Simulating Traffic for Incident Management and ITS Investment Decisions

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UTPS-type models were designed to adequately support planning activities typical of the 1960's and 1970's. However, these packages were not designed to model intelligent transportation systems (ITS) and support incident management planning. To overcome these limitations, improved algorithms have been proposed and tested in some markets. Unfortunately, these improvements generally have not been included in the commercially available packages and agencies continue to use UTPS-type packages. Therefore, our effort is intended to supplement existing planning model capabilities by exploiting the capabilities of available micro-simulation models. Micro-simulation models can assess, for a localized area or corridor, the effect of ITS implementation and incident response. We introduce a modeling methodology where a sketch-level model represents the regional network and we retain a portion of the available links to develop roadway detail in the area proximate the proposed ITS technology deployment or incident. The combined system is designed to provide real-time travel information for agencies to improve traffic flow through changeable message signs or advanced traffic signals and for travelers to alter route or destination choices through pre-trip information systems such as cable television or web sites. Within this paper, a methodology is demonstrated that uses a GIS interface between Tranplan and Corsim for a test case in Des Moines, Iowa, a medium sized urban area. Key words: travel forecasting, simulation, GIS and ITS.

INTRODUCTION

Conventional transportation planning developed in the early sixties when cities with populations exceeding 50,000 were required to develop "continuous, comprehensive, and cooperative" plans to support the development of the Interstate Defense Highway System through region-wide, systems-oreiented studies with long horizon times (*1*). In the 1970's, transportation planning shifted towards shorter horizon years focusing on corridor analysis. The eighties continued the focus on shorter horizon transportation planning and saw continued improvements in computer tools and computing capabilities. The 1990's have seen a division in planning horizons with shorter horizons focusing on transportation system management, and longer planning horizons focusing on sustainablility. Funding provided by in the Intermodal Surface Transportation Efficiency Act of 1991 promoted the development of intelligent transportation systems (ITS) to improve traffic flow and incident management response (*2*). However, planning and engineering agencies continue to forecast travel using the sequential modeling methodology developed in the 1960's, which was not developed to and have limited ability to address ITS planning issues.

Although work is being performed by the Travel Model Improvement Program (TMIP) to improve traffic models for incident management and ITS investment decisions, many planning agencies still operate computer modeling packages written in the 1970s and 1980s to develop traffic forecasts. While these UTPS-type models were sufficient for regional and corridor level analysis, they are insensitive with respect to the real-time modeling needs of ITS technologies and supporting incident management schemes. To overcome these limitations, alternative algorithms based on dynamic modeling have been proposed and tested in some markets. Unfortunately, these improvements generally have not been implemented into the commercially available packages and agencies continue to use UTPS-type packages. The TRANSIMS model represents a major research effort that is attempting to develop a region-wide micro-simulation tool for traffic modeling (*3*). Although the new model techniques are promising, most agencies have invested staff time and other resources in the conventional travel models and many are looking for a lower investment cost alternative to a completely new system.

Our effort is intended to supplement existing planning model capabilities by integrating them with a micro-simulation model. Micro-simulation models can assess, for a localized area or corridor, the effect of ITS implementation and incident response. The selected model, Corsim, however, is limited in size to approximately 500 surface and 600 freeway links for standard PC implementation. To overcome this limitation we introduce a modeling methodology where a sketch-level model represents the regional network and we retain a portion of the available links to develop roadway detail in the area proximate the proposed ITS technology deployment or incident. The methodology is demonstrated using a GIS interface between Tranplan and Corsim for a test case in Des Moines, Iowa, a medium-sized urban area.

BACKGROUND

Most existing travel models are not designed to represent time dependent delay and are therefore insensitive to evaluating different

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ITS alternatives and responding to traffic incidents (*4*). Travel Forecasting Guidelines indicate that "research is needed to more closely link planning and simulation models to provide more sensitivity to traffic management options while maintaining reasonable resource requirements" (*4*).

Ricci and Gazda identify improvements for existing model limitations including modeling smaller time intervals and integrating planning and traffic simulation models (*5*). With a focus on ITS, a paper by Ben-Akiva et al. defines the heart of successful ITS implementation and operation to be a traffic model that operates in and provides real time information on network traffic conditions (*6*). They indicate that the model should be constructed using a competent simulation model. They further indicate a need for a traffic micro-simulation model to support transportation planning activities in the future.

METHODOLOGY

Current sequential modeling packages are not designed to support Intelligent Transportation Systems (ITS) strategies and incident management responses. Therefore, our approach defines a new framework that integrates an existing travel demand model and micro-simulation package to support modeling ITS alternatives and incident response while minimizing data collection efforts. This effort uses a sketch-level planning model derived from an existing model to determine driver route choice and a traffic micro-simulation package to provide real-time network information which can be fed back into the planning model or visualized using an animation program.

The methodology for developing the system is comprised of converting the existing regional model into a sketch-level model and transferring the new network model into a format for incorporation into the simulation package. These two steps are described in this section.

Development of a Sketch-Level Planning Model

As most existing models are too large for incorporation into the Corsim simulation package (because of program limitations), only a select number of links will be taken form the model to comprise the sketch-level planning model. To determine the streets that will be incorporated into the sketch-level planning model, local knowledge about the area and the existing traffic conditions are required. Examining traffic volumes and identifying congestion locations suggest the basic streets for the network. Other network street should be selected to provide connectivity and to develop sufficient detail without using all the streets.

All attribute information for the sketch-level model is stored in the GIS with the required Tranplan information. As with the existing regional Tranplan model, the sketch-level Tranplan roadway data includes beginning and ending node numbers, distance, operating speed, and available capacity. The sketch-level network does not need explicit socio-economic data or productions and attraction data attributed to the zone centroids as the traffic assignment step will be performed using trip tables derived from the regional travel demand network. After defining the sketch-level planning network, the next step is to modify the regional origin-destination table to include only those trips which use roadways in the sketch-level model. This step involves identifying common roadway elements from both the original and sketch-level models to assign trips to only the selected streets. This selected assignment is then reported as a new trip table.

A series of Fortran programs were written which aggregate the origin-destination information to the new zone numbers in the sketch-level model. The first program develops a reference table matching the structures from the two networks by associating regional centroids with the nearest centroid in the sketch-level network. The second program examines the original origin-destination pair from the Tranplan program, assigns new zone numbers corresponding the sketch-level model, and aggregates the number of trips between the zones.

After aggregating the trip table to represent the new zone numbers, the trip table is assigned to the sketch-level planning model network using Tranplan to produce forecast volumes for the selected links that is representative of the original model forecast. Figure 1 shows a flowchart of the entire system.

Incorporation to the Simulation Package

The simulation package used in this work, Corsim, operates using a space-delimited control file that defines the network through link geometry, turning movement percentages, intersection control, zonal production rates and coordinate data. In addition, the control file contains all the run specific information such as run duration. All the data elements are extracted from the sketch-level Tranplan network and formatted for Corsim through a MapBasic and Fortran program.

The information entered into the control file for the network geometry and operating conditions is provided by the GIS network files: intersections, roadways and turning movements. Each roadway is identified through a beginning and ending node number and attributed with distance, both of which are easily incorporated into the simulation control file. The number of lanes entered for the roadway segments is based on a function of Tranplan capacity and lane channelization is entered as all possible movements allowed based on the existing geometry of the network and number of lanes. The turning movement percentages entered into the simulation are based on the output of the Tranplan assignment and the intersection control is entered with a default value of "green" for all approaches. This replicates the situation encountered within the Tranplan network. However, since there is no means to identify traffic congestion related to intersection queuing and signalization, manual effort is required to incorporate traffic signalization before performing the micro-simulation. The final item that is required for the simulation control file is the zonal productions and coordinate data contained in the intersection table.

After developing the simulation control file, a run of the micro-simulation program is performed. The Corsim program begins with an initial warm-up period for the simulation to reach an equilibrium state, then the software will simulate the network for the duration entered in the control file. After running the simulation, the network will have an output file contain various statistics including intersection delay which can be fed back into the planning model to improve the assignment and an animation file which can be brought into the TRAFVU program to visualize the network operation.

Key outputs from the simulation program are the intersection queue length, average number of vehicles in the queue and average delay times for vehicles. This information is contained in the out-

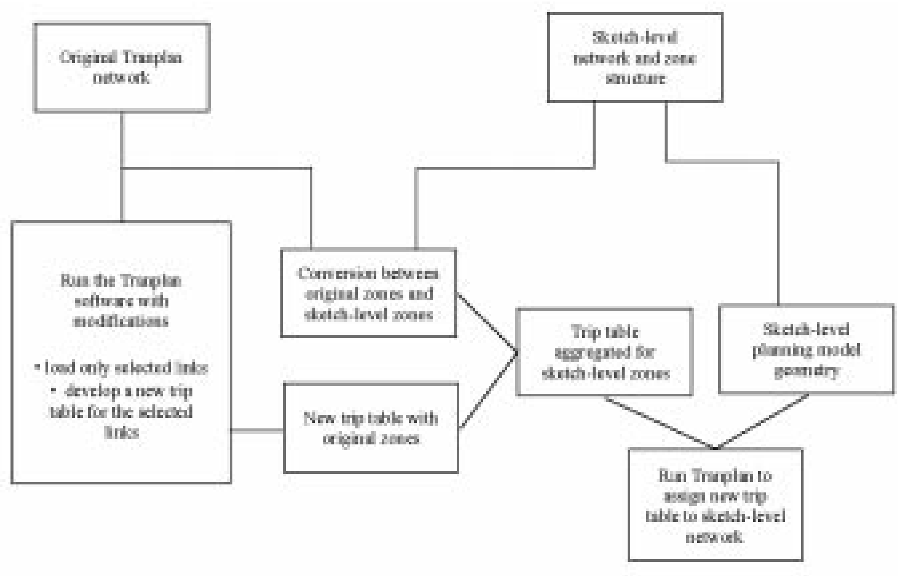

FIGURE 1 Process for developing the sketch-level planning model.

FIGURE 2 The existing Des Moines Tranplan network.

TABLE 1 Peak Hour Factors by Trip Purpose (Morning Peak)

Trip Purpose	Percentage of Trips
Home-Based Work	20%
Home-Based Other	3%
Non-Home Based	3%
Commercial Truck	3%
External-Internal, External-External	3%

put file and can be an important tool for improving the flow of vehicles through the network through feedback loops. This information can also be used through advanced traffic control strategies to change existing signal timings to improve traffic flow.

CASE STUDY: DES MOINES

The case study of the interface between Tranplan and Corsim will focus on the Des Moines metropolitan area. Des Moines, Iowa's capital, has a resident population of nearly 200,000 with almost 400,000 people in the area. The first item addressed in the case study is the development and operation of the sketch-level planning model. Before any work is implemented on the new model, the existing network model needed to be altered to represent a peak period model versus the 24-hour configuration. This was performed through a model alteration with the following factors developed in the NCHRP Report 187 document (Table 28) (*7*). This document outlines the percentage of trip, by purpose, which occur in different hours of the day. For the morning peak hour model developed, the factors are shown in Table 1. The factors were applied to the original trip table used in the network model and all trip purposes, with the exception of the home-based work, were balanced to remove directionality. The development of the peak period model was performed through a series of trip table manipulations. For orientation, Figure 2 shows the existing travel demand network model for Des Moines.

The links included in the sketch-level planning were defined from the Early Deployment Study for Intelligent Transportation Systems performed for the Des Moines area (*8*). As mentioned, this document provides a figure showing all the location for technology deployment within the metropolitan area and this figure was used to select the appropriate roadways. The sketch level planning model developed for the area is comprised of 71 zones, 125 inter-

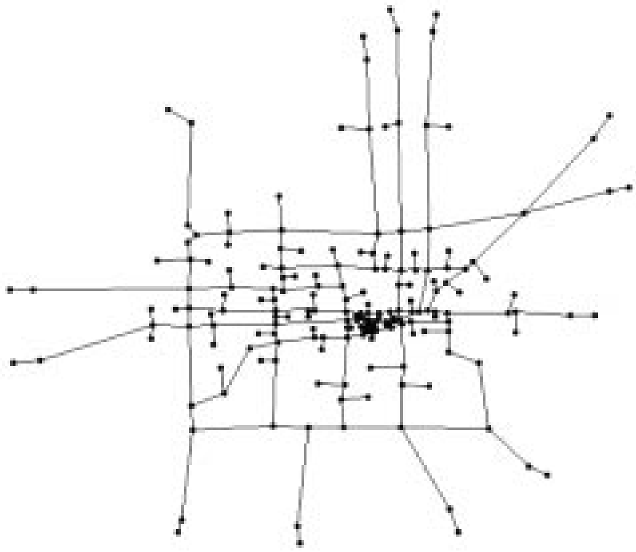

FIGURE 3 The sketch-level network for Des Moines.

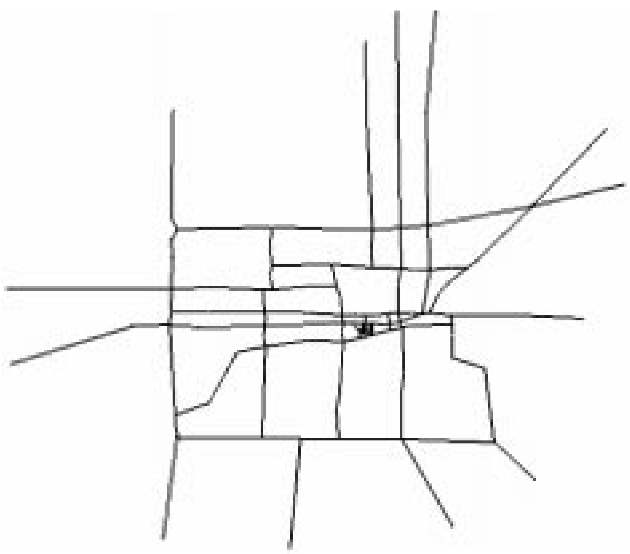

FIGURE 4 The entire network.

nal intersections and 232 roadway links representing arterials, freeway segments and source links. The network is defined representative to a typical Tranplan network within Iowa, therefore, no interchange ramps and all links are assigned a capacity to represent the number of lanes. The sketch-level network for the Des Moines area is shown in Figure 3.

Following the methodology to develop the origin-destination table for the sketch-level network, certain links from the existing were selected and a special assignment of the original network was made to assign only the traffic that used the selected links. After developing a trip table for the selected links, Fortran programs were used to develop a correspondence table between the original zone structure and the sketch-level zones and a new trip table based on the sketch-level models zonal structure was created. It is this new trip table that is assigned to the sketch-level model to perform a run of the Tranplan software. After assigning the new trip table to the sketch-level network, the limited roadway network has traffic volumes representative of the peak hour.

It is this sketch-level network, with assigned traffic data, that is used to develop the simulation network. After running the simulation for the network, the output can be viewed in the animation software, TRAF-VU. The Des Moines sketch-level model, as viewed in TRAF-VU is provided at two scales (Figure 4 shows the entire network and Figure 5 shows an area of downtown).

The combined travel demand and micro-simulation model provides the ability to forecast real-time network operations to support the advanced traveler information and traffic management strategies of ITS. Traveler information provides pre-trip network conditions through various media (cable television, web sites) and allows user to alter trip decisions, such as destination, route and mode. The traffic management strategy supports incident mitigation by identifying demand for alternate routes and provides necessary information for changeable message signs. For ITS, the traffic management strategy supports the identification of diversion routes which will help mitigate travel problem arising from activities such as the reconstruction of Interstate 235 through Des Moines.

CONCLUSIONS AND RECOMMENDATIONS

Included in this paper is a framework and methodology presented and tested which allows users to receive the benefits of real-time micro-simulation from an existing travel demand model. The steps comprising the methodology are:

- start with regional model
- convert to GIS using developed software, if not already in GIS format
- in the GIS, sketch it down to less than 500 links (leaving room to add detail)
- add new links to increase level of detail and sensitivity in study corridor (if needed)
- use developed programs to convert regional model trip tables to sketch model level
- develop network or demand alternative scenarios (if needed)
- use translation program to convert scenario(s) to Corsim
- add traffic control parameters in Corsim to represent various scenarios (if needed)
- run Corsim to assess implications of demand, network or control strategies.

The Des Moines case study demonstrated that the existing model can be aggregated to a sketch-level model and the traffic can be simulated providing real-time traffic information, such as intersection queues and travel delays which can be visualized in the animation software.

A future recommendation being addressed is the ability to perform a focused (or sub-area) modeling if sufficient detail cannot be provided through the sketch-level design. As mentioned in the pa-

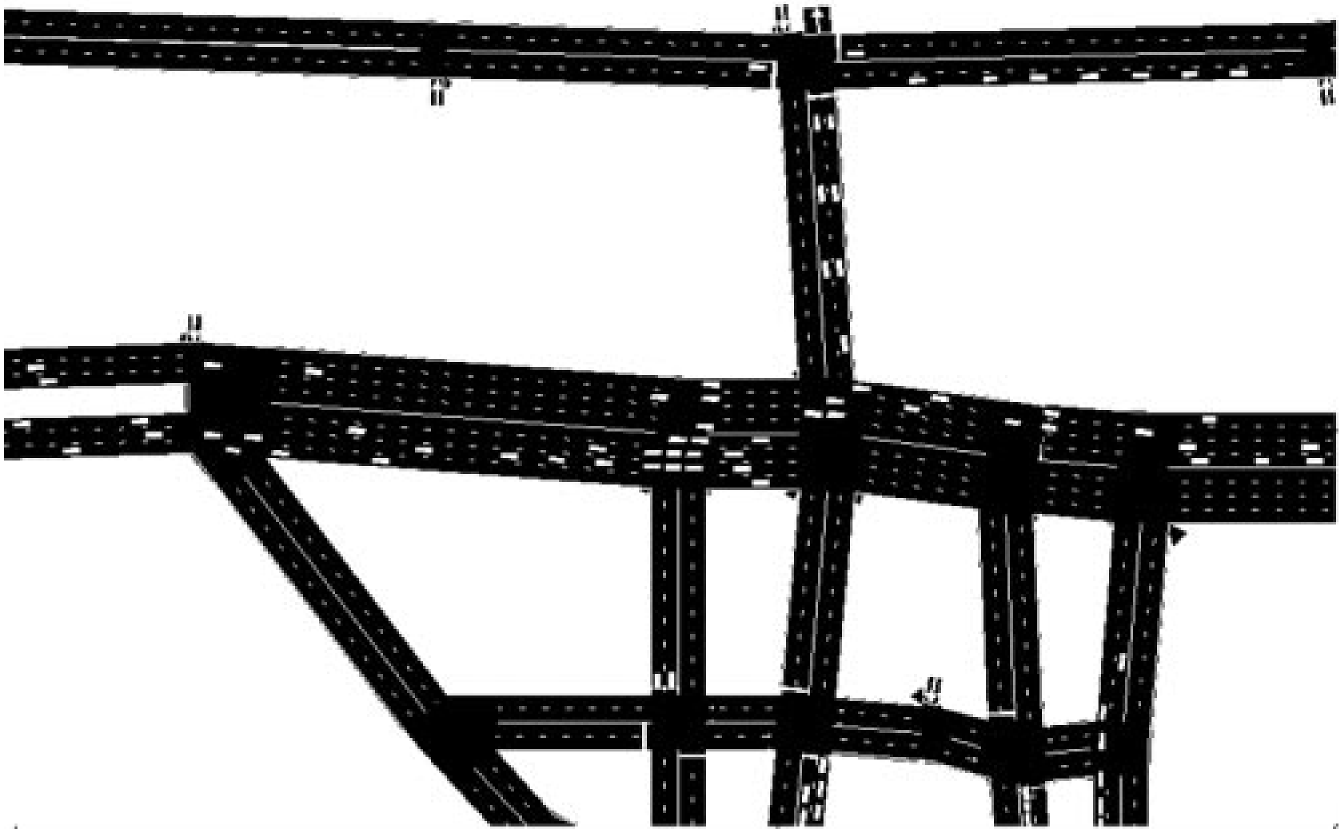

FIGURE 5 Zoomed area of downtown.

per, programs are being written which will provide the ability to "feedback" travel time and delay information into the travel demand package to improve the traffic assignment. The case study performed in this paper examined the use of the methodology for Des Moines, however, there was no effort made to calibrate or validate the output from the simulation. If investment decisions were to be based on the output from a model following this methodology, it is recommended that extensive calibration and validation efforts are performed. The final recommendation is to incorporate dynamic trip table development strategies to improve the analysis of specific time intervals.

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