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Calibrating Microsimulation Parameters for Vehicular Travel Time

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ABSTRACT

Travel time is one of the simplest yet the most important parameter for transportation facility users as well as transportation engineers. Travel time data is valuable for wide range of transportation analysis including congestion management, transportation planning and passenger's decision making. Traffic simulation models are now becoming necessary tools to understand the behavior of traffic and reduce vehicular travel times, but it is very important to calibrate these models first. This study attempts to determines the values of those parameters, using microsimulation, that significantly affect the travel time. These parameters are then used for calibrating the traffic simulation model that results in realistic travel time. Study was conducted on an urban road and field data was collected during weekdays for peak hours. The traffic network was modelled using VISSIM®. The calibration parameters were desired speed distribution, number of lanes, average standstill distance and minimum headway. After calibrating the model, the travel times collected from field data and those by simulations for different modes of transportation were in close agreement.

Keywords: Desire Speed Distribution, Microsimulation, Transportation Planning, VISSIM®.

1 INTRODUCTION

Transportation sector is one of the most vital and significant sectors of a city that plays a key role in the social, economic and cultural development of a city and ensures its successful functioning. Though, due to rapid increase in the population of metropolitan cities, this sector is facing major problems including traffic congestion, low fuel efficiency, increased vehicular travel times and exhaust emissions.

To represent on-field conditions on urban roads as close as possible and study the behavior of vehicles for effective traffic management and control analysis, microscopic traffic simulation tools have been widely used [1]. [2] has briefly discussed the different tools used for traffic modelling and analysis. These traffic simulation tools are now becoming integral part of Intelligent Transportation Systems (ITS) for traffic regulatory control in urban areas. The complication of traffic stream behavior and the difficulties in performing experiments with real world traffic make these computer-generated simulations an important analysis tool in transport and traffic engineering. However, traffic simulation models need to be calibrated and validated first.

Various microscopic traffic simulation tools consist of several controllable and uncontrollable input parameters to explain the existing traffic flow especially the driver behavior. The simulation tools have default input values for these parameters; however, they offer the user to put the values of these parameters according to the local conditions to accurately represent the on-field traffic conditions. This process is called the model calibration.

Model validation is the process to find out whether the simulation model is an accurate representation of the system under study or not by the comparison of values generated from simulation models of certain measure of effectiveness to the on-field values with the condition that the on-field values must be of the same measure of effectiveness.

It is necessary to select certain measure of effectiveness like vehicular travel time or queue length and then determine parameters that affects these measures of effectiveness (travel time/ queue length) for the proper calibration and validation of these models. After the calibration and validation of traffic simulation models, they can be used for urban congestion management, and analyze the impact of urban development plans through graphical depiction of traffic flows.

[3] described the calibration process of microscopic traffic simulation model in detail having three main phases: (Phase 1) tasks and activities which are done before the start of any calibration model like identification of goals and field data which is to be collected,(Phase 2) initial calibration of the simulation model and (Phase 3) comparison of the results from the simulation model with filed data. The study provides a very thorough procedure for the calibration of the model however, there is no direct method of model validation of the model.

[4] developed a methodology for the validation of simulation model using 5 key elements: (1) context, (2) data, (3) uncertainty, (4) feedback and (5) prediction. The simulation tool used was CORSIM® to validate the signal times in Chicago by the numerical comparison of the collected field data with the CORSIM®[5] model through visualization .

Their study does not a formal procedure for the calibration as well as validation of simulation model.

Park & Schneeberger[6] suggested a 9-step comprehensive process for the calibration and validation of Microscopic Simulation Model developed through VISSIM® for an arterial network on Lee Jackson Highway which has 12 intersections and forms a coordinated actuated signal system. Travel time and maximum queue length are used as measures of performance for the calibration and validation process. Controllable and uncontrollable input parameters as well as calibration parameters have been identified. For validation, field data is collected on some other day and then the results of the model in VISSIM® are compared. The procedure of the proposed study seems to be working well for the model calibration and validation for signalized intersections. However, Further study should be carried out on the study topic so as to determine whether this procedure is applicable to other networks or not.

The purpose of this paper is to develop a framework for the calibration and validation of microsimulation model through a case study. The simulation tool used is VISSIM® which uses psychophysical driving behavior and provides for the direct modelling of the network within the simulation tool.

2 METHODOLOGY

The methodology for this study is explained through the flowchart given in Figure **1**

2.1 Field Data Collection

To develop a microsimulation model in PTV VISSIM®, on-field data collection is one of the prerequisites, as it is required for the calibration and validation of the model. Therefore, data was collected on test site for different parameters.

Data was collected for travel time and average speed during the peak hours from 7:30 AM to 9:00 AM during weekdays (Tuesday to Friday) on an urban road in both the directions. The data was collected using mobile phone GPS as most of the vehicles in the study area lacked proper functioning speed meters. Figure **2** shows Field Travel Time comparison for different vehicle types in the study area.

Traffic volume data has also been collected for the test site using classified manual traffic count during the morning peak traffic hours (7:30 AM to 9:00 AM). Figure **3** shows the traffic volume composition in the study area.

Also, the geometric data which includes the geometry of different vehicles as well as the geometry of roads has also been collected manually.

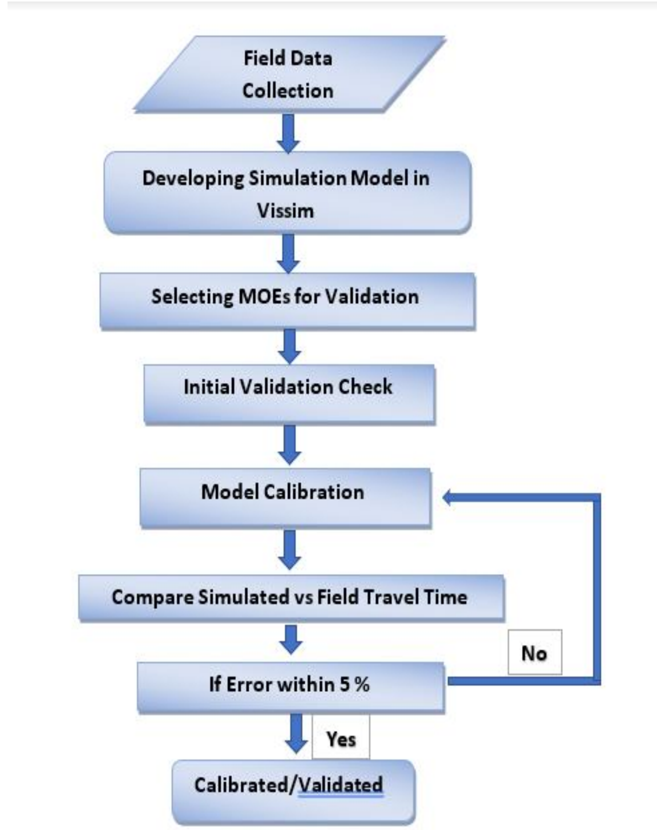

Figure 1: Study Methodology

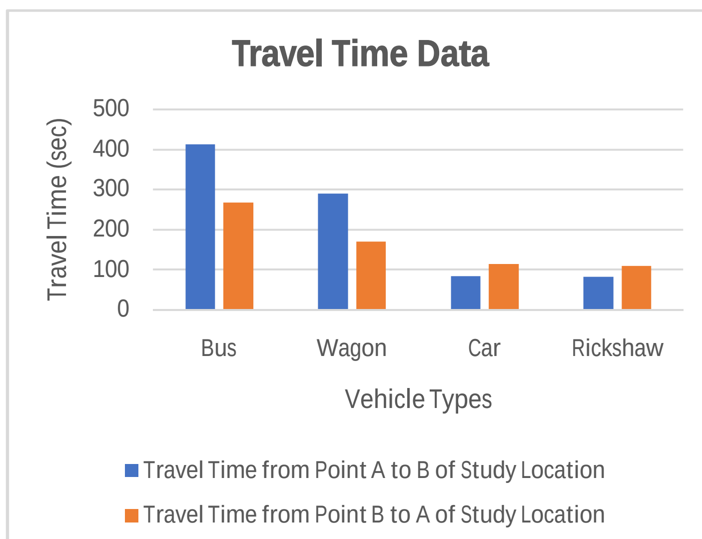

Figure 2: Field Travel Time comparison for different Vehicle Types in the Study Location

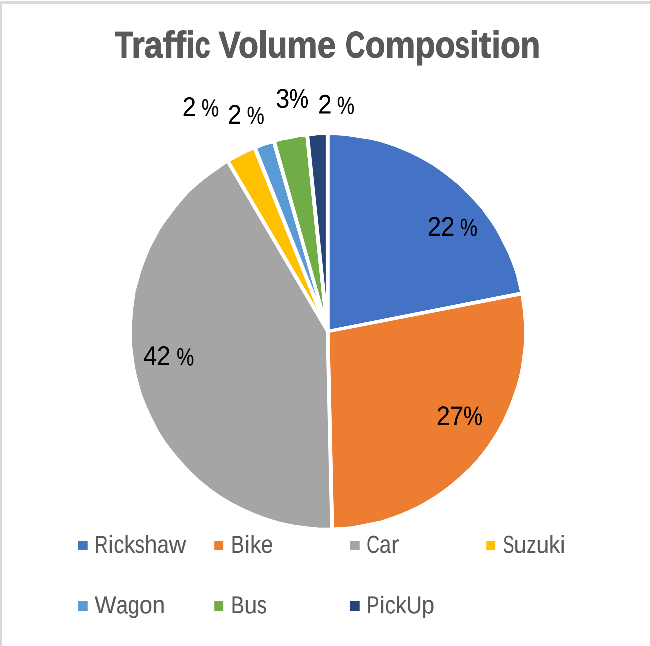

Figure 3: Traffic Volume Composition in the Study Location

2.2 Developing Simulation Model in PTV VISSIM

A simulation model of study location covering 0.95 kilometers has been developed in PTV VISSIM® [7] using different steps like defining 2D/3D Models, vehicle types, vehicle composition, routing decisions, conflict areas etc. Figure **4** shows the satellite image of the study location.

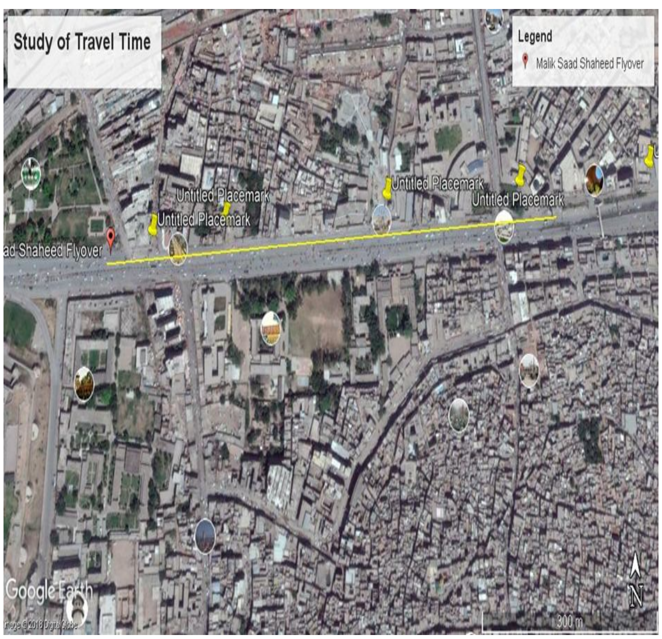

Figure 4: Google Satellite Image of the Study Location

2.3 Selecting measure of effectiveness (MOE) for Validation

Model validation is the process to find out whether the simulation model is an accuraterepresentation of the system under study or not by the comparison of values generated from simulation models of certain measure of effectiveness to the on-field values with the condition that the on-field values must be of the same measure of effectiveness.

In this research travel time has been chosen as a measure of effectiveness for validation.

2.4 Initial Validation Check

It is necessary to do an initial model validation check in order to determine whether the results of first simulation (Simulated Travel Time) matches the on-field values (Field Travel Time) and a benchmark can be set for calibration. Figure **5** shows the results after first simulation of the model in PTV VISSIM®. Figure **6** represents the box and whiskers plot of the field and simulation travel times.

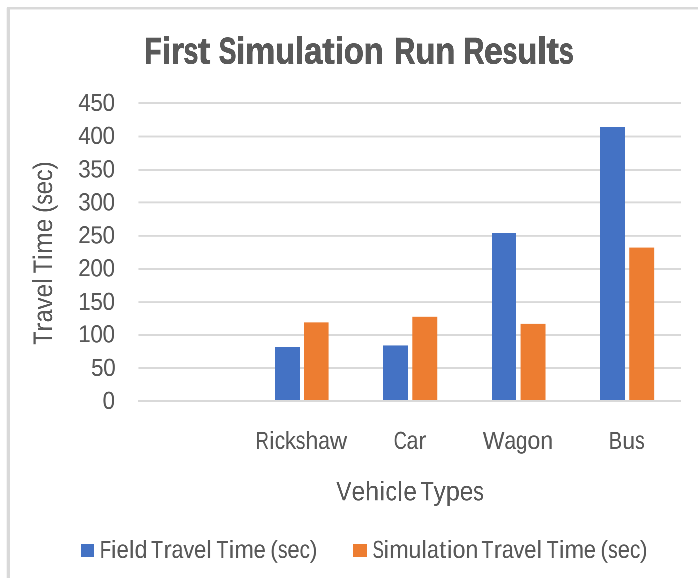

Figure 5: Results after first simulation run of the model in PTV VISSIM®

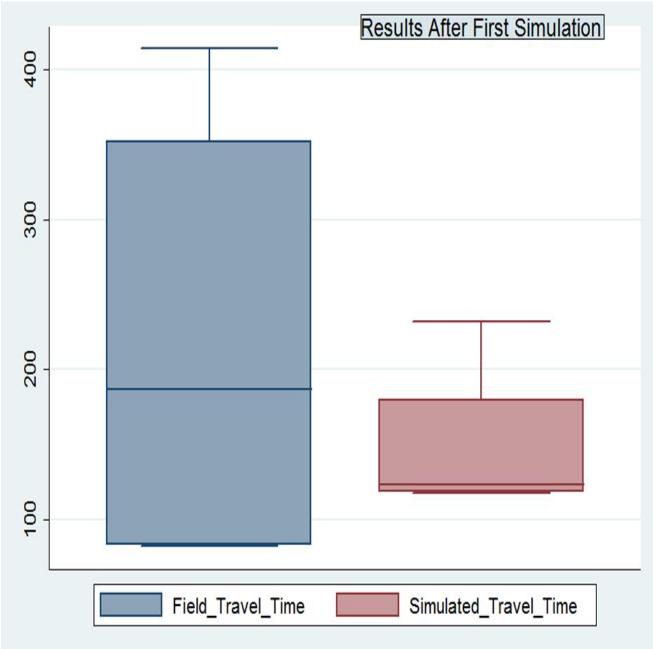

Figure 6: Box and Whiskers Plot showing comparison between Field and Simulation Results after the first simulation run

3 MODEL CALIBRATION

After the initial validation check, the simulated travel times and on-field travel times for different modes of transportation were not the same as shown in Figure **6**. It means that the model does not represent the field conditions. Hence, it is necessary to calibrate the model. Calibration is done by changing different parameters in the driving behavior.

The parameters that were changed to calibrate the model include:

1. Desired Speed Distribution
2. Number of Lanes
3. Average Standstill Distance
4. Minimum Headway

4 RESULTS AND DISCUSSIONS

For proper calibration, different parameters in driverbehavior were changed on the basis of trial and error method. A total of more than 125 simulations were run after which the difference was reduced to the acceptable range of less than 5%.After calibrating the model, the difference between the field travel time and simulated travel time for different modes of transportation has been reduced to significant amount.

Figure **7**shows the comparison of field and simulated travel time after model calibration. Figure **8** shows the box plots comparison of field and simulated travel times.

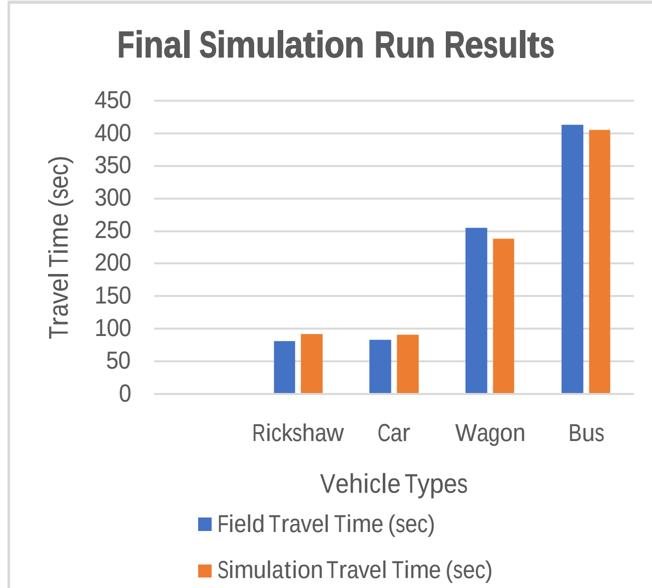

Figure 7: Results after calibrating the model in PTV VISSIM®

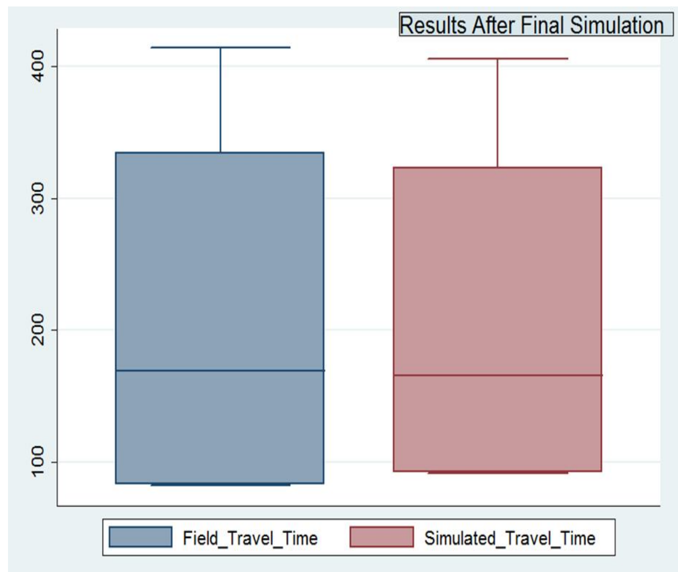

Figure 8: Box and Whiskers Plot showing comparison between Field and Simulation Results after the first simulation run

4.1 Desired Speed Distribution

It is defined as the speed which a vehicle desires to travel at, if it is not disturbed or hindered by any other vehicle. For other vehicles, the desired speed distribution was found to follow the conventional S-shaped curve. However, for Bus and Wagon, it was found to be rather different. This difference was due to the reason that these vehicles tend to stop unexpectedly at locations other than bus stops. Hence, most of its speed is distributed in a region near to zero. Figure **9** and Figure **10** shows the desired speed distributions for Bus and Wagon.

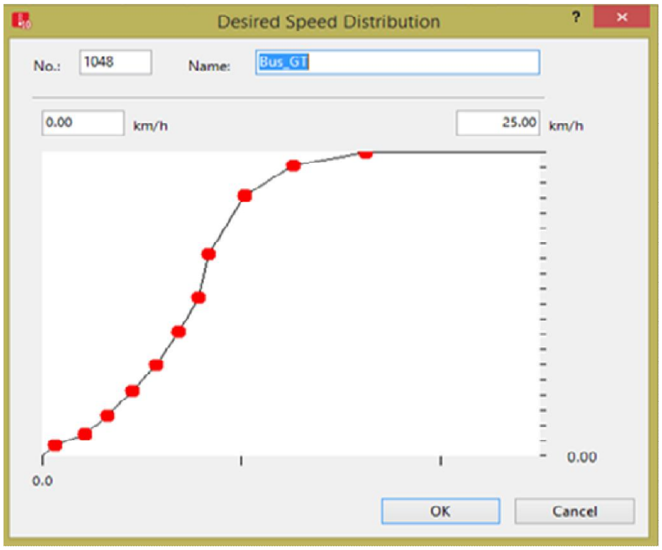

Figure 9: Desired Speed Distribution for Bus

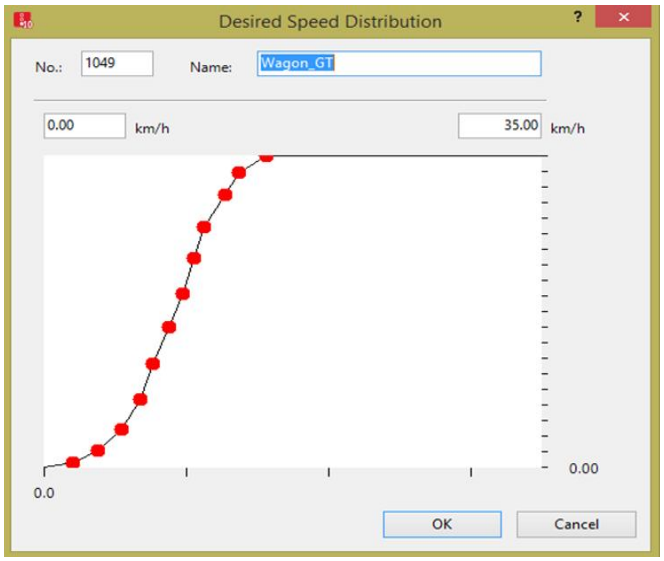

Figure 10: Desired Speed Distribution for Wagon

4.2 Number of Lanes

It was found that during peak hours, a 3-lane road acts as a 4-lane or a 5-lane road. That is due to the improper lane following of the vehicles. The vehicles somehow adjust their positions and form more than 3 lanes. Initially, the model was made with a 3-lane road network. But it was found to be well calibrated when the number of lanes were changed to 4.

4.3 Average Standstill Distance

It defines the average distance that a vehicle desires away from static obstacles such as stopped vehicles, priority rules, conflict areas etc. The default value for average standstill distance in the software is 6.56 feet which was found to be 5 feet for case study. Acceptable range is 3.2 to 9.8 feet. [6]

4.4 Minimum Headway

It is the minimum distance that must be available in front of a vehicle in order to carry out a lane change. The minimum headway was found to be 14 feet by trial-and-error method for the case study. Acceptable range is up to 23 feet. [6]

5 CONCLUSION

The purpose of the research was to calibrate a section of an urban road using PTV VISSIM® and determine the parameters that significantly affect the travel time which has also been used as a measure of effectiveness for validation in the present study case.

The parameters that were changed to calibrate the model include desired speed distribution, number of lanes, average standstill distance and minimum headway.

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