Bicycle • Pedestrian	• Freeway Mgmt • Arterial Intersections • Arterial Mgmt • Incident Mgmt • Emergency Mgmt • Work Zone • Spec Event • APTS • ATIS • Electronic Payment • RRX • CVO • AVCSS • Weather Mgmt • TDM	• Route Diversion - Pre-Trip - En-Route • Mode Shift • Departure Time Choice • Destination Change • Induced/ Foregone Demand	• LOS • Speed • Travel Time • Volume • Travel Distance • Ridership • AVO • v/c Ratio • Density • VMT/PMT • VHT/PHT • Delay • Queue Length • # Stops • Crashes/ Duration • TT Reliability • Emissions/ Fuel Consump • Noise • Mode Split • Benefit/Cost	• Tool Capital Cost • Effort (Cost/ Training) • Ease of Use • Popular/Well-Trusted • Hardware Requirements • Data Requirements • Computer Run Time • Post-Processing • Documentation • User Support • Key Parameters User Definable • Default Values • Integration • Animation/ Presentation

Figure 2. Criteria for selecting a traffic analysis tool category.

Table 1. Relevance of traffic analysis tool categories with respect to analytical context.

Analytical Context	Analytical Tools/Methodologies: Sketch Planning	Travel Demand Models	Analytical/ Deterministic Tools (HCM-Based)	Traffic Optimi-zation	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
Planning	●	●	∅	○	∅	∅	○
Design	N/A	∅	●	●	●	●	●
Operations/ Construction	∅	○	●	●	●	●	●

Notes: ● Specific context is generally addressed by the corresponding analytical tool/methodology.
∅ Some of the analytical tools/methodologies address the specific context and some do not.
○ The particular analytical tool/methodology does not generally address the specific context.
N/A The particular methodology is not appropriate for use in addressing the specific context.

Before selecting a particular tool, users are strongly encouraged to assess the strengths and weaknesses of the specific analytical tools. Appendix A provides a list of available traffic analysis tools by tool category as of August 2003 (Web site links are also provided for more information). An updated version of this list can be found at the FHWA Office of Operations Web site at:

http://ops.fhwa.dot.gov/Travel/Traffic_Analysis_Tools/traffic_analysis_tools.htm

Appendix A Traffic Analysis Tools by Category

A.1 Sketch Planning Tools

Examples of sketch planning tools:

- Better Decisions: http://mctrans.ce.ufl.edu/store/description.asp?itemID=165
- HDM (Highway Design and Management): http://hdm4.piarc.org
- IDAS (ITS Deployment Analysis System): http://idas.camsys.com
- IMPACTS: www.fhwa.dot.gov/steam/impacts.htm
- MicroBENCOST: http://mctrans.ce.ufl.edu/store/description.asp?itemID=166
- QuickZone: www.tfhrc.gov/its/quickzon.htm
- SCRITS (Screening for ITS): www.fhwa.dot.gov/steam/scrits.htm
- Sketch Methods: http://plan2op.fhwa.dot.gov/toolbox/toolbox.htm
- SMITE (Spreadsheet Model for Induced Travel Estimation): www.fhwa.dot.gov/steam/smite.htm
- SPASM (Sketch Planning Analysis Spreadsheet Model): www.fhwa.dot.gov/steam/spasm.htm
- STEAM (Surface Transportation Efficiency Analysis Model): www.fhwa.dot.gov/steam/index.htm
- TEAPAC (Traffic Engineering Applications Package)/SITE: www.strongconcepts.com/Products.htm
- TrafikPlan: http://mctrans.ce.ufl.edu/store/description.asp?itemID=162
- TransDec (Transportation Decision): http://tti.tamu.edu/researcher/v34n3/transdec.stm
- Trip Generation: http://mctrans.ce.ufl.edu/store/description.asp?itemID=179
- Turbo Architecture: http://itsarch.iteris.com/itsarch/html/turbo/turbooverview.htm

A.2 Travel Demand Models

Available travel demand modeling tools:

- b-Node Model: http://mctrans.ce.ufl.edu/store/description.asp?itemID=482
- CUBE/MINUTP: www.citilabs.com/minutp/index.html
- CUBE/TP+/Viper: www.citilabs.com/viper/index.html
- CUBE/TRANPLAN (Transportation Planning): www.citilabs.com/tranplan/index.html
- CUBE/TRIPS (Transport Improvement Planning System): www.citilabs.com/trips/index.html
- EMME/2™: www.inro.ca/products/e2_products.html
- IDAS: http://idas/camsys.com
- MicroTRIMS: http://mctrans.ce.ufl.edu/store/description.asp?itemID=483
- QRS II (Quick Response System II): http://my.execpc.com/~ajh/index.html
- SATURN (Simulation and Assignment of Traffic to Urban Road Network): http://mctrans.ce.ufl.edu/store/description.asp?itemID=157
- TModel: www.tmodel.com
- TransCAD®: www.caliper.com/tcovu.htm
- TRANSIMS (Transportation Analysis Simulation System): http://transims.tsasa.lanl.gov

A.3 Analytical/Deterministic Tools (HCM Methodologies)

There is a wide array of analytical/deterministic tools currently available, including:

- 5-Leg Signalized Intersection Capacity: http://mctrans.ce.ufl.edu/store/description.asp?itemID=36
- aaSIDRA (Signalized and Unsignalized Intersection Design and Research Aid): www.aatraffic.com/SIDRA/aboutsidra.htm
- ARCADY (Assessment of Roundabout Capacity and Delay): www.trlsoftware.co.uk/productARCADY.htm

- ARTPLAN (Arterial Planning): www.myflorida.com/planning/systems/sm/los/default.htm
- CATS (Computer-Aided Transportation Software): http://tti.tamu.edu/product/software/cats
- CCG/Calc2 (Canadian Capacity Guide): www.bagroup.com/Pages/software/CCGCALC.html
- CINCH: http://mctrans.ce.ufl.edu/store/description.asp?itemID=4
- CIRCAP (Circle Capacity): www.teppllc.com/publications/CIRCAP.html
- DELAYE (Delay Enhanced): http://mctrans.ce.ufl.edu/store/description.asp?itemID=407
- dQUEUE-TOLLSIM (Dynamic Toll Plaza Queuing Analysis Program): http://mctrans.ce.ufl.edu/store/description.asp?itemID=290
- FAZWEAVE: http://tigger.uic.edu/~jfazio/weaving
- FREEPLAN (Freeway Planning): www.11.myflorida.com/planning/systems/sm/los/default.htm
- FREWAY (Freeway Delay Calculation Program): http://mctrans.ce.ufl.edu/store/description.asp?itemID=291
- FRIOP (Freeway Interchange Optimization Model): http://mctrans.ce.ufl.edu/store/description.asp?itemID=408
- General Purpose Queuing Model: http://mctrans.ce.ufl.edu/store/description.asp?itemID=409
- Generalized Annual Average Daily Service Volume Tables: www.11.myflorida.com/planning/systems/sm/los/default.htm
- Generalized Peak-Hour Directional Service Volume Tables: www.11.myflorida.com/planning/systems/sm/los/default.htm
- GradeDec 2000: www.gradedec.com
- HCM/Cinema©: www.kldassociates.com/unites.htm
- HCS (Highway Capacity Software) 2000: http://mctrans.ce.ufl.edu/store/description.asp?itemID=48
- HiCAP™ (Highway Capacity Analysis Package): www.hicap2000.com

- HIGHPLAN (Highway Planning): www.11.myflorida.com/planning/systems/sm/los/default.htm
- Highway Safety Analysis: www.x32group.com/HSA_Soft.html
- ICU (Intersection Capacity Utilization): www.trafficware.com/ICU/index.html
- IQPAC (Integrated Queue Analysis Package): http://mctrans.ce.ufl.edu/store/description.asp?itemID=294
- Left-Turn Signal/Phase Warrant Program: http://mctrans.ce.ufl.edu/store/description.asp?itemID=56
- NCAP (Intersection Capacity Analysis Package): www.tmodel.com
- PICADY (Priority Intersection Capacity and Delay): www.trlsoftware.co.uk/productPICADY.htm
- PROGO (Progression Graphics and Optimization): http://mctrans.ce.ufl.edu/store/description.asp?itemID=78
- Quality/Level of Service Handbook: www.11.myflorida.com/planning/systems/sm/los/default.html
- Roadrunner: http://mctrans.ce.ufl.edu/store/description.asp?itemID=85
- SIG/Cinema©: www.kldassociates.com/unites.htm
- SIPA (Signalized Intersection Planning Analysis): http://mctrans.ce.ufl.edu/store/description.asp?itemID=22
- SPANWIRE: http://mctrans.ce.ufl.edu/store/description.asp?itemID=304
- SPARKS (Smart Parking Analysis): http://mctrans.ce.ufl.edu/store/description.asp?itemID=305
- Synchro: www.trafficware.com
- TEAPAC/NOSTOP: www.strongconcepts.com/Products.htm
- TEAPAC/SIGNAL2000: www.strongconcepts.com/Products.htm
- TEAPAC/WARRANTS: www.strongconcepts.com/Products.htm
- TGAP (Traffic Gap Analysis Package): www.tmodel.com

- TIMACS (Timing Implementation Method for Actuated Coordinated Systems): http://mctrans.ce.ufl.edu/store/description.asp?itemID=92

- Traffic Engineer's Toolbox: http://home.pacifier.com/~jbtech

- Traffic Noise Model: www.thewalljournal.com/a1f04/tnm

- TRAFFIX™: www.traffixonline.com

- TSDWIN™ (Time-Space Diagram for Windows®): www.fortrantraffic.com/whatsnew/new2.htm

- TS/PP-Draft (Time-Space/Platoon-Progression Diagram Generator*): www.tsppd.com*

- WEST (Workspace for Evaluation of Signal Timings): http://mctrans.ce.ufl.edu/store/description.asp?itemID=126

- WHICH (Wizard of Helpful Intersection Control Hints): http://mctrans.ce.ufl.edu/store/description.asp?itemID=127

- WinWarrants: http://home.pacifier.com/~jbtech

A.4 Traffic Optimization Tools

Examples of traffic optimization tools:

- PASSER™ II-02 (Progression Analysis and Signal System Evaluation Routine): http://ttisoftware.tamu.edu/fraPasserII_02.htm

- PASSER III-98: http://ttisoftware.tamu.edu/fraPasserIII_98.htm

- PASSER IV-96: http://ttisoftware.tamu.edu/fraPasserIV_96.htm

- PROGO: http://mctrans.ce.ufl.edu/store/description.asp?itemID=78

- SOAP84: http://mctrans.ce.ufl.edu/store/description.asp?itemID=435

- Synchro: www.trafficware.com

- TEAPAC/NOSTOP: www.strongconcepts.com/Products.htm

- TEAPAC/SIGNAL2000: www.strongconcepts.com/Products.htm

- TEAPAC/WARRANTS: www.strongconcepts.com/Products.htm

- TRANSYT-7F: http://mctrans.ce.ufl.edu/store/description.asp?itemID=437

- TSDWIN: www.fortrantraffic.com/whatsnew/new2.htm
- TS/PP-Draft: www.tsppd.com

A.5 Macroscopic Simulation Models

Examples of macroscopic simulation traffic analysis tools:

- BTS (Bottleneck Traffic Simulator): http://mctrans.ce.ufl.edu/store/description.asp?itemID=287
- FREQ12: www.its.berkeley.edu/computing/software/FREQ.html
- KRONOS: www.its.umn.edu/labs/itslab.html
- METACOR/METANET: www.inrets.fr/ur/gretia/METACOR-Ang-H-HajSalem.htm
- NETCELL: www.its.berkeley.edu/computing/software/netcell.html
- PASSER II-02: http://ttisoftware.tamu.edu/fraPasserII_02.htm
- PASSER III-98: http://ttisoftware.tamu.edu/fraPasserIII_98.htm
- PASSER IV-96: http://ttisoftware.tamu.edu/fraPasserIV_96.htm
- SATURN: www.its.leeds.ac.uk/software/saturn/index.html
- TRAF-CORFLO (Corridor Flow): http://mctrans.ce.ufl.edu/store/description.asp?itemID=441
- TRANSYT-7F: http://mctrans.ce.ufl.edu/store/description.asp?itemID=437
- VISTA (Visual Interactive System for Transport Algorithms): http://its.civil.northwestern.edu/vista

A.6 Mesoscopic Simulation Models

Three examples of mesoscopic simulation tools:

- CONTRAM (Continuous Traffic Assignment Model): www.contram.com
- DYNAMIT-P, DYNAMIT-X, DYNASMART-P, DYNASMART-X: www.dynamictrafficassignment.org
- MesoTS: http://plan2op.fhwa.dot.gov/pdfs/Pdf2/mesoscopic.pdf

A.7 Microscopic Simulation Models

Examples of microscopic traffic simulation models:

- AIMSUN2 (Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks): www.tss-bcn.com/aimsun.html
- ANATOLL: www.its.leeds.ac.uk/projects/smartest/append3d.html#a4
- AUTOBAHN: www.its.leeds.ac.uk/projects/smartest/append3d.html#a5
- CASIMIR: www.its.leeds.ac.uk/projects/smartest/append3d.html#a6
- CORSIM/TSIS (Traffic Software Integrated System): www.fhwa-tsis.com
- DRACULA (Dynamic Route Assignment Combining User Learning and Microsimulation): www.its.leeds.ac.uk/software/dracula
- FLEXSYT-II: www.flexsyt.nl/informatieuk.htm
- HIPERTRANS (High-Performance Transport): www.cpc.wmin.ac.uk/~traffic
- HUTSIM (Helsinki University of Technology Simulator): www.hut.fi/Units/Transportation/HUTSIM
- INTEGRATION: www.intgrat.com
- MELROSE (Mitsubishi Electric Road Traffic Simulation Environment): www.its.leeds.ac.uk/projects/smartest/append3d.html#a14
- MicroSim: www.zpr.uni-koeln.de/GroupBachem/VERKEHR.PG
- MICSTRAN (Microscopic Simulator Model for Traffic Networks): www.its.leeds.ac.uk/projects/smartest/append3d.html#a16
- MITSIM (Microscopic Traffic Simulator): http://web.mit.edu/its/products.html
- MIXIC: www.its.leeds.ac.uk/projects/smartest/append3d.html#a18
- NEMIS: www.its.leeds.ac.uk/projects/smartest/append3d.html#a19
- PADSIM (Probabilistic Adaptive Simulation Model): www.its.leeds.ac.uk/projects/smartest/append3d.html#a21
- PARAMICS: www.paramics-online.com

- PHAROS (Public Highway and Road Simulator): www.its.leeds.ac.uk/projects/smartest/append3d.html#a23
- PLANSIM-T: www.its.leeds.ac.uk/projects/smartest/append3d.html#a24
- ROADSIM (Rural Road Simulator): www.kldassociates.com/simmod.htm
- SHIVA (Simulated Highways for Intelligent Vehicle Algorithms): www.its.leeds.ac.uk/projects/smartest/append3d.html#a25
- SIGSIM: www.its.leeds.ac.uk/projects/smartest/append3d.html#a26
- SIMDAC: www.its.leeds.ac.uk/projects/smartest/append3d.html#a27
- SIMNET: www.its.leeds.ac.uk/projects/smartest/append3d.html#a28
- SimTraffic: www.trafficware.com
- SISTM (Simulation of Strategies for Traffic on Motorways): www.its.leeds.ac.uk/projects/smartest/append3d.html#a29
- SITRA B+: www.its.leeds.ac.uk/projects/smartest/append3d.html#a30
- SITRAS: www.its.leeds.ac.uk/projects/smartest/append3d.html#a31
- SmartPATH: www.path.berkeley.edu/PATH/Research
- TEXAS (TEXAS Model for Intersection Traffic): http://mctrans.ce.ufl.edu/store/description.asp?itemID=449
- TRANSIMS: http://transims.tsasa.lanl.gov
- TRARR: www.engr.umd.edu/~lovell/lovmay94.html
- TWOPAS: www.tfhrc.gov/safety/ihsdm/tamweb.htm
- VISSIM: www.itc-world.com
- WATSim (Wide Area Traffic Simulation): www.kldassociates.com/unites.html

A.8 Integrated Traffic Analysis Tools

There are some programs or utilities available that integrate two or more programs to provide a common data input format (all allow a user to run several programs). Some examples of integrated traffic simulation models include:

- AAPEX (Arterial Analysis Package Executive): http://mctrans.ce.ufl.edu/store/description.asp?itemID=426
- ITRAF: http://mctrans.ce.ufl.edu/store/description.asp?itemID=445
- PROGO: http://mctrans.ce.ufl.edu/store/description.asp?itemID=78
- UNITES (Unified Integrator of Transportation Engineering Software): www.kldassociates.com/unites.htm

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