Microscopic Modeling of Traffic Management Schemes along Taft Avenue, Manila

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Abstract: Heavy traffic is experienced on Taft Avenue due to it being an access to multiple establishments, schools, and offices. This study focuses on the section of Taft Avenue between Quirino Avenue and Pablo Ocampo Street. Dynameq simulations of scenarios were conducted to find which scenario would reduce travel time delay. Vistro traffic analyses of scenarios were executed in determining the traffic light configuration that would best reduce intersection delay. Dynameq proved that the best network configuration is what the current one. The configuration resulted to a 9.301, 0.942, and 6.133 percent decrease in vehicle-hour delay for the morning, afternoon, and evening study periods respectively. The optimization in Vistro includes a 20 second pedestrian crossing time and resulted to percent differences sorted from morning to evening study periods in Estrada Street Junction are -11.080, -2.439, and -24.042; while on Pablo Ocampo Street junction are 24.744, 3.566, and -37.428.

***Key words*:** Traffic Congestion, Micro-simulation, Traffic Signal Optimization, Localized Congestion

1. PROBLEM SETTING

1.1. Background of the Study

Taft Avenue in Manila City is a main road that connects three cities of the National Capital Region (NCR) - Manila, Pasay, and Parañaque. The study focuses on the section of Taft Avenue from Quirino Avenue to Pablo Ocampo Street. This section has become an interest of study because it is adjacent to four institutions - De La Salle University Manila (DLSU), De La Salle – College of St. Benilde (DLS-CSB), St. Scholastica's College (SSC), and Systems Technology Institute (STI) College Taft - and is near other establishments; thus, the road is busy.

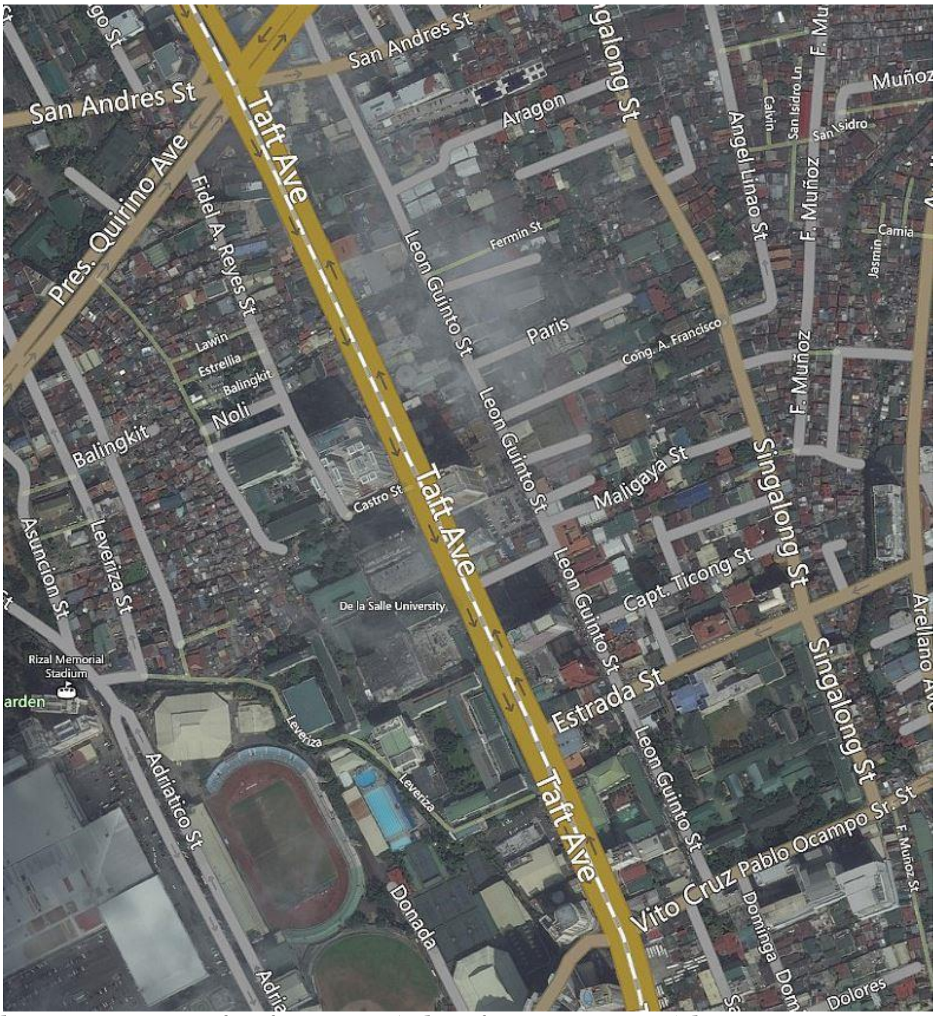

Figure 1. The Vicinity Map of Taft Avenue (taken from Bing Maps) between Pres. Quirino Avenue and Pablo Ocampo Sr. Street

1.2. Statement of the Problem

The section between Quirino Avenue to Pablo Ocampo Street is heavily congested during peak hours from 8:00-09:00 am and 6:00-7:00 pm of regular school and working days.

Most stretch of the outermost lanes in the study area are avoided or cannot be used by passing vehicles because of parked vehicles, protruding parked vehicles, waiting vehicles, public utility vehicle stopping lane, walking pedestrians (who are forced to do so due to small or no pedestrian walking lane), and construction activities. Mainly due to DLSU, waiting cars (for students) line up on one to two lanes in the southbound side of the road. This leaves two active lanes with one of them being used for public utility vehicles to stop and load/unload passengers. The study area has four u-turn slots within it which causes queue before them, in the innermost lanes of the road.

Unsynchronized Pablo Ocampo Intersection traffic light duration, which has a 120 second cycle, with the McDonalds traffic light durations, which has a 140 second cycle, leads to queuing and delay.

Vehicles waiting to take U-turns cause a bottleneck and there are four of these in the study area.

1.3. Statement of Objectives

The main objective of the study is to propose traffic management schemes to reduce traffic congestion and travel time delay in the area. The following points listed below are to be accomplished in order to achieve this main objective:

a) To identify and discuss causes of traffic congestion in the area;
b) To characterize vehicular traffic along the specific study area; and,
c) To recommend the best traffic scheme management that reduces traffic congestion and travel time delay.

1.4. Hypothesis of the Study

By eliminating some of the pedestrian crossing and optimizing the traffic signalling system, overall delay to vehicles will be reduced.

1.5. Assumptions in the Study

The following are the assumptions of the study:

1.) Traffic schemes are followed properly.
2.) The data gathered for the saturation flow and O-D matrices are assumed to have been taken under similar network conditions.

1.6. Scope, Limitation and Delimitation of the Study

The study covers traffic management schemes specially traffic signal analysis designed only for the stretch in Taft Avenue.

Dynameq, a software, was used to simulate the traffic flow and due to it lacking a component when this study was conducted, traffic signal timings cannot be incorporated in its simulations. Vistro, another software, was used for the optimization of signal timings however, it does not include U-turns and study points with no vehicle conflicts as inputs in its analysis. The effect of weather, such as impassable roads due to flooding, is not included as a variable in the software.
The study periods are at 08:00 - 09:00, 14:30 - 15:30, and 18:00 - 19:00 to simulate the morning peak hour, off-peak hour in the afternoon, and evening peak hour respectively.

1.7. Significance of the Study

This study would produce traffic management schemes to be recommended to reduce congestion and travel time delay on the study area by optimizing traffic signal and re-evaluation of pedestrian signals and u-turns.
The order of the paper is as follows:

2. FRAMEWORK

2.1 Conceptual Framework

The problem - Travel Time Delay and Congestion - is observed to be caused by the listed factors below in Figure 2. The two software were used to simulate the study area by having incorporated the theories in the "Theories" box in the figure. Traffic schemes are the output of the simulations.

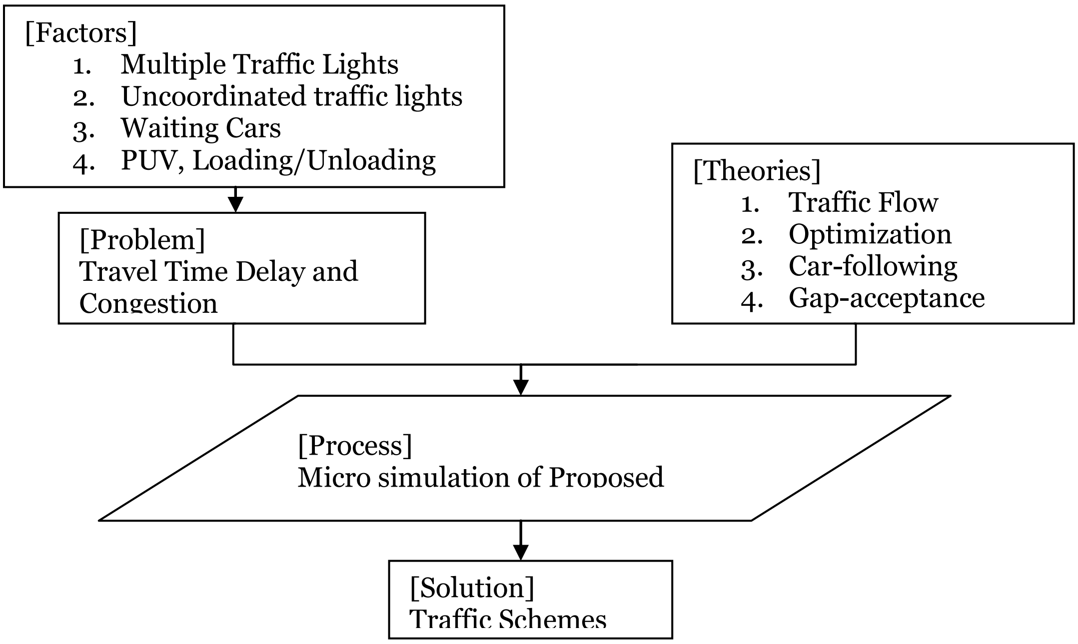

Figure 2. Conceptual Framework Diagram

2.2 Theoretical Framework

All computations involved in the analysis were processed by the software used. Some theories involved in VISTRO are: 1.) Basic Principles of Traffic Flow, 2.) Signal Design Optimization, and 3.) Network Optimization. And for DYNAMEQ are: 1.) Genetic Algorithm, 2.) Hill – Climb Algorithm, 3.) Car-Following Principle, and 4.) Gap-Acceptance.

2.3 Research Design

Details on the study area were acquired. These were analyzed and configured in the two software. Traffic signal timing was analyzed in Vistro and network modifications were simulated in Dynameq. Multiple scenarios were conducted in both software and each analysis/simulation results were taken. The results were compared and analyzed in order to determine which scenario would best reduce travel time delay in the study area. Figure 3 shows the flow of the research design.

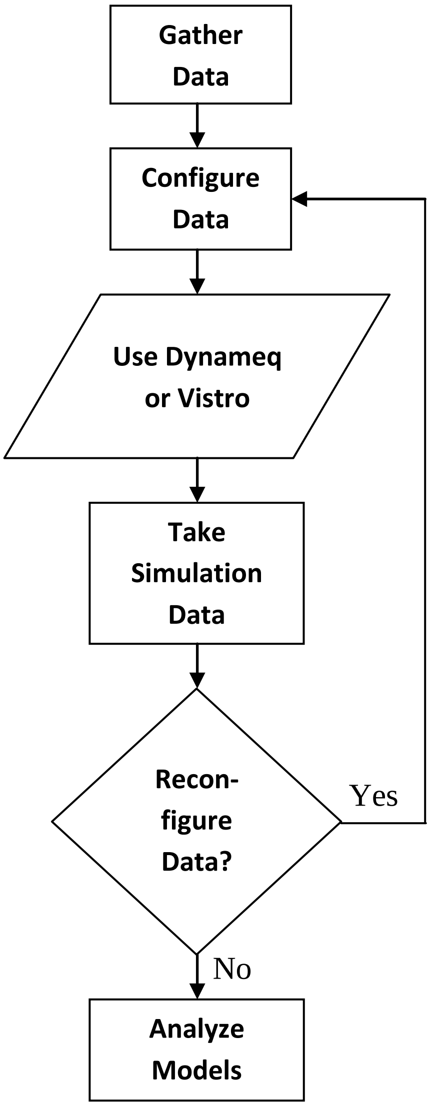

Figure 3. Research Design Flow

3. RESEARCH DESIGN AND METHODOLOGY

3.1 Gathering of Data

License-plate Observation Method was used within the study area to determine the trip distribution and average travel speed of each of the vehicle types and the total of all the vehicle types. It was conducted thrice, one for each study period. The stations in the network for the conducting of the method are marked red in Figure 4.

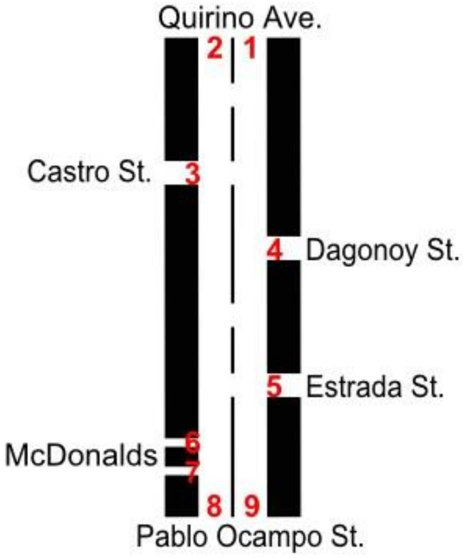

Figure 4. License-Plate Observation Stations (not scaled)

The trip distributions of vehicles are tabulated as origin-destination (O-D) matrices. The vehicle types included were: buses; b) cars (includes private vehicles and taxis); public utility jeeps (jeepneys); d) public utility vans (or fx); and trucks. But after reviewing of the raw data gathered, Cars and trucks were added together since the volume of trucks was relatively small and that the trucks were assumed to have a behaviour similar to private vehicles. Buses were added to jeeps for similar reasons.

Manual Counting Method with the aid of counters was used to determine the saturation flow in intersections and junctions for each study period. The saturation flow does not include u-turns because the software, Vistro, where data was entered does not include u-turns in its analysis. The method was conducted as indicated in Figure 4.2. The red dots in the figure were the points where the data were taken and the arrows show the directions (Northbound, Southbound, Westbound, and Eastbound) of vehicles. The legend in the left of the network shows the orientation of directions.

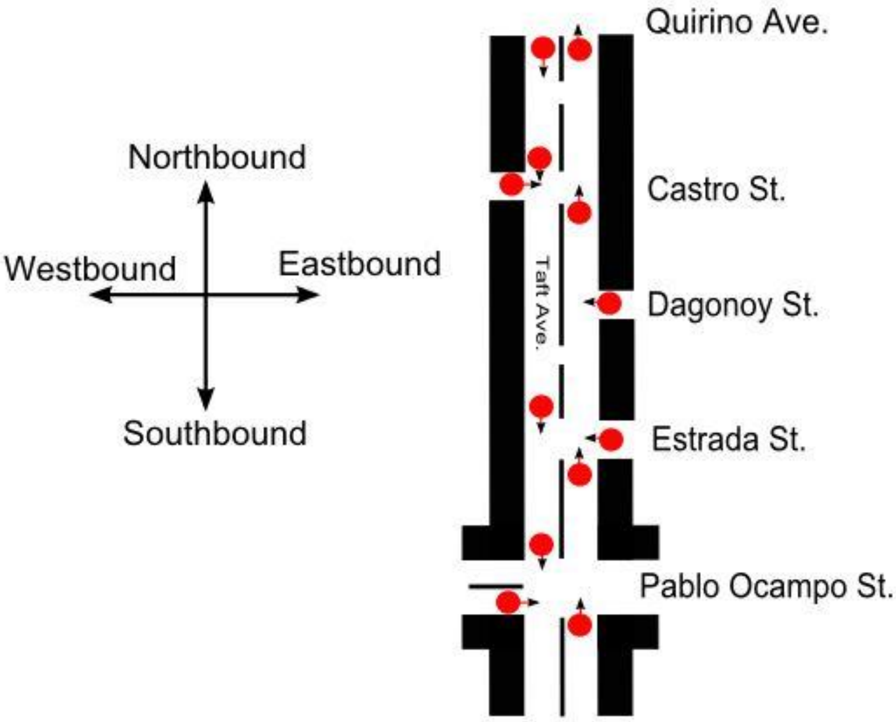

Figure 5. Manual Volume Counting Stations on the Network (Unscaled to Study Area)

Observation was used in counting the number of lanes of involved roads, the location of study points (traffic lights, pedestrian crossings, junctions, and intersections), and the phasing of traffic lights. The traffic light durations were counted with the aid of timers. The activity on each lane was also observed to determine their usage whether a lane should be prohibited or allowed. A map of the network was taken from Bing Maps as a backdrop for the network in Vistro.

The lane widths were measured to have a 2.85 meter width in all the involved roads aside from Castro Street. The particular street has no lane markings, has an opening of about 4.5 meters, and is used as a two-way, one-lane road. The numeric center-to-center distances between nodes were measured using a meter-tape.

The one-hour average travel speed and the average travel speed per fifteen-minutes of all vehicles and of each vehicle type were calculated (MS Excel aided) from the license-plate observation method. The northbound average travel speed was taken from the average speed of vehicles running from Pablo Ocampo Street intersection to Quirino Avenue Intersection. And the southbound average travel speed was taken from the average speed of vehicles running from the other way around.

Table 1 summarizes the data needed in this paper. The second column shows the units. The third column shows how the data was taken. The fourth column answers the question whether the certain data must be gathered or observed on each of the three study periods.

Table 1. Summary of Data Gathering

Needed Data	Units	Methods/Items Used	Changes with Study Period
Trip Distribution (Origin-Destination matrix)	Vehicles	License-Plate Observation Method	Yes
Travel Time	Seconds		Yes
Travel Speed	KPH		Yes
Saturation Flow	Vehicles	Manual Counting Method	Yes
Intersection/junction locations	N/A	Observation	No
Traffic light locations	N/A		No
Number of Lanes and usage	N/A		Yes
Phase Sequences	N/A		Yes
Traffic Signal Duration	Seconds	Timers	Yes
Road lengths	Meters	Meter Tape	No
Lane Widths	Meters		No
Pedestrian Crossing Widths	Meters		No

3.2 Determining Solutions

For Dynameq, the current traffic condition in the study area was first simulated for the three study periods. Since the network was the same for all study periods, reconfiguration could be tested in only one of the study periods. The evening study period was chosen to represent the whole network as it experienced the worst condition of having the lowest average travel speed and vehicular volume.

In the evening study period, the network was reconfigured and simulated to determine which modification or combination of modifications would reduce the travel time delay within the study area. VHT, VHD, VKT, and speed were the four variables considered as a basis in determining the effect of a scenario in the network.

The network's current conditions were initially simulated in Vistro for each of the study periods. These data were the baseline for the data from all succeeding scenarios. Vistro could not simulate traffic signals with no vehicle conflicts such as the traffic lights in front of DLSU's North Gate and the traffic lights for the pedestrian crossing in front of McDonald's. As an alternate solution, traffic signals in these two sections would be synchronized with the traffic light timing in Taft Avenue - Pablo Ocampo Street intersection.

The traffic signal was then optimized. The effect of adding different durations of all vehicular stop (which is an alternative for simulating pedestrian crossing time) were analyzed. Delay (in second/vehicle) and LOS were the two variables used to compare the results between each scenario optimizations.

Table 2 summarizes the data inputs for the two software.

Table 2. Data Inputs for Dynameq and Vistro

	Dynameq	Vistro
Traffic Demand	• Trip Distribution (O-D matrix) • Average Travel Speed (15-minute interval) (1-hr interval per vehicle type)	• Saturation Flow • Average Travel Speed (1-hr interval)
Network Definition	• Number of Lanes • Lane Width • Road Lengths • Road use	• Number of Lanes • Lane Width • Road Map
Traffic Control Plans	• N/A (missing template in Dynameq)	• Traffic Light Duration • Phase sequences

4. PRESENTATION, RESULTS AND DISCUSSION

To conserve space only the percent changes from the actual data and solutions are presented

4.1 DYNAMEQ Simulations

The one-hour averaged values of VHT, VHD, VKT and speed are used to determine the results of the simulations. The goal for the succeeding simulations for solutions would be to decrease the VHD.

VHT's increase means that the total vehicles have an additional total time travelling in the network. The additional time may be caused by the extra distance the vehicles would have to cover in the network due to its new set-up or the addition of delay. VHD's increase means that the total vehicles have an additional delay time in the network. The increase may be caused by the congestion of vehicles in certain points, such as turning areas, in the network. An increase in VKT would mean that more total distance is covered by the total vehicles in the network's new set-up at the given time duration of 1 hour. The speed result is derived by Dynameq from VHD and VKT values.

The evening data was chosen to represent the whole study area as it had the slowest averaged 1-hour travel speed in the network while having the lowest vehicular volume compared to the two other study periods based from the gathered data. Simulations for modifications were conducted only in the evening network and the scenario that would give the best results would be applied to the two other study periods.

Three basic scenarios on lane usage were created firstly. For the first scenario, all lanes were opened for all vehicle types. For the second scenario, all lanes were opened but the outermost lanes were only for PUV. For the third scenario, all lanes were opened but the innermost lanes are for private vehicles only.

The next table shows the percent change of each scenario's results from the current conditions. The first scenario (all lanes open) is observed to have the best results. Based on the other two basic scenarios which have lower resulting values, further combinations on lane usage is no longer necessary.

Table 3. Percent Change of Lane Usage Modification Results from Current Conditions (1800 - 1900 Study Period)

Variable	Unit	Network Configurations			
		Current Condition	Scenarios (All Lanes Opened)		
			All Lanes Open for All Vehicle Types	Outermost Lanes for PUV Only	Innermost Lanes for Private Vehicles Only
VHT	%	0	-0.706	-0.614	-0.712
VHD	%	0	-6.133	-3.049	-5.705
VKT	%	0	0.613	0.385	0.458
Speed	%	0	0.967	0.704	0.887

The next table shows the simulation results of the five u-turn scenarios. The "Baseline" values in the table are from the "all lanes opened" configuration. The results in scenario 5 are similar to the baseline because Dynameq simulates that no vehicle uses the turn since they do not need to do so on that point. The results from the five configurations did not result with a decrease in delay which would mean that the current U-turn configuration in the network is the best U-turn configuration. Also, these five scenarios being basic U-turn changes, which resulted to lower values than the current condition, would mean that further generating of combination of U-turn modifications is not needed.

Table 4. Percent Change of U-turn Modification Results from Current Conditions (1800 - 1900 Study Period)

Variables	Unit	Baseline	Scenario				
			1	2	3	4	5
VHT	%	0	2.16	2.56	0.46	2.88	0
VHD	%	0	4.09	3.94	3.65	8.48	0
VKT	%	0	1.98	2.55	0.23	3.03	0
Speed	%	0	0.01	0.01	-0.12	-0.19	0

Now that the best configuration for the evening data is determined, that configuration is applied to all the time periods.

Table 5. Percent Change of Best Scenario Network Simulation from Current Conditions

Variable	Unit	Study Period		
		0800 - 0900	1430 - 1530	1800 - 1900
VHT	%	-0.224	-0.494	-0.706
VHD	%	-9.301	-0.942	-6.133
VKT	%	0.087	0.074	0.613
Speed	%	0.232	0.609	0.967

4.2. VISTRO Simulations

Table 6 summarizes the Vistro analysis results for the current condition, optimized condition without pedestrian crossing, optimized condition with 20 second pedestrian crossing, and optimized condition with 25 second pedestrian crossing. The cells containing the results are coloured according to their values. Sorted from best to worst, the colours are

Green	Yellow	Purple	Red

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Table 6. Comparison of Results for All the VISTRO Analyses

Study Period	Location	Variables	Scenario			
			Current Condition	**Optimization**		
				without Pedestrian Crossing	with **20s** Pedestrian Crossing	with **25s** Pedestrian Crossing
0800 - 0900	Estrada Street Junction	Delay (s/veh)	**21.21**	**8.11**	**18.86**	**21.48**
		LOS	**C**	**A**	**B**	**C**
	Pablo Ocampo Street Intersection	Delay (s/veh)	**28.29**	**13.4**	**27.6**	**31.36**
		LOS	**C**	**B**	**C**	**C**
1430 - 1530	Estrada Street Junction	Delay (s/veh)	**26.62**	**9.31**	**20.22**	**23.49**
		LOS	**C**	**A**	**C**	**C**
	Pablo Ocampo Street Intersection	Delay (s/veh)	**28.29**	**15.16**	**35.29**	**41.00**
		LOS	**C**	**B**	**D**	**D**
1800 - 1900	Estrada Street Junction	Delay (s/veh)	**19.63**	**9.25**	**20.33**	**23.59**
		LOS	**B**	**A**	**C**	**C**
	Pablo Ocampo Street Intersection	Delay (s/veh)	**55.20**	**15.99**	**34.54**	**40.24**
		LOS	**E**	**B**	**C**	**D**

From the Department of Public Works and Highways (DPWH) Department Oder No. 37, 0.9 m/s should be used in calculating the duration to accommodate the slower pedestrians. The acceptable pedestrian crossing duration calculation is as follows:

$$Crossing\ Duration = \frac{total\ crossing\ length}{walking\ speed}$$

where:

total crossing length = (lane width) (number of lanes) + central refuge
central refuge = 2 meters
walking speed = 0.9 meter/second

$$Crossing\ Duration = \frac{(2.85)(8) + 2}{.9\ m/s} = 27.56 \approx 25\ seconds$$

25 seconds is taken instead of 30 seconds since 30 seconds is too long that results to a high vehicular delay.

Based in the table, the scenario with 25 second pedestrian crossing resulted to having the most of the worst results although it is closest to the proper pedestrian crossing time. The current condition result based from Vistro analysis is not the worst for the reason that it does not have time allotted for pedestrian crossing. The scenario with the 20 second pedestrian crossing has most of its results better than the current condition while having a time for pedestrians to cross but it does not conform to the DPWH Department Order No. 37.

The next table shows the application of the best traffic signal configuration to all the study time periods. And table 8 shows the percent change from the current situation to the simulated one.

Table 7. The Best Traffic Signal Configuration (Split Durations in Seconds) with a 20 second Pedestrian Crossing Phase

Location	Phases	Study Period		
		0800 - 0900	1430 - 1530	1800 - 1900
in front of Henry Sy Sr. Building	1	33	30	29
	2	27	30	31
	3	20	20	20
Estrada Street Junction	1	33	30	29
	2	27	30	31
	3	20	20	20
in front of McDonalds	1	30	32	34
	2	30	28	26
	3	20	20	20
Pablo Ocampo Street Intersection	1	22	18	18
	2	8	14	16
	3	30	28	26
	4	20	20	20
Cycle Length (seconds)		80	80	80

Table 8. Delay Percent Change of Best Traffic Signal Duration from the Current Condition

Location	Study Periods		
	0800 - 0900	1430 - 1530	1800 - 1900
Estrada Street Junction	-11.080	-24.042	3.566
Pablo Ocampo Street Intersection	-2.439	24.744	-37.428

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

From the data gathered, the main cause of travel time delay in the section between Quirino Avenue and Pablo Ocampo Street are the high number of private vehicles as supported by the data gathered in License-plate Observation Method and by the Review of Related Literature from Camara and De Macedo (2004). Also, the longest travel time delay happens in the 1800-1900 among the three study periods.

The modifications in the network definition in Dynameq includes the changing of lane and U-turn usage. The scenario which consisted of allowing all vehicle types to use any of the lanes while keeping the current U-turn configuration resulted to the best network definition configuration. The delay is reduced by -9.301, -0.942, and -6.133 percent for the morning, afternoon, and evening study periods.

Modifications in Vistro involves the optimization of traffic signals with the inclusion of pedestrian crossing time. Optimization with a 20 second pedestrian crossing is the best configuration option that reduces delay although it does not follow the computation laid out by

DPWH while the 25 second pedestrian crossing had results worse than the current condition. The percentage differences sorted from morning to evening study periods are -11.080, , -24.042, and 3.566 in Estrada Street junction and -2.439, 24.744, , and -37.428 in Pablo Ocampo Street intersection.

6.2. Recommendations

Computation or simulation on supporting the traffic signal phasing suggested in Table 5.21 should be formulated to check its effect on delay reduction.

Widening of the u-turn openings in the U-turn slot near Quirino Avenue, where buses take the turn, would allow a faster maneuvering of vehicles.

The southbound traffic, of the Taft Avenue and Pablo Ocampo Street intersection, in the area seems to be affected by the high volume of the cars using Pablo Ocampo Street to Arellano Avenue to exit to Makati City or SLEX. The route is used by cars coming not only from Taft Avenue - Pablo Ocampo St. Intersection but also the cars from Leon Guinto Street and Singalong Street. New routes may be able to distribute the volume or at least separate those that would go north and those that would take SLEX or Skyway south.

A study in simulating the addition of vehicular all stops for pedestrian crossing in the study area and analysis of its effects may be conducted.

Vehicles from the southbound course, from Taft Avenue on the other side of Quirino Avenue, to this paper's study area take the u-turn slot (the one nearest to Quirino Avenue in this papers study network) to enter the Eastbound course along Quirino Avenue since there are no left turns in Taft Avenue-Quirino Avenue Intersection. An alternate route for these vehicles could be studied.

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