THE ART OF TRAFFIC SIMULATION
(AND EFFORTS TO TURN IT INTO A SCIENCE)

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INTRODUCTION

The phrase “more of an art than a science” is often heard as part of traffic engineering and transportation planning activities. Many analysts consider this phrase to apply particularly well to traffic simulation because of the complexities of calibration and validation of the results of simulation models, as compared to more conventional traffic analysis tools. Because of the popularity of traffic simulation, there is an increasing interest in investigating the accuracy of the results of simulation models and in the comparability of results from one model to another. This paper provides a report on the results of those more “scientific” efforts as well as a look ahead to consider future results and implications.

BACKGROUND

The term “traffic simulation model” is usually applied to mean computerized models that track the movements of individual vehicles such as SimTraffic, CORSIM, VISSIM, and Paramics. While these types of models are a key focus of this paper, they are often compared to other traffic analysis tools that use different methodologies, such as those in the Highway Capacity Manual, Synchro, and TRANSYT-7F. Therefore, this paper includes consideration of these other tools and the term “traffic analysis tools” is meant

to include traffic simulation models, as well as other tools that are used to analyze roadway facilities.

One of the challenges of any discussion of traffic analysis tools is the rapidly changing list of tools that are available. As an example, Exhibit 1 shows two lists of popular traffic analysis tools. One list comes from a 2003 survey of ITE District 6 members conducted by the ITE California Border Section to determine the most popular traffic analysis tools (1). The second list shows the proposed list of traffic analysis tools from the ongoing NCHRP 3-85 research project (2). Either list can be used to get a sense of the common traffic analysis tools that have been in use in recent years.

WHY TRAFFIC SIMULATION IS AN ART

There are many reasons why traffic simulation has been called an art. They include:

- Quality of Data: Traffic simulation models require huge amounts of data. Some data may be inconsistent, inaccurate, misleading, or unavailable. Therefore, judgment must be applied in selecting key parameters for input to the models.

- Calibration Process: It is generally recognized that traffic simulation models need to be calibrated to local conditions to achieve any degree of accuracy. Since traffic varies on a daily basis, and calibration is never perfect, the calibration process requires additional judgments on the part of the analyst.

- Randomness: Most traffic simulation models are stochastic, or random. Therefore, the results will vary from one model run to the next. The number of times a model should be run in order to achieve a representative average result is part of the “artistry” involved in using traffic simulation.

Exhibit 1

Two Recent Lists of Popular Traffic Simulation Models

2003 SURVEY OF ITE DISTRICT 6 MEMBERS

- SimTraffic
- CORSIM
- VISSIM
- Paramics
- INTEGRATION

ONGOING NCHRP 3-85 RESEARCH PROJECT

- SimTraffic
- CORSIM
- VISSIM
- Quadstone Paramics
- S-Paramics
- AIMSUN
- TransModeler

- Definitions of Measures of Effectiveness: Traffic simulation models use a variety of different measures of effectiveness, such as average delay, number of stops, and maximum lengths of queues. There are currently no commonly accepted definitions of measures of effectiveness that are used by simulation models (and other traffic analysis tools). As one example, SimTraffic considers a vehicle to be "stopped" when its speed falls below 10 ft/sec, while CORSIM considers a vehicle to be "stopped" if its speed falls below 3 ft/sec (3).

- Reporting of Measures of Effectiveness: Some key decisions in the reporting of measures of effectiveness are left up to the analyst. This is in the case in all highway capacity analysis, and traffic simulation is no exception. For example, if an intersection has low overall average delays, but has a queue on one movement that backs up into an adjacent intersection, how are the overall characteristics of the intersection reported?

EFFORTS TO COMPARE THE RESULTS OF TRAFFIC SIMULATION MODELS

One recent test to compare the results of simulation models was conducted as part of the 2002 summer meeting of the Transportation Research Board's Highway Capacity Committee. The same traffic analysis problem was given to developers of several traffic simulation models who were asked to use their models to provide an analysis of the problem. There was a large variation in the results, leaving conference attendees wonder why the models were so different and how more accuracy and comparability of results could be built into the process.

More recently, the Federal Highway Administration conducted a research project to investigate the definition, interpretation, and computation of measures of effectiveness for various traffic analysis tools (3). This research found that there were large differences in the way that various traffic simulation models define and report common measures of effectiveness such as delay, queues, and vehicle miles traveled. One

common source for the differences was definitions. For example, is a vehicle traveling at 3 mph waiting behind other vehicles in a “queue” or does it have to be stopped in order to be in a queue? Another common source of the differences is treatment of vehicles that are in the system at the end of the reporting period as well as treatment of vehicles that could not enter the system because of queues extending back to the entry point.

CURRENT EFFORTS TO MAKE TRAFFIC SIMULATION MORE LIKE A SCIENCE

Various organizations are interested in the issues raised above. They include FHWA, state departments of transportation, and two committees of the Transportation Research Board (the Highway Capacity Committee and the Joint Subcommittee on Traffic Simulation). Following is a summary of various efforts to introduce more science into the practice of traffic simulation.

- FHWA Traffic Analysis Toolbox: This document provides guidance, recommendations, and examples on the selection and use of traffic analysis tools. It includes an overview of the various traffic analysis tools that are available, guidance on selecting an appropriate tool for various traffic analysis problems, and guidelines for the use of microsimulation. The Traffic Analsysis Toolbox can be found at http://www.ops.fhwa.dot.gov/trafficanalysistools/toolbox.htm.

- NGSIM Project: NGSIM (Next Generation Simulation) is an effort led by FHWA to provide improved information regarding driver behavior for use in traffic simulation models. Through this project, traffic simulation models will be able to incorporate improved algorithms for driver decisions such as merging and lane changing. Information on NGSIM can be found at http://ngsim.fhwa.dot.gov.

- Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness (3): This research project undertaken by FHWA provided analysis of how measures of effectiveness are currently defined and reported by various traffic analysis tools. It also outlined recommendations on how to make the results more accurate and comparable. In addition to pointing out current inconsistencies among the various traffic analysis tools, a key result of this research was the identification of vehicle trajectories as the "lowest common denominator" upon which any common measures of effectiveness should be based.

- NCHRP 3-85 Project: This research, sponsored by the National Cooperative Highway Research Program, is titled "Guidance for the Use of Alternative Traffic Analysis Tools in Highway Capacity Analysis". Its goal is to produce a new Part V of the Highway Capacity Manual that will provide improved guidance for the use of traffic simulation models and other traffic analysis tools. It is expected that this research will provide for improved accuracy and comparability among traffic simulation models.

- Highway Capacity Manual: An effort is under way to produce a new version of the Highway Capacity Manual in 2010. It is expected that this revised HCM will incorporate the results of the NCHRP 3-85 research project and provide updated recommendations for users of traffic analysis tools. Information on updates to the Highway Capacity Manual, as well as information on the Highway Capacity Committee can be found at http://www.ahb40.org.

WHERE DO WE GO FROM HERE?

Because of the current lack of consistency among popular traffic analysis tools, the results of traffic simulation models and other traffic analysis tools rely heavily on the knowledge and expertise of the developers of the models as well as the knowledge and expertise of the analysts who provide inputs and present the results. There are few resources available to verify the overall accuracy of the results. Current research is

underway in two areas to improve this situation:

- The NGSIM project is expected to lead to improved algorithms for vehicle interactions that could be used to improve the accuracy of all traffic simulations.

- The NCHRP 3-85 project is expected to provide additional guidance regarding the use of traffic simulation models and other traffic analysis tools in highway capacity work. Since this research is ongoing, it is difficult to predict whether it will be able to resolve the key issues identified in this paper. The project is scheduled to be completed by the summer of 2008 and the results incorporated into the Highway Capacity Manual. Efforts are underway to produce a revised version of the Highway Capacity Manual in 2010.

CONCLUSIONS

Based on the discussions included in this paper, the following conclusions can be drawn:

- For a variety of reasons, traffic simulation models (and other traffic analysis tools) are inconsistent in the way that they analyze traffic problems and report the results. The results are generally not comparable from one tool to another.

- Efforts are underway to provide more consistency in traffic simulation models and other analysis tools. Analysts interested in the issues raised in this paper are advised to monitor the results of the NCHRP 3-85 project and to watch for a new version of the Highway Capacity, possibly as soon as 2010.

REFERENCES

(1) Ruehr, Erik, To Simulate or Not to Simulate: That is the Question (Traffic Simulation in the San Diego Area and Beyond), Westernite, September-October 2004

(2) Based on discussions with NCHRP 3-85 research team

(3) Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness, FHWA/Dowling Associates, January 2007

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