Macro versus Micro Simulation Modeling Tools

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Abstract

This paper discusses the use of simulation modeling tools to evaluate traffic flow and congestion and to understand the interaction of multi-modal vehicles within a constrained roadway environment. The paper will discuss the differences between maco and micro simulation tools and will review key objectives that should be considered when selecting and using simulation modeling tools. Finally, the paper will discuss the advantages and disadvantages of micro simulation modeling and the criteria that may be used for selecting the appropriate modeling tool.

Macro and Micro Simulation Modeling Differences

Simulation modeling tools are used by traffic engineers and planning professionals to examine traffic flow and congestion and to understand the interaction of vehicles on the roadway. Macro simulation models evaluate traffic flow as a whole without consideration of the characteristics and features of individual vehicles in the traffic stream. Micro simulation tools model the individual vehicles in the traffic stream and consider the features and characteristics of the individual vehicles and use car following logic and algorithms to predict and model the movement of each vehicle in the traffic stream. The advancement of micro simulation modeling tools and techniques has greatly enlarged the understanding of traffic flow and provided detailed data that was previously unavailable to engineers, planners, stakeholders and public officials. With the increased demand for micro simulation modeling it is important to understand the differences, limitations, constraints and tradeoffs when using these advanced tools.

Objectives and Considerations

The use of advanced micro simulation modeling tools should align with the objectives and needs of the project or study. Some of these considerations include:

- Modal Requirements (Transit v. Auto Modes)
- Budget and Schedule
- Data Collection/Input Requirements
- Model Calibration
- Decision Making and Alternatives Evaluation
- Visual Graphics

Modal Requirement (Transit v. Auto Modes)

With the increased focus on transit to meet the mobility needs of growing communities and urban centers, there is a greater need to examine the differences between auto and transit travel and congestion within the same roadway environment. Micro simulation models provide a tool that can separate and distinguish auto levels of congestion and performance from transit levels of congestion and performance. Transit can be a fixed

guideway system such as light rail operating in the roadway environment or a rubber tire system (bus) operating in a mixed flow environment. When transit measures of effectiveness and performance are needed, micro simulation modeling can provide separate measures for transit and auto modes. Important factors to consider and/or measure when evaluating transit performance include:

1. **Which Lane(s) will be used by Buses?** Rubber tire transit on arterial streets typically operates in the curb lane. The curb lane experiences higher levels of congestion than other travel lanes because of right turns, entering traffic, parking, bus stops and other friction factors. In many cases the curb lane delay and congestion is significantly greater than other lanes. Micro simulation modeling can evaluate the delay and congestion by mode in the curb lane separate from other lanes of travel. This provides a higher understanding of the factors that influence and impact bus travel time and delay and provides a tool that can evaluate specific measures and alternatives to reduce transit travel time and delay.

   On freeways rubber tire transit may operate in an HOV lane adjacent to the general purpose lanes. Buses entering the freeway may enter from the right hand side of the high speed facility and then weave or "swim" across multiple lanes to enter the HOV lane. Likewise, buses operating in the HOV lane may need to swim or weave across general purpose lanes to exit the freeway. Micro simulation modeling provides a tool that can measure the delay and impacts of these swim maneuvers to both transit and auto vehicles.

2. **Signal Priority.** Under many conditions, both light rail and bus transit receive priority at signalized intersections. Micro simulation modeling can model the effectiveness of transit signal priority and measure the benefits and impacts of the signal priority strategy and options on all modes.

3. **Bus Zone Delay and Interaction.** Delay incurred by transit in the roadway environment is very different from auto delay in type and intensity. Bus zone delay is the delay incurred by transit entering and exiting the bus zone. This delay is incurred when buses are obstructed from entering the bus zone (due to congestion or queuing) and/or delay that is incurred when buses wait to reenter traffic after completing the stop. Micro simulation modeling provides a tool to measure the individual components that contribute to the total delay experienced by the bus traveling down a congested arterial and can provide a better understanding of where delay is greatest and what types of solutions should be implemented to address the highest levels of delay.

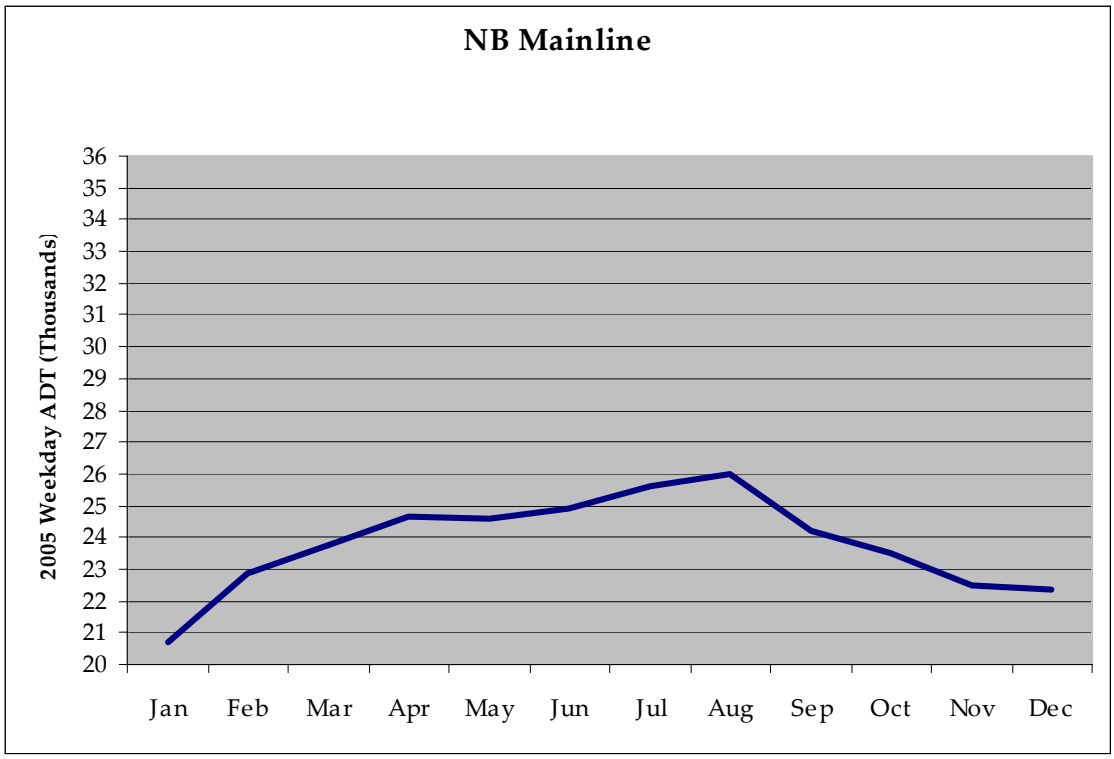
Budget and Schedule

Budget and schedule are key considerations when deciding whether to use macro or micro simulation modeling tools. Micro simulation modeling is more costly than macro simulation and requires more time and data to complete the model and conduct the analysis. Depending upon the type of project and project requirements, the differences in cost and time can be substantial.

Data Collection/Input Requirements

By its very nature, micro simulation modeling is much more detailed than macro modeling and requires more data and attention to detail. Both types of models are sensitive to volume and variations in volume. Micro simulation modeling, however, is also very sensitive to flow configuration and routing of volume through the roadway network. The routing and volume for all modes is typically specified in micro simulation modeling. This requires an understanding or estimation of origin and destination patterns for volumes entering and exiting the roadway network. For transit vehicles this routing is typically readily available from the transit schedule. For auto vehicles this data may be extracted from origin/destination surveys and or through the use of the travel demand model to estimate trip behavior and patterns.

The accuracy of the data input into the micro simulation model drives the accuracy of the results and can result in a greater understanding of the interaction and variations that occur over the peak hours and over the day. For some projects, understanding the seasonal, monthly, weekly and peak hour volume variations is a critical step in the modeling process. In most cases, the intent of the micro simulation model is not to model extreme conditions or events but to examine normally recurrent congestion that is typical for the roadway. The volumes entered into the simulation model should represent the desired conditions. Selecting the right volume set to enter into the simulation model should be made based upon the seasonal and hourly variations that will naturally occur in the corridor.



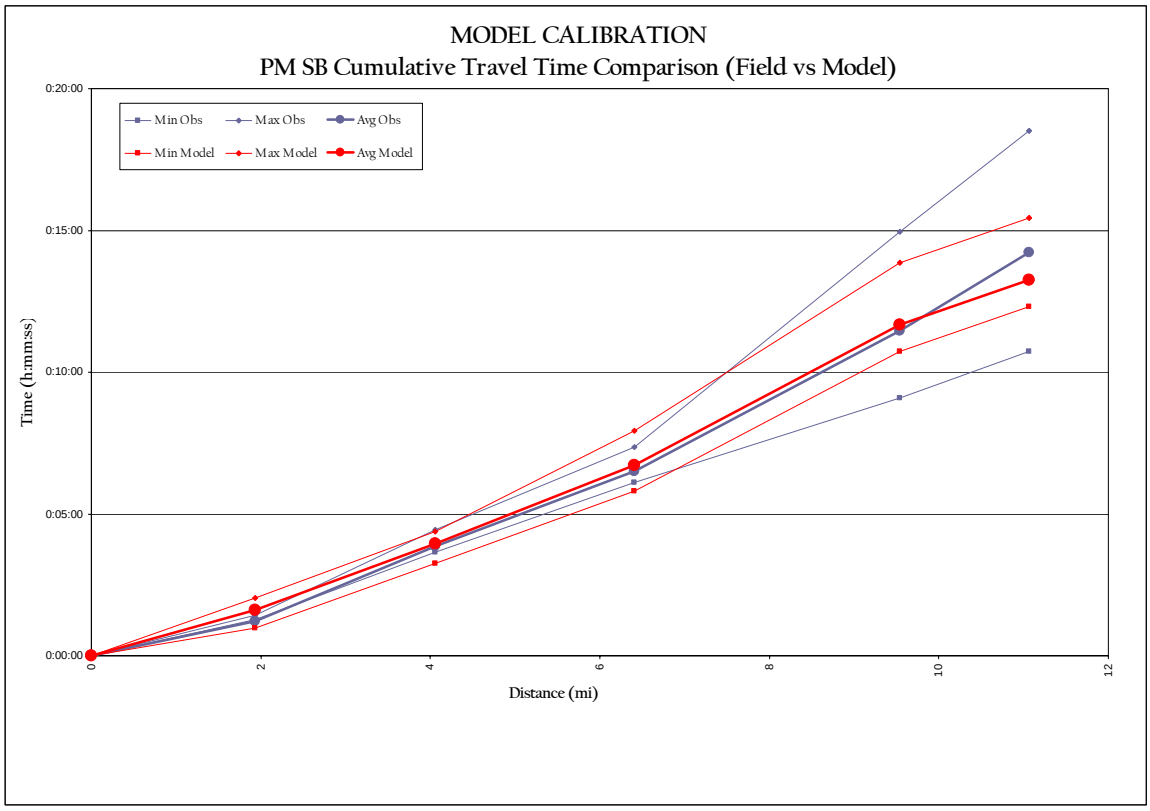
Seasonal Variations on I-5 in Bellingham Washington

Other important data collection and input requirements include roadway geometrics, lane restrictions, speed, lane distribution and saturation flow rates. Collecting this data can be tedious and detailed but the accuracy of this data is critical if the true value of the micro simulation tool is to be realized.

Model Calibration

Calibration of the model, whether macro or micro, is a critical step in the development of a reliable and useful simulation model. Calibration of a micro simulation model will require more time and effort because of the wider range of factors and inputs that influence the model results and output. Some of the parameters that can be used for calibration include volume, density, travel time, speed and flow rate. These parameters are different for different modes and therefore bus, auto and truck data for each mode is needed and each mode is calibrated separately and independent of the other modes. This modal separation and calibration is essential when non auto modes such as transit and trucks are examined.

Perhaps the most difficult parameter to calibrate and model is the variations in volume and congestion that can or will occur over the peak periods. Data collected in the field and from agency records can provide an important indication of the type and level of variation that is likely to occur. An understanding of how the modeled results and data align with and compare with these variations is essential when explaining the results to the public and elected officials who may experience some of the extremes and variations when driving the roadway.



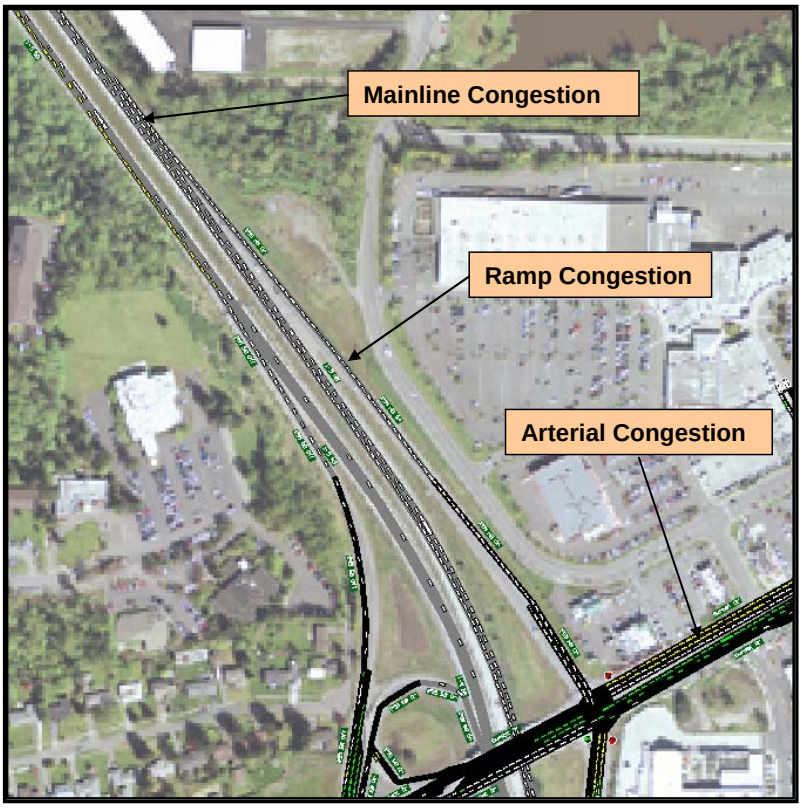
Decision Making and Alternatives Evaluation

Decision making and alternatives evaluation is a key consideration in the selection of a macro versus micro simulation tool. A micro simulation tool may not be appropriate where high level decisions are needed across a broad range of alternatives. Typically, a micro simulation tool is not used extensively as an alternatives evaluation or screening tool because of the time and expense required to model each alternative. It use is more appropriate where refinement or better understanding of a selected alternative is needed or where a decision is needed on a final set of two or three alternatives that have survived a higher level screening process. In other cases, micro simulation is used to identify the types of problems along a corridor or roadway so that solutions or alternatives can be developed that address the most immediate and pressing needs. Improvements or alternatives that can significantly impact or benefit different modes can be evaluated and compared against other modal benefits and impacts.

Visual Graphics

The visual graphics and realism of micro simulation modeling can be a key consideration when selecting the right analytical tool. Micro simulation models provide far greater realism and a visual image of the results and performance of a proposed improvement or alternative. The ability to talk through the results and provide a visual reenactment of a future or changed condition greatly enhances decision making and public acceptance. In developing the visual quality of the graphics, it is important to eliminate or explain (when elimination is not possible) events in the simulation that may not completely align with reality or expected traffic flow. Some of the common simulation details that typically need attention or "fixing" include:

- One vehicle tracking through or passing through another vehicle.
- Stacking of vehicles through an intersection.
- Restricting vehicle lane changing where it can not occur.
- Gap acceptance when vehicles enter the traffic stream or change lanes.



Advantages and Disadvantages of Micro Simulation Modeling

Micro simulation modeling is a powerful tool that can greatly enhance decision making and more effectively analyze and evaluate proposed improvements and alternatives. Some of the key **advantages** of micro simulation modeling include:

- Ability to evaluate and isolate differences by mode and by lane.
- Ability of evaluate system impacts and influences.
- Ability to model the benefits of ITS and technology improvements that may target specific classes of vehicles or conditions.
- Ability to model variations in volume and congestion over the peak hour.
- Ability to model geometric influences.
- Ability to isolate choke points and capacity constraints.

Some of the key **disadvantages** of micro simulation modeling include:

- Higher cost
- Extended time and schedule
- Difficulty in evaluating and screening a wide range of multiple alternatives and/or refinements
- Data extraction

Therefore, some of the **key criteria** to consider when deciding to use a micro simulation model are:

- **COST AND AVAILABLE BUDGET**
- **SCHEDULE CONSTRAINTS**
- **MODAL REQUIREMENTS**
- **LEVEL OF SCREENING AND DECISION MAKING**
- **VISUAL AND PUBLIC OUTREACH REQUIREMENTS**