Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools

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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. While traffic analysis tools have the capability to provide meaningful insights into transportation analyses, far too often they are misapplied. Namely, the most appropriate tool for the job is not the tool that is used.

The purpose of this *Decision Support Methodology for Selecting Traffic Analysis Tools* is to provide an overview of the role of traffic analysis tools in transportation analyses and to present a detailed methodology for selecting the appropriate tool for the job at hand. The report describes the selection process including selection criteria and worksheets that can be used in applying the selection process.

This document serves as Volume II in the Traffic Analysis Toolbox. Other volumes currently in the toolbox include: Volume I: *Traffic Analysis Tools Primer* and Volume III: *Guidelines for Applying Traffic Microsimulation Modeling Software.*
The intended audience for this report is the transportation professional or analyst who uses traffic analysis tools and makes decisions on the types of analyses to use.

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Director
Office of Transportation Management

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16. Abstract

This report provides an overview of the role of traffic analysis tools in the transportation analysis process and provides a detailed decision support methodology for selecting the appropriate type of analysis tool for the job at hand.

An introduction to the role of traffic analysis tools and tool categories is provided. A set of criteria for selecting the appropriate type of traffic analysis tool is described in detail and each tool category is scored as to its relevance to the criteria. The criteria include the analysis context, study area, facility type, travel mode, management strategy, traveler response, performance measures, and cost-effectiveness. A process and worksheets for an analyst to rate a tool category for a particular transportation analysis task are presented based on the criteria and the analyst's weighting of the criteria. Some challenges and limitations of the use of traffic analysis tools are provided.

The appendices include: a) a summary of current limitations to the highway capacity manual (HCM) methodologies, b) tool category selection worksheets, c) worksheets for selecting an individual tool within a category, d) a list of recommended further reading, and e) a list of traffic analysis tools by category.

This is the second volume in a series of volumes in the Traffic Analysis Toolbox. The other volumes currently in the Traffic Analysis Toolbox are:

Volume I: Traffic Analysis Tools Primer (FHWA-HRT-04-038)

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.
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1.0 Background and Objectives

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 crashes 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. 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 all 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 *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. This document is intended to assist practitioners in selecting the c*ategory* of tool for use (e.g., *Highway Capacity Manual* (HCM) versus traffic simulation); this document does not include an assessment of the capabilities of specific tools within an analytical tool category. Another objective of this document 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

This methodology was developed for FHWA. The FHWA Traffic Analysis Tools Team made extensive contributions to this document and to the automated tool. This document is organized into the following sections:

Section 1.0: Background and Objectives: Describes the objectives of the document and highlights the need for and the role of traffic analysis tools, including the definitions of the analytical tool categories covered in this document. This section also presents a comparison of HCM with traffic simulation models.

Section 2.0: Criteria for Selecting the Appropriate Type of Traffic Analysis Tool: 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 presented to guide users in the selection of the appropriate tool category.

Section 3.0: Methodology for Selecting a Traffic Analysis Tool: Provides guidance to users on how to use the criteria in section 2.0 to select the appropriate analytical tool category. This section includes worksheets that transportation professionals can use to select the appropriate tool category and assistance in identifying the most appropriate tool within the selected category.

Section 4.0: Available Traffic Analysis Tools: Presents a list of available analytical tools.

Section 5.0: Challenges and Limitations in the Use of Traffic Analysis Tools: Highlights some of the challenges and limitations of the analytical tools for consideration by users.

Appendix A: Limitations of HCM: Lists the limitations of the HCM methodologies.

Appendix B: Tool Category Selection Worksheet: Contains a worksheet that can be used to select an appropriate tool category for the task.

Appendix C: Tool Selection Worksheet: Contains a worksheet that can assist users with the selection of a specific traffic analysis tool.

Appendix D: Recommended Reading: Contains a list of documents that discuss or compare some of the specific traffic analysis tools.

Appendix E: Traffic Analysis Tools by Category: Provides a list of analytical tools by category and their Web site links. This is only intended to be a starting point for users once they have selected an analytical tool category.

Appendix F: References: Documents the literature reviewed and used in the development of this document.

1.1 Overview of the Transportation Analysis Process

The Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21), and 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* analytical 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 section.

1.2 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.

- **Project potential future traffic.** Traffic analysis tools can be used to project and analyze future traffic conditions. This is especially useful for planning long-term improvements and evaluating future impact.

- **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.

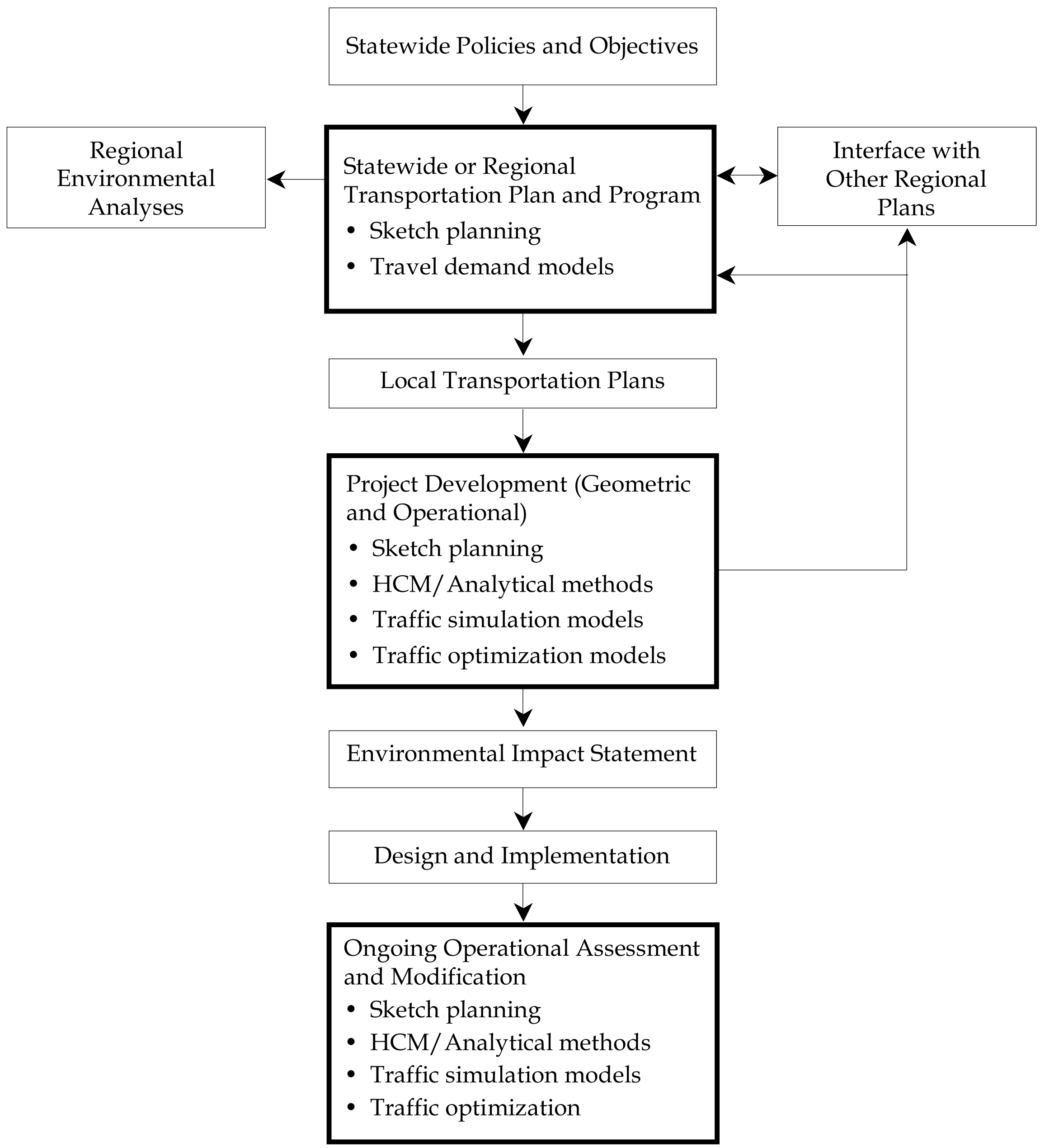
- **Improve design and evaluation time and costs.** Traffic analysis tools are relatively less costly when compared to pilot studies, field experiments, or full implementation costs. Furthermore, analytical tools can be used to assess multiple deployment combinations or other complex scenarios in a relatively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



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.

1.3 Categories of Traffic Analysis Tools

The intent of this document is to provide guidance on the selection of the appropriate type of analytical tool, not the specific tool. To date, numerous traffic analysis methodologies and tools have been developed by public agencies, research organizations, and various 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. Sketch-planning tools perform some or all of the functions of other analytical tools using simplified analytical techniques and highly aggregated data. For example, a highway engineer can estimate how much it will cost to add a lane to an existing roadway simply by using sketch-planning techniques and without doing a complete site evaluation. Similarly, traffic volume-to-capacity ratios are often used in congestion analyses. Such techniques are primarily used to prepare preliminary budgets and proposals, and are not considered a substitute for the detailed engineering analysis often needed later in the implementation process. Therefore, sketch-planning approaches are typically the simplest and least costly of the traffic analysis techniques. 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). The HCM procedures are closed-form, macroscopic, deterministic, and static analytical procedures that estimate capacity and performance measures to determine the level of service (e.g., density, speed, and delay). They are closed-form because they are not iterative. The practitioner inputs the data and the parameters and, after a sequence of analytical steps, the HCM procedures produce a single answer. Moreover, the HCM procedures are macroscopic (input and output deal with average performance during a 15-minute or a 1-hour analytical period), deterministic (any given set of inputs will always yield the same answer), and static (they predict average operating conditions over a fixed time period and do not deal with transitions in operations from one system state to another). As such, 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. The HCM procedures and their strengths and limitations are discussed in more detail in section 1.4.

- **Traffic Signal Optimization Tools:** Similar to the analytical/deterministic tools, traffic optimization tool methodologies are mostly based on the HCM procedures. However, traffic optimization tools are primarily designed to develop optimal signal phasings 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. The more advanced traffic optimization tools are capable of modeling actuated and semi-actuated traffic signals, with or without signal coordination.

- **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 simulation models were originally developed to model traffic in distinct transportation subnetworks, such as freeways, corridors (including freeways and parallel arterials), surface-street grid networks, and rural highways. They consider platoons of vehicles and simulate traffic flow in brief time increments. Macroscopic simulation models operate on the basis of aggregate speed/volume and demand/capacity relationships. The validation of macroscopic simulation models involves replication of observed congestion patterns. Freeway validation is based on both tachometer run information and speed contour diagrams constructed for the analytical periods, which are then aggregated to provide a "typical" congestion pattern. Surface-street validation is based on speed, queue, delay, and capacity information. 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 microscopic models, and do not consider trip generation, trip distribution, and mode choice in their evaluation of changes in transportation systems.

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

- **Microscopic Simulation Models:** Microscopic simulation 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 brief 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. In many microscopic simulation models, the traffic operational characteristics of each vehicle are influenced by vertical grade, horizontal curvature, and superelevation, based on relationships developed in prior research. The primary means of calibrating and validating microscopic simulation models are through the adjustment of driver sensitivity factors. Computer time and storage requirements for microscopic models are significant, usually limiting the network size and the number of simulation runs that can be completed.

1.4 Comparison of HCM and Simulation

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

1.4.1 Overview of HCM

HCM is a compilation of peer-reviewed procedures for computing the capacity and operational performance of various transportation facilities. HCM was first produced in 1950 and has undergone many major revisions since then. It is currently published by the Transportation Research Board. The current edition of HCM was produced in 2000.

Highway Capacity Manual 2000 (HCM 2000) has more than 1,100 pages and 30 chapters. Parts I and II of the manual present introductory information on capacity and the quality of service analysis. Part III presents the actual analytical procedures. Part IV provides information on applying HCM to corridor and areawide planning analyses. Part V provides introductory materials on models that go beyond the HCM procedures described in part III.

Each chapter in part III focuses on a specific facility type and capacity analysis problem. For example, there are four chapters devoted to freeway facilities: freeway facilities, basic freeway segments, ramps and ramp junctions, and freeway weaving. There are three chapters devoted to the analysis of urban facilities: urban streets, signalized intersections, and unsignalized intersections. There are also chapters that cover procedures for the analysis of multilane highways, two-lane rural roads, transit, pedestrian facilities, and bicycle facilities.

The HCM procedures are closed-form, macroscopic, deterministic, and static analytical procedures that estimate capacity, and performance measures to determine the level of service (e.g., density, speed, and delay). They are closed-form because they are not iterative. The practitioner inputs the data and parameters, and after a sequence of analytical steps, the HCM procedures produce a single answer. In general, the HCM procedures have the following characteristics:

- **Macroscopic:** HCM's input and output deal with average performance during a 15-minute or 1-hour analytical period.
- **Deterministic:** Any given set of input will always yield the same answer.
- **Static:** The HCM procedures predict average operating conditions over a fixed time period and do not deal with transitions in operation from one system state to another (such as would be addressed in a dynamic analysis).

1.4.2 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 or not 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.

Appendix A summarizes the limitations of HCM based on information listed in HCM 2000.

1.4.3 Simulation Strengths and Limitations

Simulation tools are effective in evaluating the dynamic evolution of traffic congestion problems on transportation systems. By dividing the analytical 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 capacity at 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 calibration of those parameters to 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 among 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.).

1.4.4 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 analytical 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 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 flow 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 the vehicles are slowed down, while HCM reports all delays caused by a given bottleneck (regardless of the actual physical location of the vehicles).

- Simulation models report queues only on the street segment where the vehicles are actually queued, while HCM reports all queued vehicles resulting from 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 the vehicles traveling along the link, or only stopped delay at the traffic signal.

1.4.5 Strategy for Overcoming the Limitations of HCM

Once 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)) in one tool, but at 0 km/h for another).

If it is not necessary to microscopically trace individual vehicle movement, 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 of 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)*.

2.0 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 and helps identify under what circumstances a particular tool should be used. Section 3.0 of this document contains guidance on how to use this information to select the appropriate tool.

Sections 2.1 and 2.2 present the criteria a user should consider 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:

1. Ability to analyze the appropriate **geographic scope** or study area for the analysis, including 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 that influence cost-effectiveness include tool capital cost, level of effort required, ease of use, hardware requirements, data requirements, animation, etc.

Each analytical tool category was evaluated against each criterion to identify whether or not a category of analytical tool was appropriate for use. This evaluation is presented in the form of matrices. In each matrix cell, a value has been assigned to each tool category according to its relevance or applicability to the corresponding criterion. A *solid circle* (●) indicates that the particular tool category adequately addresses the criterion. An *empty circle* (○) indicates that the traffic analysis tool category poorly addresses the specific criterion. A *null symbol* (∅) indicates that some tools within the tool category may address the criterion and others may not. *Not applicable* (N/A) indicates that the particular tool category does not address the corresponding criterion at all and should not be used for the analysis.

Figure 2 below summarizes the criteria that may be considered for the selection of a tool category.

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

1. Users should begin by identifying the project's analytical context (discussed in section 2.1).

2. Next, users should filter through criteria 1 through 6 to limit the appropriate tool categories to one or two options (as discussed in sections 2.2.1 through 2.2.6).

3. Finally, criterion 7 (tool/cost effectiveness) should be used to select the final tool category (presented in section 2.2.7) based on parameters outside of the technical context of the analysis, such as tool cost, training, hardware requirements, etc.

Step-by-step guidance for the tool selection process is presented in section 3.0. 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

Finally, a listing of available tools for each category and their Web site links are provided in section 4.0.

2.1 Analytical Context

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-term studies or other State, regional, or local transportation plans (e.g., master plans, congestion management plans, ITS strategic plans, etc.).

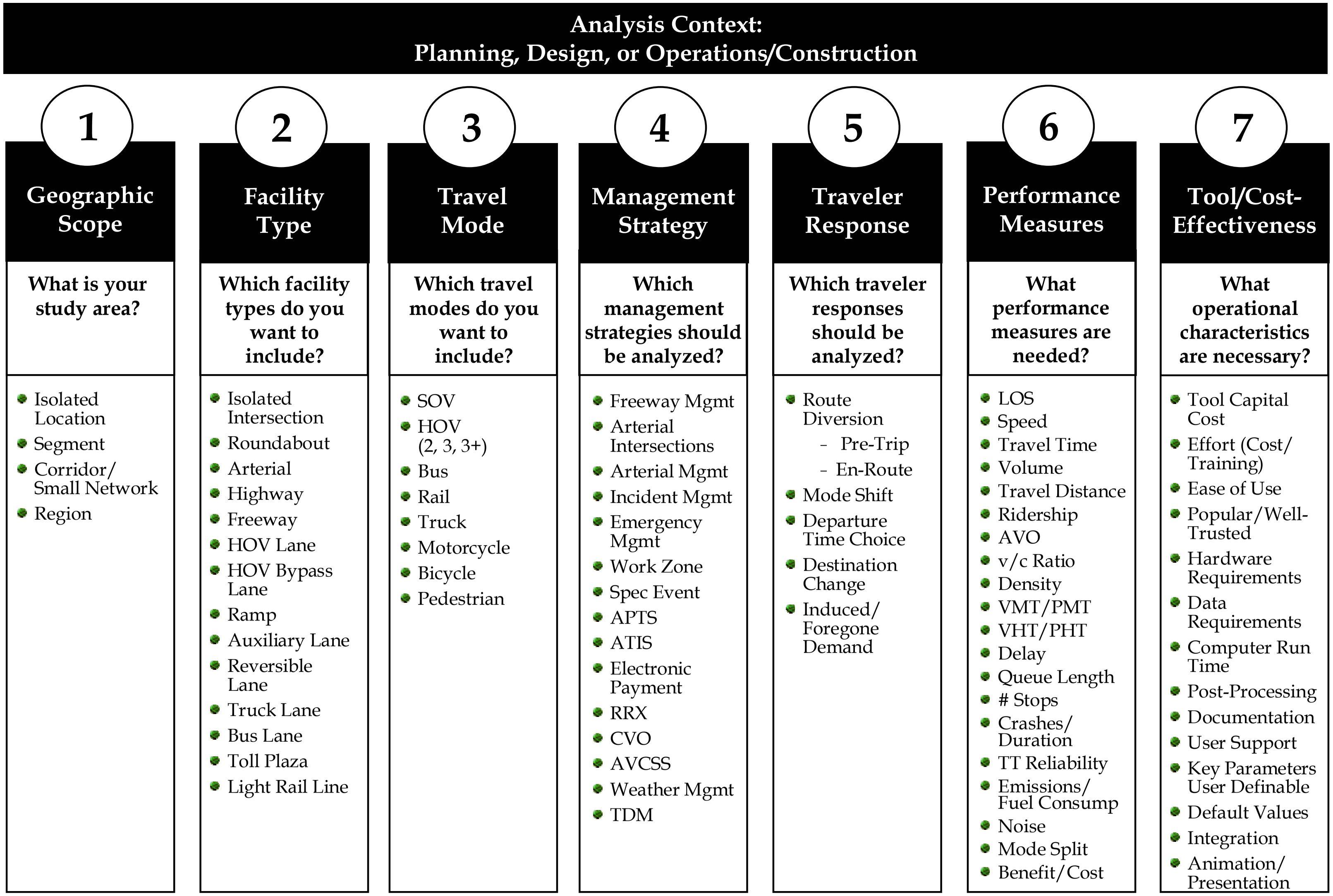


Figure 2. Criteria for selecting a traffic analysis tool category.

- **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 (e.g., 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.

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.

Notes and Assumptions:

- The role of these tools may vary according to the analytical context. For example, the use of simulation can differ considerably for planning versus operations. In planning, the system does not exist and modeling or simulation is necessary for analyzing alternatives. However, when considering traffic-responsive control measures for an existing system, real measurements should first be considered, while simulation plays a secondary role.

2.2 Criteria for Analytical Tool Selection and Assessment of Tool Capabilities

Criteria 1 through 7 from figure 2 are discussed in the following sections, with the first six criteria focusing on the various technical aspects of the analysis (e.g., facility type, travel mode, management strategy, etc.), while criterion 7 helps to identify the best tool category from a management/operational perspective.

2.2.1 Study Area/Geographic Scope

Traffic analysis tools have varying degrees of capabilities with respect to the analytical environment and geographic scope of the project. Table 2 summarizes the general relevance of each tool category based on the study area/geographic scope appropriate for the task. Four types of study areas are included:

- **Isolated Location:** Limited study area, such as a single intersection or interchange.

- **Segment:** Linear or small-grid roadway network.

- **Corridor/Small Network:** Expanded study area that typically includes one major corridor with one or two parallel arterials and their connecting cross-streets, typically less than 520 square kilometers (km^2) (200 square miles (mi^2)).

- **Region:** Citywide or countywide study area involving all freeway corridors and major arterials, typically 520 km^2 (200 mi^2) or larger.

Notes and Assumptions:

- The study area/geographic scope is the only criterion that has varying relevance with respect to the analytical context. The user should identify both the analytical context and the study area type for this matrix.

- For the traffic simulation tool categories (macroscopic, mesoscopic, and microscopic simulations), the geographic area relevance factors are identical because, in general, simulation tools feature the same geographic areas (e.g., segment, corridor, etc.), but with varying levels of detail.

- Typically, analytical/deterministic tools are based on the HCM procedures, which are more focused on single roadways or isolated locations rather than on a network or a roadway grid system.

Table 2. Relevance of traffic analysis tool categories with respect to study area/geographic scope.

Analytical Context/ Geographic Scope	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/ Deterministic Tools (HCM-Based)	Traffic Optimi-zation	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
Planning							
Isolated Location	○	○	●	∅	○	○	○
Segment	●	○	● [1]	○	∅	∅	∅
Corridor/ Small Network	∅	●	○	○	∅	∅	∅
Region	∅	●	N/A	N/A	N/A	N/A	N/A
Design							
Isolated Location	N/A	N/A	●	●	●	∅	●
Segment	N/A	○	●	∅	●	●	●
Corridor/ Small Network	N/A	∅	○	○	●	●	●
Region	N/A	∅	N/A	N/A	○	○	∅
Operations/Construction							
Isolated Location	N/A	N/A	●	●	●	∅	●
Segment	∅	○	●	●	●	●	●
Corridor/ Small Network	N/A	∅	○	∅	●	●	●
Region	N/A	∅	N/A	N/A	∅	○	∅

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.
[1]For linear networks

2.2.2 Facility Type

This section discusses the ability of the tools to analyze various facility types. Definitions for the facility types were based on HCM 2000. The relevance of the analytical tool categories with respect to the facility-type criterion is presented in table 3. The facility types include:

Table 3. Relevance of traffic analysis tool categories with respect to facility type.

Facility Type	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/ Deterministic Tools (HCM-Based)	Traffic Optimization	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
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	○	●	○	○	○	○	●

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.

- **Isolated Intersection:** Single crossing point between two or more roadway facilities.
- **Roundabout:** Unsignalized intersection with a circulatory roadway around a central island with all entering vehicles yielding to circulating traffic.
- **Arterial:** Signalized street that primarily serves through traffic and that secondarily provides access to abutting properties (signal spacing of 3.2 kilometers (km) (2 miles (mi)) or less.
- **Highway:** High-speed roadway connecting major areas or arterials, with little or no traffic signal interruption (e.g., two-lane highway, expressway).
- **Freeway:** Multilane, divided highway with a minimum of two lanes for the exclusive use of traffic in each direction and full control of access without traffic interruption.

- **HOV Lane:** Exclusive highway or street lane for vehicles with a defined minimum number of occupants (more than one), including buses, taxis, or carpools (may be used by other traffic under certain circumstances, such as during off-peak hours, for making a right or left turn, or by motorcycles, depending on the jurisdiction's traffic laws).

- **HOV Bypass Lane:** Exclusive on-ramp lane for vehicles with a defined minimum number of occupants (more than one), including buses, taxis, carpools, for specified time periods.

- **Ramp:** Short segment of roadway connecting two roadway facilities.

- **Auxiliary Lane:** Additional lane on a freeway to connect an on-ramp and an off-ramp.

- **Reversible Lane:** Roadway lane that changes directions during different hours of the day (reversible lanes are typically used to help alleviate congestion by accommodating the peak direction of traffic).

- **Truck Lane:** Designated lane for commercial vehicles, but not for public transit vehicles.

- **Bus Lane:** Highway or street lane reserved primarily for buses during specified periods (may be used by other traffic under certain circumstances, such as for making a right or left turn, or by taxis, motorcycles, or carpools that meet the requirements of the jurisdiction's traffic laws).

- **Toll Plaza:** Facility where payment transaction for the use of the roadway takes place (may be located upstream or downstream of the toll facility).

- **Light-Rail Line:** Electric-powered railway system operating single cars or short trains on a variety of alignment types on a partially controlled right-of-way.

Notes and Assumptions:

- Generally, it is not appropriate to optimize a two-lane highway or roundabout.

2.2.3 Travel Mode

Table 4 presents a matrix rating the appropriateness of each tool category in analyzing the different travel modes. The definitions for the travel modes are based on HCM 2000:

- **SOV:** Vehicle with the driver as the only occupant.

- **HOV:** Vehicle with a defined minimum number of occupants (more than one), including buses, taxis, carpools, and vanpools.

- **Bus:** Self-propelled, rubber-tired road vehicle designed to carry a substantial number of passengers and commonly operated on streets and highways.

Table 4. Relevance of traffic analysis tool categories with respect to travel mode.

Travel Mode	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/ Deterministic Tools (HCM-Based)	Traffic Optimi-zation	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
SOV	●	●	●	●	●	●	●
HOV	∅	●	∅	∅	∅	●	●
Bus	∅	●	∅	∅	∅	●	●
Rail	∅	●	○	○	○	∅	∅
Truck	∅	∅	∅	∅	∅	∅	∅
Motorcycle	○	∅	○	○	○	○	○
Bicycle	∅	∅	∅	○	○	○	∅
Pedestrian	∅	○	∅	∅	∅	∅	∅

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.

- **Rail:** Transit system using trains operating in exclusive or shared rights-of-way (includes both light and heavy rail systems).

- **Truck:** Heavy vehicle engaging primarily in the transport of goods and materials or in the delivery of services other than public transportation.

- **Motorcycle:** Self-propelled vehicle with two wheels in tandem that may be ridden by a maximum of two persons.

- **Bicycle:** Vehicle with two wheels in tandem that is propelled by human power and is usually ridden by one person.

- **Pedestrian:** Individual traveling on foot.

2.2.4 Management Strategy and Applications

The following are the major classifications of transportation management strategies (adapted from the National ITS Architecture):

- **Freeway Management:** Controls, guides, and warns traffic in order to improve the flow of people and goods on limited-access facilities. Examples of freeway management include the integration of surveillance information with freeway road geometry; vehicle control, such as ramp metering; dynamic message signs (DMS); and highway advisory radio (HAR).

- **Arterial Intersections:** Includes intersection or arterial operations, such as geometric improvements, parking adjustments, and signal timing for individual intersections. These improvements would typically involve capacity analysis, LOS analysis, and unsignalized and signalized intersection studies.

- **Arterial Management:** Applies State and local planning, capital, and regulatory and management tools to enhance and/or preserve the transportation functions of the arterial roadway through the use of surveillance devices, advanced signal algorithms, and coordination.

- **Incident Management:** Manages unexpected incidents so that the impact on the transportation network and traveler safety is minimized. Includes incident detection capabilities through roadway surveillance devices and incident response through coordination with freeway service patrols and emergency response agencies.

- **Emergency Management:** Represents public safety and other agency systems that support coordinated emergency response, including police, fire, emergency medical services, hazardous materials (HazMat) response teams, Mayday service providers, and security/surveillance services that improve traveler security in public areas.

- **Work Zones:** Uses traffic control devices (signs, channeling devices, barriers, etc.) and traveler information to maximize the availability of roadways during construction or maintenance while minimizing the impact on the traveling public and highway workers.

- **Special Events:** Manages planned events so that the impact on the transportation network and traveler safety is minimized through coordination with other traffic management, maintenance and construction management, and emergency management centers, and event promoters.

- **Advanced Public Transportation System (APTS):** Applies advanced technologies to the operations, maintenance, customer information, planning, and management functions for the transit agency. APTS includes advanced communications between the transit departments and the public, personnel and other operating entities such as emergency response services, and traffic management systems; automatic vehicle locator (AVL); traffic signal priority; transit operations software; advanced transit scheduling systems (ATSS); transit security; and fleet maintenance.

- **Advanced Traveler Information System (ATIS):** Ranges from simply providing fixed transit schedule information to multimodal traveler information, including real-time traffic conditions and transit schedules, and information to support mode and route selection.

- **Electronic Payment System:** Allows travelers to pay for transportation services by electronic means, including tolls, transit fares, and parking.

- **Rail Grade Crossing Monitors:** Manages traffic at highway-rail intersections where operational requirements demand advanced features. Includes the capabilities from the Standard Rail Crossing equipment package and augments these with additional safety features, including positive barrier systems and wayside interface equipment that detects or communicates with the approaching train.

- **Commercial Vehicle Operations (CVO):** Performs advanced functions that support commercial vehicle operations, including communications between drivers, fleet managers, and roadside officials; automates identification and safety processing at mainline speeds; and timely and accurately collects HazMat cargo information after a vehicle incident.

- **Advanced Vehicle Control and Safety System (AVCSS):** Includes vehicle safety systems such as vehicle or driver safety monitoring; longitudinal, lateral, or intersection warning control or collision avoidance; pre-crash restraint; and automated highway systems.

- **Weather Management:** Includes automated collection of weather condition data and the use of that data to detect hazards such as ice, high winds, snow, dense fog, etc. This information can be used to provide road condition information and more effectively deploy maintenance and construction resources.

- **Travel Demand Management (TDM):** TDM strategies are designed to maximize person throughput or influence the need for or time of travel. They are typically implemented in urban areas to reduce traffic congestion and air pollution, and to increase the efficiency of the transportation system. TDM strategies include employer trip reduction programs, vanpool programs, the construction of park-and-ride lots, and alternative work schedules.

Table 5 summarizes tool category relevance for analyzing major traffic management strategies. A more detailed listing of management strategies, which can be helpful in the selection of a specific traffic analysis tool, is presented in appendix C.

Notes and Assumptions:

- Some analytical/deterministic tools can estimate the impact of incidents, work zones, special events, and weather through reductions in capacity for specific times and locations. However, they cannot model the temporal and spatial effects of congestion.

- Macroscopic and mesoscopic models assume macroscopic traffic behavior (e.g., all vehicles travel at the same average speed). Therefore, they are not well suited to evaluate traffic management strategies that require the sensing of individual vehicles (e.g., adaptive control at individual intersections or arterials).

Table 5. Relevance of traffic analysis tool categories with respect to management strategy and applications.

Management Strategy and Applications	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/ Deterministic Tools (HCM-Based)	Traffic Optimiza-tion	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
Freeway Management	●	∅	∅	●	●	●	●
Arterial Intersections	○	○	●	●	●	●	●
Arterial Management	∅	∅	∅	●	●	●	●
Incident Management	∅	○	∅	○	●	●	●
Emergency Management	∅	○	∅	○	∅	∅	∅
Work Zones	∅	○	●	○	●	●	●
Special Events	∅	○	●	○	∅	∅	∅
Advanced Public Transportation System	∅	○	○	○	○	○	∅
Advanced Traveler Information System	∅	○	○	○	∅	∅	∅
Electronic Payment System	∅	○	○	○	○	○	●
Rail Grade Crossing Monitors	∅	○	○	○	○	○	●
Commercial Vehicle Operations	∅	○	○	○	○	○	∅
Advanced Vehicle Control and Safety System	∅	○	○	○	○	○	∅
Weather Management	○	○	○	○	∅	∅	∅
Travel Demand Mgmt	●	●	∅	○	∅	∅	∅

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.

2.2.5 Traveler Response

In response to different operational improvements, travelers can change their route of travel, change their time of travel (temporal choice), can use a different mode of transportation, change their destination, or completely cancel or create a new trip (induced/foregone demand). Table 6 indicates how well or how poorly the analytical tool categories can model the following traveler responses:

- **Route Diversions:** Captures changes in travel routes, including pre-trip route diversion and en route diversion.
- **Mode Shifts:** Captures changes regarding the selection of travel modes.
- **Departure Time Choices:** Captures changes in the time of travel.
- **Destination Changes:** Represents changes to travel destinations.
- **Induced/Foregone Demand:** Estimates new trips (induced demand) or foregone trips resulting from the implementation of traffic management strategies.

Table 6. Relevance of traffic analysis tool categories with respect to traveler response.

	Analytical Tools/Methodologies						
Traveler Response	**Sketch Planning**	**Travel Demand Models**	**Analytical/ Deterministic Tools (HCM-Based)**	**Traffic Optimi-zation**	**Macroscopic Simulation**	**Mesoscopic Simulation**	**Microscopic Simulation**
Route Diversion							
Pre-Trip	∅	○	N/A	○	●	●	●
En Route	∅	●	N/A	○	∅	∅	∅
Mode Shift	∅	●	N/A	○	∅	∅	∅
Departure Time Choice	∅	○	N/A	○	∅	∅	∅
Destination Change	N/A	∅	N/A	N/A	N/A	○	○
Induced/ Foregone Demand	∅	∅	N/A	N/A	N/A	N/A	∅

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.

Notes and Assumptions:

- Analytical/deterministic models assume that traffic demand is fixed throughout the analytical period. Although it may be possible to specify changes in demand (e.g., changes caused by diversion during an incident), the amount of diverted traffic and the time periods must be specified a priori by the analyst.

- Most models require that the origin-destination (O-D) distribution be provided. Some mesoscopic models are capable of updating the O-D trips in real time; however, they may not be capable of modeling the destination choice.

- For ramp metering strategies, some traffic optimization modules may be used to determine optimal ramp metering rates.

- Most traffic optimization models assume constant demand.

- Most traffic analysis tools are not capable of predicting destination changes or induced/foregone demand as a result of transportation improvements. Readers of this document should consider this when applying criteria weights to these items in the tool selection worksheet (appendix B).

2.2.6 Performance Measures

This section discusses the ability of the tool categories to produce various performance measures in the areas of safety, efficiency, mobility, productivity, and the environment (as summarized in table 7). The performance measures discussed in this section include:

- **Level of Service (LOS):** Qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. Ranges from LOS A (best) to LOS F (worst).

- **Speed:** Rate of motion (expressed in distance per unit of time).

- **Travel Time:** Average time spent by vehicles traversing a facility, including control delay, in seconds or minutes per vehicle.

- **Volume:** Number of persons or vehicles passing a point on a roadway during some time interval (expressed in vehicles, bicycles, or persons per hour).

- **Travel Distance:** Extent of the space between the trip origin and the destination, measured along a vehicular route.

- **Ridership:** Number of passengers on the transit system being evaluated.

- **Average Vehicle Occupancy (AVO):** Average number of persons per vehicle, including transit vehicles, on the transportation facility or system.

- **Volume-to-Capacity (V/C) Ratio:** Ratio of flow rate to capacity for a transportation facility.

- **Density:** Number of vehicles on a roadway segment averaged over space (usually expressed in vehicles per mile or vehicles per mile per lane).

- **Vehicle-Miles of Travel (VMT)/Person-Miles of Travel (PMT):** Total distance traveled by all vehicles or persons on a transportation facility or network during a specified time period (expressed in miles).

- **Vehicle-Hours of Travel (VHT)/Person-Hours of Travel (PHT):** Total travel time spent by all vehicles or persons on a transportation facility or network during a specified time period (expressed in hours).

- **Delay:** Additional travel time experienced by travelers at speeds less than the free-flow (posted) speed (expressed in seconds or minutes).

- **Queue Length:** Length of queued vehicles waiting to be served by the system (expressed in distance or number of vehicles).

- **Number of Stops:** Number of stops experienced by the section and/or corridor (based on some minimum travel speed).

- **Crashes:** Number of crashes on a transportation facility or network.

- **Incident Duration:** Includes all crashes and vehicle incidents, such as running out of gas and mechanical problems. It is calculated from the moment the vehicle or object obstructs travel until the incident is cleared (expressed in minutes or hours).

- **Travel Time Reliability:** Travel time reliability is a quantification of the unexpected non-recurring delay associated with excess travel demand, incidents, weather, or special events. There are several methods for predicting reliability or variability in travel times. Reliability of travel time is a significant benefit to travelers as individuals are better able to predict their travel time and budget less time for their trip.

- **Emissions:** Predicted emissions for each pollutant type on a transportation facility or network.

- **Fuel Consumption:** Fuel consumption rate associated with the use of a transportation facility or network.

- **Noise:** Sound level produced by traffic (expressed in decibels).

- **Mode Split:** Percentage of travelers using each travel mode (SOV, HOV, transit, bicycle, pedestrian, etc.).

- **Benefit/Cost:** Ratio of annualized, monetized benefits to total costs associated with transportation improvement(s).

Table 7. Relevance of traffic analysis tool categories with respect to performance measures.

Performance Measures	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/ Deterministic Tools (HCM-Based)	Traffic Optimi-zation	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
LOS	○	∅	●	●	∅	∅	∅
Speed	●	●	●	●	●	●	●
Travel Time	∅	∅	●	●	●	●	●
Volume	●	●	●	●	●	●	●
Travel Distance	○	○	○	○	○	●	●
Ridership	○	∅	○	○	○	∅	∅
Average Vehicle Occupancy (AVO)	○	∅	○	○	○	○	○
V/C Ratio	○	●	●	∅	∅	∅	∅
Density	○	○	●	●	●	●	●
VMT/PMT	∅	●	∅	∅	●	●	●
VHT/PHT	∅	●	∅	∅	●	●	●
Delay	∅	●	●	●	●	●	●
Queue Length	○	○	●	●	●	●	●
Number of Stops	∅	○	○	○	○	∅	●
Crashes	∅	○	○	○	○	∅	∅
Incident Duration	○	○	○	○	○	∅	∅
Travel Time Reliability	∅	○	○	○	○	○	○
Emissions	∅	○	○	○	○	∅	∅
Fuel Consumption	∅	○	○	○	∅	∅	∅
Noise	∅	○	○	○	○	○	○
Mode Split	○	●	●	∅	∅	∅	∅
Benefit/Cost	∅	○	○	○	○	○	○

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.

Notes and Assumptions:

- Practitioners should consider the reliability of the tools used before interpreting the results. The level of accuracy depends on several factors, including the accuracy and level of detail of the input data, analytical assumptions, the calibration of the tool to local conditions, and the accuracy of the analytical methodology.

- Relevance factors for the performance measures listed in table 7 are based on the assumption that these measures are generally direct outputs of the tool category.

- Table 7 does not take into consideration post-processing tools that can produce these measures.

2.2.7 Tool/Cost-Effectiveness

While the first six criteria help to evaluate the appropriateness of each tool category from a technical perspective, the seventh criteria (tool/cost-effectiveness) helps evaluate management and operational considerations for selecting the most appropriate tool category. Resource requirements, whether they are financial, personnel, or skill-related, can be a major consideration in selecting an analytical tool. In addition, using a more advanced and data-intensive tool may provide a greater understanding of the alternatives; however, accurate and detailed data are still needed to produce representative results. The level of effort and the operational characteristics criteria to be considered are summarized in table 8 and include the following:

- **Tool Capital Cost:** What is the average capital cost to acquire the traffic analysis tool? In this category, tools that cost, on average, less than $1,000 are considered to be inexpensive, while tools that cost from $1,000 to $5,000 are considered to be mid-range. Any tools that cost more than $5,000 are considered to be expensive. Inexpensive tools are indicated in table 8 by a *solid circle* (●), mid-range tools are indicated by a *null (or neutral) symbol* (∅), and expensive tools are indicated by an *empty circle* (○).

- **Level of Effort (Cost/Training):** Is the tool methodology type easy to learn? Does it require expensive and/or lengthy training sessions? Tools requiring little or no training are indicated by a ●, tools requiring a moderate amount of training are indicated by a ∅, and tools requiring expensive and lengthy training are indicated by an ○.

- **Easy to Use:** Is the tool generally user-friendly? (For example, Microsoft® Windows®-based tools have drag-and-drop features, etc.) Easy-to-use and intuitive tools are indicated by a ●. Tools requiring a significant amount of additional coding and/or data input and analysis are cumbersome and are indicated by an ○. Those in between are indicated by a ∅.

- **Popular/Well Trusted:** Is the tool popular and well regarded by current users? If yes, the tool category is indicated by a ●. Tools that are frequently used, but the accuracy of the results is highly constrained by data input and methodology constraints are indicated by a ∅. Tools that are generally not used in practice at this time are indicated by an ○.

- **Hardware Requirements:** How much computer power is necessary to adequately run the analysis? Tools that can be used on older computers and require minimal computing power are considered to have low hardware requirements (○), tools that require a large amount of computing power (memory and hard-drive space) are considered to have high hardware requirements (●), and tools that fall in between are considered to have medium hardware requirements (∅).

- **Data Requirements:** What is the typical amount of input data required to perform the analysis? The input data may include traffic volume, speed limit, traffic signal timing, intersection/roadway geometric characteristics, the number of general-purpose and HOV lanes, ramp metering locations and their timings, detector locations, O-D trip tables, etc. Low data requirements are indicated by a ●, moderate data requirements are indicated by a ∅, and data-intensive tools are indicated by an ○.

- **Computer Run Time:** Assuming that adequate computer hardware is available, how long does the tool take to perform the analysis? Run times of less than 5 minutes are considered minimal (●), run times averaging from 5 minutes to 1 hour are considered moderate (∅), and run times lasting more than 1 hour per run are considered long (○).

- **Post-Processing Requirements:** Does the tool generally produce output in formats that require no further post-processing or reformatting? Many tools cannot calculate travel time directly; instead, users must invest additional time to generate this output from speed and distance information. Tools requiring little or no post-processing or reformatting are indicated by a ●, those with moderate amounts are indicated by a ∅, and tools requiring a significant amount of post-processing and/or additional coding are indicated by an ○.

- **Documentation:** Does the tool have a detailed and well-written user's manual? Are there articles and reports on past projects evaluated using this type of tool? Excellent documentation is indicated by a ●, moderate documentation is indicated by a ∅, and little or no documentation is indicated by an ○.

- **User Support:** Is technical support generally available for this tool? Are there mailing lists, chat rooms, or newsgroups dedicated to this tool where users can communicate with each other? Tools with a high level of user support are indicated by a ●, moderate support is indicated by a ∅, and no support is indicated by an ○.

- **Key Parameters Can Be User-Defined:** Does the tool allow for customization of the key analytical parameters? Is the tool flexible enough to allow for customization (e.g., many microsimulation tools are flexible enough to allow users to add custom programming codes in addition to the standard package)? Available customization is indicated by a ●, limited customization capabilities are indicated by a ∅, and lack of customization is indicated by an ○.

- **Default Values Are Provided:** Does the tool generally provide default values for its parameters, rates, or impact values? In some cases, there is not enough time and resources to collect the appropriate values for all of the necessary parameters (e.g., average walking speed, average reaction time, etc.). Tools with defaults available for most parameters are indicated by a ●, tools with some defaults are indicated by a ∅, and tools with few or no defaults available are indicated by an ○.

- **Integration With Other Software:** Does the tool generally have export/import features to/from other software (e.g., integration with Microsoft® Excel, Geographic Information Systems (GIS) tools, other traffic analysis tools, etc.)? Simple export/import features are indicated by a ●, tools with some or limited capabilities are indicated by a ∅, and tools with no import/export capabilities are indicated by an ○.

- **Animation/Presentation:** Does the tool have animation/presentation features (e.g., animated, colorful, three-dimensional views, zoom-in/-out capabilities, detailed link views as opposed to "stick figures," ability to produce charts and tables, etc.)?

Table 8. Relevance of traffic analysis tool categories with respect to tool/cost effectiveness.

Tool/Cost Effectiveness	Analytical Tools/Methodologies						
	Sketch Planning	Travel Demand Models	Analytical/ Deterministic Tools (HCM-Based)	Traffic Optimi-zation	Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation
Tool Capital Cost	●	○	●	●	∅	○	○
Level of Effort	●	○	●	∅	∅	○	○
Easy to Use	●	○	●	∅	∅	○	○
Popular/Well Trusted	∅	∅	●	●	∅	○	∅
Hardware Requirements	●	∅	●	●	○	○	○
Data Requirements	●	○	●	●	○	○	○
Computer Run Time	●	∅	●	●	●	○	○
Post-Processing Requirements	∅	○	∅	∅	∅	●	●
Documentation	∅	∅	●	∅	∅	∅	∅
User Support	∅	●	○	○	∅	∅	∅
Key Parameters Can Be User-Defined	∅	●	∅	∅	●	●	●
Default Values Are Provided	●	○	●	●	●	●	●
Integration With Other Software (e.g., Excel, GIS)	○	∅	∅	∅	∅	∅	∅
Animation/ Presentation	○	∅	○	○	∅	●	●

Note: See section 2.2.7 above for descriptions of ●, ∅, and ○, for each subcriteria.

3.0 Methodology for Selecting a Traffic Analysis Tool

The purpose of this section is to provide guidance to users on how to use the criteria presented in section 2.0 to select the appropriate analytical tool category. Worksheets are provided in this section to help users work through the process of selecting the appropriate tool for addressing the project's goals and objectives. In addition, an automated tool has been developed to implement these steps. This tool can be found on the FHWA Traffic Analysis Tools Web site at:
http://ops.fhwa.dot.gov/Travel/Traffic_Analysis_Tools/traffic_analysis_tools.htm

3.1 Steps for Selecting the Appropriate Tool Category

This section details the recommended steps for selecting the appropriate tool category for the task. Depending on the project, more than one analytical tool may be capable of analyzing and producing the desired output. It should also be recognized that one specific tool might not be able to address all of the project's needs. Multiple tools may be desirable for conducting a particular study and those tools may or may not be from the same tool category.

Appendix B contains a worksheet that may be used to assist with the tool category selection process. Using the steps described below, fill out the cells of table 13:

1. **Define the context of the project and assign context relevance weights (column 2).** In most cases, the most appropriate tool category or tool depends on the type of project and the level of detail required by each project context. Therefore, the first step is to carefully think about the context of the project (whether it is planning, design, or operations/construction) and the goals, objectives, issues, and needs of the project. Next, enter the analytical context relevance weight in column 2, depending on the type of study. The values entered in column 2 should range from 0 (not relevant) to 5 (most relevant). For example, if the project is a long-range plan, the context relevance weight should be 5 for "Planning" and 0 for "Design" and "Operations/Construction." For definitions of the analytical contexts, refer to section 2.1.

1		2
Criteria		Context Relevance
0	**Analysis Context (0 = not relevant, 5 = most relevant)**	
	Planning	*5*
	Design	*0*
	Operations/Construction	*0*

Step 1 – Determine the project context (planning, design, or operations/construction). Define the project's goals and objectives, needs, and issues. Enter the context weights into Column 2. Values range from 0 (not relevant) to 5 (most relevant).

Figure 3. Selecting the appropriate tool category, step 1.

2. **Assign subcriteria relevance weights (column 2).** In this step, the user assigns relevance weights to subcriteria within each type of criterion. Subcriteria that are highly desirable as part of the project should be given higher weights. The relevance values that should be entered in column 2 range from 0 (not relevant) to 5 (most relevant). Enter the weights for each subcriterion as they relate to each other and the needs of the project.

   Here are some examples for assigning relevance weights:

   a. **Geographic Scope:** If the study area consists of a 8-km-long (5-mi-long) freeway segment with two parallel arterials on each side, plus all connecting streets, a weight of 5 should be given to “Corridor/Small Network” and weights of 0 should be given to all other subcriteria.

   b. **Facility Type:** If the facility types in the study area are primarily a freeway, its parallel arterials, and the connecting ramps and streets, but there are also auxiliary lanes and HOV lanes and the impact on those is not as important, a weight of 5 should be given to “Freeway,” “Arterial,” and “Ramps,” while a weight of 3 might be given to “HOV Lane” and “Auxiliary Lane.” Weights of 0 would be given to the other facility-type subcriteria.

   c. **Travel Mode:** The project involves ramp metering and data related to SOV, HOV, and truck modes are available. However, the project focus is on the SOV mode. A weight of 5 would be given to “SOV,” a 2 would be given to “HOV,” a 1 would be given to “Truck,” and weights of 0 would be given to the other modes.

   d. **Management Strategy/Application:** The project involves ramp metering only. A weight of 5 would be given to “Freeway Management” and the other subcriteria would be given weights of 0.

   e. **Traveler Response:** It is anticipated that there will be some route diversion as a result of ramp metering, so it should be given a high weight. There may be some mode shift or departure time choice; however, they are not nearly as relevant for the analysis. “Route Diversion” should be given a weight of 5, “Mode Shift” and “Departure Time Choice” should each be given a 2, and the other traveler responses should be given weights of 0.

   f. **Performance Measures:** The stakeholders for this project are interested in travel speed, volume, and the travel time changes anticipated from the ramp metering project. A benefit/cost comparison is also desired for determining whether the project is worthwhile to implement. The measures to be considered for the benefit/cost comparison include mobility (delay), travel time reliability, safety (crashes), emissions, and fuel consumption. Weights of 5 would be given to “Speed,” “Volume,” “Travel Time,” “Delay,” “Travel Time Reliability,” “Crashes,” “Emissions,” “Fuel Consumption,” and “Benefit/Cost.” Many of these measures are based on VMT and VHT/PHT. Therefore, if some of the desired measures are not available, “VMT/PHT” and “VHT/PHT” measures would each be given a weight of 4. Because this is a ramp metering project, it would also be desirable to know the queue length, but it is not required, so a weight of 2 would be given to "Queue Length." The other performance measure subcriteria would be given weights of 0.

g. **Tool/Cost-Effectiveness:** There is an adequate budget for addressing all aspects of the project, including the costs of acquiring the tool, staff training, hardware requirements, and analytical runs. The high priorities for the project in this area involve confidence in the results, the ability of the tool to be adjusted to local conditions, and that the results can be easily produced and presented to the stakeholders. In this case, weights of 5 would be given to "Popular/Well Trusted," "Post-Processing Requirements," "Key Parameters Can Be User-Defined," and "Animation/Presentation Features." Weights of 3 would be given to "Easy to Use," "Data Requirements," and "Default Values Are Provided." Weights of 2 would be given to "Low Tool Costs," "Level of Effort/Training," "Documentation," and "User Support." In addition, a weight of 1 would be given to "Hardware Requirements." "Integration With Other Software" is not a concern and would be given a weight of 0.

1		2
Criteria		**Sub-Criteria Relevance**
1	**Geographic Scope (0 = not relevant, 5 = most relevant)**	
	Isolated Location	*0*
	Segment	*5*
	Corridor/Small Network	*0*
	Region	*0*

Step 2 – Enter sub-criteria relevance for each criterion into Column 2. Values range between 0 (not relevant) and 5 (most relevant).

Figure 4. Selecting the appropriate tool category, step 2.

3. **Assign tool relevance values (column 3).** Most of these values are provided as part of the worksheet (appendix B) based on the assessment presented in tables 1 through 8. Only the geographic scope criterion requires user input of tool relevance values in column 3. Using the appropriate analytical context and the tool relevance factors presented in table 2, enter the tool relevance values for "Geographic Scope" in column 3:

   a. For every *solid circle* (●), assign a value of 10.

   b. For every *null symbol* (∅), assign a value of 5.

   c. For every *empty circle* (○), assign a value of 0.

   d. For every *not applicable* (N/A), assign a value of -99.

Step 3 – From table 2, enter relevance factors for Geographic Scope criteria into Column 3 using the appropriate analytical context. Use the following values: (●) = 10 points; (∅) = 5 points, (○) = 0 points, (N/A) = -99 points.

1			3						
			Tool Category Relevance*						
Criteria		Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
1 Geographic Scope (0 = not relevant, 5 = most relevant)									
	Isolated Location	0	0	0	10	5	0	0	0
	Segment	5	10	0	10	0	5	5	5
	Corridor/Small Network	0	5	10	0	0	5	5	5
	Region	0	5	10	-99	-99	-99	-99	-99

Figure 5. Selecting the appropriate tool category, step 3.

4. **Multiply columns 2 and 3 (column 4).** For the analytical context and each subcriterion, multiply the entries in column 2 by the entries in each subcolumn in column 3, and enter the products into the appropriate cells in column 4.

Step 4 – Multiply the value in Column 2 by each tool category value in Column 3, and enter the values into Column 4.

2		
Sub-Criteria Relevance	Sketch Plan	TDM
0	0	0
5	10	0
0	5	10
0	5	10

4						
Column 2 x Column 3						
Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0x0 = 0	0	0	0	0	0	0
5x10 = 50	0	50	0	25	25	25
0x5 = 0	0	0	0	0	0	0
0x5 = 0	0	0	0	0	0	0

Figure 6. Selecting the appropriate tool category, step 4.

5. **Sum the values of column 4.** For the analytical context and each criterion, add up the values for each tool category in column 4 and enter the result into the "Subtotal" row in column 4.

6. **Count the number of subcriteria relevance weights greater than 0.** For the analytical context and each criterion, count the number of relevance weights in column 2 that are greater than 0 and enter the value into the "Relevance Weights Above 0" cell.

7. **Calculate the criteria ratings.** Divide the values in the "Subtotal" rows by the number of "Relevance Weights Above 0" cell and enter the amount into the "Weighted Subtotal" row in order to normalize the scores. Repeat this process for each criterion.

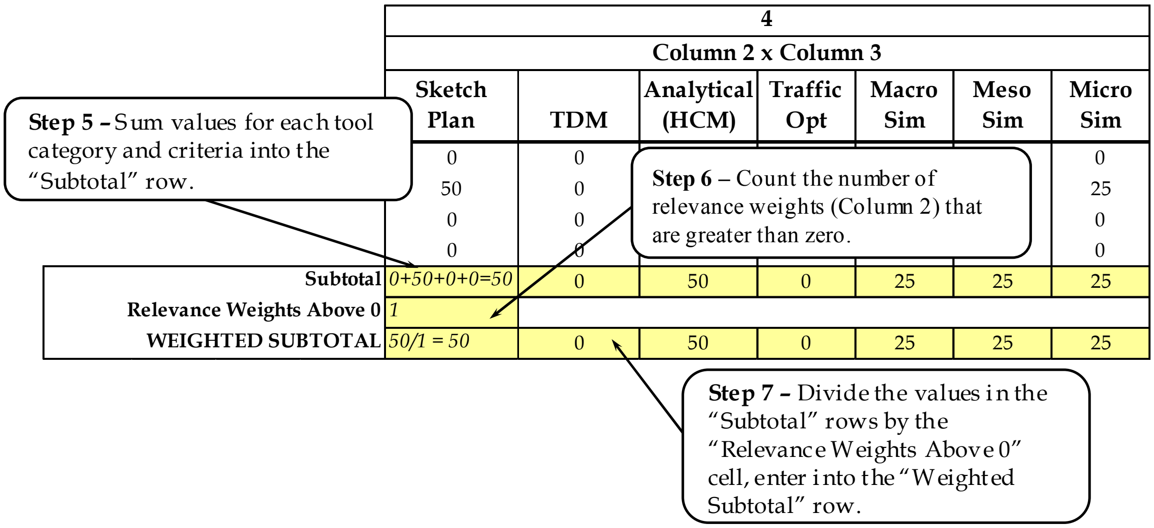


Figure 7. Selecting the appropriate tool category, steps 5–7.

8. **Group weighted subtotals (column 7).** Copy the weighted subtotals for the analytical context and seven criteria from their respective rows to column 7 at the bottom of the worksheet.

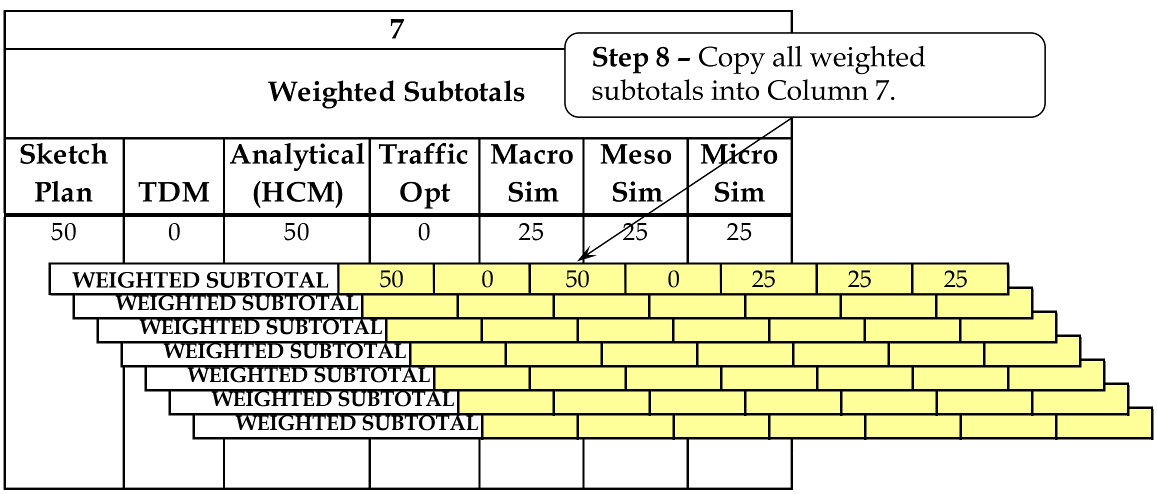


Figure 8. Selecting the appropriate tool category, step 8.

9. **Review and reassess weighted subtotals.** Review the values in column 7 for each criterion and tool category, with particular focus on the negative values. For each negative criteria value, identify the source of the negative value (column 4) and verify the subcriteria relevance in column 2. Make adjustments as necessary to the subcriteria relevance values based on the project's goals and objectives, priorities, needs, and issues.

10. **Assign criteria relevance weights (column 6).** The prior weighting scheme (column 2) was applied to the subcriteria within each major criteria category. This step involves weighting the major criteria categories against each other. This should be based on the project's goals and objectives, priorities, needs, and issues. For the analytical context and each of the seven criteria, assign the appropriate weights, ranging from 0 (not relevant) to 5 (most relevant). If a user wants to weight each of the criteria and analytical context equally, a weight of 5 can be applied to all. A different weighting scheme may be used if greater differentiations between criteria are necessary. The user should carefully consider the project's priorities, needs, and constraints when selecting the criteria weights.

6	7						
	Weighted Subtotals						
Criteria Rele-vance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5	50	50	25	0	25	25	0
3	50	0	50	0	25	25	25
3	15	33	20	16	23	21	33
3	16	25	13	13	13	21	21
4	19	[illegible]	[illegible]	[illegible]	[illegible]	27	30
1	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22
5	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23
5	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11

Step 9 – Review negative values in Column 7 and reassess relevance values for subcriteria.

Step 10 – Assign relevance weights for the analytical context and seven criteria, ranging from 0 (not relevant) to 5 (most relevant).

Figure 9. Selecting the appropriate tool category, steps 9 and 10.

11. **Multiply columns 6 and 7 (column 8).** For each context/criterion, multiply the value in column 6 by each of the subcolumns in column 7 and enter the result into the appropriate cells in column 8.

Step 11 – Multiply the value in Column 6 by Column 7 for each tool category, and enter the values in Column 8.

6	7	
Criteria Rele-vance	Sketch Plan	TDM
5	50	50
3	50	0
3	15	33
3	16	25
4	19	13
1	13	23
5	13	16
5	20	11

8						
Column 6 x Column 7						
Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
250	250	125	0	125	125	0
150	0	150	0	75	75	75
45	100	60	48	70	63	98
49	75	39	38	38	62	64
76	52	68	80	108	108	120
13	23	-124	0	22	22	22
65	82	78	82	91	110	114
100	57	111	93	93	50	57

Figure 10. Selecting the appropriate tool category, step 11.

12. **Determine the best tool categories.** Sum the products of the multiplication for each tool category in column 8 and enter the values in the "Weighted Totals" row at the bottom of the worksheet. The tool categories with the highest totals based on this mathematical process are the most appropriate tools for the task.

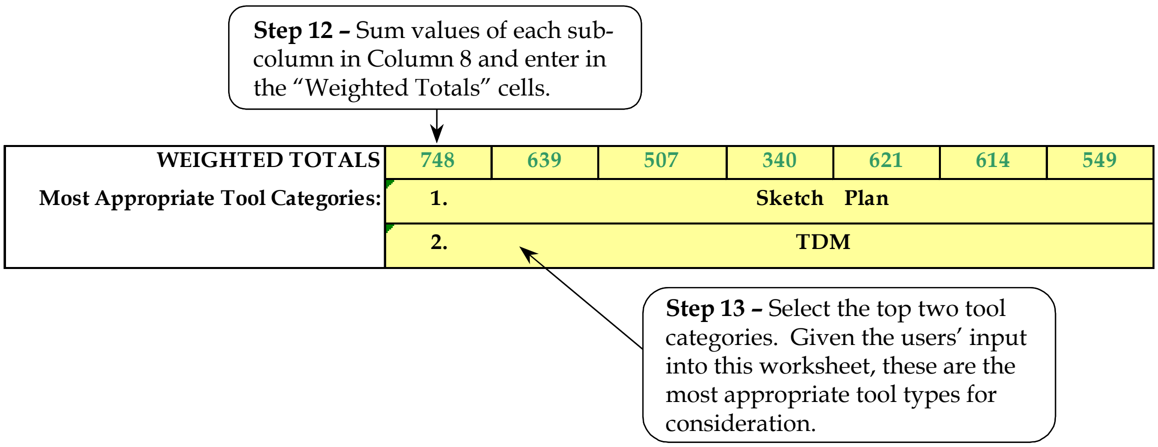


Figure 11. Selecting the appropriate tool category, steps 12 and 13.

13. **Select the top two tool categories for further consideration.** It is recommended that the user further explore the available tools for the top two most appropriate tool categories, particularly if the total scores are close in value. Tool categories with final scores of less than 0 should not be considered. It should be recognized that one specific tool may not be able to address all of the project's needs. Multiple tools may be necessary for conducting a particular study and those tools may or may not be from the same tool category. Each of the subcriteria with high relevance factors and low scores in column 4 will need to be assessed to determine if that particular category of tool weakness can be overcome through other means (e.g., there is a need for microsimulation; however, the computer resources are insufficient to accommodate the analytical needs).

3.2 Examples for Using the Tool Category Selection Worksheets

The following are three examples for using the tool category selection worksheets.

3.2.1 Example 1: Ramp Metering Corridor Study

A State department of transportation (DOT) needs to assess the future impact of ramp metering. Without the convenience of a field experiment, the DOT must estimate the volume, speed, and travel time impacts of ramp metering on a freeway corridor, the ramps, and the parallel arterials. The study corridor is approximately 24 km long (15 mi long), running north-south, with one parallel arterial on each side of the freeway less than 0.8 km (0.5 mi) away. The impact of passenger cars is the focus of the study for both the SOV and HOV travel modes. Ramp metering strategies to be considered include fixed-time and adaptive ramp metering, with the following parameter permutations: (1) with and without queue control, (2) with and without HOV bypass lanes, and (3) restrictive and less restrictive metering rates. Since ramp metering may cause diversion of traffic to the parallel arterials, the ability of the traffic analysis tool to adapt to dynamic traffic conditions is crucial to the project. In addition, the corridor is currently undergoing major infrastructure changes. HOV lanes are being constructed at the southern portion of the corridor and a few interchanges are being realigned.

The project manager has stressed that deployment of ramp meters at this corridor will not occur without the support of the local city partners. The State DOT and the local traffic jurisdictions have developed excellent working relationships over the years; however, the cities are reluctant to support the ramp metering project because they fear that the traffic queues at the on-ramps and route diversion would reduce the performance of their arterials. Therefore, an objective of the evaluation is to select the ramp metering strategy that can be accepted by all stakeholders. The ability of the tool to produce animated results is preferred, but is not crucial; however, the tool must be well accepted and widely used.

The project team consists of experienced analysts and engineers who are equipped with high-performance computers. The State has obtained the arterial/interchange signal timings from the local cities in preparation for this project. Old aerial photographs showing the corridor before construction work and design drawings from the construction sites are available.

Project Assessment

Based on the information provided, the following can be used to summarize the project:

- Project Context: Design

- Project Goal: Evaluation and selection of optimal ramp metering strategy

- Project Objectives and Background:

  – Analyze fixed-time and adaptive ramp metering under various operating parameters.
  – Corridor study area is 24 km (15 mi), with two parallel arterials.
  – Focus on roadways and passenger vehicles.
  – Aerial photographs, design drawings, and existing signal timings are available.
  – Volume, speed, and travel time are the main output.
  – Traveler response, particularly route diversion, is crucial.
  – Good presentation/animation capabilities are preferred.
  – Tool should be versatile yet sensitive enough to model small variations in parameters.
  – Tool should be popular/well-trusted by the industry.

Tool Category Selection Worksheet for Example 1

Table 9, which can be found at the end of this section, shows a completed worksheet for this example. Based on the analysis performed using the worksheet, this project can be best evaluated using three different tool categories (there are only two negative final scores, while three of seven scores are close). The most appropriate tool category is the microscopic simulation tools, followed by macroscopic and mesoscopic simulation tools.

3.2.2 Example 2: ITS Long-Range Plan

A metropolitan planning organization (MPO) plans to assess the future costs and benefits of ITS investments in its jurisdiction. The study area is the entire metropolitan area, which is about 1300 km^2 (500 mi^2); however, the MPO is only concerned about travel on freeways, highways, and major arterials.

A skeleton network with nodes, links, and trip table data is available from the local travel demand model. Aerial photographs are available. However, they are a few years old, but the major transportation infrastructure has not changed and no changes are expected in the future. Alternative modes of transportation (e.g., transit, motorcycles, trucks, and light rail) are important; however, the focus of the study is the impact on passenger cars. The ITS strategies to be considered include ramp metering, incident management, arterial management, and advanced traveler information systems (ATIS). The MPO has developed O-D trip tables for both existing and future scenarios. At least five different alternatives will need to be analyzed. As for the output, the MPO Board is mostly concerned with the benefit/cost ratios related to each of the ITS alternatives. If necessary, a second tool may be used to convert the output into monetary terms.

The project manager is an experienced modeler who has worked with demand forecasting tools in the past, but most of her team members are relatively new to the field. However, the team members are computer-savvy and seem to absorb new ideas extremely well, given the availability of learning resources. This project has a healthy budget; however, time is of the essence, since the board needs to submit a report to the finance department by the end of the fiscal year, which is only 6 months away.

Project Assessment

Based on the information provided, the following can be used to summarize the project:

- Project Context: Planning
- Project Goal: Benefit/cost evaluation of ITS investments
- Project Objectives and Background:
  - Analyze the impacts related to the deployment of ITS strategies: ramp metering, incident management, arterial management, and ATIS.

- Large study area is 1300 km^2 (500 mi^2).
- Focus on roadways and passenger vehicles.
- O-D matrices and skeleton network are available.
- Benefit/cost ratios are the main output.
- Tool should be easy to use and have good documentation.
- Deadline is in 6 months.

Tool Category Selection Worksheet for Example 2

The completed worksheet for this example is shown in table 10, located at the end of this section. Criteria and subcriteria weights that address the project's goals and objectives were given higher values. Based on the analysis performed for this example, the most appropriate tool category is the travel demand model. The sketch-planning tool category should also be considered since the scores are reasonably close. The user should further explore the specific tools that fall within these two categories to determine which tool(s) best serves the needs of the project. Other tool categories in this example have scores of less than 0 and should not be considered for analysis.

3.2.3 Example 3: Arterial Signal Coordination and Preemption

A city traffic department is conducting a major traffic signal timing improvement on one of its most critical arterials, which is about 16 km long (10 mi long). This study is being conducted in conjunction with a large redevelopment project that hopes to revive the economy in this section of town. Multiple interest groups, neighborhood groups, and city jurisdictions are involved with the project.

The arterial is vital to the city and currently serves all travel modes; however, the city is most interested in improving travel on the arterial for passenger vehicles, buses, and light rail, primarily through the use of signal coordination. No major alignment changes are being considered; however, traffic signal preemption for buses and light rail is a major component that will be introduced for the first time in this city. Many citizens are not familiar with the technology and are quite skeptical about its effectiveness. In fact, many perceive that preemption would result in worse traffic conditions. Therefore, an evaluation process and an outreach program highlighting the benefits of the project to the community are needed. The results of the analysis must be presented to the public and the stakeholders in the most effective manner.

The best and most experienced staff members have been assigned to this project. They are experts in a few modeling and simulation tools, but are looking for the best tool available with a short and flat learning curve. Otherwise, they are more inclined to use the tools that they are already familiar with. The computers available for the project are older Intel® Pentium® II machines. The city maintains good records for traffic volumes and roadway geometrics for the entire arterial and parallel roadways, and is interested in evaluating as many performance measures as can be provided by the tool. However, the following three performance measures are crucial: LOS, speed, and intersection delays, both at the aggregate level and for each travel mode. Traveler response needs to be considered since route shifting between the arterial and parallel facilities is of interest to the stakeholders.

Project Assessment

Based on the information provided, the following can be used to summarize the project:

- Project Context: Operations

- Project Goal: Signal optimization and successful introduction of signal preemption

- Project Objectives and Background:

  - Traffic signal optimization
  - Long arterial study area with parallel roadways 16 km (10 mi))
  - Emphasis on cars, buses, and light rail
  - Volumes, geometric data available
  - Traveler response, particularly route diversion, is necessary
  - Good presentation/animation capabilities
  - Avoidance of high-end, computer-intensive analytical tools
  - Dependable, trusted tool with flat learning curve
  - Output in terms of LOS, speed, travel time, and intersection delay by mode

Tool Category Selection Worksheet for Example 3

Table 11, at the end of this section, shows a completed worksheet for example 3. Based on the analysis performed using the worksheet, it seems that this project can be adequately evaluated using four different tool categories, including microscopic simulation tools, followed by macroscopic and mesoscopic simulation tools and traffic optimization tools. However, the city will probably need to improve their computing capabilities in order to conduct the analysis using simulation.

3.3 Guidance for Selecting the Specific Tool

Once the most appropriate tool category has been identified, the user should narrow down the candidate tools within the category. While the features of the specific traffic analysis tools are beyond the scope of this document, the worksheet presented in appendix C may assist users in comparing different tools during their research effort or vendor interviews. This approach is intended to help users identify what is important to consider in their selection of the specific tool(s). Instructions on how to use the worksheet are provided below:

1. **Enter the name of the tool being reviewed.** If reviewing different versions/releases of the same tool, do not forget to include the version number or release date.

Step 1 – Enter name, version, and contact information for tool being reviewed.

Tool Name: *Acme Traffic* Version/Release: *2.0*
Vendor Name/Contact Information: *AcmeSoft, Inc. / Mr. John Smith*

Figure 12. Selecting the specific tool, step 1.

2. **Assign subcriteria relevance weights (column 2).** The subcriteria listed in this worksheet are expanded versions of the ones listed in appendix B. An "other" field has been added to each criterion for users to consider other subcriteria that may not be included in this list. Subcriteria that should be highly considered in the analysis should be given higher weights. The values should range from 0 (not relevant) to 5 (most relevant). The relevance factors entered in the subcriteria relevance cells should be the relevance within that particular criteria (e.g., is the SOV travel mode more important than the HOV mode?). The subcriteria relevance weights in column 2 should be identical for every tool considered.

1	2
Criteria	**Subcriteria Relevance**
1 Geographic Scope (0 = not important, 5 = most important)	
Isolated Location	*0*
Segment	*1*
Corridor	*3*
Region	*5*
Other: ____________	

Step 2 – Enter subcriteria relevance weights in Column 2. Values range between 0 (not relevant) and 5 (most relevant).

Figure 13. Selecting the specific tool, step 2.

3. **Assign tool relevance values (column 3).** The relevance factors presented in tables 1 through 8 are generalized views of available tools for each tool category. Therefore, users must perform additional research to find the most appropriate tool within the tool category. Based on literature reviews, product specifications, or vendor interviews, the user should rate the relevance of the tools under review against the criteria presented in this worksheet. Appendix D identifies some readily available literature that contains detailed reviews of some of the more commonly used traffic analysis tools. The values entered in column 3 should range from 0 (not featured by the tool) to 5 (strongly featured by the tool). If necessary, use column 5 for additional notes and/or comments.

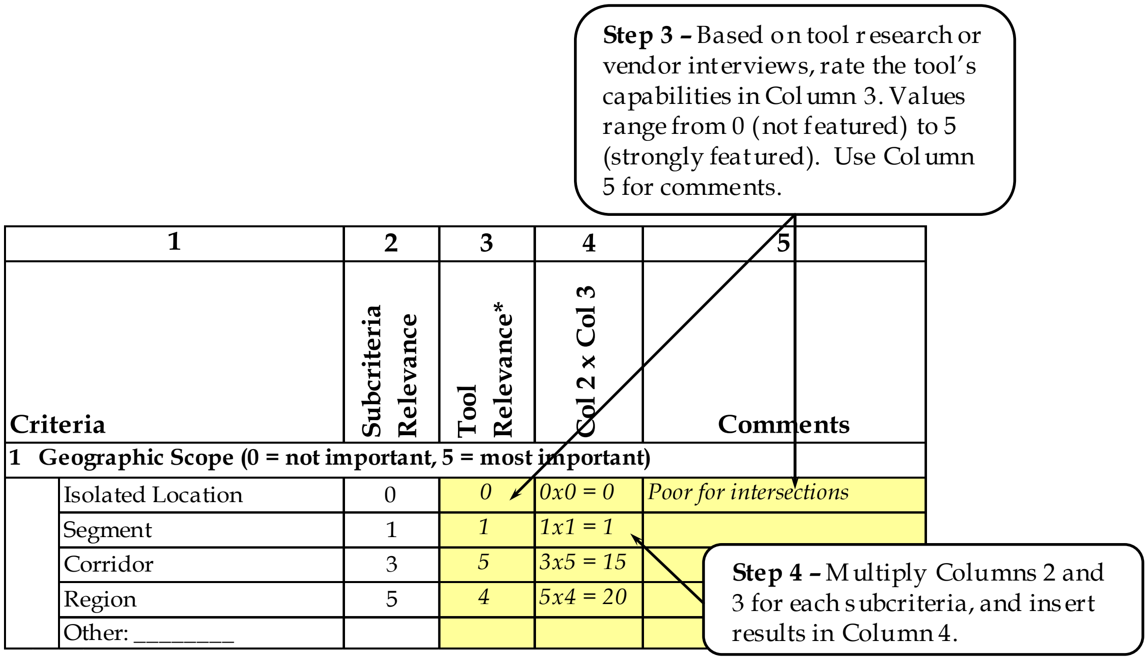


Figure 14. Selecting the specific tool, steps 3 and 4.

4. **Multiply columns 2 and 3 (column 4).** For each subcriterion, multiply the values in columns 2 and 3 and enter into column 4.

5. **Sum the values of column 4.** Add up the values in column 4 for each criteria category, and enter the total into the "Subtotal" row for each criterion.

6. **Count the number of subcriteria relevance weights above 0.** For each criterion, count the number of subcriteria relevance weights in column 2 that are larger than 0, and enter the number into the "Relevance Weights Above 0" cell.

7. **Calculate the adjusted ratings.** Divide the value in the "Subtotal" row with the "Relevance Weights Above 0" value and enter into the "Weighted Subtotal" row. Repeat this process for each criterion.

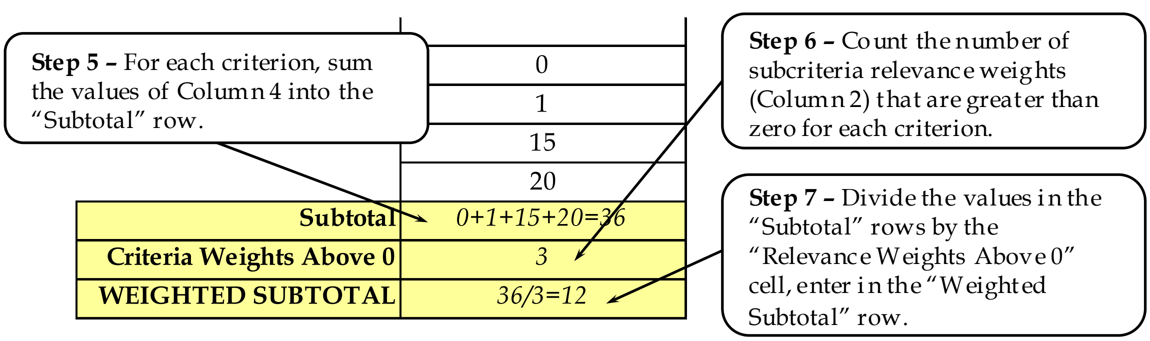


Figure 15. Selecting the specific tool, steps 5–7.

8. **Group weighted subtotals (column 8).** For each criterion, copy the weighted subtotals from the respective rows to column 8 at the bottom of the worksheet.

9. **Assign criteria relevance weights (column 7).** In steps 1 through 8, the weighting scheme was applied to the subcriteria within each major criteria category. This step involves weighting the major criteria categories against each other. This should be based on the project's goals and objectives, priorities, needs, and constraints. For each of the seven criteria, assign the appropriate weights, ranging from 0 (not relevant) to 5 (most relevant). The criteria relevance weights in column 7 should be identical for every tool considered.

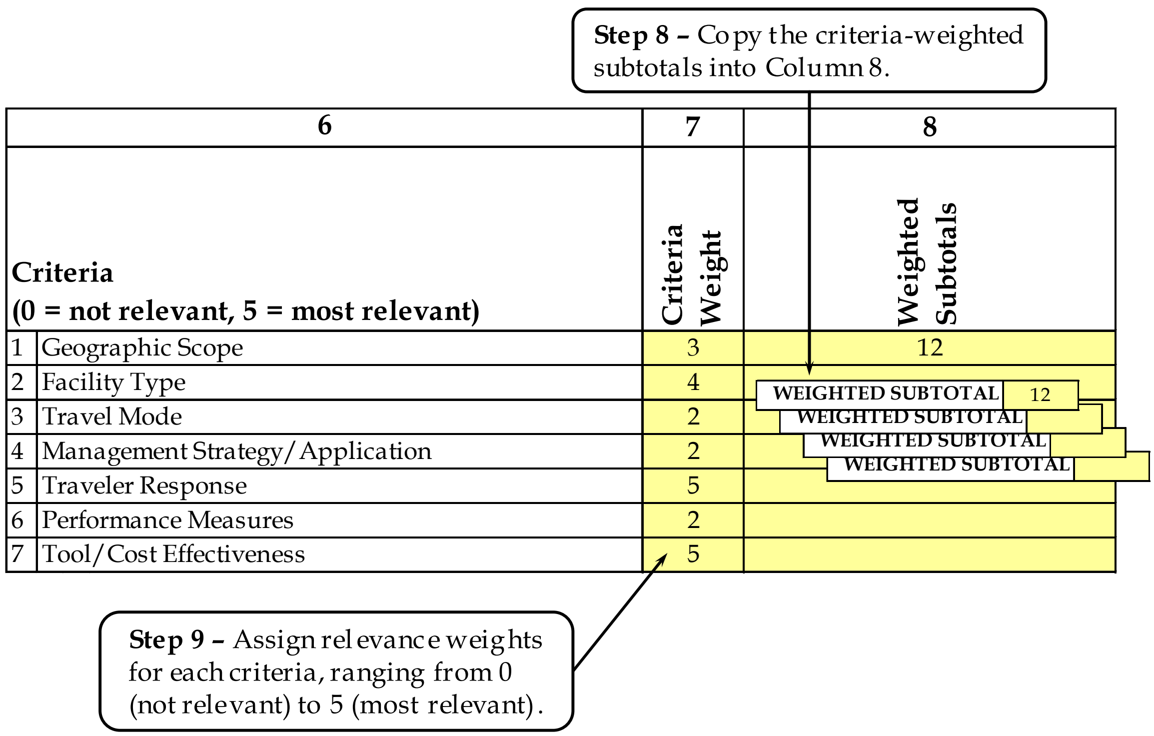


Figure 16. Selecting the specific tool, steps 8 and 9.

10. **Multiply columns 7 and 8 (column 9).** Multiply columns 7 and 8 for each criterion and enter the products into the appropriate cells in column 9.

11. **Determine the tool's total score.** Sum column 9 and enter the product in the "Total Score" cell.

12. **Repeat this process for all tools considered.** Use one worksheet for each tool under consideration. Keep in mind that the users' criteria and subcriteria relevance weights should remain constant for all tools. Users are encouraged to review as many tools as possible from each tool category selected (section 3.1). Please refer to appendix E for a list of available tools for each category and their Web site links to obtain further information.

13. **Select the best tool.** Compare the total scores of all tools under review. The one with the highest score is the probably the best tool for the project under consideration.

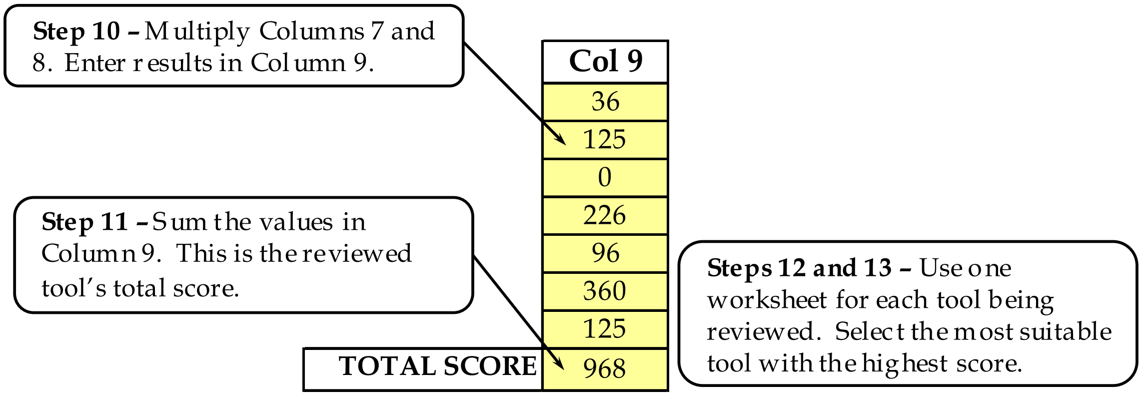


Figure 17. Selecting the specific tool, steps 10–13.

Again, the user should review the subcriteria with high weights, but low scores, to assess whether they can be addressed through other means. If the best tool selected by this process does not satisfy the users' needs (e.g., the project's goal is ramp metering analysis; however, the best tool's ramp metering feature is only a "3"), additional tools should be researched. If necessary, review the project's goals and objectives, needs, and constraints and repeat the entire process if no tool within a particular category addresses the project's needs. In most cases, the tool selection process would be iterative. Hopefully, careful consideration of the project's goals and objectives in this process will lead the user to the most appropriate tool for the project.

Table 9. Example 1 worksheet (refer to sections 2.1 and 2.2 for criteria definitions).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Context Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0 Analysis Context (0 = not relevant, 5 = most relevant)															
Planning	0	10	10	5	0	5	5	0	0	0	0	0	0	0	0
Design	5	-99	5	10	10	10	10	10	-495	25	50	50	50	50	50
Operations/Construction	0	5	0	10	10	10	10	10	0	0	0	0	0	0	0
								Subtotal	-495	25	50	50	50	50	50
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	-495	25	50	50	50	50	50
1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
1 Geographic Scope (0 = not relevant, 5 = most relevant)															
Isolated Location	0	-99	-99	10	10	10	5	10	0	0	0	0	0	0	0
Segment	0	-99	0	10	5	10	10	10	0	0	0	0	0	0	0
Corridor/Small Network	5	-99	5	0	0	10	10	10	-495	25	0	0	50	50	50
Region	0	-99	5	-99	-99	0	0	5	0	0	0	0	0	0	0
								Subtotal	-495	25	0	0	50	50	50
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	-495	25	0	0	50	50	50
2 Facility Type (0 = not relevant, 5 = most relevant)															
Isolated Intersection	0	0	5	10	10	10	10	10	0	0	0	0	0	0	0
Roundabout	0	0	0	10	0	5	0	5	0	0	0	0	0	0	0
Arterial	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
Highway	4	10	10	10	5	10	10	10	40	40	40	20	40	40	40
Freeway	5	5	10	10	5	10	10	10	25	50	50	25	50	50	50
HOV Lane	4	5	10	5	0	10	10	10	20	40	20	0	40	40	40
HOV Bypass Lane	4	0	10	0	5	5	5	10	0	40	0	20	20	20	40
Ramp	5	5	10	10	10	10	10	10	25	50	50	50	50	50	50
Auxiliary Lane	3	0	0	5	5	10	10	10	0	0	15	15	30	30	30
Reversible Lane	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0
Truck Lane	0	0	10	5	5	5	5	10	0	0	0	0	0	0	0
Bus Lane	0	0	10	0	0	5	5	10	0	0	0	0	0	0	0
Toll Plaza	0	0	5	5	0	0	0	10	0	0	0	0	0	0	0
Light Rail Line	0	0	10	0	0	0	0	10	0	0	0	0	0	0	0
								Subtotal	160	270	225	180	280	280	300
								Relevance Weights Above 0	7						
								WEIGHTED SUBTOTAL	23	39	32	26	40	40	43

Table 9. Example 1 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
	Sub-	Tool Category Relevance							Column 2 x Column 3						
Criteria	Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
3 Travel Mode (0 = not relevant, 5 = most relevant)															
SOV	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
HOV	4	5	10	5	5	5	10	10	20	40	20	20	20	40	40
Bus	3	5	10	5	5	5	10	10	15	30	15	15	15	30	30
Rail	0	5	10	0	0	0	5	5	0	0	0	0	0	0	0
Truck	0	5	5	5	5	5	5	5	0	0	0	0	0	0	0
Motorcycle	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Bicycle	0	5	5	5	0	0	0	5	0	0	0	0	0	0	0
Pedestrian	0	5	0	5	5	5	5	5	0	0	0	0	0	0	0
								Subtotal	85	120	85	85	85	120	120
								Relevance Weights Above 0	3						
								WEIGHTED SUBTOTAL	28	40	28	28	28	40	40
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)															
Freeway Management	5	10	5	5	10	10	10	10	50	25	25	50	50	50	50
Arterial Intersections	4	0	0	10	10	10	10	10	0	0	40	40	40	40	40
Arterial Management	3	5	5	5	10	10	10	10	15	15	15	30	30	30	30
Incident Management	0	5	0	5	0	10	10	10	0	0	0	0	0	0	0
Emergency Management	0	5	0	5	0	5	5	5	0	0	0	0	0	0	0
Work Zone	0	5	0	10	0	10	10	10	0	0	0	0	0	0	0
Special Event	0	5	0	10	0	5	5	5	0	0	0	0	0	0	0
Advanced Public Transportation System	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0
Advanced Traveler Information System	0	5	0	0	0	5	5	5	0	0	0	0	0	0	0
Electronic Payment System	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0
Rail Grade Crossing Monitor	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0
Commercial Vehicle Operations	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0
Advanced Vehicle Control & Safety System	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0
Weather Management	0	0	0	0	0	5	5	5	0	0	0	0	0	0	0
Travel Demand Management	0	10	10	5	0	5	5	5	0	0	0	0	0	0	0
								Subtotal	65	40	80	120	120	120	120
								Relevance Weights Above 0	3						
								WEIGHTED SUBTOTAL	22	13	27	40	40	40	40

Table 9. Example 1 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
	Sub-	Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion	4	5	10	-99	0	10	10	10	20	40	-396	0	40	40	40
En-Route Route Diversion	5	5	10	-99	0	10	10	10	25	50	-495	0	50	50	50
Mode Shift	3	5	10	-99	0	5	5	5	15	30	-297	0	15	15	15
Departure Time Choice	0	5	0	-99	0	5	5	5	0	0	0	0	0	0	0
Destination Change	0	-99	5	-99	-99	-99	0	0	0	0	0	0	0	0	0
Induced/Foregone Demand	0	5	5	-99	-99	-99	-99	5	0	0	0	0	0	0	0
								Subtotal	60	120	-1188	0	105	105	105
								Relevance Weights Above 0	3						
								WEIGHTED SUBTOTAL	20	40	-396	0	35	35	35
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS	0	0	5	10	10	5	5	5	0	0	0	0	0	0	0
Speed	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
Travel Time	5	5	5	10	10	10	10	10	25	25	50	50	50	50	50
Volume	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
Travel Distance	0	0	0	0	0	0	10	10	0	0	0	0	0	0	0
Ridership	0	0	5	0	0	0	5	5	0	0	0	0	0	0	0
Average Vehicle Occupancy (AVO)	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
V/C Ratio	0	0	10	10	5	5	5	5	0	0	0	0	0	0	0
Density	0	0	0	10	10	10	10	10	0	0	0	0	0	0	0
VMT/PMT	4	5	10	5	5	10	10	10	20	40	20	20	40	40	40
VHT/PHT	4	5	10	5	5	10	10	10	20	40	20	20	40	40	40
Delay	4	5	10	10	10	10	10	10	20	40	40	40	40	40	40
Queue Length	3	0	0	10	10	10	10	10	0	0	30	30	30	30	30
Number of Stops	0	5	0	0	0	0	5	10	0	0	0	0	0	0	0
Crashes / Accidents	0	5	0	0	0	0	5	5	0	0	0	0	0	0	0
Incident Duration	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0
Travel Time Reliability	3	5	0	0	0	0	0	0	15	0	0	0	0	0	0
Emissions	0	5	0	0	0	0	5	5	0	0	0	0	0	0	0
Fuel Consumption	0	5	0	0	0	5	5	5	0	0	0	0	0	0	0
Noise	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode Split	0	0	10	0	5	5	5	5	0	0	0	0	0	0	0
Benefit/Cost	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
								Subtotal	200	245	260	260	300	300	300
								Relevance Weights Above 0	8						
								WEIGHTED SUBTOTAL	25	31	33	33	38	38	38

Table 9. Example 1 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
7 **Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant)**															
Tool capital cost	3	10	0	10	10	5	0	0	30	0	30	30	15	0	0
Level of effort/training	1	10	0	10	5	5	0	0	10	0	10	5	5	0	0
Easy to use	3	10	0	10	5	5	0	0	30	0	30	15	15	0	0
Popular/well-trusted	5	5	5	10	10	5	0	5	25	25	50	50	25	0	25
Hardware requirements	0	10	5	10	10	10	0	0	0	0	0	0	0	0	0
Data requirements	3	10	0	10	10	0	0	0	30	0	30	30	0	0	0
Computer run time	2	10	5	10	10	10	0	0	20	10	20	20	20	0	0
Post-processing requirements	2	5	0	5	5	5	10	10	10	0	10	10	10	20	20
Documentation	3	5	5	10	5	5	5	5	15	15	30	15	15	15	15
User support	3	5	10	0	0	5	5	5	15	30	0	0	15	15	15
Key parameters can be user-defined	5	5	10	5	5	10	10	10	25	50	25	25	50	50	50
Default values are provided	3	10	0	10	10	10	10	10	30	0	30	30	30	30	30
Integration with other software	3	0	5	5	5	5	5	5	0	15	15	15	15	15	15
Animation/presentation features	4	0	5	0	0	5	10	10	0	20	0	0	20	40	40
								Subtotal	240	165	280	245	235	185	210
								Relevance Weights Above 0	13						
								WEIGHTED SUBTOTAL	18	13	22	19	18	14	16

5	6	7							8						
		Weighted Subtotals							Column 6 x Column 7						
Context/Criteria (0 = not relevant, 5 = most relevant)	Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0 Analysis Context	3	-495	25	50	50	50	50	50	-1485	75	150	150	150	150	150
1 Geographic Scope	4	-495	25	0	0	50	50	50	-1980	100	0	0	200	200	200
2 Facility Type	2	23	39	32	26	40	40	43	46	77	64	51	80	80	86
3 Travel Mode	2	28	40	28	28	28	40	40	57	80	57	57	57	80	80
4 Management Strategy/Applications	5	22	13	27	40	40	40	40	108	67	133	200	200	200	200
5 Traveler Response	2	20	40	-396	0	35	35	35	40	80	-792	0	70	70	70
6 Performance Measures	5	25	31	33	33	38	38	38	125	153	163	163	188	188	188
7 Tool/Cost Effectiveness	4	18	13	22	19	18	14	16	74	51	86	75	72	57	65
								WEIGHTED TOTALS	-3015	683	-139	696	1016	1024	1038
								Most Appropriate Tool Categories:	**1.**			**Micro Sim**			
									2.			**Meso Sim**			

* Use the following values for Tool Category Relevance: (+) = 10 points, (0) = 5 points, (-) = 0 points, (na) = -99 points

Table 10. Example 2 worksheet (refer to sections 2.1 and 2.2 for criteria definitions).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Context Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0 Analysis Context (0 = not relevant, 5 = most relevant)															
Planning	5	10	10	5	0	5	5	0	50	50	25	0	25	25	0
Design	0	-99	5	10	10	10	10	10	0	0	0	0	0	0	0
Operations/Construction	0	5	0	10	10	10	10	10	0	0	0	0	0	0	0
								Subtotal	50	50	25	0	25	25	0
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	50	50	25	0	25	25	0
1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
1 Geographic Scope (0 = not relevant, 5 = most relevant)															
Isolated Location	0	0	0	10	5	0	0	0	0	0	0	0	0	0	0
Segment	0	10	0	10	0	5	5	5	0	0	0	0	0	0	0
Corridor/Small Network	0	5	10	0	0	5	5	5	0	0	0	0	0	0	0
Region	5	5	10	-99	-99	-99	-99	-99	25	50	-495	-495	-495	-495	-495
								Subtotal	25	50	-495	-495	-495	-495	-495
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	25	50	-495	-495	-495	-495	-495
2 Facility Type (0 = not relevant, 5 = most relevant)															
Isolated Intersection	0	0	5	10	10	10	10	10	0	0	0	0	0	0	0
Roundabout	0	0	0	10	0	5	0	5	0	0	0	0	0	0	0
Arterial	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
Highway	5	10	10	10	5	10	10	10	50	50	50	25	50	50	50
Freeway	5	5	10	10	5	10	10	10	25	50	50	25	50	50	50
HOV Lane	3	5	10	5	0	10	10	10	15	30	15	0	30	30	30
HOV Bypass Lane	3	0	10	0	5	5	5	10	0	30	0	15	15	15	30
Ramp	5	5	10	10	10	10	10	10	25	50	50	50	50	50	50
Auxiliary Lane	4	0	0	5	5	10	10	10	0	0	20	20	40	40	40
Reversible Lane	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0
Truck Lane	1	0	10	5	5	5	5	10	0	10	5	5	5	5	10
Bus Lane	1	0	10	0	0	5	5	10	0	10	0	0	5	5	10
Toll Plaza	1	0	5	5	0	0	0	10	0	5	5	0	0	0	10
Light Rail Line	1	0	10	0	0	0	0	10	0	10	0	0	0	0	10
								Subtotal	165	295	245	190	295	295	340
								Relevance Weights Above 0	11						
								WEIGHTED SUBTOTAL	15	27	22	17	27	27	31

Table 10. Example 2 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
	Sub-Criteria	Tool Category Relevance							Column 2 x Column 3						
Criteria	Relevance	Sketch	TDM	Analytical	Traffic	Macro	Meso	Micro	Sketch	TDM	Analytical	Traffic	Macro	Meso	Micro
3 Travel Mode (0 = not relevant, 5 = most relevant)															
SOV	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
HOV	3	5	10	5	5	5	10	10	15	30	15	15	15	30	30
Bus	2	5	10	5	5	5	10	10	10	20	10	10	10	20	20
Rail	2	5	10	0	0	0	5	5	10	20	0	0	0	10	10
Truck	2	5	5	5	5	5	5	5	10	10	10	10	10	10	10
Motorcycle	2	0	5	0	0	0	0	0	0	10	0	0	0	0	0
Bicycle	0	5	5	5	0	0	0	5	0	0	0	0	0	0	0
Pedestrian	0	5	0	5	5	5	5	5	0	0	0	0	0	0	0
								Subtotal	95	140	85	85	85	120	120
								Relevance Weights Above 0	6						
								WEIGHTED SUBTOTAL	16	23	14	14	14	20	20
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)															
Freeway Management	5	10	5	5	10	10	10	10	50	25	25	50	50	50	50
Arterial Intersections	1	0	0	10	10	10	10	10	0	0	10	10	10	10	10
Arterial Management	5	5	5	5	10	10	10	10	25	25	25	50	50	50	50
Incident Management	5	5	0	5	0	10	10	10	25	0	25	0	50	50	50
Emergency Management	1	5	0	5	0	5	5	5	5	0	5	0	5	5	5
Work Zone	0	5	0	10	0	10	10	10	0	0	0	0	0	0	0
Special Event	0	5	0	10	0	5	5	5	0	0	0	0	0	0	0
Advanced Public Transportation System	1	5	0	0	0	0	0	5	5	0	0	0	0	0	5
Advanced Traveler Information System	5	5	0	0	0	5	5	5	25	0	0	0	25	25	25
Electronic Payment System	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0
Rail Grade Crossing Monitor	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0
Commercial Vehicle Operations	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0
Advanced Vehicle Control & Safety System	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0
Weather Management	0	0	0	0	0	5	5	5	0	0	0	0	0	0	0
Travel Demand Management	0	10	10	5	0	5	5	5	0	0	0	0	0	0	0
								Subtotal	135	50	90	110	190	190	195
								Relevance Weights Above 0	7						
								WEIGHTED SUBTOTAL	19	7	13	16	27	27	28

Table 10. Example 2 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion	5	5	10	-99	0	10	10	10	25	50	-495	0	50	50	50
En-Route Route Diversion	4	5	10	-99	0	10	10	10	20	40	-396	0	40	40	40
Mode Shift	3	5	10	-99	0	5	5	5	15	30	-297	0	15	15	15
Departure Time Choice	1	5	0	-99	0	5	5	5	5	0	-99	0	5	5	5
Destination Change	0	-99	5	-99	-99	-99	0	0	0	0	0	0	0	0	0
Induced/Foregone Demand	0	5	5	-99	-99	-99	-99	5	0	0	0	0	0	0	0
								Subtotal	65	120	-1287	0	110	110	110
								Relevance Weights Above 0	4						
								WEIGHTED SUBTOTAL	16	30	-322	0	28	28	28
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS	1	0	5	10	10	5	5	5	0	5	10	10	5	5	5
Speed	4	10	10	10	10	10	10	10	40	40	40	40	40	40	40
Travel Time	4	5	5	10	10	10	10	10	20	20	40	40	40	40	40
Volume	4	10	10	10	10	10	10	10	40	40	40	40	40	40	40
Travel Distance	4	0	0	0	0	0	10	10	0	0	0	0	0	40	40
Ridership	1	0	5	0	0	0	5	5	0	5	0	0	0	5	5
Average Vehicle Occupancy (AVO)	1	0	5	0	0	0	0	0	0	5	0	0	0	0	0
V/C Ratio	2	0	10	10	5	5	5	5	0	20	20	10	10	10	10
Density	0	0	0	10	10	10	10	10	0	0	0	0	0	0	0
VMT/PMT	4	5	10	5	5	10	10	10	20	40	20	20	40	40	40
VHT/PHT	4	5	10	5	5	10	10	10	20	40	20	20	40	40	40
Delay	4	5	10	10	10	10	10	10	20	40	40	40	40	40	40
Queue Length	2	0	0	10	10	10	10	10	0	0	20	20	20	20	20
Number of Stops	0	5	0	0	0	0	5	10	0	0	0	0	0	0	0
Crashes / Accidents	4	5	0	0	0	0	5	5	20	0	0	0	0	20	20
Incident Duration	1	0	0	0	0	0	5	5	0	0	0	0	0	5	5
Travel Time Reliability	4	5	0	0	0	0	0	0	20	0	0	0	0	0	0
Emissions	3	5	0	0	0	0	5	5	15	0	0	0	0	15	15
Fuel Consumption	3	5	0	0	0	5	5	5	15	0	0	0	15	15	15
Noise	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode Split	1	0	10	0	5	5	5	5	0	10	0	5	5	5	5
Benefit/Cost	5	5	0	0	0	0	0	0	25	0	0	0	0	0	0
								Subtotal	255	265	250	245	295	380	380
								Relevance Weights Above 0	19						
								WEIGHTED SUBTOTAL	13	14	13	13	16	20	20

Table 10. Example 2 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
7 **Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant)**															
Tool capital cost	2	10	0	10	10	5	0	0	20	0	20	20	10	0	0
Level of effort/training	4	10	0	10	5	5	0	0	40	0	40	20	20	0	0
Easy to use	4	10	0	10	5	5	0	0	40	0	40	20	20	0	0
Popular/well-trusted	4	5	5	10	10	5	0	5	20	20	40	40	20	0	20
Hardware requirements	0	10	5	10	10	10	0	0	0	0	0	0	0	0	0
Data requirements	4	10	0	10	10	0	0	0	40	0	40	40	0	0	0
Computer run time	4	10	5	10	10	10	0	0	40	20	40	40	40	0	0
Post-processing requirements	3	5	0	5	5	5	10	10	15	0	15	15	15	30	30
Documentation	4	5	5	10	5	5	5	5	20	20	40	20	20	20	20
User support	4	5	10	0	0	5	5	5	20	40	0	0	20	20	20
Key parameters can be user-defined	2	5	10	5	5	10	10	10	10	20	10	10	20	20	20
Default values are provided	4	10	0	10	10	10	10	10	40	0	40	40	40	40	40
Integration with other software	3	0	5	5	5	5	5	5	0	15	15	15	15	15	15
Animation/presentation features	2	0	5	0	0	5	10	10	0	10	0	0	10	20	20
								Subtotal	305	145	340	280	250	165	185
								Relevance Weights Above 0	13						
								WEIGHTED SUBTOTAL	23	11	26	22	19	13	14

5	6	7							8						
		Weighted Subtotals							Column 6 x Column 7						
Context/Criteria (0 = not relevant, 5 = most relevant)	Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0 Analysis Context	3	50	50	25	0	25	25	0	150	150	75	0	75	75	0
1 Geographic Scope	4	25	50	-495	-495	-495	-495	-495	100	200	-1980	-1980	-1980	-1980	-1980
2 Facility Type	2	15	27	22	17	27	27	31	30	54	45	35	54	54	62
3 Travel Mode	2	16	23	14	14	14	20	20	32	47	28	28	28	40	40
4 Management Strategy/Applications	5	19	7	13	16	27	27	28	96	36	64	79	136	136	139
5 Traveler Response	2	16	30	-322	0	28	28	28	33	60	-644	0	55	55	55
6 Performance Measures	5	13	14	13	13	16	20	20	67	70	66	64	78	100	100
7 Tool/Cost Effectiveness	4	23	11	26	22	19	13	14	94	45	105	86	77	51	57
								WEIGHTED TOTALS	602	660	-2241	-1688	-1478	-1470	-1527
								Most Appropriate Tool Categories:	**1.**	**TDM**					
									2.	**Sketch Plan**					

* Use the following values for Tool Category Relevance: (+) = 10 points, (0) = 5 points, (-) = 0 points, (na) = -99 points

Table 11. Example 3 worksheet (refer to sections 2.1 and 2.2 for criteria definitions).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Context Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0 Analysis Context (0 = not relevant, 5 = most relevant)															
Planning	0	10	10	5	0	5	5	0	0	0	0	0	0	0	0
Design	0	-99	5	10	10	10	10	10	0	0	0	0	0	0	0
Operations/Construction	5	5	0	10	10	10	10	10	25	0	50	50	50	50	50
								Subtotal	25	0	50	50	50	50	50
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	25	0	50	50	50	50	50
1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
1 Geographic Scope (0 = not relevant, 5 = most relevant)															
Isolated Location	0	-99	-99	10	10	10	5	10	0	0	0	0	0	0	0
Segment	5	5	0	10	10	10	10	10	25	0	50	50	50	50	50
Corridor/Small Network	0	-99	5	0	5	10	10	10	0	0	0	0	0	0	0
Region	0	-99	5	-99	-99	5	0	5	0	0	0	0	0	0	0
								Subtotal	25	0	50	50	50	50	50
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	25	0	50	50	50	50	50
2 Facility Type (0 = not relevant, 5 = most relevant)															
Isolated Intersection	2	0	5	10	10	10	10	10	0	10	20	20	20	20	20
Roundabout	2	0	0	10	0	5	0	5	0	0	20	0	10	0	10
Arterial	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
Highway	3	10	10	10	5	10	10	10	30	30	30	15	30	30	30
Freeway	2	5	10	10	5	10	10	10	10	20	20	10	20	20	20
HOV Lane	0	5	10	5	0	10	10	10	0	0	0	0	0	0	0
HOV Bypass Lane	0	0	10	0	5	5	5	10	0	0	0	0	0	0	0
Ramp	0	5	10	10	10	10	10	10	0	0	0	0	0	0	0
Auxiliary Lane	0	0	0	5	5	10	10	10	0	0	0	0	0	0	0
Reversible Lane	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0
Truck Lane	0	0	10	5	5	5	5	10	0	0	0	0	0	0	0
Bus Lane	4	0	10	0	0	5	5	10	0	40	0	0	20	20	40
Toll Plaza	0	0	5	5	0	0	0	10	0	0	0	0	0	0	0
Light Rail Line	5	0	10	0	0	0	0	10	0	50	0	0	0	0	50
								Subtotal	90	200	140	95	150	140	220
								Relevance Weights Above 0	7						
								WEIGHTED SUBTOTAL	13	29	20	14	21	20	31

Table 11. Example 3 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
3 Travel Mode (0 = not relevant, 5 = most relevant)															
SOV	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
HOV	3	5	10	5	5	5	10	10	15	30	15	15	15	30	30
Bus	5	5	10	5	5	5	10	10	25	50	25	25	25	50	50
Rail	5	5	10	0	0	0	5	5	25	50	0	0	0	25	25
Truck	1	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Motorcycle	1	0	5	0	0	0	0	0	0	5	0	0	0	0	0
Bicycle	1	5	5	5	0	0	0	5	5	5	5	0	0	0	5
Pedestrian	1	5	0	5	5	5	5	5	5	0	5	5	5	5	5
								Subtotal	130	195	105	100	100	165	170
								Relevance Weights Above 0	8						
								WEIGHTED SUBTOTAL	16	24	13	13	13	21	21
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)															
Freeway Management	0	10	5	5	10	10	10	10	0	0	0	0	0	0	0
Arterial Intersections	5	0	0	10	10	10	10	10	0	0	50	50	50	50	50
Arterial Management	5	5	5	5	10	10	10	10	25	25	25	50	50	50	50
Incident Management	0	5	0	5	0	10	10	10	0	0	0	0	0	0	0
Emergency Management	3	5	0	5	0	5	5	5	15	0	15	0	15	15	15
Work Zone	0	5	0	10	0	10	10	10	0	0	0	0	0	0	0
Special Event	0	5	0	10	0	5	5	5	0	0	0	0	0	0	0
Advanced Public Transportation System	3	5	0	0	0	0	0	5	15	0	0	0	0	0	15
Advanced Traveler Information System	0	5	0	0	0	5	5	5	0	0	0	0	0	0	0
Electronic Payment System	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0
Rail Grade Crossing Monitor	0	5	0	0	0	0	0	10	0	0	0	0	0	0	0
Commercial Vehicle Operations	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0
Advanced Vehicle Control & Safety System	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0
Weather Management	0	0	0	0	0	5	5	5	0	0	0	0	0	0	0
Travel Demand Management	4	10	10	5	0	5	5	5	40	40	20	0	20	20	20
								Subtotal	95	65	110	100	135	135	150
								Relevance Weights Above 0	5						
								WEIGHTED SUBTOTAL	19	13	22	20	27	27	30

Table 11. Example 3 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion	4	5	10	-99	0	10	10	10	20	40	-396	0	40	40	40
En-Route Route Diversion	4	5	10	-99	0	10	10	10	20	40	-396	0	40	40	40
Mode Shift	2	5	10	-99	0	5	5	5	10	20	-198	0	10	10	10
Departure Time Choice	1	5	0	-99	0	5	5	5	5	0	-99	0	5	5	5
Destination Change	0	-99	5	-99	-99	-99	0	0	0	0	0	0	0	0	0
Induced/Foregone Demand	0	5	5	-99	-99	-99	-99	5	0	0	0	0	0	0	0
								Subtotal	55	100	-1089	0	95	95	95
								Relevance Weights Above 0	4						
								WEIGHTED SUBTOTAL	14	25	-272	0	24	24	24
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS	5	0	5	10	10	5	5	5	0	25	50	50	25	25	25
Speed	5	10	10	10	10	10	10	10	50	50	50	50	50	50	50
Travel Time	4	5	5	10	10	10	10	10	20	20	40	40	40	40	40
Volume	4	10	10	10	10	10	10	10	40	40	40	40	40	40	40
Travel Distance	1	0	0	0	0	0	10	10	0	0	0	0	0	10	10
Ridership	4	0	5	0	0	0	5	5	0	20	0	0	0	20	20
Average Vehicle Occupancy (AVO)	3	0	5	0	0	0	0	0	0	15	0	0	0	0	0
V/C Ratio	3	0	10	10	5	5	5	5	0	30	30	15	15	15	15
Density	3	0	0	10	10	10	10	10	0	0	30	30	30	30	30
VMT/PMT	3	5	10	5	5	10	10	10	15	30	15	15	30	30	30
VHT/PHT	5	5	10	5	5	10	10	10	25	50	25	25	50	50	50
Delay	5	5	10	10	10	10	10	10	25	50	50	50	50	50	50
Queue Length	3	0	0	10	10	10	10	10	0	0	30	30	30	30	30
Number of Stops	3	5	0	0	0	0	5	10	15	0	0	0	0	15	30
Crashes / Accidents	3	5	0	0	0	0	5	5	15	0	0	0	0	15	15
Incident Duration	1	0	0	0	0	0	5	5	0	0	0	0	0	5	5
Travel Time Reliability	4	5	0	0	0	0	0	0	20	0	0	0	0	0	0
Emissions	3	5	0	0	0	0	5	5	15	0	0	0	0	15	15
Fuel Consumption	3	5	0	0	0	5	5	5	15	0	0	0	15	15	15
Noise	3	5	0	0	0	0	0	0	15	0	0	0	0	0	0
Mode Split	3	0	10	0	5	5	5	5	0	30	0	15	15	15	15
Benefit/Cost	3	5	0	0	0	0	0	0	15	0	0	0	0	0	0
								Subtotal	285	360	360	360	390	470	485
								Relevance Weights Above 0	22						
								WEIGHTED SUBTOTAL	13	16	16	16	18	21	22

Table 11. Example 3 worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
	Sub-	Tool Category Relevance							Column 2 x Column 3						
Criteria	Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant)															
Tool capital cost	2	10	0	10	10	5	0	0	20	0	20	20	10	0	0
Level of effort/training	4	10	0	10	5	5	0	0	40	0	40	20	20	0	0
Easy to use	4	10	0	10	5	5	0	0	40	0	40	20	20	0	0
Popular/well-trusted	5	5	5	10	10	5	0	5	25	25	50	50	25	0	25
Hardware requirements	4	10	5	10	10	10	0	0	40	20	40	40	40	0	0
Data requirements	3	10	0	10	10	0	0	0	30	0	30	30	0	0	0
Computer run time	3	10	5	10	10	10	0	0	30	15	30	30	30	0	0
Post-processing requirements	2	5	0	5	5	5	10	10	10	0	10	10	10	20	20
Documentation	2	5	5	10	5	5	5	5	10	10	20	10	10	10	10
User support	2	5	10	0	0	5	5	5	10	20	0	0	10	10	10
Key parameters can be user-defined	2	5	10	5	5	10	10	10	10	20	10	10	20	20	20
Default values are provided	2	10	0	10	10	10	10	10	20	0	20	20	20	20	20
Integration with other software	2	0	5	5	5	5	5	5	0	10	10	10	10	10	10
Animation/presentation features	5	0	5	0	0	5	10	10	0	25	0	0	25	50	50
								Subtotal	285	145	320	270	250	140	165
								Relevance Weights Above 0	14						
								WEIGHTED SUBTOTAL	20	10	23	19	18	10	12

5		6	7							8						
			Weighted Subtotals							Column 6 x Column 7						
Context/Criteria (0 = not relevant, 5 = most relevant)		Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0	Analysis Context	5	25	0	50	50	50	50	50	125	0	250	250	250	250	250
1	Geographic Scope	3	25	0	50	50	50	50	50	75	0	150	150	150	150	150
2	Facility Type	3	13	29	20	14	21	20	31	39	86	60	41	64	60	94
3	Travel Mode	3	16	24	13	13	13	21	21	49	73	39	38	38	62	64
4	Management Strategy/Applications	4	19	13	22	20	27	27	30	76	52	88	80	108	108	120
5	Traveler Response	1	14	25	-272	0	24	24	24	14	25	-272	0	24	24	24
6	Performance Measures	5	13	16	16	16	18	21	22	65	82	82	82	89	107	110
7	Tool/Cost Effectiveness	5	20	10	23	19	18	10	12	102	52	114	96	89	50	59
									WEIGHTED TOTALS	544	369	511	736	811	810	871
									Most Appropriate Tool Categories:	**1.**	**Micro Sim**					
										2.	**Macro Sim**					

* Use the following values for Tool Category Relevance: (+) = 10 points, (0) = 5 points, (-) = 0 points, (na) = -99 points

4.0 Available Traffic Analysis Tools

Before selecting a particular tool, users are strongly encouraged to assess the strengths and weaknesses of the specific analytical tools since this document only presents a generalized view of each tool category. Appendix E provides a list of available traffic analysis tools by tool category and Web site links for further information (available as of August 2003). 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

The worksheet in appendix C may be used to assess the capabilities of each tool in comparison to the project's goals and objectives.

5.0 Challenges and Limitations in the Use of Traffic Analysis Tools

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

- **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 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 coding 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.

- **Tools 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 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. It is hoped that future tools will be able to be linked to traffic management centers (TMCs) 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 experience, 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 "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 (e.g., area size, data requirements, duration, analytical time periods, etc.), an analytical 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 scope of the study to conform to the analytical needs.

Appendix A: Limitations of HCM

Table 12. Limitations of the HCM methodologies.

Section	Limitations
"Urban Street Methodology" (chapter 15, HCM 2000)	This methodology does not directly account for the following conditions that can occur between intersections: • Presence or lack of onstreet parking • Driveway density or access control • Lane additions leading up to or lane drops leading away from intersections • Impact of grades between intersections • Any capacity constraints between intersections (such as a narrow bridge) • Midblock medians and two-way left-turn lanes • Turning movements that exceed 20 percent of the total volume on the street • Queues at one intersection backing up to and interfering with the operation of an upstream intersection • Cross-street congestion blocking through traffic Because any one of these conditions might have a significant impact on the speed of through traffic, the analyst should modify the methodology to incorporate the effects as well as possible.
"Signalized Intersection Methodology" (chapter 16, HCM 2000)	This methodology does not take into account the potential impact of downstream congestion on intersection operation, nor does it detect and adjust for the impact of turn-pocket overflows on through traffic and intersection operation.
"Unsignalized Intersection Methodology" (chapter 17, HCM 2000)	HCM 2000 does not include a detailed method for estimating delay for yield sign-controlled intersections. All of the methods are for steady-state conditions (i.e., the demand and capacity conditions are constant during the analysis period). The methods are not designed to evaluate how fast or how often the facility transitions from one demand/capacity state to another. Analysts interested in that kind of information should consider applying simulation models.
"Pedestrian Methodology" (chapter 18, HCM 2000)	HCM 2000 treats each of these facilities from the point of view of the pedestrian. Procedures for assessing the impact of pedestrians on vehicular capacity and LOS are incorporated into other chapters. The material in HCM 2000 is the result of research sponsored by FHWA. The pedestrian methodology for midblock sidewalk analysis cannot determine the effects of high volumes of pedestrians entering from the doorways of office buildings or subway stations. It also cannot determine the effects of high volumes of motor vehicles entering or leaving a parking garage and crossing the sidewalk area. Moreover, the methodology does not consider grades; it is adequate for grades from -3 to +3 percent; however, the effects of more extreme grades have not been well documented.
"Bicycle Methodology" (chapter 19, HCM 2000)	The bicycle methodology does not account for bicycle paths or lane-width reduction caused by fixed objects adjacent to these facilities. No credible data were found on fixed objects and their effects on bicycles using these types of facilities. In addition, the methodology does not account for the effects of right-turning motor vehicles crossing bicycle lanes at intersections or midblock locations, and grade is not considered. The methodology can be used for the analysis of facilities with grades from -3 to +3 percent. The effects created by more extreme grades are unknown.

Table 12. Limitations of the HCM methodologies (continued).

Section	Limitations
"Two-Lane Highway Methodology" (chapter 20, HCM 2000)	Some two-lane highways—particularly those that involve interactions among several passing or climbing lanes—are too complex to be addressed by the procedures of HCM 2000. For analytical problems beyond the scope of HCM 2000, see part V of HCM 2000, which describes the application of simulation modeling to two-lane highway analyses. Several design treatments discussed in appendix A in HCM 2000 are not accounted for by the methodology. The operational analytical methodologies in HCM 2000 do not address two-lane highways with signalized intersections. Isolated signalized intersections on two-lane highways can be evaluated using the signalized intersections methodology (chapter 16, HCM 2000). Two-lane highways in urban and suburban areas with multiple signalized intersections at spacings of 3.2 km (2.0 mi) or less can be evaluated using the urban street methodology (chapter 15, HCM 2000).
"Multilane Highway Methodology" (chapter 21, HCM 2000)	The methodology in HCM 2000 does not take into account the following conditions: • Transitory blockages caused by construction, crashes, or railroad crossings • Interference caused by parking on the shoulders (such as in the vicinity of a country store, flea market, or tourist attraction) • Three-lane cross sections • Effects of lane drops and additions at the beginning or ending of the segments • Possible queuing delays when a transition from a multilane segment to a two-lane segment is neglected • Differences between median barriers and two-way left-turn lanes • Free-flow speeds below 72 km/h (45 mi/h) or above 97 km/h (60 mi/h)
"Freeway Methodology" (chapter 22, HCM 2000)	A complete discussion of freeway control systems or even the analysis of the performance alternatives is beyond the scope of HCM 2000. The reader should consult the references identified in HCM 2000. The methodology does not account for delays caused by vehicles using alternate routes or vehicles leaving before or after the duration of the study. Certain freeway traffic conditions cannot easily be analyzed by the methodology (e.g., multiple overlapping bottlenecks). Therefore, other tools may be more appropriate for specific applications beyond the capabilities of the methodology. Refer to part V, HCM 2000, for a discussion of simulations and other models. User demand responses, such as spatial, temporal, modal, or total demand responses caused by traffic management strategies, are not automatically incorporated within the methodology. After viewing the facility traffic performance results, the analyst can modify the demand input manually to analyze the effect of user demand responses or traffic growth. The accuracy of the results depends on the accuracy of the estimation of the users' demand responses. The freeway facility methodology is limited to the extent that it can accommodate demand in excess of capacity. The procedures address only local oversaturated flow situations, not systemwide oversaturated flow conditions. The completeness of the analysis will be limited if freeway segments in the first time interval, the last time interval, and the first freeway segment do not all have demand-to-capacity ratios less than 1.00. The rationale for these limitations is discussed in the section on demand-capacity ratio.

Table 12. Limitations of the HCM methodologies (continued).

Section	Limitations
"Freeway Methodology" (chapter 22 (continued), HCM 2000)	Given enough time, the analyst can analyze a completely undersaturated time-space domain manually, although this is difficult. It is not expected that analysts will ever manually analyze a time-space domain that includes oversaturation. For heavily congested freeway facilities with interacting bottleneck queues, the analyst may wish to review part V, HCM 2000, before undertaking this methodology.
"Basic Freeway Segment Methodology" (chapter 23, HCM 2000)	The methodology does not apply to or take into account (without modification by the analyst) the following: • Special lanes reserved for a single vehicle type, such as HOV lanes, truck lanes, and climbing lanes • Extended bridge and tunnel segments • Segments near a toll plaza • Facilities with free-flow speeds below 89km/h (55 mi/h) or in excess of 121km/h (75 mi/h) • Demand conditions in excess of capacity (refer to chapter 22, HCM 2000, for further discussion) • Influence of downstream blockages or queuing on a segment • Posted speed limit, extent of police enforcement, or presence of ITS features related to vehicle or driver guidance • Capacity-enhancing effects of ramp metering The analyst would have to draw upon other research information and develop special-purpose modifications of this methodology to incorporate the effects of the above conditions.
"Freeway Weaving Methodology" (chapter 24, HCM 2000)	The HCM 2000 methodology does not specifically address the following subjects (without modifications by the analyst): • Special lanes, such as HOV lanes, in the weaving segment • Ramp metering on entrance ramps forming part of the weaving segment • Specific operating conditions when oversaturated conditions occur • Effects of speed limits or enforcement practices on weaving segment operations • Effects of ITS technologies on weaving segment operations • Weaving segments on collector-distributor roadways • Weaving segments on urban streets • Multiple weaving segments The last subject, which has been treated in previous editions of HCM, has been deleted. Multiple weaving segments must be divided into appropriate merge, diverge, and simple weaving segments for analysis.
"Ramp and Ramp Junction Methodologies" (chapter 25, HCM 2000)	The HCM 2000 methodology does not take into account, nor is it applicable to (without modifications by the analyst), the following: • Special lanes, such as HOV lanes, as ramp entrance lanes • Ramp metering • Oversaturated conditions • Posted speed limits and the extent of police enforcement • Presence of ITS features

Source: HCM 2000

Appendix B: Tool Category Selection Worksheet

Table 13. Tool category selection worksheet (refer to sections 2.1 and 2.2 for criteria definitions).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Context Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0 Analysis Context (0 = not relevant, 5 = most relevant)															
Planning		10	10	5	0	5	5	0							
Design		-99	5	10	10	10	10	10							
Operations/Construction		5	0	10	10	10	10	10							
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
1 Geographic Scope (0 = not relevant, 5 = most relevant)															
Isolated Location															
Segment															
Corridor/Small Network															
Region															
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							
2 Facility Type (0 = not relevant, 5 = most relevant)															
Isolated Intersection		0	5	10	10	10	10	10							
Roundabout		0	0	10	0	5	0	5							
Arterial		10	10	10	10	10	10	10							
Highway		10	10	10	5	10	10	10							
Freeway		5	10	10	5	10	10	10							
HOV Lane		5	10	5	0	10	10	10							
HOV Bypass Lane		0	10	0	5	5	5	10							
Ramp		5	10	10	10	10	10	10							
Auxiliary Lane		0	0	5	5	10	10	10							
Reversible Lane		0	5	0	0	0	0	5							
Truck Lane		0	10	5	5	5	5	10							
Bus Lane		0	10	0	0	5	5	10							
Toll Plaza		0	5	5	0	0	0	10							
Light Rail Line		0	10	0	0	0	0	10							
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							

Table 13. Tool category selection worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
3 Travel Mode (0 = not relevant, 5 = most relevant)															
SOV		10	10	10	10	10	10	10							
HOV		5	10	5	5	5	10	10							
Bus		5	10	5	5	5	10	10							
Rail		5	10	0	0	0	5	5							
Truck		5	5	5	5	5	5	5							
Motorcycle		0	5	0	0	0	0	0							
Bicycle		5	5	5	0	0	0	5							
Pedestrian		5	0	5	5	5	5	5							
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)															
Freeway Management		10	5	5	10	10	10	10							
Arterial Intersections		0	0	10	10	10	10	10							
Arterial Management		5	5	5	10	10	10	10							
Incident Management		5	0	5	0	10	10	10							
Emergency Management		5	0	5	0	5	5	5							
Work Zone		5	0	10	0	10	10	10							
Special Event		5	0	10	0	5	5	5							
Advanced Public Transportation System		5	0	0	0	0	0	5							
Advanced Traveler Information System		5	0	0	0	5	5	5							
Electronic Payment System		5	0	0	0	0	0	10							
Rail Grade Crossing Monitor		5	0	0	0	0	0	10							
Commercial Vehicle Operations		5	0	0	0	0	0	5							
Advanced Vehicle Control & Safety System		5	0	0	0	0	0	5							
Weather Management		0	0	0	0	5	5	5							
Travel Demand Management		10	10	5	0	5	5	5							
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							

Table 13. Tool category selection worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion		5	10	-99	0	10	10	10							
En-Route Route Diversion		5	10	-99	0	10	10	10							
Mode Shift		5	10	-99	0	5	5	5							
Departure Time Choice		5	0	-99	0	5	5	5							
Destination Change		-99	5	-99	-99	-99	0	0							
Induced/Foregone Demand		5	5	-99	-99	-99	-99	5							
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS		0	5	10	10	5	5	5							
Speed		10	10	10	10	10	10	10							
Travel Time		5	5	10	10	10	10	10							
Volume		10	10	10	10	10	10	10							
Travel Distance		0	0	0	0	0	10	10							
Ridership		0	5	0	0	0	5	5							
Average Vehicle Occupancy (AVO)		0	5	0	0	0	0	0							
V/C Ratio		0	10	10	5	5	5	5							
Density		0	0	10	10	10	10	10							
VMT/PMT		5	10	5	5	10	10	10							
VHT/PHT		5	10	5	5	10	10	10							
Delay		5	10	10	10	10	10	10							
Queue Length		0	0	10	10	10	10	10							
Number of Stops		5	0	0	0	0	5	10							
Crashes / Accidents		5	0	0	0	0	5	5							
Incident Duration		0	0	0	0	0	5	5							
Travel Time Reliability		5	0	0	0	0	0	0							
Emissions		5	0	0	0	0	5	5							
Fuel Consumption		5	0	0	0	5	5	5							
Noise		5	0	0	0	0	0	0							
Mode Split		0	10	0	5	5	5	5							
Benefit/Cost		5	0	0	0	0	0	0							
								Subtotal	0						
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							

Table 13. Tool category selection worksheet (refer to sections 2.1 and 2.2 for criteria definitions) (continued).

1	2	3							4						
		Tool Category Relevance							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant)															
Tool capital cost		10	0	10	10	5	0	0							
Level of effort/training		10	0	10	5	5	0	0							
Easy to use		10	0	10	5	5	0	0							
Popular/well-trusted		5	5	10	10	5	0	5							
Hardware requirements		10	5	10	10	10	0	0							
Data requirements		10	0	10	10	0	0	0							
Computer run time		10	5	10	10	10	0	0							
Post-processing requirements		5	0	5	5	5	10	10							
Documentation		5	5	10	5	5	5	5							
User support		5	10	0	0	5	5	5							
Key parameters can be user-defined		5	10	5	5	10	10	10							
Default values are provided		10	0	10	10	10	10	10							
Integration with other software		0	5	5	5	5	5	5							
Animation/presentation features		0	5	0	0	5	10	10							
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							

5	6	7							8						
		Weighted Subtotals							Column 6 x Column 7						
Context/Criteria (0 = not relevant, 5 = most relevant)	Criteria Relevance	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0 Analysis Context															
1 Geographic Scope															
2 Facility Type															
3 Travel Mode															
4 Management Strategy/Applications															
5 Traveler Response															
6 Performance Measures															
7 Tool/Cost Effectiveness															
								WEIGHTED TOTALS							
								Most Appropriate Tool Categories:	1. ________						
									2. ________						

* Use the following values for Tool Category Relevance: (+) = 10 points, (0) = 5 points, (-) = 0 points, (na) = -99 points

Appendix C: Tool Selection Worksheet

Table 14. Tool selection worksheet.

Tool Name: ________________________________ **Version/Release:** ______________________

Vendor Name/Contact Information: ____

1	2	3	4	5
Criteria	**Sub-Criteria Relevance**	**Tool Relevance***	**Col 2 x Col 3**	**Comments**
1 Geographic Scope (0 = not relevant, 5 = most relevant)				
Isolated Location				
Segment				
Corridor/Small Network				
Region				
Other: ____________________				
Subtotal				
Relevance Weights Above 0				
WEIGHTED SUBTOTAL				
2 Facility Type (0 = not relevant, 5 = most relevant)				
Isolated Intersection				
Roundabout				
Arterial				
Highway				
Urban				
Rural				
Freeway				
Mainline				
Shoulder				
HOV Lane				
Barrier-separated				
Buffer-separated				
Shoulder HOV				
HOT Lane				
HOV Bypass Lane				
Ramp				
Auxiliary Lane				
Reversible Lane				
Truck Lane				
Bus Lane				
Toll Plaza				
Light Rail Line				
Other: ____________________				
Subtotal				
Relevance Weights Above 0				
WEIGHTED SUBTOTAL				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	**Sub-Criteria Relevance**	**Tool Relevance***	**Col 2 x Col 3**	**Comments**
3 Travel Mode (0 = not relevant, 5 = most relevant)				
SOV				
HOV				
HOV 2+				
HOV 3+				
As percentage of total vehicles				
Bus				
Local				
Express				
Train				
Truck				
Motorcycle				
Bicycle				
Pedestrian				
Other: ____________________				
Subtotal				
Relevance Weights Above 0				
WEIGHTED SUBTOTAL				
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)				
Freeway Management				
Adding general purpose lanes				
Adding HOV lanes				
Geometric improvements				
Interchange geometric improvements				
Electronic toll collection (ETC)				
Fixed-time ramp metering				
Adaptive/actuated ramp metering				
Centrally controlled metering				
Add HOV bypass				
Freeway connector metering				
Reconstruction management				
Arterial Intersections				
Adding lanes				
Pre-timed signal				
Actuated signal				
Traffic adaptive control signal				
Centrally controlled signal				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
4 Management Strategy/Application (0 = not relevant, 5 = most relevant) (continued)				
Work Zone/Special Events				
Road closures due to events				
Traffic diversion due to events				
Work zone management				
Work zone safety monitoring				
Maintenance/construction vehicle AVL				
Maintenance/construction vehicle maintenance				
Advanced Public Transportation Systems				
Fleet maintenance				
Automatic scheduling for transit				
Automatic vehicle location (AVL)				
Transit security systems				
Electronic transit fare payment				
Advanced Traveler Information Systems				
Pre-trip ATIS				
Telephone-based traveler information				
Web-based traveler information				
Kiosks				
Handheld traveler information				
En-route ATIS				
Highway Advisory Radio (HAR)				
Dynamic Message Sign (DMS)				
Transit DMS				
In-vehicle/handheld traveler information				
Rail Grade Crossing Monitor				
Commercial Vehicle Operations				
Fleet administration				
Electronic screening				
Weigh-in-motion				
Electronic clearance				
Safety information exchange				
On-board safety monitoring				
Electronic roadside safety inspection				
HazMat incident response/management				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
4 Management Strategy/Application (0 = not relevant, 5 = most relevant) (continued)				
Advanced Vehicle Control & Safety System				
Ramp rollover warning				
Downhill speed warning				
Longitudinal collision avoidance				
Lateral collision avoidance				
Intersection collision avoidance				
Vision enhancement for crashes				
Safety readiness				
Automated highway system				
Traffic Surveillance				
CCTV/radar/microwave				
Loop detectors				
Probe vehicles				
Travel Demand Management (TDM)				
Dynamic ridesharing				
Congestion pricing				
Flex-time				
Park and ride facilities				
Preferential parking				
Trip reduction programs				
Traffic Calming				
Roundabout				
Raised intersection				
Speed humps				
Speed control				
Parking Management				
On-street				
Off-street/parking garages				
Bicycle Program				
Bike lane/path routing				
Bike racks/lockers				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	**Sub-Criteria Relevance**	**Tool Relevance***	**Col 2 x Col 3**	**Comments**
4 Management Strategy/Application (0 = not relevant, 5 = most relevant) (continued)				
Weather Management				
Data collection				
Information processing/distribution				
Automated treatment				
Winter maintenance				
Resource allocation management				
Other: ____________				
		Subtotal		
		Relevance Weights Above 0		
		WEIGHTED SUBTOTAL		
5 Traveler Response (0 = not relevant, 5 = most relevant)				
Route Diversion				
Pre-Trip Route Diversion				
En-Route Route Diversion				
All-or-nothing				
Capacity restraint				
Stochastic/probabilistic				
Incremental				
Equilibrium				
Dynamic				
Transit system-based				
Route-based				
Timetable-based				
Multipath				
Other: ____________				
Departure Time Choice				
Mode Shift				
Logit				
Nested logit				
Other: ____________				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
5 Traveler Response (0 = not relevant, 5 = most relevant) (continued)				
Destination Choice				
Gravity model				
FRATAR model				
Trip chaining				
Parking cost-based				
Other: ____________				
Induced/Foregone Demand				
Other: ____________				
Subtotal				
Relevance Weights Above 0				
WEIGHTED SUBTOTAL				
6 Performance Measures (0 = not relevant, 5 = most relevant)				
LOS				*Circle all that apply:* Aggregated by link/node/vehicle type/facility type/regionwide/other: ______
Speed				link/node/vehicle type/facility type/regionwide/other: ______
Space-mean speed				link/node/vehicle type/facility type/regionwide/other: ______
Time-mean speed				link/node/vehicle type/facility type/regionwide/other: ______
Travel Time				link/node/vehicle type/facility type/regionwide/other: ______
Volume				link/node/vehicle type/facility type/regionwide/other: ______
Detector volume				link/node/vehicle type/facility type/regionwide/other: ______
Link average volume				link/node/vehicle type/facility type/regionwide/other: ______
Travel Distance				link/node/vehicle type/facility type/regionwide/other: ______
Ridership				link/node/vehicle type/facility type/regionwide/other: ______
Transit frequency				
Transit reliability				
Average Vehicle Occupancy (AVO)				link/node/vehicle type/facility type/regionwide/other: ______
V/C Ratio				link/node/vehicle type/facility type/regionwide/other: ______
Density				link/node/vehicle type/facility type/regionwide/other: ______
VMT/PMT				link/node/vehicle type/facility type/regionwide/other: ______
VHT/PHT				link/node/vehicle type/facility type/regionwide/other: ______
Delay				link/node/vehicle type/facility type/regionwide/other: ______
Stopped delay				link/node/vehicle type/facility type/regionwide/other: ______
Intersection delay				link/node/vehicle type/facility type/regionwide/other: ______
Total delay				link/node/vehicle type/facility type/regionwide/other: ______
Queue Length				link/node/vehicle type/facility type/regionwide/other: ______
Number of Stops				link/node/vehicle type/facility type/regionwide/other: ______

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
6 Performance Measures (0 = not relevant, 5 = most relevant) (continued)				
Crashes/ Accidents				link/node/vehicle type/facility type/regionwide/other: ______
Accidents by severity				link/node/vehicle type/facility type/regionwide/other: ______
Incident Duration				link/node/vehicle type/facility type/regionwide/other: ______
Travel Time Reliability				link/node/vehicle type/facility type/regionwide/other: ______
Emissions				link/node/vehicle type/facility type/regionwide/other: ______
Fuel Consumption				link/node/vehicle type/facility type/regionwide/other: ______
Noise				link/node/vehicle type/facility type/regionwide/other: ______
Vehicle Operating Costs				
Agency operating costs				
Mode Split				link/node/vehicle type/facility type/regionwide/other: ______
Monetized Benefits				link/node/vehicle type/facility type/regionwide/other: ______
Net Benefit				link/node/vehicle type/facility type/regionwide/other: ______
Implementation Cost				link/node/vehicle type/facility type/regionwide/other: ______
Benefit/Cost				link/node/vehicle type/facility type/regionwide/other: ______
Other: ______________________________				link/node/vehicle type/facility type/regionwide/other: ______
Subtotal				
Relevance Weights Above 0				
WEIGHTED SUBTOTAL				
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant)				
Tool capital cost				Price:
Level of effort/training				Training classes available:
Easy to use				
Windows-based				
Drag-and-drop capabilities				
Popular/well-trusted				Years in the U.S. market:
Hardware requirements				Recommended minimum hardware:
Data requirements				
Volume				
Geometry				
Road conditions				
Signal or meter phase/timing				
Node requirements				
Link requirements				
O-D tables				

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	**Sub-Criteria Relevance**	**Tool Relevance***	**Col 2 x Col 3**	**Comments**
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant) (continued)				
Turn movements/fractions				
Traffic composition				
Occupancy				
Control devices				
Spacing				
Computer run time				Average run time:
Post-processing requirements				
Metric option available				
U.S. standards option available				
Documentation				
User's Manual				Where to download:
Newsgroup available				Newsgroup address:
Chat rooms available				Chat room address:
E-mail lists available				How to join list:
User support				Tech support contact:
Free/affordable annual cost of support				Price:
Toll-free support available				Toll-free number:
24-hour support available				24-hour support number:
Rapid response				Turnaround time:
Key parameters can be user-defined				
Default values are provided				
Integration with other software				Compatible software:
Geocoding to GIS available				
Data exchange				
Animation/presentation features				
Dynamic				
Passive				
Network size limitations				Size limitations (nodes, links, vehicles):
Compatible with most operating systems				Ideal OS:

Table 14. Tool selection worksheet (continued).

1	2	3	4	5
Criteria	Sub-Criteria Relevance	Tool Relevance*	Col 2 x Col 3	Comments
7 Tool/Cost Effectiveness (0 = not relevant, 5 = most relevant) (continued)				
Other model capabilities/conditions				
Oversaturated conditions				
Weaving				
Effects of Incidents (objects, breakdowns, crashes)				
Weather effects (rain, ice, wind, snow)				
Queue spill back				
Effects of pedestrians				
Effects of bicycles/motorbikes				
Effects of parked vehicles				
Effects of commercial vehicles				
Acceleration/deceleration effects				
Models U.S. (right-hand side) roadways				
Other: ____________________________				
Subtotal				
Relevance Weights Above 0				
WEIGHTED SUBTOTAL				

6	7	8	9
Criteria (0 = not relevant, 5 = most relevant)	Criteria Weight	Weighted Subtotals	Col 7 x Col 8
1 Geographic Scope			
2 Facility Type			
3 Travel Mode			
4 Management Strategy/Applications			
5 Traveler Response			
6 Performance Measures			
7 Tool/Cost Effectiveness			
		TOTAL SCORE	

* Use the following values for Tool Relevance: 0 = not featured, 5 = strongly featured by the tool.

Appendix D: Recommended Reading

The following documents are recommended reading for detailed overviews and comparisons of some of the more commonly used traffic analysis tools:

Algers, S., E. Bernauer, M. Boero, L. Breheret, C. DiTaranto, M. Dougherty, K. Fox, and J.F. Gabard. *Smartest Review of Micro-Simulation Models*, Transport RTD, August 1997 (available at www.its.leeds.ac.uk/projects/smartest/index.html).

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Freeman, W.J., K.Y. Ho, and E.A. McChesney. *An Evaluation of Signalized Intersection System Analysis Techniques* (available at www.trafficware.com/documents/1999/00055.pdf).

Mekemson, J., E. Herlihy, and S. Wong. *Traffic Models Overview Handbook*, Publication No. FHWA-SA-93-050, FHWA, 1993.

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"This Week's Survey Results: Micro-Simulation Software Characteristics, Part I," *The Urban Transportation Monitor*, Feb. 8, 2002, pp. 8-11.

"This Week's Survey Results: Micro-Simulation Software Characteristics, Part II," *The Urban Transportation Monitor*, Feb. 22, 2002, pp. 8-12.

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"This Week's Survey Results: Urban Transportation Planning Software, Part II," *The Urban Transportation Monitor*, Apr. 19, 2002, pp. 8-13.

Traffic Analysis Software Tools, Circular No. E-CO14, Transportation Research Board/National Research Council, September 2002.

Appendix E: Traffic Analysis Tools by Category

E.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/ti_ved/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

E.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): http://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

E.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): www11.myflorida.com/planning/systems/sm/los/default.htm

- CATS (Computer-Aided Transportation Software): http://tti.tamu.edu/product/software/cats

- CCG (Canadian Capacity Guide)/Calc2: 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): www11.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: www11.myflorida.com/planning/systems/sm/los/default.htm

- Generalized Peak-Hour Directional Service Volume Tables: www11.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): www11.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: www11.myflorida.com/planning/systems/sm/los/default.htm
- 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 Program): 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

E.4 Traffic Optimization Tools

Examples of traffic optimization tools:

- PASSER™ (Progression Analysis and Signal System Evaluation Routine) 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
- 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

E.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

E.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

E.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.htm

E.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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