Calibration of a Micro-Simulation Model With and Without Network Incidents

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Abstract

Incidents, pre-programmed or random, are major sources of congestion on urban freeways. With many urban freeways in the United States operating close to capacity, the need to reduce the impact of incident-related congestion has become critical. Incident Management Strategies (IMS), when properly developed and deployed, have the potential to reduce such urban congestion. The problem addressed in this paper deals with the question of dynamically finding alternate paths in a given network when a section of the network is temporarily incapacitated because of incidents. Instant knowledge of such alternate paths with surplus capacities may enable Traffic Management Centers (TMC) to efficiently divert traffic from the affected portion of the network, thereby helping alleviate congestion. As a part of this effort, the authors adapted a micro-simulation model AIMSUN to assess the impact of deploying IMS's on an urban network. This paper deals with a major focus area of this study, calibration of the micro simulation model.

Calibration of the proposed model is demonstrated on a heavily traveled portion of an urban network in the Detroit metropolitan region. The network contains two freeways in the north-south and east-west directions (Interstate 75 and Interstate 696) instrumented with various ITS devices, and a number of major arterials. The model calibration process is conducted in two separate channels. Initially, the model is calibrated without any incident data. Upon completion of no-incident calibration, the model is further validated with incident data. Travel time and traffic volume data (in 5 minute increments) were obtained from sensors installed by the Michigan Department of Transportation at strategic locations on the two freeways. A set of statistical tests are reported that shows excellent correlation between the observed data and the model output. The calibrated model with extensive field data may be used as a tool to assess the traffic consequences of various IMS's.

1. Introduction

Incidents continue to be major sources of congestion on urban freeways. Law enforcement, transportation, and emergency service agencies in the United States are working together to develop viable Incident Management Strategies (IMS) to alleviate freeway congestion problems. A traffic incident is defined as "any occurrence on a roadway that impedes normal traffic flow" *(1)*. Typically, these are non-recurring events that cause temporary reductions in roadway capacity. Similar definitions are also provided in other sources *(2-3)*. Incidents can be pre-programmed, such as work zone activities, reconstruction projects, etc., or random, such as traffic crashes, disabled vehicles, spilled cargo, etc. These events, particularly, the latter types, contribute significantly to traffic congestion on U.S. highways *(4)*.

With many of the U.S. roadways operating close to capacity under the best of conditions, the need to reduce the impact of incident-related congestion has become critical. One way to achieve this is to improve the management of traffic after an incident has occurred. Key components of successful IMS's are early detection, efficient recovery, and effective diversion of traffic to the surrounding links in the network. Emerging technologies such as variable message signs (VMS), vehicle-to-vehicle communication, vehicle infrastructure integration (VII) and intellidrive applications may be used for such purposes. Crucial components of an IMS are the recovery process and the use of traffic diversion strategies.

2. Problem Statement

The problem addressed in this paper deals with the question of dynamically finding alternate paths in a given network when a section of the network is temporarily incapacitated because of incidents.. Instant knowledge of such alternate paths with surplus capacities may enable Traffic Management Centers (TMC) to efficiently divert traffic from the affected portion of the network, thereby helping alleviate congestion. The overall purpose of the project conducted jointly at Wayne State University (WSU) with Grand Valley State University was to develop methods to describe traffic flow in a freeway environment, both with and without traffic incidents. As a part of this effort, the authors developed a micro-simulation model to assess the impact of deploying IMS's on an urban network. This paper deals with a major focus area of this study, calibration of the micro simulation model.

3. Literature Review

As a part of an earlier project that served the basis of the work, a thorough review of the pertinent literature was conducted in four specific areas: (1) IMS's and alternate route diversion on freeways and arterials, (2) various types of path and route choice models applied in IMS, (3) measures of effectiveness (MOE's) used to evaluate IMS, and (4) the application of micro-simulation models to analyze IMS's (5). A detailed discussion of this literature is beyond the scope of this report. A brief summary of this review is presented below.

Many simulation software packages have been used over the years for dynamic traffic assignment, a complete discussion of which is beyond the scope of this paper. Examples include: CONTRAM *(6)*, INTEGRATION *(7)* and DYNASMART *(8)*, DYNAMIT/MITSIM *(9-10)*, AIMSUN *(11)*, CORSIM *(12)*, PARAMICS *(13)*, VISSIM *(14)*. Each model has its own special characteristics, and was developed with a specific focus. CONTRAM, INTEGRATION and DYNASMART are 'macro-particle' traffic simulation models where individual vehicles are tracked as they move through the network; but their velocities are determined by macroscopic speed/flow/density relationships. By contrast, DYNAMIT/MITSIM, CORSIM, PARAMICS, and VISSIM are micro-simulation models, where each vehicle is modeled as an individual entity through the entire simulation process. AIMSUN is unique in it that all the three features, (i.e. macro, micro and meso) are embedded in the model. Some models also allow representation of alternative route choice behaviors, including allowances for dynamic response to real-time information. Examples of simulation-based research under congested conditions are included in the works of Breheret et al. *(15)*, Ha et al. *(16)*, Hounsell et al. *(17)*, Smith and Ghali*(18)* and Smith and Russam*(19)*.

Koutsopoulos et al. proposed a stochastic traffic assignment approach for assessing the effectiveness of motorist information systems in reducing recurrent traffic congestion *(20)*. The model was used for examining interactions among important parameters of the problem such as level and amount of information provided, users' access to information, and congestion levels. Abdel-Aly et al. reviewed a number of studies to understand driver behavior when influenced by an Advanced Traveler Information System (ATIS) *(21)*. They concluded that there is a need to understand how drivers choose or change routes in the absence of information in order to predict their route choice behavior in the presence of information. The study concluded that ATIS is helpful in driver decision making.

Khattak et al. developed a methodology for incident duration prediction by using a series of truncated regression models *(22)*. The model accounts for the fact that incident information at a traffic operations center is acquired over the life of the incident. Cragg and Demetsky examined the merits and demerits of using simulation model as a decision aid for deploying traffic diversion strategies *(23)*. A methodology for using such a model was demonstrated to determine the effects of various incident types on freeway traffic flow and the diversion of freeway traffic on the arterial network. The study concluded that simulation is an effective tool for IMS.

Madanat and Feroze predicted incident clearance time for the Borman Expressway, Indiana *(24)*. A parametric least-generalized cost path algorithm was developed to determine a complete set of extreme efficient time-dependent paths that simultaneously consider travel time and cost criteria. FHWA developed a framework for evaluating a multiagency traffic incident management program involving many agencies *(25)*.

Balke et al. conducted a survey of traffic, law enforcement, and emergency service personnel to identify incident management performance measures in Texas *(26)*. The basic objective of the survey was to collect driver behavior information and preferred route selection during incidents on road networks. Hidas et al. investigated the effectiveness of variable message signs (VMS) for incident management *(27)*. A survey was conducted in the Sydney metropolitan region to collect information on driver response to a range of VMS messages. They proposed a route-choice model to predict diversion rates resulting from various VMS's.

FHWA developed an alternate route information guide during various types of incidents *(28)*. Five aspects are broadly discussed in the study (a) alternate route planning (b) alternate route selection (c) alternate route plan development (d) traffic management planning, and (e) implementation. FHWA also developed an Incident Command System (ICS), a tool for systematic command, control, and coordination for emergency response *(29)*. ICS allows agencies to work together using a common terminology and a standardized operating procedure for controlling personnel, facilities, equipment, and communications at an incident scene

Wirtz et al. tested a dynamic traffic assignment model for managing major freeway incidents *(30)*. Incidents of various scales and durations were modeled for a highway network in the northern Chicago area, and the impact of incidents and response actions were measured. It was found that the best response action to a given incident scenario was not necessarily intuitive and that implementing the wrong response could often worsen congestion.

The detailed literature review conducted as part of the project clearly indicated that:

- Traffic incidents are major causes of delays on US highways. IMS's, if properly deployed, may have a significant impact on reducing traffic congestion and delay.
- Micro-simulation models are being increasingly used to analyze procedures to alleviate congestion problems
- Various MOE's have been used to evaluate different operational strategies, including: travel time, delay, queue length, traffic volume and volume to capacity ratio.
- Information, when properly communicated to motorists relative to time, space and sequence can be utilized effectively by motorists to find alternate paths in the network.

4. Scope of the Paper

As a part of the larger project that serves as the basis of this paper, a framework was developed for using micro-simulation techniques in assessing the effect of IMS's on freeways. The framework includes the calibration and application of the micro-simulation model on an actual transportation network in the Detroit metropolitan area. The objective of this paper is to elaborate on model calibration, a key component of the overall model development process. A special feature of the model calibration includes efforts to test the ability of the model to generate output to replicate actual network conditions under two separate scenarios: (1) normal operating conditions, and (2) conditions reflecting different types of incidents. Since the broad purpose of this project was to test the feasibility of using micro-simulation techniques for assessing the network consequences of various incident management strategies, it is imperative that the model is capable of replicating traffic behavior under various conditions including different types of incidents. Hence the second part of the calibration process is considered a key component of the overall model development process.

5. Background Information

The Michigan Department of Transportation (MDOT), in collaboration with the U.S. Department of Transportation (USDOT) has established a Traffic Management Center (TMC) in Detroit, designed to monitor the performance of the regional freeway network, instrumented with state-of-the-art ITS equipment, including sensors, detectors, cameras, and close-circuit televisions. Much of the data used in the study was extracted from archived records of the MDOT/TMC, commonly referred to as the Michigan Intelligent Transportation Systems Center (MITSC), as well as from the web-based database provided by the Southeast Michigan Council of Governments (SEMCOG).

5.1 Network Description

The test network in the Detroit metropolitan area consists of two freeways and 11 arterials (Figure 1). The freeways, Interstate 75 (I-75) and Interstate 696 (I-696) provide major mobility needs in the region in the North-South and East-West directions respectively. The arterials serve a combination of mobility and access function in the region. A summary of the network features is presented in Table 1.

TABLE 1 Network Summary

Highway Name	Highway Class	# of Lanes per direction	Posted Speed Limit (miles per hour)	Approximate Length (miles)
I-75	Freeway	3*	70	18.97
I-696	Freeway	3*	70	14.48
Telegraph	Major Arterial	3	40	15.16
Woodward	Major Arterial	4	40	16.05
Ryan	Major Arterial	2	30	12.38
Van Dyke	Major Arterial	3	40	12.58
M-59	Arterial	3	40	15.88
8 Mile	Arterial	4	45	13.57
12 Mile	Arterial	2	40	13.32
14 Mile	Arterial	2	40	13.27
Big Beaver	Arterial	3	40	7.90
Baldwin Ave	Arterial	2	40	4.15
Walton Blvd	Arterial	2	40	3.00

Note*: Some sections of freeway (I-75 and I-696) consist of 4 lanes per direction

The network presented in Figure 1 analyzed consists of 3263 nodes and 3721 sections. A section is defined as a group of contiguous links where vehicles move in the same direction. The partition of the traffic network into sections is usually governed by the physical boundaries of the area and the existence of turning movements. There are 185 centroids representing 185 zones that comprise 34225 origin destination (O-D) pairs. The network contains a total of 50 sensors on the two freeways that record the traffic characteristics continuously. VMSs can be placed before freeway exits to inform drivers of regulations that are applicable only during certain periods of the day or under certain traffic conditions. Freeway ramps, merging points and exit points are coded according to their lengths and curvatures. Traffic volume and signal timing data were collected from the Southeast Michigan Council of Governments (SEMCOG), two local county road commissions, and Traffic.com, a private agency that works closely with MDOT.

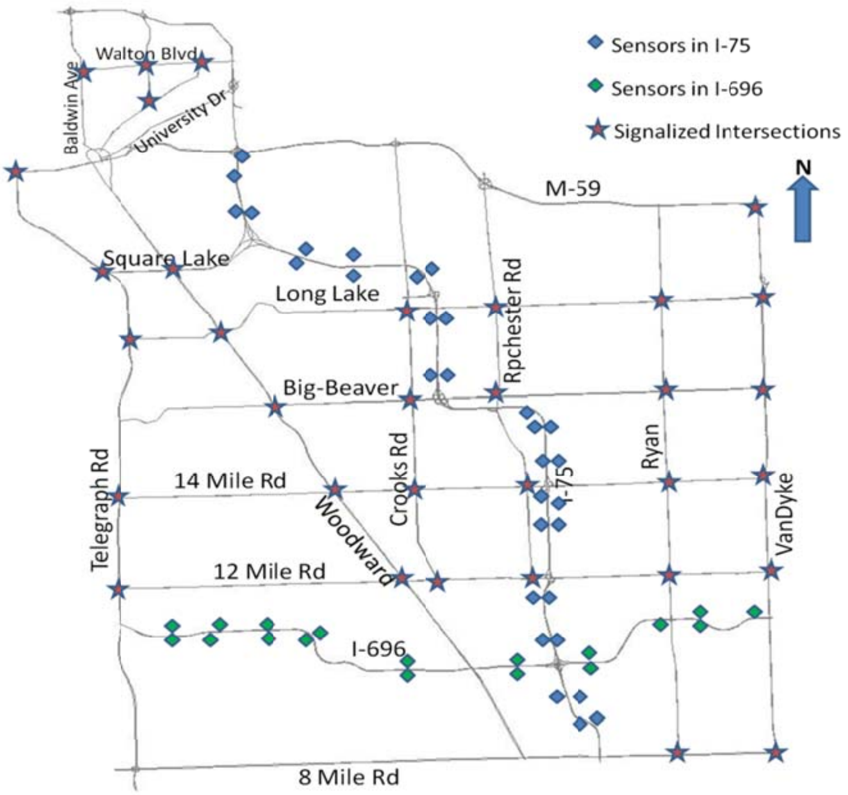

FIGURE 1 Study Area Network

5.2 Incident Data

The Alliance for a Safer Greater Detroit initiated a Freeway Courtesy Program in September 1994 with the purpose of enhancing motorist safety and security while reducing traffic congestion. The program that started with two vans in 1994 has continued to grow, and is currently administered by MDOT as a part of its larger freeway incident management program over the three county area (Wayne, Oakland and Macomb) in metro Detroit. FCP is now integrated with the Michigan Intelligent Transportation Systems Center (MITSC) in Detroit. In 2007, the program employed 24 drivers who operated 24 vans 24 hours a day over the weekdays with a reduced service during weekends.

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Currently, the FCP database includes six types of events or troubles: Flat Tire, No Gas, Mechanical, Accident, Debris and Abandoned Vehicle. Detailed information on 30 such events on the first four categories and 15 on the last two categories were collected for the study from the FCP data for the year 2009. Wherever possible the FCP data was coordinated with traffic sensor data (nearest to the location of the event) for information on the exact location, clearance time, date, flow and travel time. These data were then used for calibration purposes.

6. Methodology

The micro-simulator available in the AIMSUN software is used to test the methodology. AIMSUN is developed by Transportation Simulation Systems (TSS), Barcelona, Spain and is capable of incorporating various types of incidents in a network consisting of detectors, traffic signals, VMS and other attributes. The input data requirement for AIMSUN is a set of scenarios (network description, traffic control plan and traffic demand data) and parameters (simulation time, statistical intervals, reaction time, etc.) which define the experiment *(10)*.

The proposed model calibration process conducted in two separate channels is shown in Figure 2. Initially, the model is calibrated without any incident data. Upon completion of no incident calibration, the model is further validated with incident data. Upon successful calibration on both channels, the model was considered appropriate for testing different IMS strategies. These are further elaborated in the following sections.

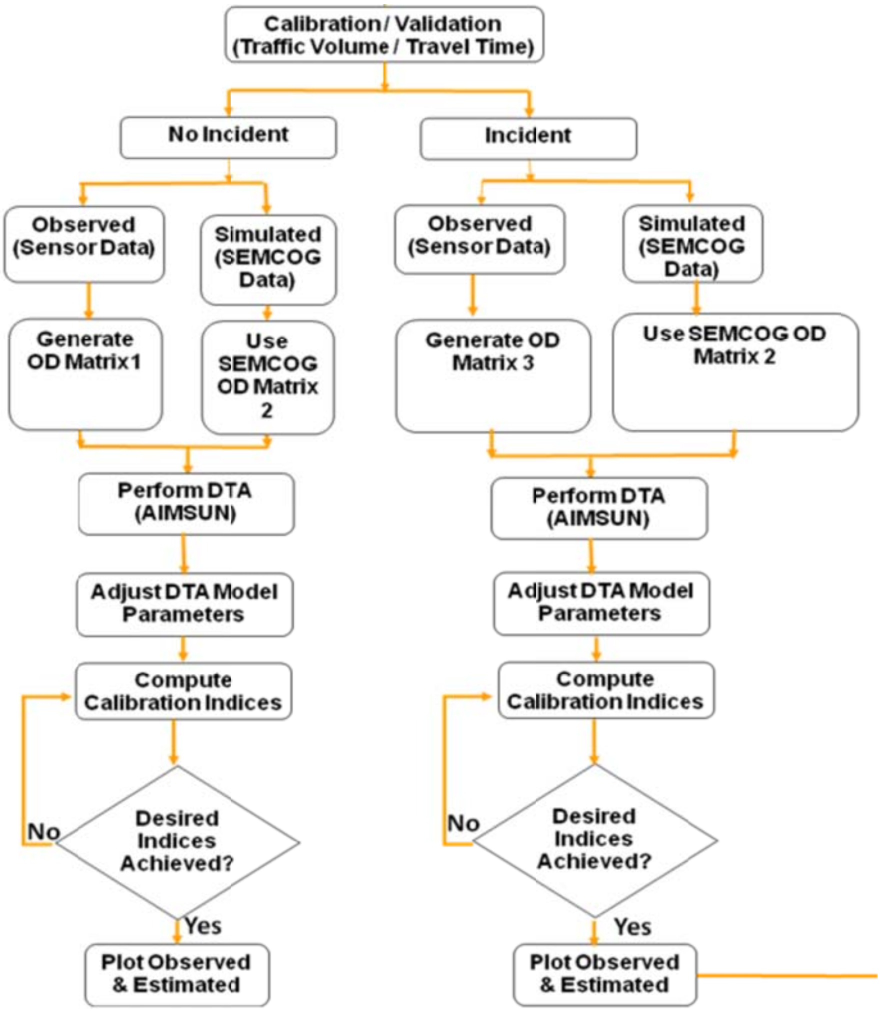

FIGURE 2 Model Development Process

The purpose of model calibration is to ensure that the model output is a reasonable replication of traffic flow characteristics observed in the field. The parameters that explain the field data are then used in testing the effectiveness of different strategies. A special characteristic of this study is the utilization of archived data collected from sensors in the freeway network available through MDOT/MITSC and a private operator, Traffic.com. As stated above, calibration is conducted in two channels: (1) No-Incident calibration and (2) Incident calibration. Also, a set of three OD matrices are shown in Figure 2. These are explained below.

- OD Matrix 1: This OD matrix is developed for calibration of model under no-incident scenario. The observed traffic volume data recorded by various sensors on a specific day is input into the

AIMSUN tool. This data is used by AIMSUN to generate a trip table (185*185)[1](OD Matrix 1) in 5 minute intervals through matrix adjustment. The OD matrix thus developed is used for simulating the real time scenario.

- OD Matrix 2: This OD matrix is developed for calibration under no-incident scenario. Unlike the OD Matrix 1, this matrix (185*185) is generated from SEMCOG's large regional matrix estimated for the year 2015. This data is input into AIMSUN tool in the form of an OD Matrix directly.
- OD Matrix 3: This OD Matrix is developed for calibration of model under incident scenario. The procedure is similar to the development of OD Matrix 1 excepting that the traffic volume data used in this case is the data recorded by various sensors over the incident duration.

Table 2 lists a set of tests that were conducted for model validation.. These goodness-of-fit statistics are used in literature for micro-simulation model calibration *(32-37)*.

TABLE 2 Goodness-of-fit measures for Calibration (*31-36*)

Goodness-of-fit Measures	Formulae	Desirable
RMSE (Measures Overall % Error)	$\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i-y_i}{y_i}\right)^2}$	Close to 0
Correlation Coefficient: *r* (Measures Linear Association)	$\frac{1}{n-1}\sum_{i=1}^{n}\frac{\left(x_i-\overline{x}\right)\left(y_i-\overline{y}\right)}{\sigma_x\sigma_y}$	Close to 1
Theil's Inequality Coefficient: *Ui*(Disproportionate Weight of Large Errors)	$\frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_i-y_i\right)^2}}{\sqrt{\frac{1}{n}\sum^{n}\quad{}^2}\quad\sqrt{\frac{1}{n}\sum^{n}\quad{}^2}}$	Close to 0
Theil's Component: *Us* (Measure of Variance Proportion)	$\frac{n\left(\sigma_y-\sigma_x\right)^2}{\sum_{i=1}^{n}\left(y_i-x_i\right)^2}$	Close to 0
Theil'sComponent:*Uc* Measure of Covariance Proportion	$\frac{2\left(1-r\right)n\sigma_y\sigma_x}{\sum_{i=1}^{n}\left(y_i-x_i\right)^2}$	Close to 1
Theil'sComponent:*Um* (Measure of Bias Proportion)	$\frac{n\left(\overline{y}-\overline{x}\right)^2}{\sum^{n}\left(y_i-x_i\right)^2}$	Close to 0

Notations used in the goodness-of-fit measures are:

x_i : Simulated traffic measurement value at time *i*

y_i: Actual traffic measurement value at time *i*

$\overline{x}$: Mean of simulated traffic measurement values

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[1] The study area includes a total of 185 Traffic Analysis Zones (TAZ) that includes 158 internal zones and 27 external stations.

$\overline{y}$: Mean of actual traffic measurement values

σ_x : Standard deviation of simulated traffic measurement values

σ_y : Standard deviation of actual traffic measurement values

7. Results

7.1 No Incident Calibration

Traffic volume data collected from sensors over an extended period (usually three to six hours), when input to AIMSUN was instrumental in creating a 185 x 185 O-D matrix for the same time period(OD Matrix1, also termed as observed data). A sub-area O-D matrix (185*185) is generated for the network under consideration from SEMCOG'S large regional matrix.. (OD Matrix 2, also termed as simulated data). The two 185 x 185 O-D matrices developed using two different tools from two different sources are input back to AIMSUN and are subjected to dynamic traffic assignment (DTA) while adjusting the DTA parameters. Sensors are coded in the model network and are used to record traffic volumes at 5 minute intervals.

7.1(a) Traffic Volume Calibration

These traffic volumes on major links are compared to assess if a reasonable correspondence is achieved between the two assignments. DTA parameters are adjusted until a desired degree of correspondence is reached. One such match between field data and model data (obtained through iterative process adjusting selected model parameters) for a specific sensor location on I-75 freeway is presented in Figure 3. Each of the data pairs represents a five minute volume for the observed data (OD Matrix 1) and the simulated data (OD Matrix 2). There are 36 five minute intervals over the simulation period of three hours as shown in these figures. These figures indicate that even though there is not a perfect match between the two sets of data, a reasonable correspondence was achieved. The procedure was repeated with entirely different sets of sensor data collected on different dates for more reliability in model calibration.

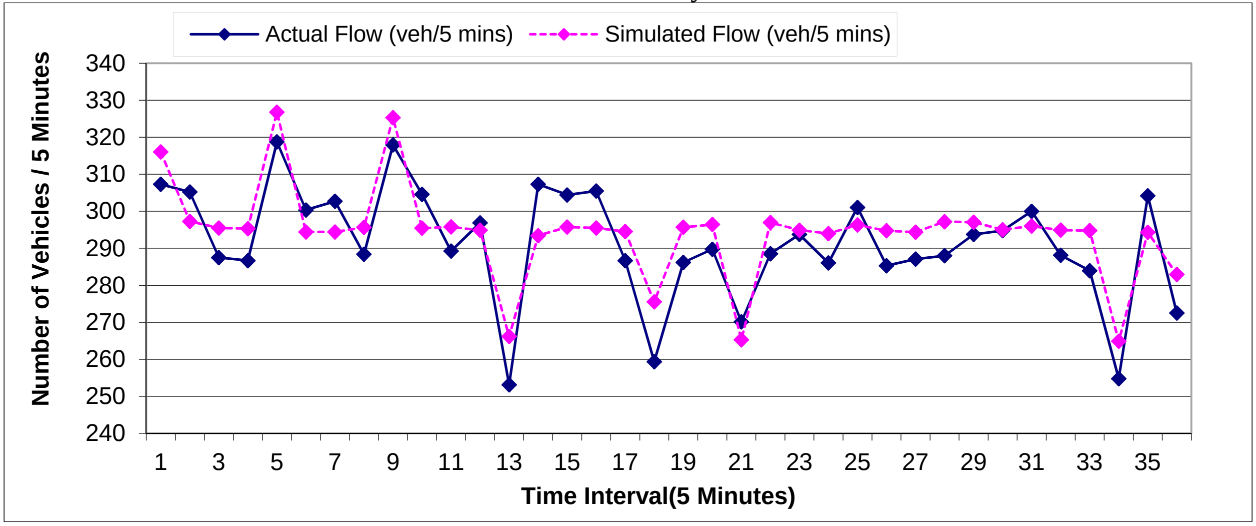

FIGURE 3 No Incident - Sensor MI075200N (S of 12 Mile at I-75), Date:7/12/2008, Time: 3:00PM-6:00PM

7.1 (b) Travel Time Calibration

The actual travel time observed on various links was obtained from SEMCOG cut-lines (Transportation Data Management System). AIMSUN is also capable of calculating the travel time on various links of the network following the simulation. The simulated travel time is plotted against observed travel time on 7/12/2008 for a total of 16 selected links on the network and is shown in Figure 4. These links are identified in the project report. These data sets represent the best comparison (visually) achieved by repeated iterations. It is to be noted that the SEMCOG cut-line (Transportation Data Management System) does not provide day specific travel time data. Thus, the simulated travel time data is compared with the observed travel time recorded by SEMCOG on a different date, 3/1/2009.

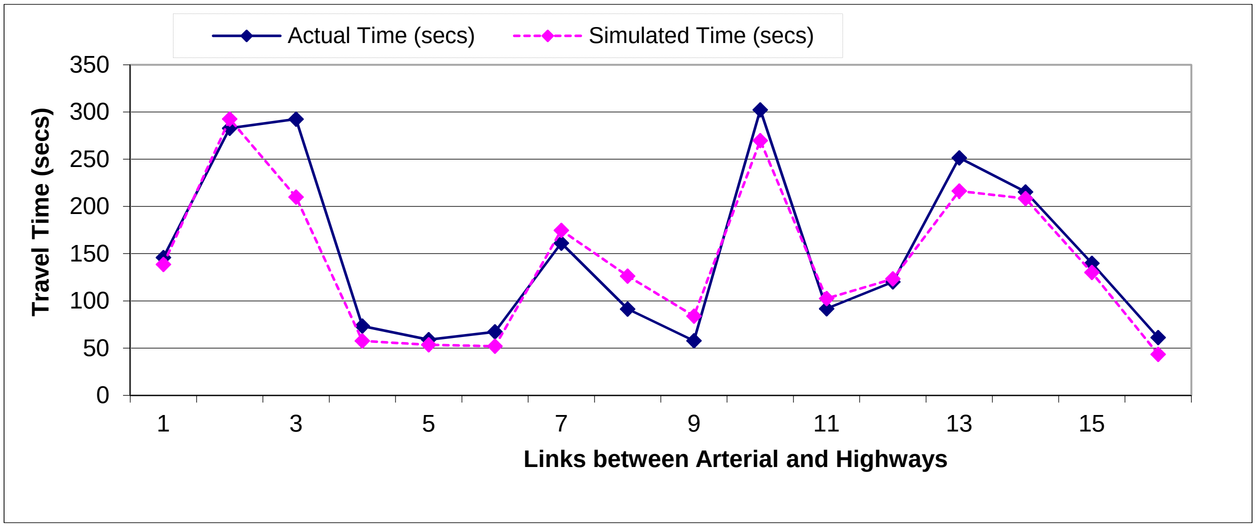

FIGURE 4 No Incident - 7/12/2008, TIME: 3:00PM-4:00PM

7. 2 Incident Calibration

The input data for the Incident Calibration are extracted from two sources: FCP (Freeway Courtesy Patrol) database, O-D Matrix 2.The incidents are identified by their respected codes from FCP. Codes 1, 2, 3, 4, 5 and 6 are categorized as Abandoned Vehicles, Flat Tire, No Gas, Mechanical Problems, Debris and Accidents respectively. The date, time, number of lanes and the lane where the incident occurred are identified from FCP database. Traffic volume data for five minute intervals corresponding to the same date and time is imported into AIMSUN from sensor data. The sensor data creates a 185*185 trip table in AIMSUN that serves as the observed data for the simulation (OD Matrix 3).The trip table generated from the sub-area OD Matrix 3 serves as the simulated data used for simulating various incidents.

7.2(a) Traffic Volume Calibration:

The location on I-75 where the incident occurred, and the lanes affected were manually de-activated and the simulation was run using the OD Matrix 2. The manual de-activation part can be considered as a surrogate for the incident within the model. After the simulation, the traffic volume data for five minute intervals was recorded for a number of sensor locations. This set of data served as the simulated flow data for the Incident simulation. The same procedure is implemented using the OD Matrix 3. This set of volume data in five minute intervals served as the observed flow data. Thus, a set of traffic volume data was collected for each of the six types of incidents recorded. (Only a sample of these incident calibrations is reported in this paper). These two sets of data, when plotted, showed close resemblance to each other. One such set for sample comparison is shown in Figure 5 for one type of incident, Abandoned Vehicles that resulted in closing of the right lane on the freeway. Accordingly, the right lane was manually de-activated within the model.

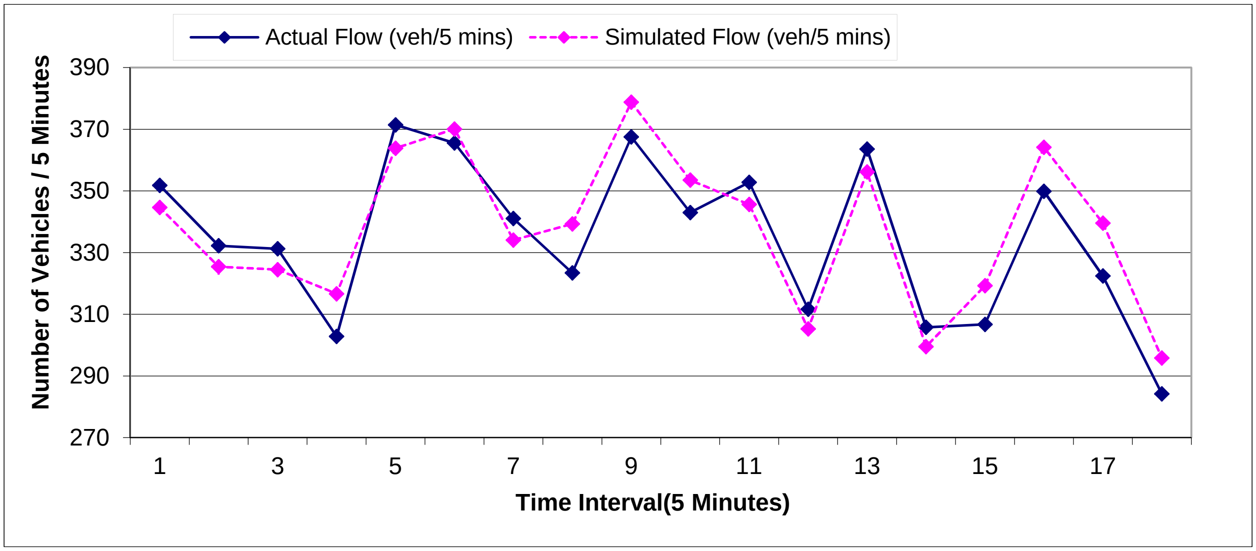

FIGURE 5 Right Lane Closed at SB I-75 @ 12 Mile - Sensor MI075180S (N of I-696 at I-75, Abandon Vehicle, Date: 01/9/2009, Time 8:35 AM to 10:00AM)

7.2(b) Travel Time Calibration:

Results for travel time calibration for different incidents for 16 selected links in the network are shown in the project report. One such sample comparison is presented in Figure 6with Abandoned Vehicle as the incident. An excellent correlation of model output is observed.

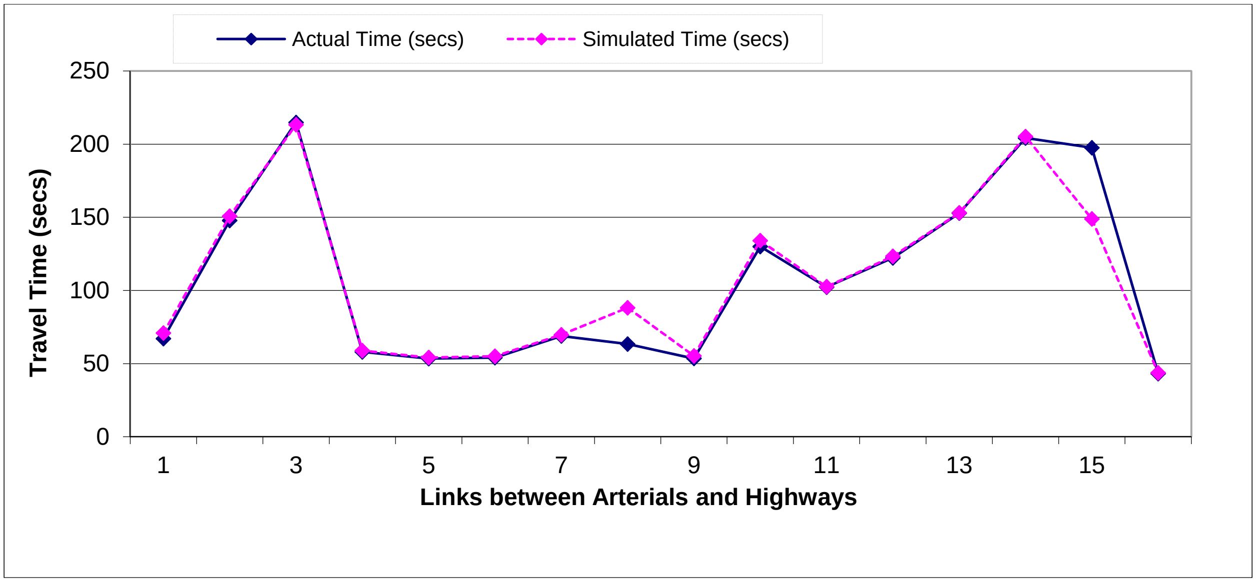

FIGURE 6 Right Lane Closed at SB I-75 @ 12 Mile

7.2 (c) Overall Calibration Results:

The simulated volume and actual volume are plotted in Figure 7(a) and the simulated travel time and actual travel time are plotted in Figure 7(b). Each of these figures shows a total of 384 data points (32 locations with 12 five minute counts). The RMSE value is computed as 0.0001. Further, the two sets of values, when plotted on a graph, formed a linear representation at 45° (Figure 7(a) and 7(b)), thus indicating a close correspondence between the observed data and the model output.

Table 3 shows the goodness of fit results (presented in Table 2) for traffic volume calibration, both with and without incidents. The results are self-explanatory. The correlation coefficients vary from a low of 0.85 to a high of 0.98. Similarly, the Root Mean Square (RMS) Error values range between 0.02 to 0.04. All other test results presented in Table 3 reflect a high degree of correspondence between the observed data and the model output. Similarly, Table 4 shows goodness of fit results for travel time calibration. As in the previous case, a high degree of correlation between the observed data and the model output is clearly evident from Table 4.

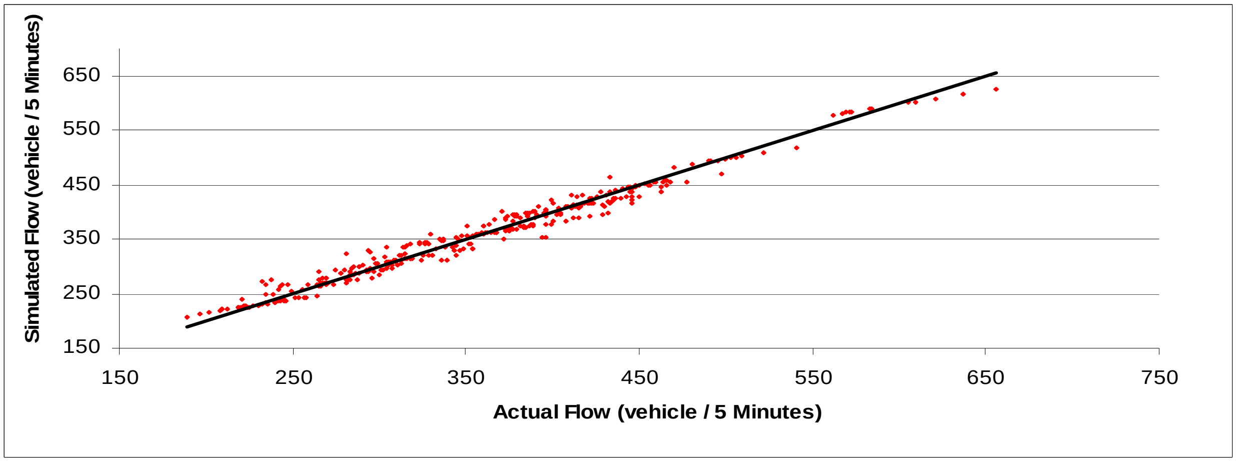

FIGURE 7(a) Actual and Simulated flow on I-75 (4PM -5PM)

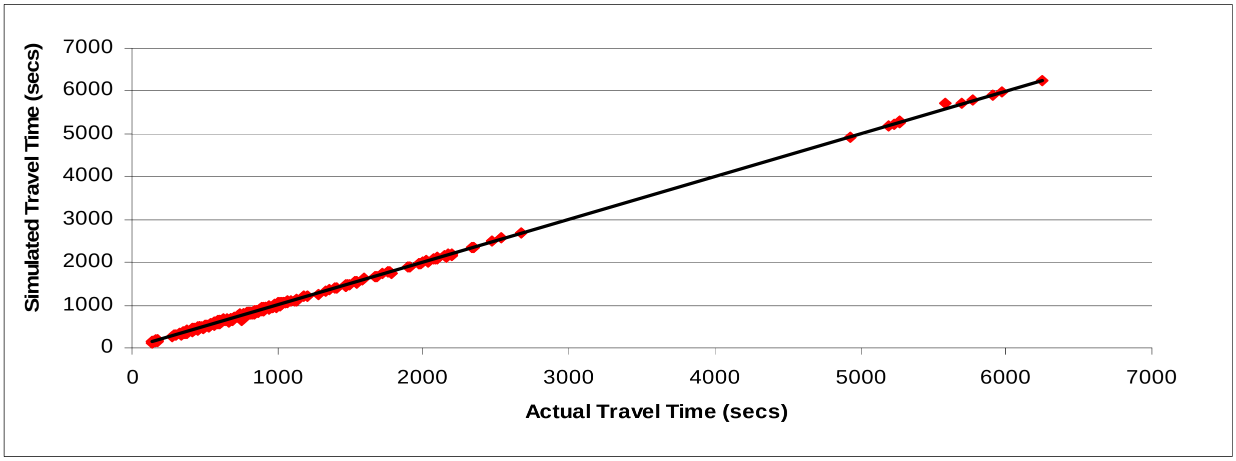

FIGURE 7(b) Actual and Simulated Travel Time on I-75 (4PM -5PM)

TABLE 3 Summary of Results (Traffic Volume Calibration):

With/Without Incident	Types of troubles	Date, Time of the Incident	Location of the Incident	Location of the Sensor	Root Mean Square Error (RMSE) % Error	Correlation Coefficient (*r*)	Theil's Weight of Large Errors (*Ui*)	Theil's Variance Proportion (*Us*)	Theil's Covariance Proportion (*Uc*)	Theil's Bias Proportion (*Um*)
No Incident	No troubles	7/12/2008, 3PM-6PM	No Incident	S of 12 Mile at I-75	0.03	0.85	0.01	0.12	0.89	0.12
				S of 14 Mile at I-75	0.07	0.95	0.03	0.05	0.98	0.10
				S of 12 Mile at I-75	0.03	0.86	0.02	0.29	0.84	0.02
		9/22/2008, 3PM-6PM	No Incident	S of 12 Mile at I-75	0.02	0.95	0.01	0.03	0.98	0.12
				S of 14 Mile at I-75	0.02	0.86	0.01	0.23	0.87	0.04
				S of 14 Mile at I-75	0.03	0.95	0.01	0.26	0.86	0.02
With Incident	Abandoned Vehicles	1/19/2009, 8:35AM-10:00AM	SB-I-75 @ 12 Mile (Right Lane)	North of I-696 at I-75	0.03	0.92	0.02	0.01	0.97	0.14
				S of 14 Mile at I-75	0.04	0.88	0.02	0.00	0.98	0.07
	Flat Tire	1/19/2009, 5:40PM-7:05PM	SB-I-75 @ 12 Mile (Right Lane)	S of 12 Mile at I-75	0.03	0.97	0.02	0.12	0.80	0.13
				S of 14 Mile at I-75	0.03	0.98	0.02	0.06	0.81	0.18
	No Gas	1/24/2009, 3:15PM-4:40PM	NB-I-75 @ 13 Mile (Right Lane)	S of 14 Mile at I-75	0.03	0.90	0.01	0.14	0.90	0.04
				S of 12 Mile at I-75	0.02	0.92	0.01	0.20	0.86	0.01
	Mechanical Problems	1/26/2009, 2:25PM-3:50PM	SB-I-75 @ 12 Mile (Right Lane)	S of 12 Mile at I-75	0.03	0.95	0.01	0.11	0.89	0.09
				S of 14 Mile at I-75	0.03	0.97	0.01	0.15	0.89	0.03
	Debris on Road	2/6/2009, 4:25PM-5:50PM	SB-I-75 @ 14 Mile (Right Lane)	S of 14 Mile at I-75	0.02	0.91	0.01	0.02	0.98	0.11
				S of 15 Mile at I-75	0.02	0.96	0.01	0.10	0.95	0.01
	Accident	1/13/2009, 8:10AM-9:35AM	SB-I-75 @ 13 Mile (Right Lane)	S of 12 Mile at I-75	0.03	0.93	0.01	0.02	0.86	0.34
				S of 14 Mile at I-75	0.03	0.96	0.01	0.02	0.90	0.26

TABLE 4Summary of Results (Travel Time Calibration):

With/Without Incident	Types of troubles	Date, Time of the Incident	Location of the Incident	Root Mean Square Error (RMSE) % Error	Correlation Coefficient (*r*)	Theil's Weight of Large Errors (*Ui*)	Theil's Variance Proportion (*Us*)	Theil's Covariance Proportion (*Uc*)	Theil's Bias Proportion (*Um*)
No Incident	No troubles	7/12/2008, 3PM-4PM	No Incident	0.21	0.96	0.08	0.16	0.82	0.09
		9/22/2008, 3PM-4PM	No Incident	0.15	0.97	0.07	0.10	0.80	0.15
With Incident	Abandoned Vehicles	1/19/2009, 8:35AM-10:00AM	SB-I-75 @ 12 Mile (Right Lane)	0.12	0.97	0.06	0.13	0.94	0.00
	Flat Tire	1/19/2009, 5:40PM-7:05PM	SB-I-75 @ 12 Mile (Right Lane)	0.06	0.99	0.04	0.19	0.85	0.03
	No Gas	1/24/2009, 3:15PM-4:40PM	NB-I-75 @ 13 Mile (Right Lane)	0.11	0.98	0.04	0.03	0.89	0.14
	Mechanical Problems	1/26/2009, 2:25PM-3:50PM	SB-I-75 @ 12 Mile (Right Lane)	0.07	0.98	0.05	0.04	0.94	0.07
	Debris on Road	2/6/2009, 4:25PM-5:50PM	SB-I-75 @ 14 Mile (Right Lane)	0.18	0.96	0.07	0.01	0.87	0.17
	Accident	1/13/2009, 8:10AM-9:35AM	SB-I-75 @ 13 Mile (Right Lane)	0.06	0.99	0.02	0.00	0.98	0.08

8. Conclusions

As a part of the larger project that serves as the basis of this paper, a framework was developed for using micro-simulation techniques in assessing the effect of incident management strategies on urban freeways. The framework includes the calibration and application of the micro-simulation model AIMSUN on an actual transportation network in the Detroit metropolitan area. The objective of this paper is to elaborate on model calibration, a key component of the overall model development process. A special feature of the model calibration includes efforts to test the ability of the model to generate output to replicate actual network conditions under two separate scenarios: (1) normal operating conditions, and (2) conditions reflecting different types of incidents. Since the broad purpose of this project was to test the feasibility of using micro-simulation techniques for assessing the network consequences of various incident management strategies, it is imperative that the model is capable of replicating traffic behavior under different types of incidents in the first place. Hence the second part of the calibration process is considered a key component of the model, if is to be used as a tool for assessing the traffic consequences of various incident management strategies.

The calibration of the proposed model is demonstrated on a heavily traveled portion of an urban network in the Detroit metropolitan region. The network contains two freeways (Interstate 75 and Interstate 696) instrumented with various ITS devices, and a number of major arterials with signalized intersections. The model calibration process is conducted in two separate channels. Initially, the model is calibrated without any incident data. Upon completion of no-incident calibration, the model is further validated with incident data. Travel time and traffic volume data (in 5 minute increments) were obtained from sensors installed by the Michigan Department of Transportation at strategic locations on the two freeways. A set of statistical tests are reported in the paper that show excellent correlation between the observed data and the model output.

The calibrated model may be used to assess the traffic consequences of various IMS's. AIMSUN has the capability to deploy four types of IMS's as a tool for alleviating traffic congestion. These are: Lane Closure, Section Incident, Forced Turning, and Congestion, each with a specific implication. The model output (travel time, volume, delay, and queue length) between two scenarios (with and without the incident) under "Guided" and "Unguided" conditions would reflect the possible traffic consequence of the IMS deployed. Clearly, a model, calibrated with extensive field data is likely to produce more credible results for deployment purposes. The application phase of the model is beyond the scope of this paper.

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