Abstract: In the state of practice, traffic operators require dynamic traffic information in order to make decision to choose the suitable traffic operational plan that could mobilize traffic safer and with less travel delay. Data from conventional point detection system is widely available for determining travel time. Nonetheless, the penetration of detector stations is directly correlated to the accuracy of estimated link travel time. The theoretical as well as practical challenge is the improvement of accuracy of estimated travel time using available or lower level of data from point detection system. This paper aimed to propose on-line microsimulation to be an alternated method for estimating link travel time on expressway with low density of detector stations. The results from the study show that the proposed method is able to represent link travel time on both traffic conditions when implement on expressway with low density of detector stations or long links.

Key Words: Dynamic traffic information, Point detector, On-line microsimulation, Expressway

1. INTRODUCTION

Travel time has been identified by Austroads as an important system performance measure (Cunningham et al., 1995). Travel time information is applied in various usage and purposes. In Advanced Traveler Information System (ATIS) application, travel time information is used as an index to indicate traffic situation of road network and helps travelers to save trip time through better path selection. Accurate travel time estimation could help reduce transport costs by avoiding congested sections and increase the service quality of commercial delivery goods.

In the state of practice, traffic information is required by traffic operators to monitor traffic conditions and make a suitable action on traffic operation with an objective to efficiently manage traffic on the network. Traffic information can also be disseminated to travelers on variable message signs or on-board vehicle route guidance unit or any other device so that
travelers can optimize their own travel. Reliable real-time traffic information is a key factor to yield successful ATIS outcomes. In order to provide accurate (and reliable) real-time travel time information, real-time traffic data are collected using several kinds of traffic surveillance system. Inductive loop detector is the most common traffic detector equipment that is widely used to measure point-based traffic data, including traffic volume, occupancy, and speed. Therefore, accuracy of traffic data using point-based detector is dependent on the number of detectors and their placement. The more detectors are equipped; the more accuracy of traffic data is resulted. It is costly to improve accuracy of traffic data by increasing the number of detectors on road network.

To convert traffic data into information (i.e. travel time), several highway agencies have employed a simple method (or its variation) to approximate road segment speed using spot speed measured on upstream and downstream end of the segment in order to estimate segment travel time. Travel time information is calculated from the average link speed and road length. Nevertheless, this method is suggested for measuring instantaneous vehicle speed traversing on any location or small space typically less than 0.8 km (Turner et al., 1998) where detections are available. It is important to obtain traffic state on each road link in real-time in order to estimate link speed and then convert it into link travel time information (and detected traffic incident). Therefore, Collection of real-time spot speed data and then the calculation of link speed using these spot speed data are normally carried out in practice. The sufficient amount of traffic data requirement is the main concern to implement this method in practical operation.

Frequently, road segments (between detections) are longer than those suggested in which this simple method cannot well reflect average segment travel time. In past researches on the subject of real-time traffic state and travel time estimation, the macroscopic flow model is the most popular traffic model applied to formulate dynamic traffic state estimation, with travel time information as a byproduct of traffic state estimation model. Macroscopic model is relied on traffic data measured by point traffic detection (surveillance) system such as inductive loop detector or other detectors with similar performance. Traffic state estimation model using macroscopic model is formulated based on the law of conservation on traffic stream. It is known as the conservation or continuity equation. The limitation of traffic macroscopic model is depended on the quality of traffic data measured by traffic surveillance system. It is difficult to know accurate traffic state data in case of long length of road section in which point detectors are equipped far apart. Few studies attempt to improve the accuracy of the estimation by the introduction of filtering techniques to develop dynamic traffic state estimator based on traffic macroscopic model (Mihaylova et al., 2007, Nanthawichit, 2003, van Lint, 2008, Ye et al., 2006).

In recent years, microscopic traffic simulation model is widely employed for analyzing transportation problems which cannot be carried out by conventional analysis methods, especially when network-wide study is conducted. The high performance of computing is made available to analyze complicated problems with less time consuming. Computational performance of microscopic traffic simulation modeling makes it possible to analyze individual travelers’ behaviors. It could be used to estimate travel time on any road section with low density of traffic detectors which conventional analysis methods might reflect unreliable travel time information.

This paper aimed to propose on-line microsimulation to be an alternate method for estimating link travel time on expressway with low density of detector stations. Conventional analysis
methods were conducted for performance comparison. However, several factors affect the estimated link speed accuracy such as detector spacing, detector placement, and aggregation time interval. To best replicate the real-world condition, an expressway corridor was used as a case study in order to reproduce similar effects of real-world detector spacing and placement. Furthermore, traffic data in this case study was aggregated to 5 minute time interval and therefore aggregation time interval effect being also neglected. This paper was organized as follows: After the introduction, travel time estimation method and on-line microsimulation for travel time estimation were clarified. Then the study methodology including the study area, traffic data collection, and travel time estimation and evaluation method were explained. The results of travel time estimation and comparison with other methods were presented in the next section. Finally, discussion, and conclusion and direction of future study were presented.

2. TRAVEL TIME ESTIMATION

Travel time on a road section is required for advanced traveler information system in order to inform travel information to road users. Moreover, it is used for dynamic route guidance system for suggesting shortest route displayed on an on-board unit. Travel time is composed of running time, or time in which the mode of transport is in motion, and stopped delay time (Turner et al., 1998) as shown in Figure 1.

According to the definition of travel time, it can be simply estimated as shown in Equation (1) and (2).

\[ TT_s = \text{Running Time} + \text{Stopped Time} \]  \hspace{1cm} (1)

\[ TT_s = \frac{d}{v_s} + \text{Stopped Time} \]  \hspace{1cm} (2)

where \( TT_s \) is segment travel time, \( d_s \) is the length of the segment, and \( v_s \) is an average segment speed. Due to simplified travel time definition, the average segment speed is an important parameter to estimate travel time that vehicles transverse on road segment. This segment speed cannot directly be measured using any point detector. Therefore, traffic operators are
required to approximate an average segment speed by relying on point detector data that are measured as spot speed on a road segment. In order to estimate the average segment speed from spot speed measurement, several detector stations have to be installed. Speed data can be converted from occupancy, volume, and effective vehicle length that can be measured by a single loop detector. Speed data can be directly obtained using double loop or similar detectors as well. Several methods can be used to estimate segment speed in practice. In this study, three simple methods that are normally used in practice (Kothuri et al., 2007) for estimating segment speed, namely average, weighted average, and San Antonio, were further conducted for estimating travel time. Three methods of conventional segment speed estimation are described as follows:

2.1 Average Speed

The average speed is one of the simplest methods to estimate segment speed based on spot speed measurement using point detector data. Spot speeds are measured at upstream and downstream end of the segment in every time step. Then the average speed is calculated using simple arithmetic mean as shown in Equation (3). Traffic speed on segment is assumed to be uniformly distributed under short time interval and short segment length.

\[
v_s(k) = \frac{v_u(k) + v_d(k)}{2}
\]

(3)

where \(v_s(k)\) is the estimated segment speed at time \(k\), \(v_u(k)\) and \(v_d(k)\) is the measured spot speed at upstream and downstream detector at time \(k\) respectively.

2.2 Weighted Average

The weighted average method is proposed to estimate segment speed using spot speed data measured by upstream and downstream detector. This method takes account of traffic flows (volumes) that are also simultaneously measured with spot speeds in each time interval. Estimated segment speed is calculated from the Equation shown in (4).

\[
v_s(k) = \frac{q_u(k)v_u(k) + q_d(k)v_d(k)}{q_u(k) + q_d(k)}
\]

(4)

where \(q_u(k)\) and \(q_d(k)\) is traffic flow (volume) on upstream and downstream detector station respectively.

2.3 San Antonio

This method has been used according to San Antonio Transguide project which employs the minimum spot speed value between upstream and downstream detector station as illustrated in Equation (5).

\[
v_s(k) = \min(v_{up}(k), v_{down}(k))
\]

(5)

As seen from these three simple methods for estimating segment speed toward segment travel
time estimation, it is clear that these methods just attempt to approximate segment speed based on what happens at the detection station. It is necessary that traffic state on the segment must be reflected by the traffic data at the detection points. However, possible that many traffic states may not be detected at the detection points. For example, vehicles stop or slow-down due to an incident at the middle of a link. The inability of the detector data to represent segment traffic states comes from two main factors. First, the location of detector station is not suitable to accurately capture traffic states. Second, the number of detector station equipped on road section. Thus, an accuracy of segment speed estimation using these conventional methods heavily depends on the density of point detector stations when using on road section with detector stations are located far apart. In order to overcome the limitation, microscopic traffic model could be proposed instead of conventional methods. The concept of on-line microsimulation was described in the following section.

3. ON-LINE MICROSIMULATION FOR TRAVEL TIME ESTIMATION

The concept of on-line microsimulation was proposed to be an alternate method for estimating traffic state and travel time information on road segment as shown in Figure 2 which illustrated on-line microsimulation as an estimator instead of conventional methods and macroscopic model.

The components of microscopic traffic simulation model generally include physical component of road network, traffic control system, and driver-vehicle units which driver behavior models and route choice models are associated. The complex data and numerous model parameters are required by these components which need to be calibrated for a particular study area (Mcnally and Oh, 2002).
On-line microsimulation model could be used instead of conventional travel time estimation methods as well as macroscopic traffic model for estimating travel time. Traffic data measured on point detection devices should be transmitted to traffic control center via cable optic or several wireless communications such as Asymmetric Digital Subscriber Line (ADSL), General Packet Radio Services (GPRS), and Worldwide Interoperability for Microwave Access (WIMAX). Traffic data were checked for outliers and correctness and then input to microsimulation to estimate traffic state and travel time occurred on each road segment. The use of microsimulation model should well produce more accurate segment speed than conventional methods when using on expressway with low density of point detectors or long segment length. However, microsimulation model requires the adjustment of model parameters, The adjustment aims to minimize percentage errors between estimated and measured travel time which a zero value is ideally desired.

The process of on-line microsimulation is shown in Figure 3. The process starts for \( k^{th} \) time interval, in which the corresponding OD flow demand is called as the input of the simulation model. The simulation model must be well calibrated. Microsimulation provides traffic data especially link traffic data which can not directly measured from the field and these traffic information can be used to describe traffic state (condition) on each road segment. After that traffic information is saved on traffic database and then go back to the input data at \( k+1 \) time interval. It is an advantage of using microsimulation for estimating travel time information in case of low density of detectors on roadway.

![Figure 3 Flow chart of on-line microsimulation model](image)
4. EVALUATION METHOD

The proposed travel time estimation method in this study was evaluated against three conventional travel time estimation methods under the limitation of low density of point detectors practically equipped on expressway section. Estimated travel time using proposed and conventional methods were evaluated against observed travel time. The evaluation was carried out for expressway traffic. Since this study did not aim to study the impact of several factors on the estimated link speed accuracy, such as detector spacing, detector placement, aggregation time interval, and others, thus the comparison of the travel time estimation by microsimulation method and the other methods were carried out for a case study, representing generic traffic condition and expressway configuration. The site selected as a case study and evaluation method were described as follows.

4.1 Site Study

The study site was a 11-km road section of the Chalerm Mahanakhon line on Bangkok Expressway Network in Bangkok, Thailand. The direction was from Daokanong to Port junction as shown in Figure 4. A schematic diagram of this site is shown in Figure 5. The road section was divided into ten segments ranging from 390 meters to 1,977 meters with four on-ramps and two off-ramps. The number of lanes varies from two to three. Traffic data were collected using video image processing cameras produced by National Electronic and Computer Technology Center (NECTEC).

![Figure 4 Daokanong – Port junction on Bangkok expressway network](image)

![Figure 5 Schematic diagram of study site](image)
Field of view of seven point detectors measured by video image processing camera was shown in Figure 6. Six road segments started from station no.2 and finished at station no.10 were considered in this study because of the completeness of traffic data from installed video image processing cameras. Benchmarked travel time information for each time period was extracted from video records manually for accuracy comparison.

Traffic simulation model of selected site study was developed using PARAMICS v.5.2 development suite and then the model was calibrated based on the idea of combinatorial model parameters calibration (ROTWANNASIN et al., 2009). Traffic data on 7 detector stations were used as upstream and downstream traffic data of road segments. Individual segment speed and stopped time was extracted from microsimulation model, which were executed from 06:00 until 21:00 in order to estimate segment travel time. Three set of traffic data was divided in this study which are morning-peak (06:00 – 10:00), off-peak (10:00 – 16:00), and evening-peak (16:00 – 21:00). Morning-peak was conducted in the process of model parameters calibration, and then all three periods was conducted in the evaluation process in order to investigate the performance of travel time estimator.

Conventional travel time estimation methods based on three segment speed estimation methods included average speed, weighted average, and San Antonio. It were denoted as C1, C2, and C3 respectively. The computed travel time were compared against proposed travel time estimation based on the on-line microsimulation model.

### 4.2 Evaluation Method

In order to evaluate the proposed travel time estimation by on-line microsimulation model and the three conventional travel time estimation methods, estimated and observed travel times were plotted as diagonal plot in order to investigate the under or over estimation of each implemented method. Consequently, mean absolute percentage error (MAPE) was determined to measure the amount of estimation error by comparing observed travel time with estimated travel time as shown in Equation (6). Moreover, the percentage error was also computed as shown in Equation (7) in order to illustrate dynamic percentage error that each static estimation (single time interval) method was unable to capture.

\[
MAPE = 100 \frac{1}{n} \sum_{k=1}^{n} \left| \frac{t_{est}(k) - t_{obs}(k)}{t_{obs}(k)} \right| 
\]

\[
\%Error(k) = \frac{t_{est}(k) - t_{obs}(k)}{t_{obs}(k)} \times 100
\]

where \(t_{obs}(k)\) is an observed travel time at time \(k\) and \(t_{est}(k)\) is an estimated travel time at time \(k\). MAPE is separately calculated by three periods of time.
Figure 6 Field of view at seven point detectors using video image processing cameras
4. RESULTS AND DISCUSSION

Seven road segments were defined by video image processing camera of 7 stations (camera at station no.8 was unavailable) equipped on Chalerm Mahanakhon Line, Bangkok expressway from station no.2 until station no.10. The three selected conventional methods were employed for calculating segment speed using upstream and downstream detector as described in Equation (3) - (5) to get segment travel time estimate. Seven segment travel times were aggregated into path (route) travel time which vehicle traversed from station no.2 and finish on station no.10. Dynamic travel time estimated by on-line microsimulation and the three conventional methods were shown in Figure 7.

From the Figure 7, travel time estimated by on-line microsimulation is quite lower than the observed travel time from 07:00 until 09:00, higher than the observed travel time from 09:00 until 10:00, and lower than the observed travel time during off-peak and evening-peak period. For conventional travel time estimation methods, C3 is quite close to the observed travel time on three periods but it shows over estimation from 17:30 to 18:40 while on-line microsimulation method and C1 and C2 result in estimated travel time quite close to the observed travel time.

In order to illustrate over or under estimation on travel time information of on-line microsimulation and three conventional methods, estimated and observed travel time was plotted as shown in Figure 8. Figure 8(a) illustrates that travel time estimated by on-line microsimulation model is both under and over estimation during the morning-peak period (06:00-10:00). Note that this data set was also used for calibrating model parameters. During off-peak period and evening-peak period, travel time estimates are over and under estimation respectively. Figure 8(b) illustrates travel time estimation by C1 in which the estimated travel time is under estimated in all three time periods. Figure 8(c) illustrates travel time estimation by C2 in which, similar to C1, the estimated travel time is under estimated in all three time periods. Figure 8(d) illustrates travel time estimation by C3, in which the estimated travel time is both under and over estimation in three time periods. The general trend of the estimation methods is as follows: in the morning-peak period is most of methods...
give over estimation, during off-peak period they give both under and over estimation, and they give quite over estimation in the evening peak period.

As previously described on how under and over estimation of each travel time estimation methods, the levels of percentage error were calculated and plotted by departure time as shown in Figure 9. The figure could show how much the percentage error on each travel time estimation methods by time interval of 5 minutes.

Figure 9(a) illustrates that the travel time estimated by on-line microsimulation deviates approximately within lower and upper bound of 50%, except from 09:00 to 10:00 which estimated travel time is higher than observed travel time more than 50%. Figure 9(b) and Figure 9(c) show that the estimated travel times by C1 and C2 are under estimated with most of estimation are lower than observed travel time about 50% with smallest error at 18:30. Figure 9(d) shows that the travel time estimated by C3 has a huge percentage error of travel time estimation, about 150% higher than the observed travel time at 18:30 while other methods yield more accurate travel time estimates.
According to the deviation of percentage error of travel time estimates as shown in Figure 9, minimum, maximum, mean absolute percentage error, and MAPE standard deviation of travel time estimates by on-line microsimulation model and three conventional methods were analyzed and shown by three time periods in Table 1.
Table 1 Minimum, maximum, mean absolute percentage error, and standard deviation of travel time estimates by online microsimulation and three conventional methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Min</th>
<th>Max</th>
<th>MAPE</th>
<th>Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsimulation</td>
<td>-38.29</td>
<td>84.12</td>
<td>28.66</td>
<td>23.99</td>
</tr>
<tr>
<td>C1</td>
<td>-53.65</td>
<td>-8.71</td>
<td>33.22</td>
<td>9.71</td>
</tr>
<tr>
<td>C2</td>
<td>-57.34</td>
<td>-14.26</td>
<td>33.92</td>
<td>9.53</td>
</tr>
<tr>
<td>C3</td>
<td>-33.26</td>
<td>52.66</td>
<td>16.90</td>
<td>13.50</td>
</tr>
</tbody>
</table>

(a) Morning-peak period (06:00-10:00)

(b) Off-peak period (10:00-16:00)

<table>
<thead>
<tr>
<th>Methods</th>
<th>Min</th>
<th>Max</th>
<th>MAPE</th>
<th>Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsimulation</td>
<td>-32.42</td>
<td>38.17</td>
<td>17.65</td>
<td>7.21</td>
</tr>
<tr>
<td>C1</td>
<td>-53.25</td>
<td>-12.83</td>
<td>25.92</td>
<td>7.75</td>
</tr>
<tr>
<td>C2</td>
<td>-53.68</td>
<td>-10.28</td>
<td>25.21</td>
<td>8.31</td>
</tr>
<tr>
<td>C3</td>
<td>-44.23</td>
<td>42.20</td>
<td>14.17</td>
<td>9.88</td>
</tr>
</tbody>
</table>

(c) Evening-peak period (16:00-21:00)

<table>
<thead>
<tr>
<th>Methods</th>
<th>Min</th>
<th>Max</th>
<th>MAPE</th>
<th>Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsimulation</td>
<td>-36.56</td>
<td>-2.42</td>
<td>16.13</td>
<td>8.61</td>
</tr>
<tr>
<td>C1</td>
<td>-36.92</td>
<td>3.15</td>
<td>18.48</td>
<td>9.14</td>
</tr>
<tr>
<td>C2</td>
<td>-35.02</td>
<td>9.90</td>
<td>16.82</td>
<td>8.82</td>
</tr>
<tr>
<td>C3</td>
<td>-26.37</td>
<td>158.68</td>
<td>19.31</td>
<td>27.35</td>
</tr>
</tbody>
</table>

Table 1(a) shows that estimated travel time during morning-peak period estimated by online microsimulation model has the minimum error of -38.29%, the maximum error of 84.12%, a mean absolute percentage error of 28.66%, and a MAPE standard deviation of 23.99%. The estimated travel time by C3 is the most accurate which has the minimum error of -33.26%, the maximum error of 52.66%, a mean absolute percentage error of 16.90%, and a MAPE standard deviation of 13.50%. Travel time estimated between 06:00 and 10:00 using C3 is more reliable than using microsimulation but the maximum errors of C3 is quite high and fluctuates in all time periods.

Table 1(b) shows that estimated travel time during off-peak period estimated by online microsimulation model has the minimum error of -32.42%, the maximum error of 38.17%, a mean absolute percentage error of 17.65%, and a MAPE standard deviation of 7.21%. The estimated travel time by C3 is still the most accurate which has the minimum error of -44.23%, the maximum error of 42.20%, a mean absolute percentage error of 14.17%, and a MAPE standard deviation of 9.88%. However, the minimum and maximum error of travel times by C3 deviates greater than those by microsimulation. Furthermore, the MAPE standard deviation of C3 is higher than that of microsimulation as the error of travel time by C3 fluctuates more than the error of travel time by microsimulation during off-peak period.

Table 1(c) shows that estimated travel time during evening-peak period estimated by online microsimulation model has the minimum error of -36.56%, the maximum error of -2.42%, a mean absolute percentage error of 16.13%, and a MAPE standard deviation of 8.61%. C3 has the minimum error of -26.37%, the maximum error of 158.68%, a mean absolute percentage error of 19.31%, and a MAPE standard deviation of 27.35%. It is obviously shown that the estimated travel time using microsimulation model is more reliable than C3 during evening-peak period.

Furthermore, the absolute percentage error was plotted as shown in Figure 10 in order to
clearly illustrate the fluctuation of absolute error. The errors of travel time by microsimulation were compared against the three convention methods. Figure 10 shows that the absolute percentage error of estimated travel time using microsimulation model is higher than those by the conventional methods between 09:00 and 10:00 and then the absolute percentage error of estimated travel time information by C3 is higher than microsimulation model and other conventional methods between 17:30 and 18:30. MAPE is illustrated by compared microsimulation with three conventional methods as shown in Figure 11.

![Figure 10](image1.png)

**Figure 10 Absolute percentage errors of on-line microsimulation and three conventional methods by departure time.**

![Figure 11](image2.png)

**Figure 11 Mean absolute percentage errors of travel time estimated by on-line microsimulation and three conventional travel time estimation methods**

Referring to Figure 11, from 06:00 to 10:00 (morning-peak period), on-line microsimulation for travel time estimation is quite well performed. It is more accurate than conventional methods C1 and C2 but less accurate than C3 which has MAPE value less than 20%. MAPE
of C1 and C2 during morning-peak period has MAPE value more than 30%. From 10:00 to 16:00 (off-peak period), travel time estimation by C1 and C2 deviate by approximately 25% while travel time estimation by on-line microsimulation is less than 20% and that of C3 is less than 15%. From 16:00 to 21:00 (evening-peak period), on-line microsimulation model shows the best performance for estimating travel time with less MAPE value than the conventional methods.

5. CONCLUSION AND DIRECTION OF FUTURE STUDY

Travel time information on expressway is an important piece of traffic parameters that are required by operators and travelers. In practice, traffic detectors such as loop detector, ultrasonic, infrared, and video image processing are employed on expressways in many countries. There are several limitations of these kinds of equipment such as detector station spacing, detector placement, and aggregation time interval. Traffic analyzers should realize these limitations when analyzing traffic parameters using traffic data measured from these traffic detection arrangements. The travel time estimation can be inaccurate when it is estimated on a segment with low density of point detectors, or long segment length, using conventional methods that are normally used for estimating segment speed using upstream and downstream speeds measured at both ends of the segment.

On-line microsimulation is found to be a good method for estimating travel time. The findings in this paper illustrate that the on-line microsimulation model is quite well performed. Nonetheless, a closer look at the estimation shows that this method gives under and over estimation during morning-peak period and under estimation in both off-peak and evening-peak period. MAPE values are calculated for three periods which are 28.66%, 17.65%, and 16.13% respectively. These values can be compared with those from three conventional methods; average(C1), weighted(C2), and San Antonio(C3). MAPE values on three time periods imply that C3 is the most accurate method during both evening-peak and off-peak period with a MAPE value lower than 20%. Microsimulation is shown the best performance for estimating travel time during evening-peak period when C3 has a huge over estimation in this period while on-line microsimulation model, C1, and C2 are more accurate.

Moreover, it could be interpreted that the estimated travel time using microsimulation is the most reliable method, compared to the conventional methods in this study. MAPE value of travel time estimated by microsimulation is comparatively low in the first period and then the smallest in the third period while the values of MAPE by C3 vary by time periods and are more unpredictable. The algorithm of C3 is highly sensitive because it relies on the minimum value of measured traffic speeds between upstream and downstream detector station. Travel time estimation by C3 is easily over estimated when traffic speed decreases especially at the location where detector station is located close to merging area. Spot speeds at ends of the segment are not a good proxy of a link speed, and thus resulting in less accurate travel time. However, detector density improvement is another suitable solution but it is a huge cost to invest on infrastructure. The benefit of using these kinds of traffic data and investment cost that expressway operators have to be traded-off.

For the future study, the estimation of travel time by on-line microsimulation should be further improved by integrating dynamic feedback estimation using filtering techniques and by model refinement on model parameters for specific periods. The improved methods should be uncomplicated to implement in practice. Furthermore, the study to improve the
reliability of estimated travel time by integrated intelligent traffic detector such as automatic vehicle location (AVL) and automatic vehicle identification (AVI). Traffic data gathering by these detectors could be combined with on-line microsimulation for increasing the accuracy of traffic state and also travel time information.

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