A Study on Travel Time and Delay Survey and Traffic Data Analysis and Visualization Methodology

Reigna Jewel Ritz M. MACABABBAD
Graduate Student
Institute of Civil Engineering,
University of the Philippines
Diliman, Quezon City
1101 Philippines
E-mail: rjmmacababbad@gmail.com

Jose Regin F. REGIDOR
Associate Professor
Institute of Civil Engineering
College of Engineering
University of the Philippines
Diliman, Quezon City
1101 Philippines
E-mail: r.regin@gmail.com

Abstract: Travel time and delay studies are used to evaluate traffic conditions, determine levels of service and to plan for improvements. Transportation planners and engineers of the Metro Manila Development Authority (MMDA) still employ the manual or stop watch method using a test car in obtaining travel time and delay data. Thus, it is necessary to develop and demonstrate an efficient method using tools for assessment of road traffic conditions. This paper presents a Geographical Positioning System or GPS based travel time and delay survey and data analysis methodology. It presents the development and application of a methodological framework and also data analysis and presentation through the use of digital maps. The use of GPS in this research provides fundamental inputs towards the development of a probe car system for use in travel time and delay studies in the Philippine cities.

Key Words: GPS, travel time, delay, methodology

1. INTRODUCTION

Travel time, a fundamental measure in transportation, is the total elapsed time necessary for a vehicle to travel from one point to another over a specified route under existing traffic conditions. Delay on the other hand is the time lost to travel because of traffic frictions and traffic control devices. Travel time and delay studies are used to evaluate traffic conditions such as the onset of congestion along major corridors, and the impacts of developments such as transportation infrastructure, commercial, residential and industrial projects. Results are used to determine levels of service and to plan for improvements.

Currently, transport planners and engineers of the MMDA still employ the stop watch method for travel time and delay data collection. This method is labor intensive and is prone to human errors.

There are commercially available and tested devices like GPS that provide real-time measurements of location and automated data gathering. Such devices are essential elements of probe car systems that are already in use in other countries for accurate estimates of travel speeds. However, there is no established methodology that would be applicable for MMDA’s travel time and delay studies. Thus, there is a need to develop and demonstrate a more efficient method using tools for travel time and delay surveys.
This study is part of a larger project on probe car system. The use of GPS in this research provides fundamental inputs towards the development of a probe car system for use in travel time and delay studies in the Philippine cities. Probe cars are usually designed to acquire traffic information at anytime on roads from alleys to main streets at a relatively low cost. Probe vehicle data is being utilized for many purposes such as real-time traffic management and or creating database for traffic analysis, planning and other management. Some of the explored outputs from probe vehicle data are social-based and individual-based outcome maps such as corridor speeds, travel time contours, and traffic congestion 3D maps that visualize the road transport level of service. Better information collection for abovementioned purposes leads to less congestion and less impact to the environment which increases certainty and opportunities for infrastructure industry.

2. RESEARCH QUESTIONS AND OBJECTIVES

This research is geared mainly toward addressing the following questions:

- What is a suitable and practical methodology necessary in order to gather reliable travel time and delay data of a road corridor?
- What method of analysis and presentation or visualization of obtained data will be used?

In effect, this research aims to achieve two main objectives. The primary objective is to develop and demonstrate an efficient method of visualizing traffic characteristics using tools for assessment of road traffic conditions. This method should be an accurate and cost-effective data-gathering technique that will facilitate data analysis through spatial presentations. The secondary objective is to provide input towards the development of a probe car system.

3. REVIEW OF RELATED LITERATURE

3.1 Conventional Travel time and Delay Survey Methodology

The transport planners and engineers of MMDA use the manual test vehicle technique in obtaining travel time and delay information. The survey is accomplished by at least two surveyors: one driving and the other recording the time as the vehicle passes predetermined checkpoints. An observer with one of two stop watches is the most common method used. The observer starts the first watch at the beginning of the test run and records the time at various control points along the route. The second stop watch if used measures the length on individual stopped delays. The time, location, and cause of delays are noted on forms provided for the surveyors.

Travel time and delay study is conducted yearly for major thoroughfares such as the radial and circumferential roads in Metro Manila. This is done through three runs: one for morning peak, one for midday and another run for afternoon peak on a road corridor during a particular field day. A total of six runs are performed which include northbound and southbound travel each for peak and off-peak periods. Finally, the obtained data are recorded as basis for transport planning and traffic operations.
3.2 GPS-based Travel Time and Delay Survey Studies

A local study by Mauricio, et al. (2003) on travel time and delay analysis using Geographic Information System (GIS) and GPS raised the following findings:

a) GPS has provided an effective and convenient way of collecting travel data;

b) It is very capable of providing a very accurate depiction of vehicle location and speed compared to conventional method or stop watch technique;

c) The problems encountered with the use of GPS include loss of GPS signal due to tunnels, underpasses, flyovers, and trees.

Mauricio, et al. (2003) presented their obtained data through time-distance, speed-distance, and distance-speed diagrams and used GIS to illustrate the study routes only. However, this initial research did not come up with an established methodology that could easily be applied for future travel time and delay studies.

The use of GPS for travel time data collection has been widely explored and studied since 1998. (Czerniak and Reilly, 1998; Quiroga and Bullock, 1998) Advanced technologies like GPS-equipped probe car system that has both real time and post-processing traffic data collection capabilities are increasingly used in other countries. (Byon, et al., 2006; Wang, 2008; McNally, et al., 2003) There are also studies that integrate GIS with GPS data for visualization of obtained information. (Ohmori, et al., 2002 and Owusu, et al., 2006)

Most GPS-based studies on travel time data collection cover two important components namely, the hardware and software part of the system. The hardware consists of the GPS device, laptop, and or other equipment mounted on a test vehicle that can collect and store traffic conditions by monitoring the location and speed of the test vehicle. On the other hand, the software part refers to the data processing procedures and tools that can be used for post-processing or real time monitoring of traffic data. Some good examples that developed GPS-based travel time collection system are GPS-GIS Integrated System for Travel Time Surveys or GISTT (Byon, et al., 2006) and GPS-Trek (Li, et al., 2002).

There are important factors such as sample size requirements that may have an impact on a certain study. The common approach for transportation engineers is to rely only on the old method presented by manuals to determine the sample size requirements. However, it had been known that the old method contains systematic numerical errors and may not be applicable to GPS-based traffic data collection. This had been thoroughly examined by Li, et al. (2002) wherein it was found out that five to ten samples would give reliable data for travel time and delay studies.

4. METHODOLOGY

The methodological framework shown in Figure 1 and applied to this study is designed and implemented with a flexibility that would facilitate the collective and progressive development of tools and methods to be used. A survey procedure discussed in detail in the next section is developed based on the performed preliminary study and further refined through case studies or application on other land developments.
5. DEVELOPED METHODOLOGY

The developed methodology consists of five procedures discussed below. This also includes the tools utilized in data gathering and traffic analyses.

5.1 Selection of GPS Unit

It is relevant to choose a locally available GPS unit that can log necessary variables for travel time and delay with PC connection capability at a minimum cost. For this study, Table 1 lists the important vehicle parameters that the GPS device should be able to determine.

Other notable specifications to be considered are its memory and data transfer capability through PC interface. Selection of a GPS unit used for this study was narrowed down to Garmin Etrex Summit HC.

Table 1 Vehicle parameters logged by GPS unit

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measurement Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>seconds (s)</td>
</tr>
<tr>
<td>Distance</td>
<td>meters (m)</td>
</tr>
<tr>
<td>Speed</td>
<td>kilometers per hour (kph)</td>
</tr>
<tr>
<td>Position</td>
<td>latitude + longitude</td>
</tr>
</tbody>
</table>

To validate the accuracy of chosen GPS unit, static positioning with respect to referenced position using the GPS device needs to be performed. This is done by collecting position data of the GPS unit in static mode at known referenced locations for about 20 minutes. Validation test for the chosen handheld GPS unit showed that the average error with respect to a known coordinate is about five meters.

5.2 Verification Tests

Preliminary runs on the study corridor have to be conducted to help familiarize the surveyors with the use of GPS unit. This would also give information on the possible factors like high rise buildings, trees, and overpass that could affect GPS signal.

5.3 Field Procedure

5.3.1 Determination of Sample Size Requirement

The determination of sample size is crucial to obtain a more representative data of the real traffic conditions. Li, et. Al (2002) through several case studies has presented a modified
equation to determine the sample size requirement. It was estimated that five to ten samples provide reliable data.

5.3.2 Timing of Data Collection
Travel time data is to be collected during the AM peak, midday, and PM peak periods on weekdays and weekends. For weekday data collection, data is to be collected only on Tuesdays, Wednesdays and Thursdays, so as to avoid the atypical traffic conditions on Mondays and Fridays. However, in cases of holiday that falls on a Monday, data is to be collected on Wednesday and Thursday only. Conversely, when a holiday falls on a Friday, data is to be collected on Tuesday and Wednesday only. For weekend data collection, Sundays only and excluding long weekends are to be considered. For the purposes of this study, the AM peak period is defined as 7 AM to 9 AM, the midday as 12 PM to 2 PM, and the PM peak as 4 PM to 6 PM. Survey days should also exhibit fair weather conditions.

5.3.3 GPS Set-up
The GPS device is placed on the panel under the front windshield of the vehicle where it can have unobstructed view of the sky to receive satellite signals. The logged positional and time data will be downloaded onto a laptop computer for post processing.

5.3.4 Field Data Collection
The operator must be familiar with the GPS unit to conduct field data collection. One operator, the driver, can perform field data collection in most cases. The operator may be required to mark the start and end points of a run.

The user interface of the GPS unit when power key is pressed and held displays the satellite GPS information, time, date and battery capacity. The GPS receiver must collect satellite data and establish its current location. This is achieved when the operator stands still outdoors under a clear view of the sky for about 30 seconds. The operator should make sure that all indicators satisfy the requirements. These include battery status which indicates that the power is sufficient and a 3D fix of satellite signal is attained. Moreover, GPS settings must be set to the desired units of measure (e.g. m, sec, km/hr) and frequency of data collection (e.g. 1 second, 5 seconds).

The operator can start to collect GPS position data a reasonable distance upstream of the start point and to stop data collection once the test car passes the end point. The operator will need to stop recording the position data when required test runs were completed continuously by saving the entire track.

5.4 Data Processing and Management

5.4.1 Selection and Exporting of GPS Data
The GPS device utilizes Mapsource utility software to transfer data from the GPS unit to the computer. Understanding the Mapsource interface is necessary in order to perform selection of data that are of interest to the surveyor. The user then can choose to export the file in .txt or excel worksheet format. The excel files contain essential information for traffic studies such as travel time, travel distance, travel speed, and position which can be readily analyzed using the built-in excel functions.
5.4.2 Preparation of Data Worksheet
Fundamental data worksheet is needed in processing and computing of average travel times and speeds. This facilitates easier calculations and plotting of graphs.

5.5 Data Analysis and Presentation

5.5.1 Corridor Analysis
A description of the study corridor and dates of survey provide background information for the analysis. Then, travel time trajectories and speed profiles are shown through graphs for northbound and southbound directions each for peak and off-peak hours. Speed maps which show average travel speed for each segment of the study corridor are plotted on a base map using Adobe Photoshop CS, an image editor tool.

5.5.2 Network Analysis
Records of several probe vehicle runs that cover a certain study area are needed to come up with a network analysis. Traffic analysis is presented through travel time contour map which shows the travel time from certain origins corresponding to certain departure times by using contour lines. The travel time from the origin to few nodes along major roads on the road network is obtained by adding calculated average travel times per segment.

Then, spatial interpolation through the use of Surfer 9 is performed to generate contour lines with equal travel time. Surfer 9 is a software for surface mapping system that is also applied to generate rain fall contour lines in water resources engineering and many other related applications.

6. RESULTS

6.1 Equipment and Procedures
Overall, the GPS equipment performed well and the data collection procedures that were utilized were effective.

6.1.1 Equipment Performance
The GPS unit runs on two AA batteries. During the preliminary study, alkaline batteries were used which last for two to three days and then they had to be discarded and replaced with new ones. This made the researcher opt for rechargeable batteries to be used during the validation part in order to save on added costs and reduce wastes. The rechargeable batteries last for two to three days as well but charging it takes ten hours. The other significant equipment problem is the limited number of data points that it can store which is 10,000 data points only or approximately equal to 2.7 hours when frequency of data collection is set to one second. This resulted in lost data sets specially during the PM peak period on the first survey day for validation part. However, this was addressed by using a second GPS unit when the memory of the first GPS unit reached 80%.

6.1.2 Personnel Compliance with Data Collection Protocol
Almost most of the traffic surveys were performed by the researcher. However, there were few instances when a surveyor was assigned to do the data collection wherein some errors such as failure to check on the equipment’s frequency of data collection has resulted to unusable data. This is due to the failure to specify procedures in advance and to adequately train the personnel.
6.1.3 Overall Data Collection Success Rate
Despite the occurrence of the data collection problems noted above, the overall data collection success rate was approximately 95%. The five percent was due to equipment and operator error.

6.1.4 Total Resources Required
The total in-field resources required to conduct the traffic surveys amounted to approximately 8.5 hours per survey day. This is more than the seven hours that theoretically would be required for the actual travel time and delay runs (two hours in the AM, two hours in the midday and 3 hours in the PM peak periods). Some of the additional time is for driving to and from the study corridors.

6.2 Travel Time and Delay Results

6.2.1 Preliminary Study
The performance of a preliminary study is a primary step in the development of travel time and delay survey methodology and traffic data analysis. This entails determining tools and methods to be used, learning and applying traffic survey concepts using chosen tools and established procedures on study corridors or areas and exploring possible presentation of traffic data analyses.

A preliminary study using test vehicle is conducted on short segments of major corridors that are main access roads of University of the Philippines (UP) Diliman on July 13, 2010. The point of origin or destination is set at UP Diliman and particularly in front of the Quezon Hall. The access roads considered for network analysis were certain segments of Commonwealth Avenue, Visayas Avenue, North Avenue, Quezon Avenue, and Katipunan near the point of reference. The area covers MRT3 to UP, LRT2 to UP, and SM North EDSA to UP jeepney routes.

The traffic data analyses are performed both for corridor and network levels. Traffic data obtained using GPS device are presented in conventional travel time trajectories and speed profiles, corridor speed maps, and travel time contours. Example outputs are shown in Figures 2 to 4 respectively. The test segment on Katipunan Avenue from Aurora Boulevard to Commonwealth Avenue is about 4.25 kilometers in length. Road widening project is ongoing particularly between Shuster and Commonwealth Avenue during the survey. This study corridor is generally surrounded by schools, commercial establishments and residential areas. There are two to four lanes along the test segment and only one traffic signal in the CP Garcia – Katipunan Avenue intersection. Inspection of the trajectory in Figure 2 indicates that the test vehicle traveled very steadily over the segment from the distance 0-2800 while unsteady travel was experienced at sections 2801-4200. The corridor speed maps for morning and afternoon peak shown in Figure 3 are generated by arbitrarily assigning certain colors to represent different travel speed ranges. Then, designating the corresponding colors according to the average travel speeds per segment of the study corridor. Figure 4 shows the travel time contour maps for inbound and outbound directions during morning peak. This is obtained by calculating the average travel time per segment from the origin or destination to every predetermined node along the study corridors. Then, a resulting XYT (latitude, longitude, travel time) data file is used to create a contour map. The contour lines in the study area indicate the amount of travel time required to reach or leave an arbitrarily chosen point of interest which is the UP Diliman.
Figure 2 Travel time trajectory and speed profile of Katipunan Avenue

Figure 3 Corridor speed maps for (1) northbound and (2) southbound directions for both (a) morning peak and (b) afternoon peak
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6.2.2 Validation
The developed methodology is further validated by applying it to a different land development and also conducting evaluation and development monitoring of the procedures described in the previous chapter. For validation purposes, the chosen study area was vicinity covering the hospital complexes near Quezon City Circle as shown in the Figure 5. The hospitals included are Lung Center of the Philippines (LCP), National Kidney Transplant Institute (NKTI), Philippine Children’s Medical Center (PCMC), Philippine Heart Center (PHC), and East Avenue Medical Center (EAMC).

6.2.1 Traffic Analyses
A total of ten corridors are considered as main access roads for the hospital complexes. The summary of the description of each road corridor and survey dates are presented in Table 2. A total of five runs for northbound and southbound directions for each study period are
performed on a regular weekday. About two to four survey days are needed to complete the required number of runs for each study corridor. This is favorable because it allows randomness of traffic on a day-to-day basis to be factored in and thus, a more accurate estimates of travel time and delay would be obtained.

### Table 2 Summary of description of road corridors and conducted surveys

<table>
<thead>
<tr>
<th>Study corridors</th>
<th>Survey dates</th>
<th>Length (m)</th>
<th>*No. of lanes per direction</th>
<th>No. of checkpoints</th>
<th>No. of signalized intersections</th>
<th>Other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) East Avenue</td>
<td>8/17, 8/18</td>
<td>1860</td>
<td>4 lanes; divided</td>
<td>9</td>
<td>3</td>
<td>Main access road for PHC and EAMC</td>
</tr>
<tr>
<td>2) Timog Avenue</td>
<td>8/17, 8/18</td>
<td>2160</td>
<td>2 lanes; undivided</td>
<td>9</td>
<td>3</td>
<td>Roundabout at Timog Avenue-Tomas Morato intersection</td>
</tr>
<tr>
<td>3) North Avenue</td>
<td>8/18, 8/24</td>
<td>2070</td>
<td>3 lanes; divided</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4) West Avenue</td>
<td>8/18, 8/24</td>
<td>2330</td>
<td>2 lanes; undivided</td>
<td>7</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>5) Quezon Avenue</td>
<td>8/24, 8/25</td>
<td>2860</td>
<td>4 lanes; undivided</td>
<td>8</td>
<td>1</td>
<td>Underpass at Quezon Avenue-EDSA intersection; Main access road for NKTI, LCP</td>
</tr>
<tr>
<td>6) BIR Road</td>
<td>8/25, 8/26, 9/2, 9/7</td>
<td>850</td>
<td>2 lanes; divided</td>
<td>3</td>
<td>2</td>
<td>Main access road for PCMC</td>
</tr>
<tr>
<td>7) Agham Road</td>
<td>8/25, 8/26, 9/2, 9/7</td>
<td>870</td>
<td>3 lanes; divided</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8) Segment of</td>
<td>8/26, 9/2, 9/7</td>
<td>2700</td>
<td>4 lanes; divided</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Mindanao Avenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) Visayas Avenue</td>
<td>9/7, 9/15, 9/21, 9/22</td>
<td>2500</td>
<td>3 lanes; divided</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10) Segment of</td>
<td>9/15, 9/21, 9/22</td>
<td>4480</td>
<td>9 lanes; divided</td>
<td>5</td>
<td>0</td>
<td>Overpass at Commonwealth Avenue-Tandang Sora Avenue intersection</td>
</tr>
<tr>
<td>Commonwealth Avenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11) Kalayaan Avenue</td>
<td>8/25, 9/7, 9/21, 9/22</td>
<td>1840</td>
<td>2-3 lanes; divided</td>
<td>7</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>12) Quezon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memorial Circle</td>
<td>8/17, 8/18</td>
<td>1880</td>
<td>10 lanes</td>
<td>7</td>
<td>0</td>
<td>Elliptical road, 590m diameter</td>
</tr>
</tbody>
</table>

*In the 4th column, divided means presence of a center island while undivided means absence of a center island.

Calculations for corridor analyses following the same procedures used in the preliminary study are performed to determine the travel time and delay of each study corridor. The computed travel time and delays are summarized in Table 3.

The generated speed maps for northbound and southbound directions for each study period are shown in Figures 6 items a to f. Similar to the previous, certain colors are assigned to represent different travel speed ranges. Then, the corresponding colors are designated according to the average travel speeds per segment of the study corridor. Figures 6 a to f visually present the variations of travel speed on each segment of the study corridors during peak and off-peak periods. Traffic data presented in this manner is easy to understand since
visual inspection through maps also allows identification and perception of the actual land developments along the study corridors that may have impacts on travel time and delays at certain time periods.

Table 3 Summary of calculated travel times and delays

<table>
<thead>
<tr>
<th>Study corridor</th>
<th>Direction</th>
<th>Average travel time (min)</th>
<th>Average delay (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AM Peak</td>
<td>Midday</td>
</tr>
<tr>
<td>1) East Avenue (Quezon Memorial Circle-EDSA)</td>
<td>NB</td>
<td>4.23</td>
<td>7.24</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>6.13</td>
<td>5.52</td>
</tr>
<tr>
<td>2) Timog Avenue (EDSA-Quezon Ave.)</td>
<td>NB</td>
<td>4.42</td>
<td>6.53</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>11.11</td>
<td>8.12</td>
</tr>
<tr>
<td>3) North Avenue (Quezon Memorial Circle-EDSA)</td>
<td>NB</td>
<td>6.69</td>
<td>6.79</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>5.87</td>
<td>5.07</td>
</tr>
<tr>
<td>4) West Avenue (EDSA-Quezon Ave.)</td>
<td>NB</td>
<td>4.66</td>
<td>5.11</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>5.82</td>
<td>5.66</td>
</tr>
<tr>
<td>5) Quezon Avenue (Quezon Memorial Circle-Delta)</td>
<td>NB</td>
<td>7.04</td>
<td>8.41</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>6.24</td>
<td>6.01</td>
</tr>
<tr>
<td>6) BIR Road (East Avenue-Quezon Ave.)</td>
<td>NB</td>
<td>2.38</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>2.87</td>
<td>1.90</td>
</tr>
<tr>
<td>7) Agham Road (Quezon Avenue-North Ave.)</td>
<td>NB</td>
<td>2.50</td>
<td>1.97</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>3.35</td>
<td>2.87</td>
</tr>
<tr>
<td>8) Segment of Mindanao Avenue (North Ave.-Tandang Sora Ave.)</td>
<td>NB</td>
<td>4.04</td>
<td>4.06</td>
</tr>
<tr>
<td>9) Visayas Avenue (Quezon Memorial Circle-Tandang Sora Ave.)</td>
<td>NB</td>
<td>4.56</td>
<td>5.71</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>7.07</td>
<td>7.79</td>
</tr>
<tr>
<td>10) Segment of Commonwealth Avenue (Quezon Memorial Circle-Don Antonio)</td>
<td>NB</td>
<td>4.97</td>
<td>5.25</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>20.19</td>
<td>5.14</td>
</tr>
<tr>
<td>11) Segment of Kalayaan Avenue (Quezon Memorial Circle-Kamias Road)</td>
<td>NB</td>
<td>4.25</td>
<td>4.67</td>
</tr>
<tr>
<td></td>
<td>SB</td>
<td>8.77</td>
<td>5.44</td>
</tr>
<tr>
<td>12) Quezon Memorial Circle</td>
<td></td>
<td>3.66</td>
<td>2.76</td>
</tr>
</tbody>
</table>

*NB-northbound; SB-southbound

For travel time contours, the point of origin or destination is set at the main entrance of PHC along East Avenue. Figures 7 a to f show the travel time contour maps for inbound and outbound directions for AM peak, midday, and PM peak periods considering the point of interest. These are generated by following similar procedures in the preliminary study. Visualization of traffic data through these figures gives information on variations of travel time for each survey period on a network level.
Figure 6 Corridor speed maps on a weekday

Northbound during AM peak

(b) Southbound during AM peak

(c) Northbound during midday

(d) Southbound during midday

(e) Northbound during PM peak

(f) Southbound during PM peak

(g) speed ranges for a to f
Figure 7 Road travel time for inbound and outbound directions of Philippine Heart Center for each study period.
7. CONCLUSION

The study presents a GPS-based travel time and delay survey and data analysis methodology that is being developed to gather reliable travel time and delay data of a road corridor. It presents the development and application of a methodological framework and also data analysis and presentation through the use of digital maps. The proposed methodology demonstrates an efficient method using tools for travel time and delay survey and data analysis.

Previous local studies presented travel time and delay data through travel time trajectories and speed profiles for a corridor level of traffic analysis. In this study, traffic data are presented further through speed maps and travel time contour maps for a network level of traffic analysis. Visualizations of traffic data on a network level are relatively new concept in the Philippines. Speed maps on a network level adequately illustrate the level of service of a road network. In travel time contour map, the contour lines in the study area indicate the amount of travel time required to reach or leave an arbitrarily chosen point of interest.

Travel speed maps and travel time contour maps are easy to understand and reflect accurate travel conditions. Several uses and applications for such digital maps would help traffic engineers and planners for improved traffic management, planning and operations and transport efficiency of goods and people. Technical outputs presented in the form of digital maps would be easy to understand and very useful for road users. Considering, for instance, the traffic information presented in this study, the constituents of the UP Diliman could refer to travel time contour maps for intelligent travel decisions. Moreover, travel time contour maps of the PHC are valuable for faster emergency response and even for ordinary citizens who have immediate medical needs that only the PHC could adequately provide. These maps could also be used for critical situations like in cases of fire so that outside help will reach the place at the soonest possible time. Such presentation of travel time data would also be valuable when applied further to other land developments such as malls and factories.

Positional and speed data on a per second basis generated from the GPS device can be further utilized for vehicle emission analysis by deriving acceleration and or deceleration characteristic of the test vehicle and also for the development of drive cycles. This gives more value to the GPS derived traffic data than the information obtained from conventional or stop watch method.

The use of GPS in this study provides inputs towards the development of a probe car system but to a certain degree only. This study have shown that the use of GPS device alone allows post processing of obtained data from survey runs while the probe car system is designed for real time update and collection of traffic information. For a probe car system to be realized, other important IT requirements such as communication system and central facility have to be put in place.

Further travel time and delay studies on weekends using the established methodology for the same study area may be performed to determine the variations of traffic information and obtain complete and reliable travel time and delay data. Improving the traffic analysis by automating or creating a program that would facilitate easier and faster travel time and delay computations is also recommended. The advent of cellular phones with capabilities similar to GPS units (e.g., android phones) may also be considered for more cost-effective data
collection. However, these also need to be properly calibrated and their outputs validated for reliability.

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