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Decision Support Methodology for Selecting Traffic Analysis Tools

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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. Yet, congestion continues to grow at an alarming rate, adversely impacting our quality of life, increasing the potential for accidents and undesired long delays. These are expected to only escalate, calling for the need for transportation professionals to increase the productivity of existing transportation systems through the use of operational improvements. In order to assess the potential effectiveness of a particular strategy, it must be analyzed using traffic analysis tools or methodologies.

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

The objective of the Decision Support Methodology for Selecting Traffic Analysis Tools is to assist traffic engineers 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 analysis 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.

This methodology was developed for the Federal Highway Administration (FHWA) by Cambridge Systematics, Inc. in association with Dowling Associates and Dr. Alexander Skabardonis. This document is organized into the following sections:

- **Section 1.0 – Background and Objectives:** Describes the objectives of the document and highlights the needs and roles of traffic analysis tools, including the definitions of the analysis tool categories covered in this document. This section also presents a comparison of the HCM with traffic simulation models.

- **Section 2.0 – Criteria for Selecting the Appropriate 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 the users in the selection of the appropriate tool category.

- **Section 3.0 – Guidelines to Users:** Provides guidance to the users on how to use the criteria in Section 2.0 to select the appropriate analysis tool category. This section includes worksheets that transportation professionals can utilize to select the

appropriate tool category, and assistance to identify the most appropriate tool within the selected category.

- **Section 4.0 – Available Traffic Analysis Tools:** Refers to a list of available analysis tools.

- **Section 5.0 – Analysis Tools Challenges and Limitations:** Highlights some of the analysis tools challenges and limitations for consideration by the users.

- **Appendix A –** Contains a worksheet that can assist users with the selection of a specific traffic analysis tool.

- **Appendix B –** Contains a list of recommended further reading of documents that discuss or compare some of the specific traffic analysis tools.

- **Appendix C –** Provides a list of analysis tools by category and their contact web sites. This is only intended to function as a starting point for users once they have selected an analysis tool category.

- **Appendix D –** Documents the literature reviewed and used in the development of this document.

1.1 Overview of Traffic Analysis Tools

The Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21) and the Federal/State Clean Air legislation have reinforced the importance of traffic management and control of existing highway capacity. As transportation agencies deploy more sophisticated hardware and software system technologies, there is an increasing need to:

- Respond to recurring and non-recurring congestion in a proactive fashion;

- Predict and evaluate the outcome of various improvement plans without the inconvenience of a field experiment;

- Assist Transportation Management Center (TMC) operators in their decision-making by developing on-line and off-line strategies for assessing various freeway and surface street management and control strategies; and

- Evaluate and optimize traffic flow and traffic signal timing patterns to mitigate increasing or changing travel demands.

Out of these needs, traffic analysis tools emerge as one of the most efficient methods to evaluate transportation improvement projects. This document addresses quantifiable *traffic operations* analysis tools categories, but does not include real-time or predictive

models. Traffic analysis tools may include software packages, methodologies, and procedures, and are defined as those typically utilized 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; and
- Evaluating various analysis contexts, including planning, design and operations/construction projects.

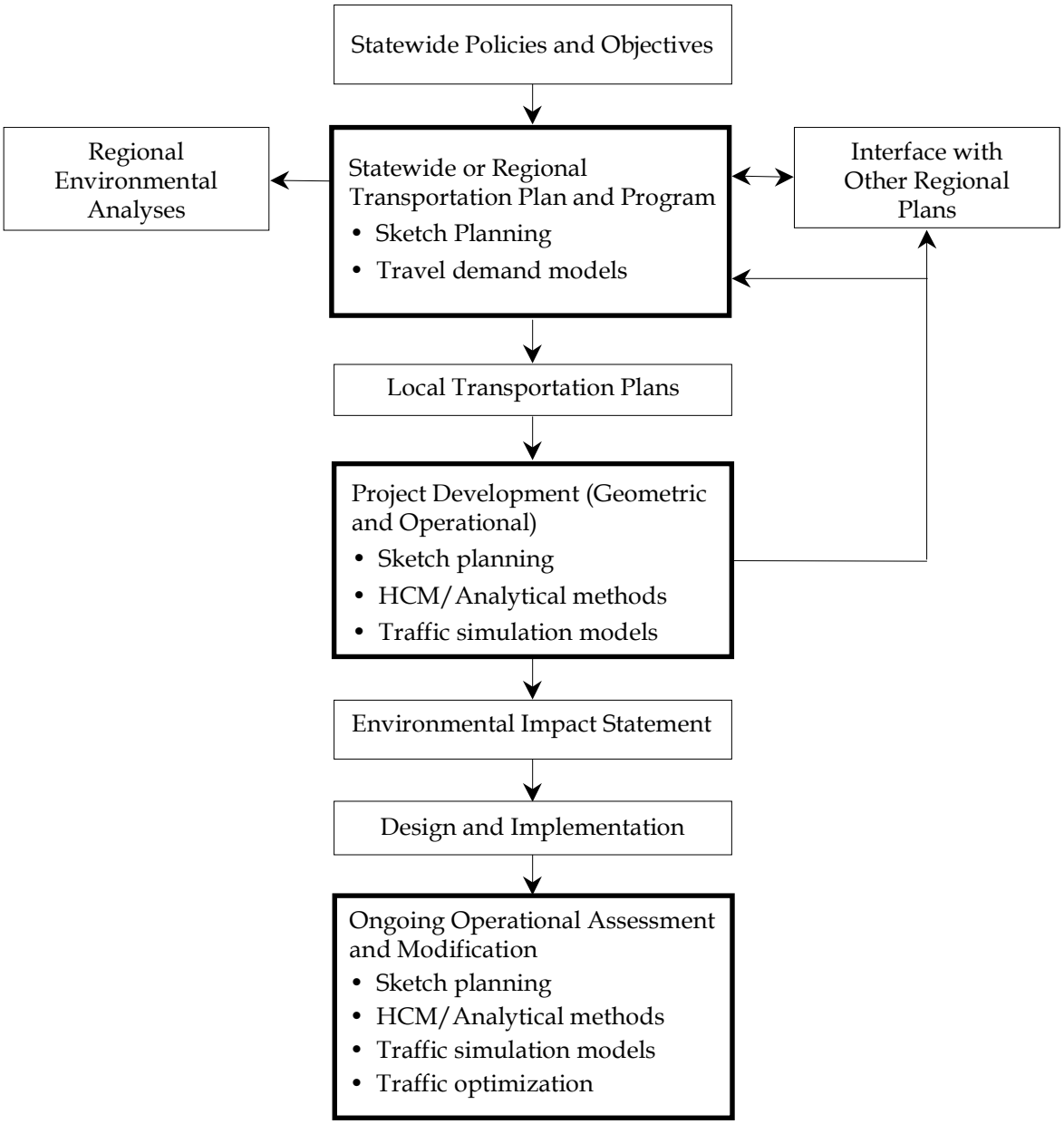
Figure 1.1 presents an overview of the transportation analysis process along with its various evaluation contexts and types of traffic analysis tools that are typically used in each context.

1.2 Role of Traffic Analysis Tools

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

- **Improve the decision-making process –** Traffic analysis tools help develop better planning/engineering decisions for complex transportation problems. They are used to estimate the impacts resulting from deployment of traffic management and other strategies, and 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 impacts.
- **Evaluate planning/operational alternatives and prioritize –**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 chances of having successful deployments.
- **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, analysis tools can be used to assess multiple deployment combinations or other complex scenarios in a relatively short time.

Figure 1.1 Overview of the Transportation Analysis Process



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

- **Reduce disruptions to traffic –** Traffic management and control strategies come in many forms and options, and analysis 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 a tool 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 schemes to maximize performance of a transportation facility.

- **Monitor performance –** Analysis tools can also be used to evaluate and monitor the performance of existing transportation facilities. In the future, there is hope that monitoring systems can be directly linked to analysis tools for a more direct and real-time 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 analysis tool, not of the specific tool. To date, numerous traffic analysis methodologies and tools have been developed by public agencies, research organizations, and various consultants. The traffic analysis tool categories include the following:

- **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 evaluation of specific projects or alternatives without conducting an in-depth engineering analysis. Sketch-planning tools perform some or all of the functions of other analysis tool types using simplified analyses techniques and highly aggregate 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 traffic analysis techniques. However, sketch-planning techniques are usually limited in scope, analytical robustness, and presentation capabilities.

- **Travel demand models –** Predicting travel demand, traffic operations, and impacts in response to operational strategies requires 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, as well as the representation of traffic flow

in the highway network. These attributes are found in the structure and orientation of travel demand models, mathematical models that forecast future travel demand from current conditions, and future projections of household and employment characteristics. Travel demand models were originally developed to determine the benefits and impacts of major highway improvements in metropolitan areas. Today, travel demand models are used in more wide-ranging tasks, including development of transportation master plans, evaluation of proposed land-use changes, initial design of transportation facilities, evaluation of air quality impacts, and assessment of future transportation needs. However, these tools were not designed to evaluate travel management strategies, such as ITS and operational strategies. Travel demand models have only 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). 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. Moreover, HCM procedures are macroscopic (inputs and outputs deal with average performance during a 15-minute or a one-hour analysis 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 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, but are limited in their ability to analyze network or system effects. HCM procedures and their strengths and limitations are discussed in more detail in Section 1.4.

- **Traffic optimization tools –** Similar to analytical/deterministic tools, traffic optimization tool methodologies are largely based on 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, and splits optimization including left turns, as well as coordination/offset plans. Some optimization tools can also be used for optimizing the 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 deterministic relationships of flow, speed, and density of the traffic stream. The simulation in a macroscopic model takes place on a section-by-section basis rather than 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 small time increments. Macroscopic simulation models operate on the basis of aggregate speed/volume and demand/capacity relationships. 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 analysis 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 less 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 properties of both microscopic (discussed below) and macroscopic simulation models. As in microscopic models, the mesoscopic models' unit of traffic flow is the individual vehicle. Similar to microscopic simulation models, mesoscopic tools assign vehicle types and driver behavior, as well as their relationships with the 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 at 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 typical planning analysis techniques.

- **Microscopic simulation models –** Microscopic simulation models simulate the movement of individual vehicles, based on theories of car-following and lane-changing. Typically, vehicles enter a transportation network using a statistical distribution of arrivals (a stochastic process), and are tracked through the network on a second-by-second basis. Upon entry, each vehicle is assigned a destination, a vehicle type, and a driver type. 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 is through the adjustment of driver sensitivity factors. Computer time and storage requirements for microscopic models are large, usually limiting the network size and the number of simulation runs that could be completed.

1.4 HCM Versus Simulation

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

1.4.1 Overview of the HCM

The HCM is a compilation of peer-reviewed procedures for computing the capacity and operational performance of the various facilities. The 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 the HCM was produced in the year 2000.

The Year 2000 HCM has over 1,100 pages and 30 chapters. The chapters in Parts I and II of the manual present introductory information on capacity and quality of service analysis. Part III chapters present the actual analytical procedures. Part IV provides information on applying the HCM to corridor and area-wide 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 systems, basic freeway sections, merging and diverging sections, and weaving sections. There are three chapters devoted to the analysis of urban facilities: urban streets, signalized intersections, and unsignalized intersections. There are also chapters with procedures for the analysis of multi-lane 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, HCM procedures have the following characteristics:

- **Macroscopic –** HCM's inputs and outputs deal with average performance during a 15-minute or a one-hour analysis period;

- **Deterministic –** Any given set of inputs will always yield the same answer; and

- **Static –** HCM procedures predict average operating conditions over a fixed time period and do not deal with transitions in operations from one state to another (such as would be addressed in a dynamic analysis).

1.4.2 HCM Strengths and Limitations

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 are well tested with significant field-validation experience. The HCM procedures, though, 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 from one location interfering with another location would violate this assumption. The HCM procedures are of limited value in analyzing the following:

- Queues that spill back from one intersection to another;
- Queues that overflow turn pockets;
- Queues from city streets that back up onto freeway; and
- Queues from ramp meters that back up onto city streets.

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

- Multi-lane or two-lane rural roads where traffic signals or stop signs significantly impact capacity and/or operations;
- Truck climbing lanes;
- Short through lane adds or drops at a signal;
- Two-way left turn lanes;
- Roundabouts of more than a single lane; and
- Tight diamond interchanges.

The following sections summarize limitations of the HCM based on information listed in the HCM 2000.

Limitations of the HCM Urban Street Methodology (HCM 2000, Chapter 15). The urban streets methodology does not directly account for the following conditions that can occur between intersections:

- Presence or lack of on-street parking;
- Driveway density or access control;
- Lane additions leading up to or lane drops leading away from intersections;
- The 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; and

- 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 best as possible.

Limitations of the HCM Signalized Intersection Methodology (HCM 2000, Chapter 16). The methodology does not take into account the potential impact of downstream congestion on intersection operation. Nor does the methodology detect and adjust for the impacts of turn-pocket overflows on through traffic and intersection operation.

Limitations of the HCM Unsignalized Intersection Methodology (HCM 2000, Chapter 17). 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.

Limitations of the HCM Pedestrian Methodology (HCM 2000, Chapter 18). 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 the Federal Highway Administration.

The pedestrian methodology for midblock sidewalk analysis cannot determine the effects of high volumes of pedestrians entering from 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 gives no consideration to grades; it is adequate for grades between –3 and +3 percent; however, the effects of more extreme grades have not been well documented.

Limitations of the HCM Bicycle Methodology (HCM 2000, Chapter 19). The bicycle methodology does not account for bicycle paths or lane width reduction due to 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 there is no consideration of grade. The methodology can be used for analysis of facilities with grades between –3 and +3 percent. The effects created by more extreme grades are unknown.

Limitations of the HCM Two-Lane Highway Methodology (HCM 2000, Chapter 20). Some two-lane highways – particularly those that involve interactions among several passing or climbing lanes – are too complex to be addressed with the procedures of HCM 2000. For analytical problems beyond the scope of HCM 2000, see Part V of the HCM 2000 manual, which describes the application of simulation modeling to two-lane highway

analyses. Several design treatments discussed in HCM 2000 Appendix A are not accounted for by the methodology.

The operational analysis methodologies in HCM 2000 do not address two-lane highways with signalized intersections. Isolated signalized intersections on two-lane highways can be evaluated with the methodology in HCM 2000 Chapter 16, "Signalized Intersections." Two-lane highways in urban and suburban areas with multiple signalized intersections at spacings of 2.0 miles or less can be evaluated with the methodology of HCM 2000 Chapter 15, "Urban Streets."

Limitations of the HCM Multilane Highway Methodology (HCM 2000, Chapter 21). The methodology in HCM 2000 does not take into account the following conditions:

- Transitory blockages caused by construction, accidents, 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;
- The effect of lane drops and additions at beginning or end of segments;
- Possible queuing delays when transitions from a multilane segment into a two-lane segment are neglected;
- Differences between median barriers and two-way left-turn lanes; and
- FFS below 45 mph or above 60 mph.

Limitations of the HCM Freeway Methodology (HCM 2000, Chapter 22). 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 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 study time duration.

Certain freeway traffic conditions cannot easily be analyzed by the methodology. Multiple overlapping bottlenecks are an example. Therefore, other tools may be more appropriate for specific applications beyond the capabilities of the methodology. Refer to HCM 2000 Part V for a discussion of simulation 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. On 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 user 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.

The analyst can, given enough time, 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 HCM 2000 Part V before undertaking this methodology.

Limitations of the HCM Basic Freeway Segment Methodology (HCM 2000, Chapter 23). 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 high-occupancy vehicle (HOV) lanes, truck lanes, and climbing lanes;
- Extended bridge and tunnel segments;
- Segments near a toll plaza;
- Facilities with free-flow speeds below 55 mph or in excess of 75 mph;
- Demand conditions in excess of capacity (refer to HCM 2000, Chapter 22 for further discussion);
- The influence of downstream blockages or queuing on a segment;
- Posted speed limit, the extent of police enforcement, or the presence of ITS features related to vehicle or driver guidance; or
- Capacity-enhancing effects of ramp metering.

The analyst would have to draw on other research information and develop special-purpose modifications of this methodology to incorporate the effects of the above conditions.

Limitations of the HCM Freeway Weaving Methodology (HCM 2000, Chapter 24). 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; and
- Multiple weaving segments.

The last subject, which has been treated in previous editions HCM, has been deleted. Multiple weaving segments must be divided into appropriate merge, diverge, and simple weaving segments for analysis.

Limitations of the HCM Ramp and Ramp Junction Methodologies (HCM 2000, Chapter 25). The methodology in HCM 2000 does not take into account nor is it applicable (without modifications by the analyst) to the following:

- Special lanes, such as HOV lanes, as ramp entrance lanes;
- Ramp metering;
- Oversaturated conditions;
- Posted speed limit and extent of police enforcement; and
- Presence of ITS features.

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 analysis period into time slices, a simulation model can evaluate the buildup, dissipation, and duration of traffic congestion. Simulation models, by evaluating systems of facilities, can evaluate the interference that occurs when congestion builds up at one location and impacts the capacity of another location.

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.

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;
- The impacts of driveway access;

- The impacts of raised medians;
- The impacts of on-street parking, commercial vehicle loading, and double parking; and,
- The interference that can occur between bicycles, pedestrians, and vehicles sharing the same roadway.

Simulation models also assume "100 percent safe driving," so they will not be effective at 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 (for example, visibility obstructions or roadside distractions such as a stalled vehicle).

1.4.4 Differences Between HCM and Simulation

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

Not only are there differences in approach, there are differences in the definition of the performance measures produced by simulation models and HCM tools.

- Simulation models report density for actual vehicles, while the HCM reports density in terms of equivalent passenger cars (trucks and other heavy vehicles are counted more than once in the computation of density);
- Simulation models report vehicle flows in terms of actual vehicles, while the 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 the HCM reports all delay caused by a given bottleneck (regardless of the actual physical location of the vehicles); and
- Simulation models report queues only on the street segment where the vehicles are actually queued, while the HCM reports all queued vehicles caused by a given bottleneck (regardless of the actual physical location of the vehicles).

1.4.5 Strategy for Overcoming Limits 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 analysis tools vary in data requirements, capabilities, methodology, and outputs. In addition, the performance measures between the simulation models and the HCM procedures may differ in definition and/or the methodology (e.g., number of stops may be estimated at speeds of less than 5 mph in one tool, but 0 mph for another).

If it is not necessary to microscopically trace individual vehicle movements, then the analyst can take advantage of the simpler data entry and control optimization features available in many macroscopic simulation models. However, macroscopic models often have to make certain assumptions 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 section of a particular simulation tool.

More information on this issue may be found in the "Guidelines for Applying Traffic Micro-Simulation Modeling Software" developed for the FHWA by Dowling Associates and Cambridge Systematics, Inc.

2.0 Criteria for Selecting the Appropriate Traffic Analysis Tool Category

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 type of tool should be used. Section 3.0 of this document contains guidance on how to use this information to select the appropriate type of tool. The end of the section discusses comparisons between HCM analysis methods and simulation, including their strengths, weaknesses, and differences, as well as a strategy for overcoming the limitations of HCM.

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 the identification of the analysis context for the task at hand: planning, design, or operations/construction. Seven additional criteria are necessary to help identify the analysis tools that are most appropriate for a particular project. Depending on the analysis 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 a network.

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

3. Ability to analyze various **travel modes**, such as single-occupancy vehicles (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 at hand, mainly from a management or operational perspective. Parameters influencing cost-effectiveness include tool capital cost,

level of effort required, ease of use, hardware requirements, data requirements, animation, etc.

Each analysis tool category was evaluated against each criterion to identify whether or not a category of analysis tool is 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 *full circle* (●) symbol means that the particular tool category adequately addresses the criterion. On the other hand, an *empty circle* (○) symbol means that traffic analysis tool category poorly addresses the specific criterion. A *null* (∅) symbol means that some tools within the tool category may address the criterion and others may not, while "*not applicable*" (na) is used when the particular tool category does not address the corresponding criterion at all and should not be used for the analysis.

Figure 2.1 summarizes the criteria that may be considered for the selection of a tool category.

- The users should begin by identifying the project's analysis context (discussed in Section 2.1).
- Next, the users would filter through Criteria 1 through 6 to limit the appropriate tool categories down to one or two options, as discussed in Sections 2.2.1 through 2.2.6.
- Finally, Criterion 7 (cost/tool effectiveness) would be used to select the final tool category (presented in Section 2.2.7) based on parameters outside the technical context of the analysis such as tool cost, training, hardware requirements, etc.

Step-by-step guidance on tool selection process is presented in Section 3.0, along with a list of recommended further readings. Finally, a listing of available tools for each category and their web site links are provided in Section 4.0.

2.1 Analysis Context

The first step in selecting the appropriate type of traffic analysis tool is the identification of the analysis context of the project. Figure 2.1 illustrates a typical transportation analysis process, which contains several analysis phases, including:

- **Planning –** Includes short- or long-range studies or other state, regional, or local transportation plans (i.e., master plans, Congestion Management Plans, ITS strategic plans, etc.).
- **Design –** This analysis phase includes approved and funded projects that are going through alternatives analysis or preliminary design to determine the best option for implementation. This phase also includes the analysis of roadway features needed to operate at a desired level of service (LOS). Full design projects (i.e., horizontal/vertical alignments, pavement design, etc.) are not included under this category.

Figure 2.1 Criteria for Selecting a Tool Category

Analysis Context: Planning, Design, or Operations/Construction

1 Geographic Scope	2 Facility Type	3 Travel Mode	4 Management Strategy	5 Traveler Response	6 Performance Measures	7 Tool/Cost-Effectiveness
What is your study area?	**Which facility types do you want to include?**	**Which travel modes do you want to include?**	**Which management strategies should be analyzed?**	**Which traveler responses should be analyzed?**	**What performance measures are needed?**	**What operational characteristics are necessary?**

• Isolated Location
• Segment
• Corridor/ Small Network
• Region
	• Isolated Intersection
	• Roundabout
	• Arterial
	• Highway
	• Freeway
	• HOV Lane
	• HOV Bypass Lane
	• Ramp
	• Auxiliary Lane
	• Reversible Lane
	• Truck Lane
	• Bus Lane
	• Toll Plaza
	• Light Rail Line
		• SOV
		• HOV (2, 3, 3+)
		• Bus
		• Rail
		• Truck
		• Motorcycle
		• Bicycle
		• Pedestrian
			• Freeway Mgmt
			• Arterial Intersections
			• Arterial Mgmt
			• Incident Mgmt
			• Emergency Mgmt
			• Work Zone
			• Spec Event
			• APTS
			• ATIS
			• Electronic Payment
			• RRX
			• CVO
			• AVCSS
			• Weather Mgmt
			• TDM
				• Route Diversion
				  - Pre-Trip
				  - En-Route
				• Mode Shift
				• Departure Time Choice
				• Destination Change
				• Induced/ Foregone Demand
					• LOS
					• Speed
					• Travel Time
					• Volume
					• Travel Distance
					• Ridership
					• AVO
					• v/c Ratio
					• Density
					• VMT/PMT
					• VHT/PHT
					• Delay
					• Queue Length
					• # Stops
					• Crashes/ Duration
					• TT Reliability
					• Emissions/ Fuel Consump
					• Noise
					• Mode Split
					• Benefit/Cost
						• Tool Capital Cost
						• Effort (Cost/ Training)
						• Ease of Use
						• Popular/Well-Trusted
						• Hardware Requirements
						• Data Requirements
						• Computer Run Time
						• Post-Processing
						• Documentation
						• User Support
						• Key Parameters User Definable
						• Default Values
						• Integration
						• Animation/ Presentation

- **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 2.1 presents the general relevance of each tool category for each analysis context, including planning, design, and operations/construction.

Table 2.1 Relevance of Traffic Analysis Tool Categories with respect to Analysis Context

Analysis Context	Analysis Tools/Methodologies						
	Sketch Planning	**Travel Demand Models**	**Analytical/ Deterministic Tools (HCM-based)**	**Traffic Optimi-zation**	**Macroscopic Simulation**	**Mesoscopic Simulation**	**Microscopic Simulation**
Planning	●	●	∅	○	∅	∅	○
Design	na	∅	●	●	●	●	●
Operations/ Construction	∅	○	●	●	●	●	●

Note: ● – The specific context is generally addressed by the corresponding analysis tool/methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context and some do not.
na – The particular methodology is not appropriate for use to address the specific context.

2.2 Criteria for Analysis Tool Selection and Assessment of Tool Capabilities

Criteria 1 through 7 from Figure 2.1 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 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 analysis environment and geographic scope of the project. Table 2.2 summarizes the general relevance of each tool category based on the study area/geographic scope appropriate for the task at hand. Four types of study areas are included:

Table 2.2 Relevance of Traffic Analysis Tool Categories with respect to Study Area/Geographic Scope

Analysis Context/ Geographic Scope	Analysis 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	∅	●	na	na	na	na	na
Design							
Isolated Location	na	na	●	●	●	∅	●
Segment	na	○	●	∅	●	●	●
Corridor/ Small Network	na	∅	○	○	●	●	●
Region	na	∅	na	na	○	○	○
Operations/ Construction							
Isolated Location	na	na	●	●	●	∅	●
Segment	∅	○	●	●	●	●	●
Corridor/ Small Network	na	∅	○	○	●	●	●
Region	na	∅	na	na	○	○	○

Note: ● – The specific context is generally addressed by the corresponding analysis tool/ methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context and some do not.
na – The particular methodology is not appropriate for use to address the specific context.
(1) For linear networks.

- **Isolated Location –** Limited study area, such as a single intersection or interchange;

- **Segment –** Linear or small grid roadway network;

- **Corridor/Small Network –** An expanded study area which typically includes one major corridor with one or two parallel arterials and their connecting cross-streets, typically less than 200 square miles; and

- **Region –** City-wide or county-wide study area involving all freeway corridors and major arterials, typically 200 square miles or larger.

Notes and assumptions:

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

- For the traffic simulation tool categories (macro-, meso-, and micro-simulation), the geographic area relevance factors are identical, because in general, simulation tools feature the same geographic areas (i.e., segment, corridor, etc.), but with varying levels of detail.

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

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 the *Highway Capacity Manual 2000*. The relevance of analysis tool categories with respect to the facility type criterion is presented in Table 2.3. The facility types include:

- **Freeway –** A 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. It may be used by other traffic under certain circumstances, such as off-peak hours, for making a right or left turn, or by motorcycles, depending on the jurisdiction's traffic laws.

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

Table 2.3 Relevance of Traffic Analysis Tool Categories with respect to Facility Type

Facility Type	Analysis Tools/Methodologies						
	Sketch Planning	**Travel Demand Models**	**Analytical/ Deterministic Tools (HCM-based)**	**Traffic Optimiza-tion**	**Macroscopic Simulation**	**Mesoscopic Simulation**	**Microscopic Simulation**
Isolated Intersection	○	∅	●	●	●	●	●
Roundabout	○	○	●	○ (1)	∅	○	∅
Arterial	●	●	●	●	●	●	●
Highway	●	●	●	∅ (1)	●	∅	○
Freeway	∅	●	●	∅	●	●	●
HOV Lane	∅	●	∅	○	●	●	●
HOV Bypass Lane	○	●	○	∅	∅	∅	●
Ramp	∅	●	●	●	●	●	●
Auxiliary Lane	○	○	∅	∅	●	●	●
Reversible Lane	○	∅	○	○	○	○	∅
Truck Lane	○	●	∅	∅	∅	○	●
Bus Lane	○	●	○	○	∅	○	●
Toll Plaza	○	∅	∅	○	○	○	●
Light-Rail Line	○	●	○	○	○	○	●

Note: ● – The specific context is generally addressed by the corresponding analysis tool/ methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context, some do not.
na – The particular methodology is not appropriate for use to address the specific context.
(1) Generally it is not appropriate to optimize a 2-lane highway or roundabout.

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

- **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.

- **Reversible Lane –** A 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.

- **Auxiliary Lane –** An additional lane on a freeway to connect an on-ramp and an off-ramp.

- **Ramp –** A short segment of roadway connecting two roadway facilities.

- **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.

- **Toll Plaza –** Facility where payment transactions for the use of the roadway takes place. It may be located upstream or downstream of the tolled facility.

- **Highway –** High speed roadway connecting major areas or arterials, with little or no traffic signal interruption (i.e., two-lane highway, expressway).

- **Arterial –** A signalized street that primarily serves through traffic and that secondarily provides access to abutting properties, with signal spacing of two miles or less.

- **Roundabout –** An unsignalized intersection with a circulatory roadway around a central island with all entering vehicles yielding to the circulating traffic.

- **Isolated Intersection –** Single crossing point between two or more roadway facilities.

2.2.3 Travel Mode

Table 2.4 presents the matrix rating the appropriateness of each tool category in analyzing different travel modes. The definitions for the travel modes are based on the *Highway Capacity Manual 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;

- **Rail –** Including both light and heavy rail systems, rail is a transit system using trains operating in exclusive or shared right-of-way;

- **Truck –** A heavy vehicle engaging primarily in the transport of goods and materials or in the delivery of services other than public transportation;

- **Motorcycle –** A self-propelled vehicle with two wheels tandem that may be ridden by two persons maximum;

Table 2.4 Relevance of Traffic Analysis Tool Categories with respect to Travel Mode

Travel Mode	Analysis 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	∅	○	∅	∅	∅	∅	∅

Note: ● – The specific context is generally addressed by the corresponding analysis tool/ methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context and some do not.
na – The particular methodology is not appropriate for use to address the specific context.

- **Bicycle –** A vehicle with two wheels tandem propelled by human power, and usually ridden by one person; and

- **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 –** Control, guidance, and warning of traffic in order to improve the flow of people and goods on limited access facilities. Examples of freeway management include 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 arterials operations, such as geometric improvements, parking adjustments, signal timing for individual intersections. These types of improvements would typically involve capacity analysis, level of service (LOS) analysis, as well as unsignalized and signalized intersection studies.

- **Arterial Management –** The application of state and local planning, capital, 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 to the transportation network and traveler safety is minimized. It 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 Zone –** The use of traffic control devices (signs, channeling devices, barriers, etc.) and traveler information to maximize the availability of roadways during construction or maintenance, while minimizing the impacts on the traveling public and highway workers.

- **Special Event –** Manages planned events so that the impact to the transportation network and traveler safety is minimized, through coordination with other traffic management, maintenance and construction management and emergency management centers, as well as event promoters.

- **Advanced Public Transportation System (APTS) –** The application of advanced technologies to the operations, maintenance, customer information, planning, and management functions for the transit agency. APTS includes advanced communications between transit departments with 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 scheduling systems (ATSS); transit security; and fleet maintenance.

- **Advanced Traveler Information System (ATIS) –** Ranges from simply providing fixed transit schedule information to multi-modal traveler information including real-time traffic conditions and transit schedules along with 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 Monitor –** Manages traffic at highway-rail intersections where operational requirements demand advanced features. It includes capabilities from the Standard Rail Crossing equipment package and augments these with additional safety features, including positive barrier systems and wayside interface equipment which detects, or communicates with the approaching train.

- **Commercial Vehicle Operations (CVO) –** Performs advanced functions supporting commercial vehicle operations including communications between drivers, fleet managers, and roadside officials; automates identification and safety processing at mainline speeds; and timely and accurate HAZMAT cargo information after a vehicle incident.

- **Advanced Vehicle Control and Safety System –** Vehicle safety systems including vehicle or driver safety monitoring; longitudinal, lateral, or intersection warning control or collision avoidance; pre-crash restraint; and automated highway systems.

- **Weather Management –** Automated collection of weather conditions and the use of the 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 needs for or time of travel. They are typically implemented in urban areas in order 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 2.5 summarizes the 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 Table 3.2.

Notes and Assumptions:

- Some analytical/deterministic tools can estimate the impacts of incidents, work zones, special events, and weather through reductions in the 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 sensing of individual vehicles (e.g., adaptive control at individual intersections or arterials).

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 2.6 represents how well or badly the analysis tool categories can model these traveler responses.

- **Route Diversion –** Capture changes in travel routes, including pre-trip route diversion and en-route route diversion;

Table 2.5 Relevance of Traffic Analysis Tool Categories with respect to Management Strategy and Applications

Management Strategy and Applications	Analysis 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 Zone	∅	○	●	○	●	●	●
Special Event	∅	○	●	○	∅	∅	∅
Advanced Public Transportation System	∅	○	○	○	○	○	∅
Advanced Traveler Information System	∅	○	○	○	○	∅	∅
Electronic Payment System	∅	○	○	○	○	○	●
Rail Grade Crossing Monitor	∅	○	○	○	○	○	●
Commercial Vehicle Operations	∅	○	○	○	○	○	∅
Advanced Vehicle Control and Safety System	∅	○	○	○	○	○	∅
Weather Management	○	○	○	○	∅	∅	∅
Travel Demand Mgmt	●	●	∅	○	∅	∅	∅

Note: ● – The specific context is generally addressed by the corresponding analysis tool/ methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context and some do not.
na – The particular methodology is not appropriate for use to address the specific context.

Table 2.6 Relevance of Traffic Analysis Tool Categories with respect to Traveler Response

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

Note: ● – The specific context is generally addressed by the corresponding analysis tool/methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context, some do not.
na – The particular methodology is not appropriate for use to address the specific context.

- **Mode Shift –** Capture changes regarding the selection of travel mode;
- **Departure Time Choice –** Capture changes in the time of travel;
- **Destination Change –** Represent changes to travel destinations; and
- **Induced/Foregone Demand –** Estimate new trips (induced demand) or foregone trips resulting from the implementation of traffic management strategies.

Notes and assumptions:

- Analytical/deterministic models assume that the traffic demand is fixed throughout the analysis period. Although it may be possible to specify changes in demand (due to diversion for example 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 it may not be capable of modeling 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 demands.

- Most traffic analysis tools are not capable of predicting destination changes or induced/foregone demand as a result of transportation improvements. Users of this document should consider this when applying criteria weights to these items in the tool selection worksheet (Table 3.1).

2.2.6 Performance Measures

This section discusses the tool categories' ability to produce various performance measures, in the areas of safety, efficiency, mobility, productivity, and environmental (as summarized in Table 2.7). 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, ranging from LOS A (best) to LOS F (worst).

- **Speed –** A rate of motion expressed as 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 –** The 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 –** The extent of space between the trip origin and destination, measured along a vehicular route.

- **Ridership –** The number of passengers on the evaluated transit system.

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

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

- **Density –** The number of vehicles on a roadway segment averaged over space, usually expressed as 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.

Table 2.7 Relevance of Traffic Analysis Tool Categories with respect to Performance Measures

Performance Measures	Analysis 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/ Accidents	∅	○	○	○	○	∅	∅
Incident Duration	○	○	○	○	○	∅	∅
Travel Time Reliability	∅	○	○	○	○	○	○
Emissions	∅	○	○	○	○	∅	∅
Fuel Consumption	∅	○	○	○	○	∅	∅
Noise	∅	○	○	○	○	○	○
Mode Split	○	●	●	∅	∅	∅	∅
Benefit/Cost	∅	○	○	○	○	○	○

Note: ● – The specific context is generally addressed by the corresponding analysis tool/ methodology.
○ – The particular analysis tool/methodology does not generally address the specific context.
∅ – Some of the analysis tools/methodologies may address the specific context and some do not.
na – The particular methodology is not appropriate for use to address the specific context.

- **Delay –** The 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 as a distance unit.

- **Number of Stops –** Number of stops experienced by section and/or corridor, based on some minimum travel speed.

- **Crashes/Accidents –** Number of accidents on a transportation facility or network.

- **Incident Duration –** Includes all crashes/accidents 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 of 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 –** The fuel consumption rate associated with the use of a transportation facility or network.

- **Noise –** The sound level produced by the traffic, expressed in decibels.

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

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

Notes and assumptions:

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

- The relevance factors for the performance measures listed in Table 2.7 are based on the assumption that these measures are generally direct outputs of the tool category.

- Table 2.7 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 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 analysis tool. In addition, using a more advanced and data intensive tool may provide a "richer" understanding of the alternatives, but accurate and detailed data are still needed to produce representative results. The level of effort and operational characteristics criteria to consider are summarized in Table 2.8, and include the following:

- **Tool capital cost –** What is the capital cost to acquire the traffic analysis tool? Under this category, tools that cost under $1,000 are considered inexpensive, while tools ranging between $1,000 and $5,000 are considered mid-range. Any tools costing more than $5,000 are considered expensive. Inexpensive tools are rated in Table 2.8 with a "●," mid-range are neutral "∅," and expensive tools are rated as "○."

- **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 to no training receive a "●," "∅" is assigned to tool types requiring a moderate amount of training, and tools requiring expensive and lengthy training receive a "○."

- **Easy to use –** Is the tool generally user-friendly? (i.e., Windows-based, has drag-and-drop features, etc.). Easy to use and intuitive tools are scored with a "●." Tools requiring a significant amount of additional coding and/or data input and analysis is cumbersome are assigned a "○." Those in between are coded as neutral "∅."

- **Popular/well-trusted –** Is it popular and well-regarded by current users? If yes, the tool category is assigned a "●." A "∅" is assigned to tools that are well-used, but accuracy of the results is highly constrained by data inputs and methodology constraints. A "○" is used for tools that are generally not used in practice at this time.

- **Hardware requirements –** What are the minimum computer requirements to adequately run the analysis? Pentium II and older computers are considered low hardware capability (○), Pentium III and their equivalents are considered medium (∅), while Pentium IV and beyond are considered adequate computing capabilities (●).

- **Data requirements –** What typical amount of input data is required to perform the analysis? The input data may include traffic volume, speed limit, traffic signal timing, intersection/roadway geometric characteristics, number of general purpose and HOV lanes, ramp meter locations and their timings, detector locations, Origin-Destination (O-D) trip tables, etc. Low data requirements are assigned a "●," moderate data requirements a "∅," and "○" for data intensive tools.

Table 2.8 Relevance of Traffic Analysis Tool Categories with respect to Tool/ Cost Effectiveness

Tool/Cost Effectiveness	Analysis 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 text for descriptions of ●, ○, and ∅ for each subcriteria.

- **Computer run time –** Assuming adequate computer hardware is available, how long does the tool take perform the analysis? Run times of less than five minutes are considered minimal (●), while run times averaging between five minutes and one hour are considered moderate (∅). Run times lasting more than one hour per run are considered long (○).

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

- **Documentation –** Does the tool have a detailed and well-written user's manual? Are there articles and reports on past projects evaluated using this tool type? Excellent documentation is assigned a "●," moderate a "∅," and little to no documentation a "○."

- **User support –** Is technical support generally available for this tool type? Are there mailing lists, chat rooms or newsgroups dedicated to this tool, where users can communicate with each other? A "●" is assigned to tool types with a high level of user support, "∅" for moderate, and "∅" for no support.

- **Key parameters can be user-defined –** Does the tool type allow for customization of the key analysis parameters? Is the tool type flexible enough to allow for customization (i.e., many micro-simulation tools are flexible enough to allow users to add custom programming codes in addition to the standard package)? If customization is available the tool receives a "●," if not a "○" is assigned. A "∅" is used for tools with limited customization capabilities.

- **Default values are provided –** Does the tool type 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 on all of the necessary parameters (i.e., average walking speed, average reaction time, etc). A "●" is used for tools with defaults available for most parameters, "∅" for tools with some, and "○" for tools with little or no defaults available.

- **Integration with other software –** Does the tool type generally have export/import features to/from other software (i.e., integration with Excel, GIS tools, other traffic analysis tools, etc)? Simple export/import features are assigned a "●," tools with some or limited capabilities a "∅," and "○" for tools with no import/export capabilities.

- **Animation/presentation –** Does it have animation/presentation features (i.e., animated, colorful, 3-D views, zoom in/out capabilities, detailed link views as opposed to "stick figures," able to produce charts and tables, etc)? The relevance factors used are excellent (●), some presentation outputs (∅), and no features (○).

3.0 Guidelines to Users

The purpose of this section is to provide guidance to the users on how to utilize the criteria presented in Section 2.0 to select the appropriate analysis tool category. Worksheets are provided in this section to help the users work through the process of selecting the appropriate tool to address the project's goals and objectives.

3.1 Steps for Selecting the Appropriate Tool Category

This section details the recommended steps for the selection of the appropriate tool category for the task at hand. Depending on the project, more than one analysis tool may be capable of the analysis and produce the desired outputs. In some cases, a combination of tools from multiple analysis tool categories may be required to address an analytical problem.

Table 3.1 presents a worksheet that may be used to help in the tool category selection process. Using the steps described below, fill out the cells of Table 3.1 accordingly:

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 level of detail required by each project context. Therefore, the first step is to carefully think about the context of the project at hand (whether it is planning, design, or operations/construction), as well as the goals, objectives, issues, and needs of the project. Next, enter the analysis context relevance weight into Column 2 depending upon the type of study. The values entered in Column 2 should range between 0 (not relevant) and 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 analysis contexts, please 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).

Table 3.1. 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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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		-999	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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	5	5							
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 3.1. Tool Category Selection Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	10	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	0	10	10	10	10							
Arterial Intersections		0	0	10	10	10	10	10							
Arterial Management		5	5	0	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	0	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							
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion		5	10	-999	0	10	10	10							
En-Route Route Diversion		5	10	-999	0	10	10	10							
Mode Shift		5	10	-999	0	5	5	5							
Departure Time Choice		5	0	-999	0	5	5	5							
Destination Change		-999	5	-999	-999	-999	0	5							
Induced/Foregone Demand		5	5	-999	-999	-999	-999	5							
								Subtotal							
								Relevance Weights Above 0							
								WEIGHTED SUBTOTAL							

Table 3.1. Tool Category Selection Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS		0	5	10	10	10	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	5	5							
V/C Ratio		0	10	5	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	0	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 3.1. Tool Category Selection Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	10	10	10	5	0	5							
Hardware requirements		10	5	10	10	10	0	0							
Data requirements		10	0	10	10	5	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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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, (∅) = 5 points, (○) = 0 points, (na) = -999 points.

2. **Assign sub-criteria relevance weights (Column 2) –** In this step, the user assigns relevance weights to sub-criteria within each type of criterion. Sub-criteria that are highly desired to be considered as part of the project should be given higher weights. The relevance values that should be entered in Column 2 range between 0 (not relevant) and 5 (most relevant). Enter weights for each sub-criterion as they relate to each other and the project needs.

   Examples for assigning relevance weights follows:

   a. **Geographic Scope:** If the study area consists of a 5-mile 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 to all other sub-criteria.

   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 impacts on those are not as important, a weight of 5 should be placed on "Freeway," "Arterial," and "Ramps," while a weight of 3 might be assigned to "HOV Lane" and "Auxiliary Lane." A weight of 0 would be applied to the other facility type sub-criteria.

   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 assigned to "SOV," and 2 to "HOV," 1 to the "Truck," and 0 to the other modes.

   d. **Management Strategy/Application:** The project involves ramp metering only. A weight of 5 would be assigned to "Freeway Management" and the other sub-criteria would receive a 0 weight.

   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, but they are not nearly as relevant for the analysis. "Route Diversion" should be assigned a weight of 5, "Mode Shift" and "Departure Time Choice" each a weight of 2, and the other traveler responses a 0 weight.

   f. **Performance Measures:** The stakeholders for this project are interested in travel speed, volume, and travel time changes anticipated from the ramp metering project. A benefit/cost comparison is also desired to determine if the project is worthwhile to implement. The measures to consider for the benefit/cost comparison include mobility (delay), travel time reliability, safety (accidents), emissions, and fuel consumption. Weights of 5 would be assigned to "Speed," "Volume," "Travel time," "Delay," "Travel time reliability," "Crashes/accidents," "Emissions," "Fuel Consumption" and "Benefit/Cost." Many of these measures are based on VMT and VHT/PHT. Therefore, in case some of the desired measures are not available, "VMT/PHT" and "VHT/PHT" measures would be assigned a weight of 4. As this is a ramp metering project, it would also be nice to know queue length but it is not required, so assign a weight of 2 to "Queue

Length." The other performance measure sub-criteria would be assigned a 0 weight.

g. **Tool/Cost-Effectiveness:** There is adequate budget to address all aspects of the project including cost to acquire the tool, staff training costs, hardware requirements and analysis runs. The high priorities for the project in this area involve confidence in the results, 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 assigned to "Popular/well-trusted," "Post-processing requirements," "Key parameters can be user-defined," and "Animation/presentation features." Weights of 3 would be assigned to "Easy to use," "Data requirements," and "Default values are provided." Weights of 2 would be assigned to "Low tool costs," "Level of effort/training," "Documentation," and "User support." And a weight of 1 would be assigned to "Hardware requirements." "Integration with other software" is not of concern and would receive a 0 weight.

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).

3. **Assign tool relevance values (Column 3) –** Most of these values are provided as part of the worksheet (Table 3.1) based on the assessment presented in Tables 2.1 through 2.8. Only the geographic scope criterion requires user input of tool relevance values in Column 3. Using the appropriate analysis context and the tool relevance factors presented in Table 2.2, enter the tool relevance values for Geographic Scope in Column 3:

   a. For every *full circle* (●) sign, assign a value of 10;

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

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

   d. For every *"not applicable"* (na), assign a value of –999.

Step 3 – From Table 2.2, enter relevance factors for Geographic Scope criteria into Column 3 using the appropriate analysis context. Use the following values: (+) = 10 points, (o) = 5 points, (-) = 0 points, (na) = -999 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	-999	-999	10	10	10	5	10
	Segment	5	5	0	10	10	10	10	10
	Corridor/Small Network	0	-999	5	0	0	10	10	10
	Region	0	-999	5	-999	-999	0	0	0

4. **Multiply Columns 2 and 3 (Column 4) –** For the analysis context and each sub-criterion, multiply the entries in Column 2 with the entries in each sub-column in Column 3, and enter the products into the appropriate cells in Column 4.

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

2	3			4						
Sub-Criteria Relev	Too			Column 2 x Column 3						
	Sketch Plan	TDM	An (	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0	-999	-999		*0x-999 = 0*	0	0	0	0	0	0
5	5	0		*5x5 = 25*	0	50	50	50	50	50
0	-999	5		*0x-999 = 0*	0	0	0	0	0	0
0	-999	5		*0x-999 = 0*	0	0	0	0	0	0

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

6. **Count the number of sub-criteria relevance weights above zero –** For the analysis context and each criterion, count the number of relevance weights in Column 2 that are larger than zero, and enter the value into the "Relevance Weights Above 0" cell.

7. **Calculate the criteria ratings –** Divide the values in the "Subtotal" rows with the number of "Relevance Weights Above 0" cell, and enter into the "Weighted Subtotal" row. Repeat this process for each criterion.

	4						
	Column 2 x Column 3						
	Sketch Plan	**TDM**	**Analytical (HCM)**	**Traffic Opt**	**Macro Sim**	**Meso Sim**	**Micro Sim**
	0	0	[illegible]	[illegible]	[illegible]	[illegible]	0
	25	0					50
	0	0					0
	0	0					0
Subtotal	*0+25+0+0=25*	0	50	50	50	50	50
Relevance Weights Above 0	*1*						
WEIGHTED SUBTOTAL	*25/1 = 25*	0	50	50	50	50	50

Step 5 – Sum values for each tool category and criteria into the "Subtotal" row.

Step 6 – Count the number of relevance weights (Column 2) that are greater than zero.

Step 7 – Divide the values in the "Subtotal" rows with the "Relevance Weights Above 0" cell, enter into the "Weighted Subtotal" row.

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

7						
Weighted Subtotals						
Sketch Plan	**TDM**	**Analytical (HCM)**	**Traffic Opt**	**Macro Sim**	**Meso Sim**	**Micro Sim**
25	0	50	50	50	50	50

WEIGHTED SUBTOTAL	25	0	50	50	50	50	50
WEIGHTED SUBTOTAL							
WEIGHTED SUBTOTAL							
WEIGHTED SUBTOTAL							
WEIGHTED SUBTOTAL							
WEIGHTED SUBTOTAL							
WEIGHTED SUBTOTAL							

Step 8 – Copy all weighted subtotals into Column 7.

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 sub-criteria relevance in Column 2. Make adjustments as necessary to the sub-criteria 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 sub-criteria 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, needs, issues, and priorities. For the analysis context and each of the seven criterions, assign appropriate weights, ranging

from 0 (not relevant) to 5 (most relevant). If a user wants to weight each of the criteria and analysis context equally, a weight of 5 can be applied to all. A different weighting scheme may be used if greater differentiations between criterions are necessary. The user should carefully consider the project's priorities, needs, and constraints when selecting the criteria weights.

Step 9 – Review negative values in Column 7 and re-assess relevance values for sub-criteria.

6	7						
Criteria Rele-vance	Weighted Subtotals						
	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5	25	0	50	50	50	50	50
3	25	0	50	50	50	50	50
3	15	33	20	16	23	21	33
3	16	25	13	13	13	21	21
4	19	13	17	20	27	27	30
1	13					2	22
5	13					2	23
5	20					0	11

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

11. **Multiply Columns 6 and 7 (Column 8) –** For each context/criterion, multiply the value in Column 6 with each of the sub-columns in Column 7, and enter the result into the appropriate cells in Column 8.

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

6	7			8						
Criteria Rele-vance				Column 6 x Column 7						
	Sketch Plan	TDM	Ana (H	Sketch Plan	TDM	Analytical (HCM)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5	25	0		125	0	250	250	250	250	250
3	25	0		75	0	150	150	150	150	150
3	15	33		45	100	60	48	70	63	98
3	16	25		49	75	39	38	38	62	64
4	19	13		76	52	68	80	108	108	120
1	13	23		13	23	-2664	0	22	22	22
5	13	16		65	82	78	82	91	110	114
5	20	11		100	57	111	93	93	50	57

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 are the most appropriate tools for the task at hand.

Step 12 – Sum values of each sub-column in Column 8 and enter into the "Weighted Totals" cells.

WEIGHTED TOTALS	548	389	-1908	740	821	814	874
Most Appropriate Tool Categories:	**1.**	**Micro Sim**					
	2.	**Macro Sim**					

Step 13 – Select the top two tool categories. Given the users' input into this worksheet, these are the most appropriate tool types for consideration.

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 zero 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 to conduct a particular study and those tools may or may not be from the same tool category. Each of the sub-criteria with high relevance factors and low scores in Column 4 will need to be assessed to determine if that particular category of tool weaknesses can be overcome through other means (e.g., the need for micro-simulation, but not having the computer requirements to accommodate the analysis needs).

3.2 Examples for Using the Tool Category Selection Worksheets

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 impacts 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 parallel arterials. The study corridor is approximately 15 miles long running north-south, with one parallel arterial on each side of the freeway less than ½ mile away. Passenger car impacts are 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 create traffic diversion to the parallel arterials, the traffic analysis tool's ability 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 the deployment of ramp meters at this corridor will not happen without the support from the local City partners. The State DOT and the local traffic jurisdictions have developed excellent working relationships over the years, but the Cities are reluctant to support the ramp metering project, fearing that the traffic queues at the on-ramps and route diversion would reduce the performance of their arterials. So, an objective of the evaluation is to select the ramp metering strategy that can be accepted by all stakeholders. The tool's ability to produce animations of the results is preferred but 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 for this task. The State has obtained the arterial/interchange signal timings from the local Cities in preparation for this project. Old aerial photos representing the corridor before the 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 the optimal ramp metering strategy.
- Project Objectives and Background:
  - Analyze fixed-time and adaptive ramp metering under various operating parameters;
  - Corridor study area (15 miles) with two parallel arterials;
  - Focus on roadways and passenger vehicles;
  - Aerial photos, design drawings, and existing signal timings available;
  - Volume, speed, and travel time as the main output;
  - Traveler response, particularly route diversion is crucial;
  - Good presentation/animation capabilities preferred;
  - Tool should be versatile yet sensitive enough to model small variations in parameters; and
  - Tool should be popular/well-trusted by the industry.

Tool Category Selection Worksheet for Example #1

Table 3.2 shows a completed worksheet for this example. Based the analysis performed using the worksheet, this project can be best evaluated using three different tool categories (only two negative final scores, while three of seven scores are close). The most appropriate tool category is 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 500 square miles, but 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 in EMME/2 format from the local travel demand model. Aerial photos are available; they are a few years old, but the major transportation infrastructure has not changed, and none is expected in the future. Alternative modes of transportation such as transit, motorcycles, trucks, and light rail are important, but the impacts on passenger cars are the focus of the study. The ITS strategies to be considered include ramp metering, incident management, arterial management, and advanced traveler information (ATIS). The MPO has developed origin-destination (O-D) trip tables both for 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 outputs 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 in the field. However, they are computer-savvy and seem to absorb new things extremely well, given the availability of learning resources. This project has a healthy budget, but 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 six 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 impacts related to the deployment of ITS strategies: ramp metering, incident management, arterial management, and ATIS;
  - Large study area (500 square miles);
  - Focus on roadways and passenger vehicles;

Table 3.2. 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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	-999	5	10	10	10	10	10	-4995	25	50	50	50	50	50
Operations/Construction	0	5	0	10	10	10	10	10	0	0	0	0	0	0	0
								Subtotal	-4995	25	50	50	50	50	50
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	-4995	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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
1 Geographic Scope (0 = not relevant, 5 = most relevant)															
Isolated Location	0	-999	-999	10	10	10	5	10	0	0	0	0	0	0	0
Segment	0	-999	0	10	5	10	10	10	0	0	0	0	0	0	0
Corridor/Small Network	5	-999	5	0	0	10	10	10	-4995	25	0	0	50	50	50
Region	0	-999	5	-999	-999	0	0	0	0	0	0	0	0	0	0
								Subtotal	-4995	25	0	0	50	50	50
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	-4995	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	5	5	40	40	40	20	40	20	20
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	260	280
								Relevance Weights Above 0	7						
								WEIGHTED SUBTOTAL	23	39	32	26	40	37	40

Table 3.2. Example #1 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	10	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	0	10	10	10	10	50	25	0	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	0	10	10	10	10	15	15	0	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	0	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	40	120	120	120	120
								Relevance Weights Above 0	3						
								WEIGHTED SUBTOTAL	22	13	13	40	40	40	40

Table 3.2. Example #1 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion	4	5	10	-999	0	10	10	10	20	40	-3996	0	40	40	40
En-Route Route Diversion	5	5	10	-999	0	10	10	10	25	50	-4995	0	50	50	50
Mode Shift	3	5	10	-999	0	5	5	5	15	30	-2997	0	15	15	15
Departure Time Choice	0	5	0	-999	0	5	5	5	0	0	0	0	0	0	0
Destination Change	0	-999	5	-999	-999	-999	0	5	0	0	0	0	0	0	0
Induced/Foregone Demand	0	5	5	-999	-999	-999	-999	5	0	0	0	0	0	0	0
								Subtotal	60	120	-11988	0	105	105	105
								Relevance Weights Above 0	3						
								WEIGHTED SUBTOTAL	20	40	-3996	0	35	35	35
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS	0	0	5	10	10	10	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	5	5	0	0	0	0	0	0	0
V/C Ratio	0	0	10	5	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	0	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 3.2. Example #1 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1		2	3							4						
			Tool Category Relevance*							Column 2 x Column 3						
Criteria		Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	10	10	10	5	0	5	25	50	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	5	0	0	30	0	30	30	15	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	190	280	245	250	185	210
									Relevance Weights Above 0	13						
									WEIGHTED SUBTOTAL	18	15	22	19	19	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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
0	Analysis Context	3	-4995	25	50	50	50	50	50	-14985	75	150	150	150	150	150
1	Geographic Scope	4	-4995	25	0	0	50	50	50	-19980	100	0	0	200	200	200
2	Facility Type	2	23	39	32	26	40	37	40	46	77	64	51	80	74	80
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	13	40	40	40	40	108	67	67	200	200	200	200
5	Traveler Response	2	20	40	-3996	0	35	35	35	40	80	-7992	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	15	22	19	19	14	16	74	58	86	75	77	57	65
									WEIGHTED TOTALS	-34515	690	-7406	696	1021	1019	1032
									Most Appropriate Tool Categories:	1.	Micro Sim					
										2.	Macro Sim					

*Use the following values for Tool Category Relevance: (●) = 10 points, (∅) = 5 points, (○) = 0 points, (na) = -999 points.

- O-D matrices and skeleton network available;
- Benefit-cost ratios as the main output;
- Tool should be easy to use and have good documentation; and
- Deadline in six months.

Tool Category Selection Worksheet for Example #2

The completed worksheet for this example is shown in Table 3.3. Criteria and sub-criteria weights that address the project's goals and objectives were given higher values. Based on the analysis performed for this example case, the most appropriate tool category is the Travel Demand Model. The sketch planning tool category could also be considered, as the score is reasonably close. The user should further explore the specific tools that fall within these two categories to determine which tool(s) best serve their project's needs. Other tool categories in this example result in scores of less than zero, and should not be considered for analysis.

3.2.3 Example #3 – Arterial Signal Coordination and Pre-emption

A City traffic department is conducting a major traffic signal timing improvement on one of its most critical arterials, which is about ten miles long. This study is being conducted in conjunction with a large redevelopment project, hoping to revive the economy of this section of the 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, but 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, the evaluation process, coupled with an outreach program highlighting the benefits of the project to the community, is needed. Results of the analysis must be presented to the public and stakeholders in the most effective manner.

The best and most experienced staff members are 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 they are already familiar with. The computers available for the project are older Pentium II machines. The City maintains good records of traffic volumes and roadway geometrics for the entire arterial and parallel roadways, and is interested in evaluating as many performance measures as the tool can provide, but 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 as route shifting between the arterial and parallel facilities is of interest to the stakeholders.

Table 3.3. 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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	-999	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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	-999	-999	-999	-999	-999	25	50	-4995	-4995	-4995	-4995	-4995
								Subtotal	25	50	-4995	-4995	-4995	-4995	-4995
								Relevance Weights Above 0	1						
								WEIGHTED SUBTOTAL	25	50	-4995	-4995	-4995	-4995	-4995
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	5	5	50	50	50	25	50	25	25
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	270	315
								Relevance Weights Above 0	11						
								WEIGHTED SUBTOTAL	15	27	22	17	27	25	29

Table 3.3. Example #2 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	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	10	5	5	5	5	5	10	20	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	150	85	85	85	120	120
								Relevance Weights Above 0	6						
								WEIGHTED SUBTOTAL	16	25	14	14	14	20	20
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)															
Freeway Management	5	10	5	0	10	10	10	10	50	25	0	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	0	10	10	10	10	25	25	0	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	0	5	5	25	0	0	0	0	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	40	110	165	190	195
								Relevance Weights Above 0	7						
								WEIGHTED SUBTOTAL	19	7	6	16	24	27	28

Table 3.3. Example #2 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion	5	5	10	-999	0	10	10	10	25	50	-4995	0	50	50	50
En-Route Route Diversion	4	5	10	-999	0	10	10	10	20	40	-3996	0	40	40	40
Mode Shift	3	5	10	-999	0	5	5	5	15	30	-2997	0	15	15	15
Departure Time Choice	1	5	0	-999	0	5	5	5	5	0	-999	0	5	5	5
Destination Change	0	-999	5	-999	-999	-999	0	5	0	0	0	0	0	0	0
Induced/Foregone Demand	0	5	5	-999	-999	-999	-999	5	0	0	0	0	0	0	0
								Subtotal	65	120	-12987	0	110	110	110
								Relevance Weights Above 0	4						
								WEIGHTED SUBTOTAL	16	30	-3247	0	28	28	28
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS	1	0	5	10	10	10	5	5	0	5	10	10	10	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	5	5	0	5	0	0	0	5	5
V/C Ratio	2	0	10	5	5	5	5	5	0	20	10	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	0	5	5	15	0	0	0	0	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	240	245	285	385	385
								Relevance Weights Above 0	19						
								WEIGHTED SUBTOTAL	13	14	13	13	15	20	20

Table 3.3. Example #2 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1		2	3							4						
			Tool Category Relevance*							Column 2 x Column 3						
Criteria		Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	10	10	10	5	0	5	20	40	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	5	0	0	40	0	40	40	20	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	165	340	280	270	165	185
									Relevance Weights Above 0	13						
									WEIGHTED SUBTOTAL	23	13	26	22	21	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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	-4995	-4995	-4995	-4995	-4995	100	200	-19980	-19980	-19980	-19980	-19980
2	Facility Type	2	15	27	22	17	27	25	29	30	54	45	35	54	49	57
3	Travel Mode	2	16	25	14	14	14	20	20	32	50	28	28	28	40	40
4	Management Strategy/Applications	5	19	7	6	16	24	27	28	96	36	29	79	118	136	139
5	Traveler Response	2	16	30	-3247	0	28	28	28	33	60	-6494	0	55	55	55
6	Performance Measures	5	13	14	13	13	15	20	20	67	70	63	64	75	101	101
7	Tool/Cost Effectiveness	4	23	13	26	22	21	13	14	94	51	105	86	83	51	57
									WEIGHTED TOTALS	602	670	-26129	-19688	-19492	-19473	-19530
									Most Appropriate Tool Categories:	1.	TDM					
										2.	Sketch Plan					

*Use the following values for Tool Category Relevance: (●) = 10 points, (∅) = 5 points, (○) = 0 points, (na) = -999 points.

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 (10 miles);
  - Emphasis on cars, buses, and light rail;
  - Volumes, geometric data available;
  - Traveler response, particularly route diversion is necessary;
  - Good presentation/animation capabilities;
  - Avoid high-end, computer-intensive analysis tools;
  - Dependable, trusted tool with flat learning curve; and
  - Outputs in terms of LOS, speed, travel time and intersection delay, by mode.

Tool Category Selection Worksheet for Example #3

Table 3.4 shows a completed worksheet for Example #3. Based 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 likely 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 tool candidates within the category. While the features of the specific traffic analysis tools are beyond the scope of this document, the worksheet presented in Appendix A may assist the 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 tool being reviewed –** If reviewing different versions/releases of the same tool, do not forget to include the version number or release date.

Table 3.4. Example #3 Worksheet

Refer to Sections 2.1 and 2.2 for criteria definitions

Criteria	Context Relevance	Tool Category Relevance							Column 2 x Column 3						
		Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	-999	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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
1 Geographic Scope (0 = not relevant, 5 = most relevant)															
Isolated Location	0	-999	-999	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	-999	5	0	0	10	10	10	0	0	0	0	0	0	0
Region	0	-999	5	-999	-999	0	0	0	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	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	3	10	10	10	5	10	5	5	30	30	30	15	30	15	15
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	120	95	140	125	195
								Relevance Weights Above 0	6						
								WEIGHTED SUBTOTAL	15	33	20	16	23	21	33

Table 3.4. Example #3 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	10	5	5	5	5	5	5	10	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	200	105	100	100	165	170
								Relevance Weights Above 0	8						
								WEIGHTED SUBTOTAL	16	25	13	13	13	21	21
4 Management Strategy/Application (0 = not relevant, 5 = most relevant)															
Freeway Management	0	10	5	0	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	0	10	10	10	10	25	25	0	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	0	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	85	100	135	135	150
								Relevance Weights Above 0	5						
								WEIGHTED SUBTOTAL	19	13	17	20	27	27	30

Table 3.4. Example #3 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim
5 Traveler Response (0 = not relevant, 5 = most relevant)															
Pre-Trip Route Diversion	4	5	10	-999	0	10	10	10	20	40	-3996	0	40	40	40
En-Route Route Diversion	4	5	10	-999	0	10	10	10	20	40	-3996	0	40	40	40
Mode Shift	2	5	10	-999	0	5	5	5	10	20	-1998	0	10	10	10
Departure Time Choice	1	5	0	-999	0	5	5	5	5	0	-999	0	5	5	5
Destination Change	0	-999	5	-999	-999	-999	0	5	0	0	0	0	0	0	0
Induced/Foregone Demand	0	5	5	-999	-999	-999	-999	5	0	0	0	0	0	0	0
								Subtotal	55	100	-10989	0	95	95	95
								Relevance Weights Above 0	4						
								WEIGHTED SUBTOTAL	14	25	-2747	0	24	24	24
6 Performance Measures (0 = not relevant, 5 = most relevant)															
LOS	5	0	5	10	10	10	5	5	0	25	50	50	50	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	5	5	0	15	0	0	0	15	15
V/C Ratio	3	0	10	5	5	5	5	5	0	30	15	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	0	5	5	15	0	0	0	0	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	345	360	400	485	500
								Relevance Weights Above 0	22						
								WEIGHTED SUBTOTAL	13	16	16	16	18	22	23

Table 3.4. Example #3 Worksheet (continued)

Refer to Sections 2.1 and 2.2 for criteria definitions

1	2	3							4						
		Tool Category Relevance*							Column 2 x Column 3						
Criteria	Sub-Criteria Relevance	Sketch Plan	TDM	Analytical (HCM Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	10	10	10	5	0	5	20	40	40	40	20	0	20
Hardware requirements	4	10	5	10	10	10	0	0	40	20	40	40	40	0	0
Data requirements	3	10	0	10	10	5	0	0	30	0	30	30	15	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	280	160	310	260	260	140	160
								Relevance Weights Above 0	14						
								WEIGHTED SUBTOTAL	20	11	22	19	19	10	11

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 Based)	Traffic Opt	Macro Sim	Meso Sim	Micro Sim	Sketch Plan	TDM	Analytical (HCM Based)	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	15	33	20	16	23	21	33	45	100	60	48	70	63	98
3 Travel Mode	3	16	25	13	13	13	21	21	49	75	39	38	38	62	64
4 Management Strategy/Applications	4	19	13	17	20	27	27	30	76	52	68	80	108	108	120
5 Traveler Response	1	14	25	-2747	0	24	24	24	14	25	-2747	0	24	24	24
6 Performance Measures	5	13	16	16	16	18	22	23	65	82	78	82	91	110	114
7 Tool/Cost Effectiveness	5	20	11	22	19	19	10	11	100	57	111	93	93	50	57
								WEIGHTED TOTALS	**548**	**391**	**-1991**	**740**	**823**	**816**	**876**
								Most Appropriate Tool Categories:	**1.**			**Micro Sim**			
									2.			**Macro Sim**			

*Use the following values for Tool Category Relevance: (●) = 10 points, (∅) = 5 points, (○) = 0 points, (na) = -999 points.

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*

2. **Assign sub-criteria relevance weights (Column 2) –** The sub-criteria listed in this worksheet are expanded versions of the ones listed in Table 3.1. An "other" field has been added to each criterion for users to consider other sub-criteria that may not be included in this list. Sub-criteria that should be highly considered in the analysis should be given higher weights. The values should range between 0 (not relevant) and 5 (most relevant). The relevance factors entered in the sub-criteria relevance cells should be the relevance within that particular criteria (e.g., is the SOV travel mode more important than the HOV mode). The sub-criteria relevance weights in Column 2 should be identical for every tool considered.

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

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

3. **Assign tool relevance values (Column 3) –** The relevance factors presented in Tables 2.1 through 2.8 are generalized views of available tools for each tool category. Therefore, the 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 B 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.

Step 3 – Based on tool research or vendor interviews, rate the tool's capabilities into Column 3. Values range from 0 (not featured) to 5 (strongly featured). Use Column 5 for comments.

1	2	3	4	5
Criteria	**Sub-Criteria Relevance**	**Tool Relevance***	**Col 2 x Col 3**	**Comments**
1 Geographic Scope (0 = not important, 5 = most important)				
Isolated Location	0	*0*	*0x0 = 0*	*Poor for intersections*
Segment	1	*1*	*1x1 = 1*	
Corridor	3	*5*	*3x5 = 15*	
Region	5	*4*	*5x4 = 20*	
Other: _____				

Step 4 – Multiply Columns 2 and 3 together for each sub-criteria, and insert results into Column 4.

4. **Multiply Columns 2 and 3 (Column 4) –** For each sub-criterion, multiply the values in Columns 2 and 3 and enter into Column 4.

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

6. **Count the number of sub-criteria relevance weights above zero –** For each criterion, count the number of sub-criteria relevance weights in Column 2 that are larger than zero, and enter 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.

Step 5 – For each criterion, sum the values of Column 4 into the "Subtotal" row.

Step 6 – Count the number of sub-criteria relevance weights (Column 2) that are greater than zero for each criterion.

	0
	1
	15
	20
Subtotal	*0+1+15+20=36*
Criteria Weights Above 0	*3*
WEIGHTED SUBTOTAL	*36/3=12*

Step 7 – Divide the values in the "Subtotal" rows with the "Relevance Weights Above 0" cell, enter into the "Weighted Subtotal" row.

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 sub-criteria 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, needs, constraints, and priorities. For each of the seven criteria, assign 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.

Step 8 – Copy the criteria weighted subtotals into Column 8.

6		7	8
Criteria (0 = not relevant, 5 = most relevant)		**Criteria Relevance**	**Weighted Subtotals**
1	Geographic Scope	3	36
2	Facility Type	4	WEIGHTED SUBTOTAL 36
3	Travel Mode	2	WEIGHTED SUBTOTAL
4	Management Strategy/Application	2	WEIGHTED SUBTOTAL
5	Traveler Response	5	WEIGHTED SUBTOTAL
6	Performance Measures	2	
7	Tool/Cost Effectiveness	5	

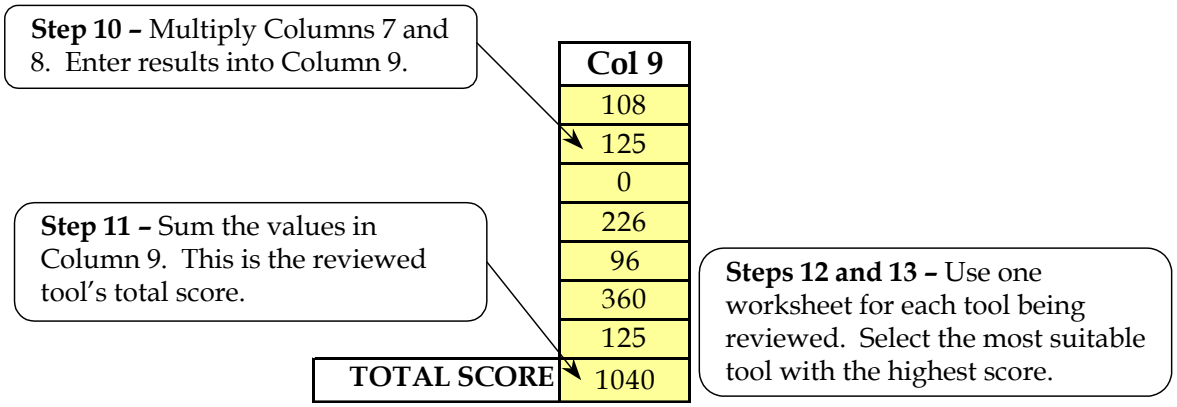
Step 9 – Assign relevance weights for each criteria, ranging from 0 (not relevant) to 5 (most relevant).

10. **Multiply Columns 7 and 8 (Column 9) –** Multiply Columns 7 and 8 together 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 sub-criteria relevance weights should remain constant for all tools. The users are encouraged to review as many tools as possible from each tool category selected (Section 3.1). Please refer to Appendix B for a list of available tools for each category and a web site to obtain further information.

13. **Select the best tool –** Compare the total scores of all tools under review, and the one with the highest score is the likely the best tool for the project under consideration.



Again, the user should review the sub-criteria 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 (i.e., the project's goal is ramp metering analysis, but 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, in case 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 at hand.

4.0 Available Traffic Analysis Tools

Before selecting a particular tool, users are strongly encouraged to assess the strengths and weaknesses of the specific analysis tools, as this document only presents a generalized view of each tool category. Appendix C provides a list of available traffic analysis tools by tool category, along with a web site link for further information, as of November 2002. 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 A may be used to assess the capabilities of each tool, compared to the project's goals and objectives.

5.0 Analysis Tools Challenges and Limitations

Each tool and tool category are designed to perform different traffic analysis functions, and there is no one analysis tool that can do-all and solve-all. This section addresses some of the challenges and limitations of available traffic analysis tools.

- **Garbage in, garbage out.** If good data are not available, the user should consider a less data-intensive tool category, such as a sketch planning tool instead of micro-simulation. 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.

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

- **Limitations in funding** to conduct the study, purchase tools, run analysis scenarios, and train the users are often a consideration in a transportation study. Traffic analysis tools can require a significant capital investment. Software licensing and training fees can make up a large portion of the budget. Plus, 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 on your investments.

- **Training limitation.** Traffic simulation tools usually have steep learning curves, and some agencies suggest that transportation professionals do not receive adequate modeling and simulation training.

- **Limitations in resources** (staff, capabilities, and funding) to build the network and conduct the analysis. Most traffic analysis tools are resource-intensive to implement, especially the model construction and calibration (front-end) phases for simulation analyses. Careful scheduling and pre-agreed acceptance criteria are necessary to keep the project focused and on target.

- Data entry, and the **diversity and inconsistency of the data** needed to run each of the different tools are of issue. Each tool uses unique analysis 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 analysis effort. Adequate resources must be budgeted for data collection.

- **Lack of understanding** of analysis tools limitations and assumptions. Often times, limitations and "bugs" are not discovered until the project is underway. It is

important to glean experiences from past projects or communicate with fellow users of a particular tool or tool category, to assess the tool's capabilities and limitations. By researching other's experiences, the users can gain a better understanding of what they may be up against as the project progresses.

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

- **Lack of features.** Some analysis tools are not designed to evaluate specific strategies that the users would like to implement. This is especially more prevalent in modeling ITS strategies or other advanced traffic operations strategies. Often times "tricking" the tool into mimicking a certain strategy is a short-term solution, but there needs to be a degree of flexibility for the advanced users to customize the tools.

- **Desire to run real-time solutions**. Many tools require a significant amount of time to set-up, model and analyze. There is hope that future tools would be able to be linked to TMCs and detectors, so the analysis can be implemented directly and at real-time. In addition, this would allow transportation professionals to respond to recurring and nonrecurring congestion using real-time solutions.

- Often times, **simpler or more popular analysis tools are being used, although they might not be the best tools for the job**. Due to the high cost of some of the more sophisticated tools, lack of resources, past experience, and 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 at hand.

- There are **biases against models and traffic analysis tools** in general, not only because of the challenges listed above, but because models are not always reliable and are often considered "black boxes." These users prefer "eyeballing" methods using back-of-envelope calculations, charts or nomographs to estimate the results. This may be adequate for simpler tasks, but today's complex projects require more advanced tools.

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

Appendix A

Tool Selection Worksheet

Table A.1. 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 A.1. 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 A.1. 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 A.1. 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 A.1 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 A.1 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 A.1 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 A.1 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 A.1 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 B

Recommended Further Reading

Appendix B. Recommended Further 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, 1997, *Smartest Review of Micro-Simulation Models*, Transport RTD, August, Internet, available from http://www.its.leeds.ac.uk/projects/smartest/index.html.

- Elefteriadou, L. et al., 1999, *Beyond the Highway Capacity Manual: A Framework for Selecting Simulation Models in Traffic Operational Analysis*, Paper Number 991233, Transportation Research Board, Washington, D.C., January.

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

- Mekemson, J, E. Herlihy, and S. Wong, 1993, *Traffic Models Overview Handbook*, Federal Highway Administration, Report Number FHWA-SA-93-050.

- Skabardonis, A., 1999, *Assessment of Traffic Simulation Models*, Washington State Department of Transportation, Seattle, Washington, May.

- Skabardonis, A., and A. D. May, 1998, *Simulation Models for Freeway Corridors: State-of-the-Art and Research Needs*, Preprint, Paper Number 981275, Transportation Research Board, Washington, D.C., January.

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

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

- *This Week's Survey Results: Urban Transportation Planning Software, Part I*, 2002, The Urban Transportation Monitor, April 5, pages 9-11.

- *This Week's Survey Results: Micro-Simulation Software Characteristics, Part II*, 2002, The Urban Transportation Monitor, April 19, pages 8-13.

- *Traffic Analysis Software Tools*, 2002, Circular Number E-CO14, Transportation Research Board/National Research Council, September.

Appendix C

Traffic Analysis Tools by Category

Appendix C. Traffic Analysis Tools by Category

C.1 Sketch Planning Tools

Examples of sketch planning tools include:

- Better Decisions: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=165
- HDM (Highway Design and Management): http://hdm4.piarc.org/
- IDAS (ITS Deployment Analysis System): http://idas.camsys.com/
- IMPACTS: http://www.fhwa.dot.gov/steam/impacts.htm
- MicroBENCOST: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=166
- Quick HOV: http://www.dowlinginc.com/pages/services.html
- QuickZone: http://www.tfhrc.gov/its/quickzon.htm
- SCRITS (SCReening for ITS): http://www.fhwa.dot.gov/steam/scrits.htm
- Sketch Methods: http://plan2op.fhwa.dot.gov/toolbox/toolbox.htm
- SMITE (Spreadsheet Model for Induced Travel Estimation): http://www.fhwa.dot.gov/steam/smite.htm
- SPASM (Sketch Planning Analysis Spreadsheet Model): http://www.fhwa.dot.gov/steam/spasm.htm
- SPF (Simplified Project Forecasting): http://www.fhwa.dot.gov/
- STEAM (Surface Transportation Efficiency Analysis Model): http://www.fhwa.dot.gov/steam/index.htm
- TEAPac/SITE: http://www.strongconcepts.com/Products.htm
- TrafikPlan: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=162
- TransDec (Transportation Decision): http://tti.tamu.edu/researcher/v34n3/transdec.stm

- Trip Generation:
  http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=179

- Turbo Architecture: http://itsarch.iteris.com/itsarch/html/turbo/turbooverview.htm

C.2 Travel Demand Models

The following is a listing of travel demand modeling tools that are available:

- b-Node Model:
  http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=482

- CUBE/MinuTP: http://citilabs.com/v.cube/cube.html

- CUBE/TP+/Viper: http://citilabs.com/v.cube/cube.html

- CUBE/TranPlan: http://citilabs.com/v.cube/cube.html

- CUBE/TrIPS (Transport Improvement Planning System):
  http://citilabs.com/v.cube/cube.html

- emme/2: http://www.inro.ca/

- IDAS (ITS Deployment Analysis System): http://idas.camsys.com/

- MicroTRIMS:
  http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=483

- QRS-II: http://my.execpc.com/~ajh/index.html

- SATURN (Simulation and Assignment of Traffic to Urban Road Network):
  http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=157

- TModel: http://www.tmodel.com

- TransCAD: http://www.caliper.com/tcovu.htm

- TRANSIMS (Transportation Analysis and Simulation System):
  http://transims.tsasa.lanl.gov/

C.3 Analytical/ Deterministic Tools (HCM Methodologies)

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

- 5-Leg Signalized Capacity:
  http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=36

- aaSIDRA (Signalized & unsignalized Intersection Design and Research Aid): http://www.aatraffic.com/SIDRA/aboutsidra.htm
- Arcady (Assessment of Roundabout Capacity and Delay): http://www.trlsoftware.co.uk/productARCADY.htm
- CATS (Computer Aided Transportation Software): http://tti.tamu.edu/product/software/cats/
- CCG/Calc2 (Canadian Capacity Guide): http://www.bagroup.com/Pages/software/CCGCALC.html
- CINCH: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=4
- CirCap (Circle Capacity): http://www.teppllc.com/publications/CIRCAP.html
- DELAYE: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=407
- dQUEUE-TOLLSIM (Dynamic Toll Plaza Queuing Analysis Program): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=290
- FAZWeave: http://tigger.uic.edu/~jfazio/weaving/
- FREWAY: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=291
- FRIOP (The Freeway Interchange Optimization Model): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=408
- General Purpose Queuing Model: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=409
- GradeDec 2000: http://www.gradedec.com/
- HCS (Highway Capacity Software) 2000: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=48
- HiCAP (Highway Capacity Analysis Package): http://www.hicap2000.com/
- Highway Safety Analysis: http://www.x32group.com/HSA_Soft.html
- HCM/Cinema: http://www.kldassociates.com/unites.htm
- ICU (Intersection Capacity Utilization): http://www.trafficware.com/ICU/index.html
- IQPac (Intersection Queue Analysis Package): http://www.itsa.org/committe.nsf/1dfaefa4b7926600852565d8004a23c7/1366c5b2fb4066f4852563a200704f24?OpenDocument

- Left-Turn Signal/Phase Warrant Program: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=56
- NCAP (iNtersection Capacity Analysis Package): http://www.tmodel.com/
- Picady (Priority Intersection Capacity and DelaY): http://www.trlsoftware.co.uk/productPICADY.htm
- RoadRunner: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=85
- SIG/Cinema: http://www.kldassociates.com/unites.htm
- SIPA (Signalized Intersection Planning Analysis): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=22
- SNAG/PROGO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=78
- SPANWIRE: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=304
- SPARKS: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=305
- SYNCHRO: http://www.trafficware.com/
- TEAPac (Traffic Engineering Applications Package)/NOSTOP: http://www.strongconcepts.com/Products.htm
- TEAPac/SIGNAL2000: http://www.strongconcepts.com/Products.htm
- TEAPac/WARRANTS: http://www.strongconcepts.com/Products.htm
- TGAP (TModel's Gap Analysis Program): http://www.tmodel.com/
- TIMACS: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=92
- Traffic Engineer's Toolbox: http://home.pacifier.com/~jbtech/
- Traffic Noise Model: http://www.thewalljournal.com/a1f04/tnm/
- TRAFFIX: http://wtraffixonlineww..com/
- TSDWin (Time Space Diagram for Windows): http://www.fortrantraffic.com/whatsnew/new2.htm
- TS/PP-Draft (Time-Space/Platoon-Progression): http://www.tsppd.com

- WEST (Workspace for Evaluation of Signal Timings): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=126
- WHICH (Wizard of Helpful Intersection Control Hints): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=127
- WinWarrants: http://home.pacifier.com/~jbtech/

C.4 Traffic Optimization

Examples of traffic optimization tools include the following:

- MAXBAND: http://www-cta.ornl.gov/research/its/maxband.htm
- 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
- SNAG/PROGO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=78
- SOAP: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=435
- SYNCHRO: http://www.trafficware.com/
- TEAPac/NOSTOP: http://www.strongconcepts.com/Products.htm
- TEAPac/SIGNAL2000: http://www.strongconcepts.com/Products.htm
- TEAPac/WARRANTS: http://www.strongconcepts.com/Products.htm
- TRANSYT-7F: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=437
- TSDWIN: http://www.fortrantraffic.com/whatsnew/new2.htm
- TS/PP-Draft: http://www.tsppd.com

C.5 Macroscopic Simulation Models

The following are examples of macrosimulation traffic analysis tools, along with their web site contact information:

- BTS (Bottleneck Traffic Simulator): http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=287
- CONTRAM (CONtinuous TRaffic Assignment Model): http://www.contram.com/
- FREQ: http://www.its.berkeley.edu/computing/software/FREQ.html
- KRONOS: http://www.its.umn.edu/labs/itslab.html
- METACOR/METANET : http://www.inrets.fr/ur/gretia/METACOR-Ang-H-HajSalem.htm
- NETCELL : http://www.its.berkeley.edu/computing/software/netcell.html
- SATURN: http://www.its.leeds.ac.uk/software/saturn/index.html
- TRAF-CORFLO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=441
- TRANSYT-7F: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=437
- VISTA (Visual Interactive System for Transport Algorithms): http://its.civil.northwestern.edu/vista/

C.6 Mesoscopic Simulation Models

Three examples of mesoscopic simulation tools include:

- DYNAMIT-P, DYNAMIT-X, DYNASMART-P, DYNASMART-X: http://www.dynamictrafficassignment.org
- MesoTS: http://plan2op.fhwa.dot.gov/pdfs/Pdf2/mesoscopic.pdf

C.7 Microscopic Simulation Models

Some examples of microscopic traffic simulation models include:

- AIMSUN2 (Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks): http://www.tss-bcn.com/aimsun.html
- ANNATOLL: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a4
- Autobahn: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a5
- CASIMIR: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a6

- CORSIM/TSIS (Traffic Software Integrated System): http://www.fhwa-tsis.com/
- DRACULA (Dynamic Route Assignment Combining User Learning and microsimulAtion): http://www.its.leeds.ac.uk/software/dracula/
- EVIPAS: http://goulias2.pti.psu.edu/projects/p-evipas.htm
- FLEXSYT II: http://152.99.129.29/cdrom/2065.pdf, http://avvisn0.rws-avv.nl/cgi-bin/wdbcgiw/avv/AVV.home
- FREEVU: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a10
- HiPerTrans (High Performance Transport): http://www.cpc.wmin.ac.uk/~traffic/
- HUTSim (Helsinki University of Technology Simulator): http://www.hut.fi/Units/Transportation/HUTSIM/
- INTEGRATION: http://www.intgrat.com/
- MELROSE (Mitsubishi ELectric ROad traffic Simulation Environment): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a14
- MicroSim: http://www.zpr.uni-koeln.de/GroupBachem/VERKEHR.PG/
- MICSTRAN (MICroscopic Simulator model for TRAffic Networks): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a16
- MITSIM: http://web.mit.edu/its/products.html
- MIXIC: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a18
- NEMIS: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a19
- PADSIM (Probabilistic ADaptive SImulation Model): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a21
- PARAMICS: http://www.paramics-online.com/
- PHAROS (Public Highway And ROad Simulator): http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a23
- PLANSIM-T: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a24
- ROADSIM (Rural Road Simulator): http://www.kldassociates.com/simmod.htm
- SHIVA (Simulated Highways for Intelligent Vehicle Algorithms): http://almond.srv.cs.cmu.edu/afs/cs/usr/rahuls/www/shiva.html

- SIGSIM: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a26
- SIMDAC: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a27
- SIMNET: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a28
- SimTraffic: http://www.trafficware.com/simtraffic.htm
- SISTM: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a29
- SITRA B+: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a30
- SITRAS: http://www.its.leeds.ac.uk/projects/smartest/append3d.html#a31
- SmartPATH: http://www-path.eecs.berkeley.edu/~delnaz/SmartPath/sm.html
- TEXAS (Traffic Experimental Analytical Simulation): http://www-mctrans.ce.ufl.edu/ti_ved/store/shopcart1.asp
- TRAFFICQ: http://www.mva-group.com
- TRANSIMS: http://transims.tsasa.lanl.gov/
- TRARR: http://www.engr.umd.edu/~lovell/lovmay94.html
- TWOPAS: http://www.tfhrc.gov/safety/ihsdm/tamweb.htm
- VISSIM: http://www.itc-world.com/
- WATSim (Wide Area Traffic Simulation): http://www.kldassociates.com/unites.htm

C.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://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=426
- ITRAF: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=445
- PROGO: http://www-mctrans.ce.ufl.edu/ti_ved/store/description.asp?itemID=78

Appendix D

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Appendix D. References

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