Traffic Impact Analysis of UPD College of Science and College of Engineering Complexes Using Microsimulation

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Abstract: The construction of the College of Science and College of Engineering Complexes in the University of the Philippines Diliman is expected to change trip patterns and generate traffic on the road network. These effects could be assessed through traffic microsimulation. Traffic simulation is a powerful tool in assessing road network performance to aid design and planning. VISSIM is chosen since it can visualize complex traffic conditions. The study developed the traffic model using VISSIM to replicate and analyze the road network of the study area. Traffic counts during peak period were conducted in the study area and the data was used to calibrate and validate the model. The GEH statistic was used to compare the volumes produced from field observations to that of the simulated model. Out of the 84 movements, 80 passed the calibration and validation process which represents 95.24% of all the movements. Using the vehicle delay time to analyze the level of service of each intersection produced by the calibrated and validated VISSIM model, it was concluded that the traffic to be generated by the new complexes does not have a significant effect on the road network.

1. INTRODUCTION

1.1. Background

The University of the Philippines is making constant efforts in improving its facilities and resources to establish itself as one of the premiere universities in the country and in South East Asia. One of its campuses, the University of the Philippines Diliman in Quezon City, has started developing itself by strengthening the programs it offered, involving the university in modernization endeavors, and constructing new academic buildings. Two of these newly constructed academic complexes are those of the College of Science and College of Engineering.

On the second semester of the academic year 2013-2014, UP Diliman registered 24,188 students according to the Tinig ng Plaridel website—5,745 students enrolled in the College of Engineering, while 2,692 students from the College of Science. With the College of Science and College of Engineering being two of the top colleges in reference to the most number of enrolled students and RGEP courses offered, and once the construction of the new academic complexes has finished, the 5,745

Figure 1. The Existing and Proposed College of Engineering Complex and National Science Complex Locations and the Adjacent Roads

Engineering students who will transfer to the new buildings and the existing 2,692 College of Science students would actually increase the transportation demand and alter the travel pattern on the road network of the area. Therefore, these expected effects of the academic complexes to the traffic in the network must be assessed.

Traffic simulation modelling is now a major tool in assessing road traffic and can be a tool for prediction which can be used for planning purposes. It is able to replicate the movements of the individual vehicles in the traffic stream (Supernak, 1983) and describes the motion of each individual vehicle (Barcelo, 2010). Traffic flows can be modelled macroscopically in which, traffic flows are treated like a fluid characterized by aggregate macroscopic variables such as density, volume and speed. A macroscopic level of simulation is efficient for large networks but it does not take into account the details for individual drivers. Traffic flows can also be disaggregated and be modelled microscopically where the dynamics of the individual vehicles that compose the traffic is considered such as driver behavior and route choice. There is also a mesoscopic approach which involves simplification of vehicular dynamics and in some way combines the aspects of microscopic simulation and macroscopic simulation.

Hence, through the use of a microsimulation tool, the future impact of the traffic generated by the new buildings can be assessed and possible problems within the road network can be prevented.

1.2. Objectives

The objectives that the study aims to reach are the following:

a) Develop microsimulation models that would replicate the existing and future conditions of the road network on the study area;

b) Analyze the impact of the traffic generated by the academic complexes by comparison of the developed microsimulation models for the existing and future conditions; and,

c) Recommend solutions to traffic problems found in the network, if there are any.

1.3. Literature Review

Guo et al. (2013) created a model of a university campus in search of a parking space which made use of an agent-based microscopic model. Agent- based means that the individual or the driver has the freedom to choose his own speed, acceleration, and route depending on how he perceives his environment. Agent-based microscopic models make use of driver behaviour properties, and some softwares that are well-known for being agent-based are PARAMICS, VISSIM, AIMSUN, and TRANSIMS, as mentioned in the study. Since the problem is a bit similar to the study, the researchers were given an idea to use an agent-based type of model to work on.

Sun et al. (2013) compared the performance of the two microsimulation tools, CORSIM and VISSIM, on an urban street network. The main difference between the two is the vehicular and driver behavior, primarily in the car-following and gap acceptance logic. For CORSIM, each driver has an ideal safety distance. Depending on the aggressiveness of the driver, he could accept narrower gaps compared to others. On the other hand, VISSIM uses the Widemann psycho-physical approach where the simulated driver reacts by either decelerating or braking whenever the driver notices that the gap between his vehicle and the lead vehicle is smaller to what he considers as safe distance. Using average control delay as basis, results of the study showed that VISSIM handles large intersections with high throughput traffic better while CORSIM produced better results on unsaturated intersection and more accurate in replicating small scale intersections. Both simulators did not fare good when it comes to the simulation of the average queuing length, having large difference from the field data. For the cross-sectional traffic volume, both simulators produced acceptable results but CORSIM had closer values to the real traffic data. Sun et.al. (2013) pointed out that each simulator has a particular advantage when it comes to replicating traffic. These advantages come from the principles and models used by the software and its default parameter setting which includes the driver behavior, traffic environment setting, etc. It should be the future researchers' discretion when it comes to selecting the appropriate simulation tool based on the given scenario.

Park and Schneeberger (2003) proposed a procedure to calibrate and validate VISSIM for signalized intersections. According to them, no guidelines have been set yet in terms of calibration and validation of the microsimulation models that is being widely used already. The procedure consisted of nine steps which were found effective on their study. For the calibration part, they used a statistical tool to compare the simulated results with the field data. They did multiple runs for the statistical tool to be valid.

Woody's report (2006) was also about the calibration and validation of VISSIM, but this time for freeways. He proposed three steps for this: base model development, planning for the calibration, and the model calibration, and validation which will be adapted later on for the methodology though his procedure was a bit complicated since it involved the calibration of driver behavior parameter.

2. METHODOLOGY

2.1. Development of the Microsimulation Model

The procedures presented by Park and Schneeberger and Woody from their separate studies will be adapted and modified for the methodology of this study. The flowchart below was based from these studies and this would serve as the guide in executing the research.

2.1.1. Data Collection

A traffic volume count survey was conducted on the 4th and 5th day of February, 2014. Intersection turning counts were collected in 15-minute-intervals from 13 stations, which are shown in Figure 2 below. Station 5 is used as a control station to verify the hourly volume variation and peak hour of the traffic volume count as illustrated in Figure 3. The survey was done from 6am to 7pm for the control station and 6 to 9 in the morning and 4 to 7 in the evening for the other 12 stations. The data gathered was used to determine the peak hour period of the day, which was from 8-9 in the morning.

Figure 2. Survey Stations and Locations

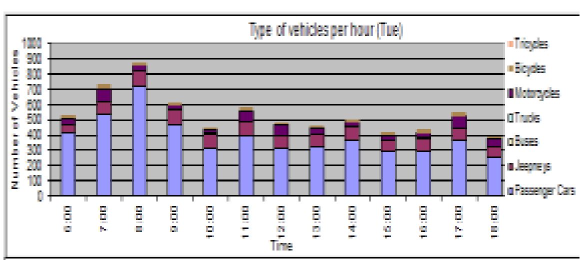

Figure 3. Hourly Volume Variation for Station 5, Tuesday Data

While in order to collect data for the proposed Engineering Complex, an interview survey was conducted. The survey consisted of questions asking the student's course, preferred mode of transport, and his class schedule.

2.1.2. Development of the Base Model

The next step is the development of the base model. Due to the scale of the study area, measurements for road geometry is done using a scaled image obtained from Google Earth application as actual measurements would be tedious and time-consuming. This image is also used as a background image in VISSIM which serves as a scale and a guide creating, placing and connecting road links. An ocular was also done in the study area to observe the existing traffic controls such as speed limits and stop/yield signs.

Figure 4. VISSIM Model of the Existing Condition

2.2. Model Calibration

Calibration is done in order for the simulated model to reflect the field condition. Parameters in the software were adjusted to achieve desired calibration results. The data for Tuesday peak hour period was used for the calibration of the model.

2.2.1. Measurements of Performance

The results of the traffic micro-simulation model should replicate the observed traffic flow to establish the validity of its results. For this simulation, the traffic volume count at intersections will be used as a measurement of performance because this data is readily available from the traffic count survey and can easily be measured and obtained from simulation.

2.2.2. Calibration Parameters

The default values of the parameters used in VISSIM must be configured to replicate the traffic behaviour observed in the study area. The modifications were made on the model which was based on a study of Ge and Menendez (2012) on the sensitivity analysis of the calibration parameters in VISSIM.

It was found out that the model was more sensitive to 5 parameters, namely: (1) Average Standstill

Distance, (2) Additive Part of Desired Safety Distance, (3) Multiplicative Part of Desired Safety Distance, (4) Safety Distance Reduction Factor and (5) Lane Change Distance. Parameters 1, 2, 3, and 5 were tweaked in this study.

2.2.3. Desired Speed Distribution

Desired Speed refers to the speed of vehicles at free flow. The following speed distribution was set for the road network which was based from the existing traffic rules.

Table 4. Desired Speed Distribution

Location	Desired Speed (kph)
C.P. Garcia	50-60
Katipunan	50-60
CS Complex	20
Rest of road network	30

2.2.4 Calibration Analysis

2.2.4.1 GEH Statistic

GEH Statistic is a formula developed by Geoffrey E. Havers used to compare two sets of traffic volumes. This serves as better comparison tool than deviation as it does not rely heavily on the observed values. The formula for the GEH is given by

$$\mathrm{GEH} = \sqrt{\frac{2(\mathrm{M}-\mathrm{C})^2}{\mathrm{M}+\mathrm{C}}} \quad (4)$$

A GEH value of less than or equal to 5.0 would indicate that the difference between the model and actual results is acceptable. As a rule, 85% of the traffic volumes for the entire model must pass this criterion for the model to be accepted.

2.2.4.2. Calibration Results

Using the GEH Statistic test, a sample data for the Tuesday data of Station 5 is shown in Table 2. While the summary of all stations, indicating if they passed the GEH statistic or not, is shown in Table 3.

Table 1. GEH Statistic of the Movements for Station 5, Tuesday Data

STA	MOV	OBS. VOL	SIM. VOL	GEH	≤5.0?
5	M1	342	440	**4.96**	**Pass**
	M2	91	105	**1.41**	**Pass**
	M3	9	10	**0.32**	**Pass**
	M4	129	137	**0.69**	**Pass**
	M5	125	120	**0.45**	**Pass**
	M6	13	18	**1.27**	**Pass**
	M7	86	74	**1.34**	**Pass**
	M8	41	37	**0.64**	**Pass**
	M9	17	15	**0.5**	**Pass**
	M12	15	13	**0.53**	**Pass**
	M13	5	9	**1.51**	**Pass**

Table 2. Summary of the Stations that Passed the GEH Statistic, Tuesday Data

Station	No. of Passed Movements
1: E. Jacinto – CP Garcia	5/6
2: CHE	1/2
3: Arki – UP Press	10/10
4: OUR	6/6
5: EEE – CS Amphitheater	13/13
6: NIGS	8/8
7: Fine Arts	6/6
8: NISMED	9/9
9: NIMBB	8/8
10: Math Building	3/3
11: NIP	5/6
14: P. Velasquez – CP Garcia	4/5
15: Katipunan – CP Garcia	6/6
Total	**80/84**

80 movement volumes out of the 84 had a GEH of less than five. Meaning that 95.24% passed the GEH statistic, which is higher than the required 85% criterion.

After several trial and error attempts in calibrating the model by using the range of values used in the study of Ge & Menendez (2012), the researchers have determined the values of the parameters, as shown in Table 3, which produced a properly calibrated model.

Table 3. Summary of the Calibration Parameters Used in the Study

Parameter	**Value**
Car Following	
Average Standstill Distance	2.50
Additive Part of Safety Distance	1.50
Multiplicative Part of Safety Distance	1.50
Lane Change	
Minimum Headway	1.00 m
Lane Change Distance	250 m
Emergency Stop Distance	7m

Lateral	
Keep lateral distance to vehicle on next lane(s)	Enabled
Consider next turning direction	Enabled
Overtake on same lane Distance standing Distance driving	Enabled 0.30 m 0.50 m

2.3. Model Validation

For this study, the validation procedure was the same for calibration. Since both models for the peak hours of Tuesday and Wednesday are needed for the study, the model calibrated for peak hour of Tuesday will be validated using the peak hour data for Wednesday. Table 4 illustrates the summary of all the stations' GEH statistic and if it passed or not.

Table 4. Summary of the Stations that Passed the GEH Statistic, Wednesday Data

Station	No. of Passed Movements
1: E. Jacinto – CP Garcia	5/6
2: CHE	2/2
3: Arki – UP Press	10/10
4: OUR	6/6
5: EEE – CS Amphitheater	13/13
6: NIGS	8/8
7: Fine Arts	6/6
8: NISMED	8/9
9: NIMBB	8/8
10: Math Building	3/3
11: NIP	6/6
14: P. Velasquez – CP Garcia	4/5
15: Katipunan – CP Garcia	5/6
Total	**80/84**

Again, 80 out of the 84 link volumes passed the GEH criterion requirement which is to be equal or greater than 85%. Thus, the researchers can safely say that the model is now calibrated and validated and can be used for the analysis.

2.4. Future Model Development

The calibrated and validated model is modified to project the future road network when the College of Engineering Complex is complete. A master plan of the planned road network for the complex was obtained from the College of Engineering Administration. This is used as basis in constructing the road networks on VISSIM. Figure 4 shows the modifications/additions done on the model based from master plan of the complex.

Figure 5. VISSIM Model of the Future Condition

For the future inputs of the model, a survey for the students in the university was done which asks for their schedule, movement (origin -> destination) and preferred mode of transportation which was classified into non-motorized, private and public transportation. An O-D matrix and modal split was done using the survey data. A list of classes in Engineering was obtained from the UP Computerized Registration System (CRS) which also contains the number of enrolled students per class

2.5. Traffic Impact Analysis

Average vehicle delay was used as a measure of traffic impact of the future condition. VISSIM defines average vehicle delay as the time difference between the ideal travel time to the simulated travel time. The average vehicle delay for every movements at intersections within the study area is measured in VISSIM. This is done for both models for the existing and future conditions.

The Levels of Service (LOS) of the signalized and unsignalized intersections was assessed using the table from the US Highway Capacity Manual which is shown in Table 4. The difference on LOS would serve as the quantification of the traffic impact induced by the completion of the College of Engineering Complex.

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Table 5. Levels of Service Criteria for Intersections

Level of Service	Average Vehicle Delay (sec/veh)	Description
SIGNALIZED INTERSECTION		
A	<= 10	Free flow
B	>10 – 20	Stable Flow
C	>20 – 35	Stable Flow
D	>35 – 55	Approaching Unstable Flow
E	>55 – 80	Unstable Flow
F	>80	Forced Flow
UNSIGNALIZED INTERSECTION		
A	0-10	Free flow

B	>10-15	Stable Flow
C	>15-25	Stable Flow
D	>25-35	Approaching Unstable Flow
E	>35-50	Unstable Flow
F	>50	Forced Flow

3. RESULTS AND DISCUSSION

3.1. Comparison of Existing and Future Conditions

3.1.1. Vehicle Delay

The measurement of the average vehicle delay was started from 900 simulation seconds. This is to allow the model to be filled up with vehicles thus, reducing the deviation of measurements due to vehicles travelling at free flow speed at the start of simulation.

Table 6 and 7 shows the vehicle delay (second/ vehicle) of each movement for Station 5 Tuesday for the existing and future conditions, respectively.

Table 6. Vehicle Delay per Movement of Station 5 (Tuesday), Existing Condition

Movement	Delay Time (sec/veh)
M1	0.16
M2	0.53
M4	0.41
M5	0.64
M7	0.25
M8	0.51

Table 7. Vehicle Delay per Movement of Station 5 (Tuesday), Future Condition

Movement	Delay Time (sec/veh)
M1	0.14
M2	0.33
M4	0.63
M5	0.69
M7	0.31
M8	0.42

Table 8 below illustrates the summary of the comparison of the two conditions in terms of vehicle delay time. The movement with the highest delay was chosen and will be the basis of the level of service (LOS) of that intersection.

Table 8. Comparison of the Vehicle Delay Times of the Two Conditions (Tuesday Data)

Station	Highest Vehicle Delay Time	
	Existing Condition	Future Condition
1	11.97 [M2]	11.13 [M2]
3	0.96 [M6]	1.51 [M6]
4	0.62 [M6]	0.87 [M6]
5	0.64 [M5]	0.69 [M5]
7	0.84 [M1]	0.74 [M5]
8	1.98 [M2]	2.69 [M5]
9	0.28 [M3]	0.15 [M8]
10	0.15 [M3]	0.19 [M3]
11	0.11 [M3]	0.09 [M6]
14	46.01 [M1]	44.15 [M1]
15	43.38 [M3]	35.88 [M3]

The same goes for Tables 9, 10, and 11 – Tables 9 and 10 show the vehicle delay per movement of Station 5 of the existing and future conditions, respectively; while Table 10 summarizes the delay times of all the intersections present in the network.

Table 9. Vehicle Delay per Movement of Station 5 (Wednesday), Existing Condition

Movement	Delay Time (sec/veh)
M1	0.1
M2	0.01
M4	0.3
M5	0.24
M7	0.15
M8	0.15

Table 10. Vehicle Delay per Movement of Station 5 (Wednesday), Future Condition

Movement	Delay Time (sec/veh)
M1	0.11
M2	0.07
M4	0.17
M5	0.13
M7	0.21
M8	0.3

Table 11. Comparison of the Vehicle Delay Times of the Two Conditions (Wednesday Data)

Station	Highest Vehicle Delay Time	
	Existing Condition	Future Condition
1	5.22 [M6]	6.01 [M2]
3	0.33 [M4]	0.3 [M2]
4	0.32 [M6]	0.09 [M1]
5	0.30 [M4]	0.3 [M8]
7	0.29 [M5]	0.54[M1]
8	1.18 [M9]	2.24 [M2]
9	0.06 [M3]	0.11[M2]
10	0.03 [M3]	0.07 [M2]
11	0.12 [M4]	0.14[M1]
14	9.43 [M1]	9.32[M1]
15	27.48 [M3]	27.06[M3]

3.1.2. Level of Service

For the intersections, the level of service was determined by the value of the delay time. The movement that has the highest vehicle delay time will tell the level of service of the intersection. Referring to Table 8 for the delay times of the existing and future conditions for the Tuesday data, and Table 5 for the corresponding level of service, Figures 6 and 7 illustrates the LOS per intersection:

Figure 6. Level of Service per Intersection, Tuesday Existing Condition

Figure 7. Level of Service per Intersection, Tuesday Future Condition

Figure 8. Level of Service per Intersection, Wednesday Existing Condition

Figure 9. Level of Service per Intersection, Wednesday Existing Condition

Figures 9 and 10 illustrate the Level of Service (LOS) per intersection for the existing and future condition, respectively, of the Wednesday data.

Comparing Figures 6 and 7, it can be seen that almost all intersections except for Stations 14 and 15 has an LOS A. Station 14, the intersection of P. Velasquez and C.P. Garcia, currently and will still experience an LOS C as shown in the figures. While Station 15, Katipunan – C.P. Garcia intersection has a LOS D. For the Wednesday figures, all intersections except for Station 15 which has an LOS A, yet Station 15 experiences an LOS C. It can be noticed that there was no change in the levels of service in all of the intersections.

4. CONCLUSION

The researchers were able to develop a microsimulation model for the College of Science and College of Engineering Complexes including the adjacent roads (i.e. C.P. Garcia Ave and Katipunan Ave). Volume was used as measure of effectiveness of the calibration and validation procedure and the GEH Statistic was applied to compare the simulated results to the observed data. The parameters used in the study were based from trial-and-error adjustments and inspecting the visualization of the microsimulation model.

Out of the 84 movements, 80 movements passed the GEH Statistics for the calibration procedure. This represents 95.24% of the movements which is greater than the required passing of 85% of the movements. The same is true for the validation of the model. Thus, the microsimulation model can be used for analysis and prediction.

Using the developed model, modifications were done for the model of the future condition where the proposed road network has been established. To compare the future condition to the current condition, the researchers compared the average vehicle delays measured at the intersections within the study area. The measured vehicle delays are also assessed for their corresponding Level of Service based on the US Highway Capacity Manual of 2000. Except for one movement (Sta. 15 – M6), the difference on the average vehicle delays between the existing and future condition ranges from 0 to 3 seconds. However, no changes in LOS of intersections happened. Therefore, no significant impact will be observed because of the completion of both the College of Science and College of Engineering Complexes.

5. RECOMMENDATIONS

The researchers suggest doing the following for further studies:

- Use additional performance measures such as travel time for calibration purposes to have a much realistic emulation of the traffic flow.
- Conduct surveys on more days to identify the worst traffic condition of the study area
- Improve the microsimulation model by incorporating the pedestrian movements which may affect the traffic flow of vehicles within the study area. The simulation for public transport (jeepneys) in the model can be enhanced by integrating the vehicle occupancy and dwell time of jeepneys (Ikot and Toki)
- Create vehicle models for tricycles and jeepneys for better visualization of the model
- Validate the calibration parameters used if it is the realistic values for the local condition

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