JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE PROJECT FOR COMPREHENSIVE TRAFFIC MANAGEMENT PLAN FOR METRO MANILA

TECHNICAL REPORT NO. 1

CASE STUDIES ON SELECTED INTERSECTIONS

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ABBREVIATIONS

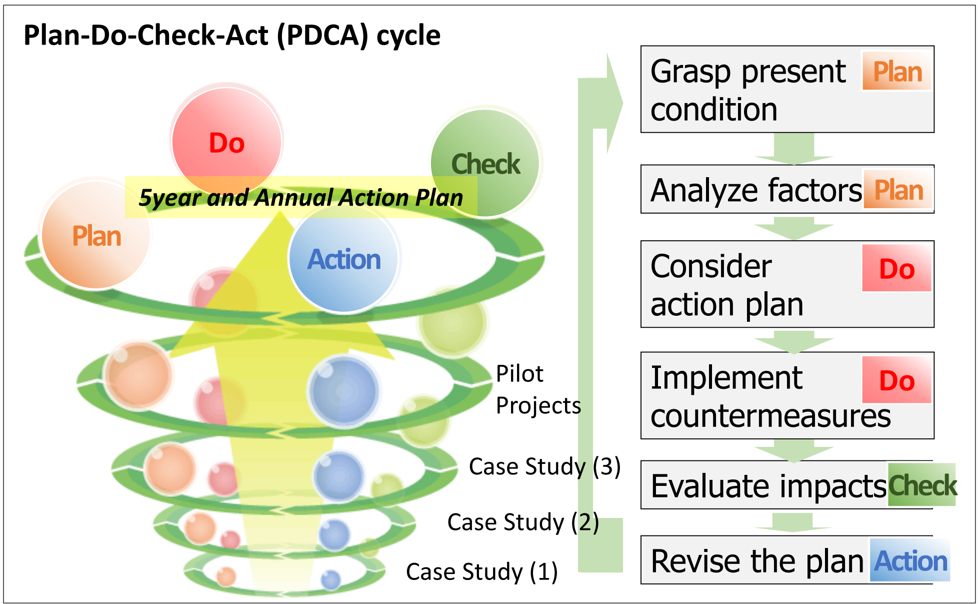
AM	(ante meridiem) means “before noon,”
BCR	benefit-cost ratios
CAD	computer-aided dispatch
CAVITEX	Manila-Cavite Expressway
CPT	Counterpart Project Team
CTMP	Comprehensive Traffic Management Plan
EDSA	Epifanio delos Santos Avenue
GEH	Geoffrey E. Havers
IS	intersection
JCC	Joint Coordination Committee
JICA	Japan International Cooperation Agency
JPT	JICA Project Team
KPH	kilometres per hour
KPI	key performance indicator
LGU	local government unit
LOS	level of service
MC	motorcycle
MIA	Manila International Airport
MMARAS	Metro Manila Accident Reporting Analysis System
MMDA	Metropolitan Manila Development Authority
MRT	metro rail transit
MUCEP	MMUTIS Update and Capacity Enhancement Project
NAIA	Ninoy Aquino International Airport
NB	northbound
O&M	operations and maintenance
PCU	passenger car unit
PDCA	plan-do-check-action
PHP	Philippine peso
PM	(post meridiem) means “after noon,”
PT	public transportation
PTV	Planung Transport Verkehr (German for "Traffic in cities - simulation model").
PUB	public utility bus
PUJ	public utility jeepney
PUV	public utility vehicle
SB	southbound
SUV	sport utility vehicle
TM	traffic management
UV	utility vehicle
VAT	Value added tax
VISSIM	Verkehr In Städten - SIMulationsmodell
VISTRO	Vision Traffix and Optimization

1 CASE STUDIES OF TRAFFIC BOTTLENECKS

1.1 Introduction

There are various causes of congestion at traffic bottlenecks in Metro Manila. Traffic management should be considered to tackle these problems and issues. To solve these problems and issues, there should be an understanding of traffic bottlenecks in a scientific perspective and data-based analysis of the causes to provide solutions evaluation (benefit and cost analysis) to improve traffic bottlenecks.

Three case studies were conducted in this CTMP Project from 2019 to 2020 to build the capacity of project counterparts and serve as references in the development of the five-year action plan. Using the design and management method of plan-do-check-action (PDCA) cycle, the JPT and counterparts from MMDA and selected LGUs studied three case studied.



Source: JPT

Figure 1.1: PDCA Cycle in the CTMP Project

The PDCA approach which the JPT adopted in implementing the case studies involved the following stages:

(a) **Plan:** This stage involved the selection of the intersections where severe congestion occurred along the roads that MMDA and selected LGUs manage, then identifying the causes of congestion by sight; collecting data to help analyze congestion causes (i.e., intersection drawings, vehicle movement data, signal phasing and timing plans, and travel time); observing the sites again to understand traffic flow, pedestrian volume, as well as vehicle, passenger, and pedestrian behavior.

(b) **Do:** Based on the data collected and site observations conducted, improvement measures were developed which include intersection geometry modification, pavement marking modification, signal phasing and timing parameter optimization, traffic control device, and other traffic engineering measures. In order to compare the different measures or combination of measures, multiple scenarios were prepared for each bottleneck.

(c) **Check:** Microscopic traffic simulation was conducted using Vissim, a traffic simulation program. A simulation tool was utilized to model the current condition, to experiment which countermeasures best fit the factors of congestion, and to measure the effectiveness of the proposed countermeasures. It simulates the movement of each vehicle in the bottleneck and immediate vicinity, as well as the signal operation, based on various parameters. The program produces such evaluation parameters as average speed and delay. However, Vissim cannot simulate non-engineering measures such as the strict enforcement of traffic rules. Selected MMDA counterparts, in particular, were also able to hone their skills and understanding about VISTRO, another traffic simulation program, which was used in the project to optimize signal timing within a corridor---this was used in Case Study No. 2. This “Check” stage requires moving back and forth between the two previous stages and this stage to select, drop, and combine the measures that will produce the best scenario, i.e., the one that gives vehicles the shortest travel delay and fastest speed.

(d) **Act:** Once the effectiveness of the packaged improvement measures was confirmed in the simulation, the cost of the measures was estimated using the standard unit costs adopted by MMDA, including indirect costs. Finally, the countermeasures were compiled into a proposal for approval of the MMDA chairman and the LGU chief executives. The MMDA counterpart was very interested in implementing the traffic management measures in Case Study 2, so MMDA decided to do it as a pilot project. Case Study 1 has also been calculated in sufficient quantities to be implemented locally and can be implemented if the MMDA is willing to do so. JPT and counterparts of MMDA and LGUs have also calculated the quantities for Case Study 3, and the LGUs counterparts in the project can take the lead in implementing.

1.2 Selection of Case Study Areas

Based on the analysis of TBNs using travel speed data from Waze, it has become clear that traffic congestion in Metro Manila occurs at points (intersections, U-turn slots, and merging points), segments along the corridors, and areas. To ease traffic congestion with the proper traffic management measures, it is essential to analyze the precise causes of congestion at traffic bottlenecks. However, even though there are a lot of traffic bottlenecks in Metro Manila, little attempt had previously been made to analyze the causes of congestion and to develop suitable improvement measures. Therefore, to develop the proper methodology and to understand how to tackle traffic bottlenecks, three (3) types of case studies were conducted in this project. The case studies are listed as the following: intersections at major roads, a segment along a corridor, and intersections at local roads.

(a) **Case Study 1: Improvement of Intersection Bottlenecks at Major Roads**

The criteria for selecting the locations for case study 1 were discussed among the CPT and JPT members. Both agreed on the following: medium to large, signalized intersection; and both main and intersecting roads (Class A or B) should have at least two lanes for each direction.

(i) Congestion exists daily during morning and afternoon peak hours;
(ii) Data required for developing countermeasures is already available or easily obtained;
(iii) The main cause of congestion is the insufficient capacity of intersection due to obstructions; and
(iv) Congestion is isolated and no spill back of queue from the downstream intersection occurs.

Based on the results of discussion, Roxas Boulevard–MIA Road intersection, EDSA–Taft Avenue intersection, and EDSA–Shaw Boulevard intersection are selected as the locations for case study 1.

(b) **Case Study 2: Improvement of a Segment Bottleneck along a Corridor**

Through the case study 1 activities, it was found that congestion in one intersection affects adjacent intersections in connecting roads upstream. As the next step, traffic situation in the following five major corridors (Class A) were to be analyzed using the MMDA's travel speed survey, Waze data, etc.

(i) EDSA;
(ii) C5;
(iii) Ortigas Avenue;
(iv) Shaw Boulevard; and
(v) Alabang–Zapote Road.

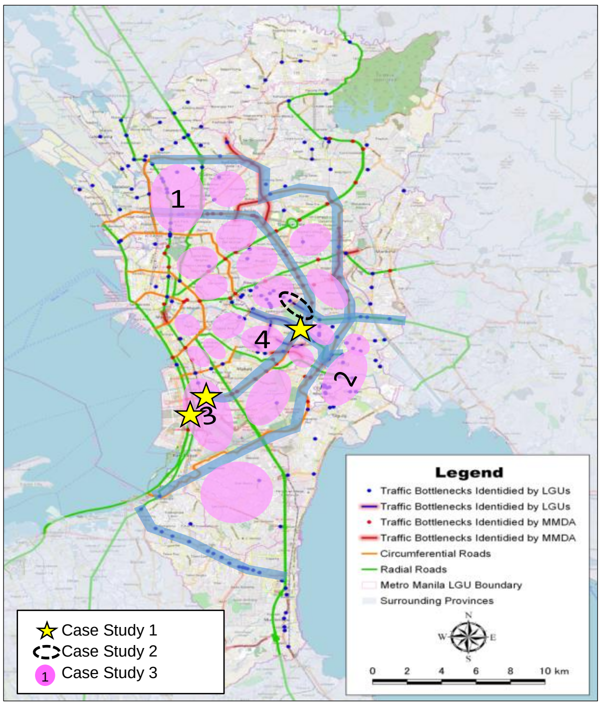
The segment along the Ortigas corridor between Santolan and Connecticut streets was selected as the location of case study 2. The corridor analysis was based on the criteria listed below.

(i) Bottlenecks were found along the corridor (low speed sections from MMDA travel time survey and Waze data)
(ii) Countermeasures are cost-effective:
- Despite the demand not exceeding capacity, some poor intersection geometry and

signal control not being appropriate for traffic conditions cause congestion.

- Modifications of the intersection layout, optimized signal timing, and adjusted offset timing for a corridor are simple and affordable

The results of the corridor analysis confirmed the need for traffic management measures appropriate for corridor segments/link



Source: JPT

Figure 1.2: Locations of Case Studies 1, 2,3

(c) **Case Study 3: Improvement of Intersection Bottlenecks on Local Roads**

There is also traffic congestion on local roads that are used by road users to access the main corridors. As a result, road users are forced to use major corridors, such as EDSA, without diversion. Therefore, case study 3 targeted local roads (Class C and D) to improve the intersections and enhance the traffic management capacity of the LGUs. MMDA discussed with the 17 LGUs and identified the 4 LGUs for each region as locations for the case study. Each pilot LGU and the MMDA CPT identified the target traffic bottleneck intersections and areas as shown in Table 1.1. Some of the issues facing the intersections are lack or inadequate signal control, mixed traffic, poor geometric design, PUJ volumes, pedestrian behavior, and concentration of traffic, etc.

Table 1.1: Selected Intersections for Case Study 3

LGU	Selected Intersection	Main Issue
1. Caloocan	Samson Road–New Abbey Road	• PT stop location • Inadequate signal phase, many conflicts
2. Mandaluyong	F. Martinez Avenue–San Rafael St.	• No traffic signal, mixed traffic, insufficient lane markings and sidewalk
3. Pasig	Pasig Boulevard Rotonda	• Non-operation of signal at peak hours • High pedestrian volume • Bad geometric layout
4. Pasay	Antonio Arnaiz Avenue–P. Zamora St.–P. Burgos St.	• Inadequate signal phase, PUJs

Source: JPT

2 CASE STUDY 1: IMPROVEMENT OF INTERSECTION BOTTLENECKS ON MAJOR ROADS

2.1 Procedure

There are many bottlenecks in Metro Manila where congestion occurs frequently. Some of them are on major arterial roads, while others are on secondary or local roads. Although these areas are recognizable as bottlenecks, little attempt has been made to identify and understand the causes and effects of these bottlenecks, not to mention the improvement measures to be applied to them.

As the first step of the project, bottleneck points on the roads managed by MMDA were identified. The causes of bottleneck were analyzed, and improvement measures were developed.

The overall approach of the case studies is shown in Figure 2.1. As a first round of the PDCA cycle, locations where severe congestion occurs along the roads that MMDA manages were selected.

Three locations were selected for the case study. The JPT and the MMDA CPT selected three (3) candidate locations among the 181 bottlenecks which the MMDA identified during an earlier survey of bottlenecks on roads under its responsibility (see Figure 2.1). After much discussion on the road type, traffic volume, severity of congestion, vehicle composition, profile of area around the site, and availability of intersection directional turning movement count data, travel time survey data and intersection signal layout drawing, lane configuration, lane assignment, type and location of signal and detector equipment, and existing traffic regulations, the following three (3) locations were selected as case study sites:

(i) Roxas Boulevard–MIA Road,

(ii) Epifanio de los Santos Avenue (EDSA)–Taft Avenue, and

(iii) EDSA–Shaw Boulevard.

Once the candidate locations were selected, the data necessary for understanding and analyzing the causes of congestion were collected. The data collected includes the following:

(i) Intersection drawings (AutoCAD) showing intersection geometry, pavement marking, signal equipment, and other facilities such as pedestrian bridge;

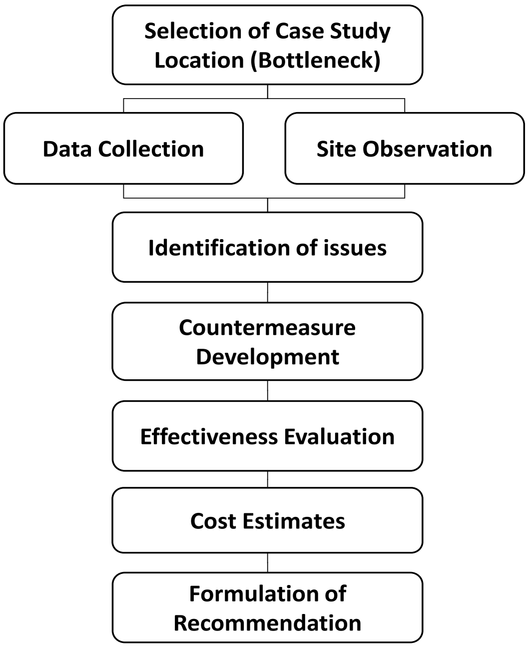
(ii) Intersection turning movement count data (hourly volume and peak hour volume converted into passenger car unit (PCU);

(iii) Traffic signal phasing and timing plans; and

(iv) Travel time survey results.

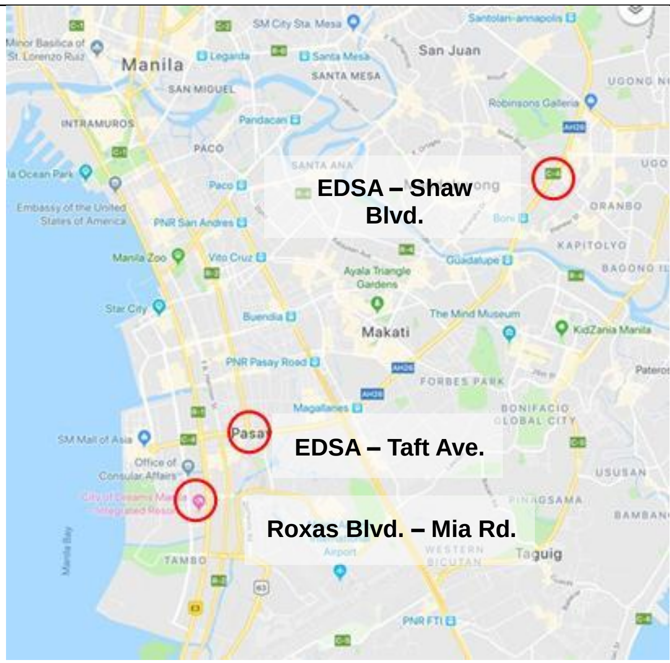
Site observation was also conducted jointly by the JPT and the CPT to understand the traffic flow and volume of pedestrians. The site observation identified the causes of congestion which include, in addition to excessive traffic demand, intersection geometry, damaged pavement, inadequate pavement marking, long dwell time of public transportation, driver behavior, ingress and egress from the roadside facility, excessive pedestrian movement, and potential obstruction (bus/jeepney stop, driveway, illegal parking, jaywalking, street vendor, etc.).

A survey sheet was prepared beforehand where the possible causes of congestion were listed. The schematic drawing of the target intersection was shown on the survey sheet to indicate the location of identified issues (see Figure 2.2).



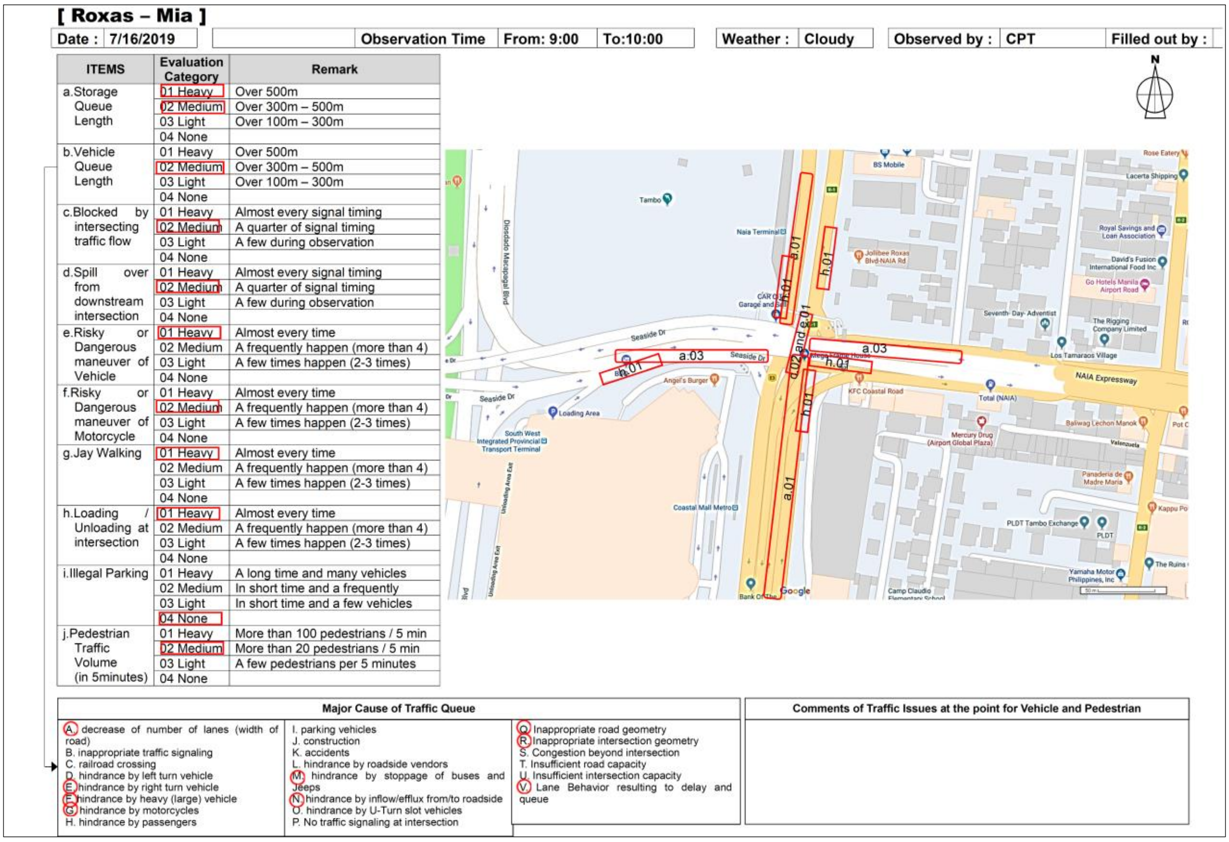
Source: JPT

Figure 2.1: Case Study Process



Source: Google/ JPT

Figure 2.2: Case Study Locations



[Roxas – Mia]

Date : 7/16/2019 | Observation Time From: 9:00 To:10:00 | Weather : Cloudy | Observed by : CPT | Filled out by :

ITEMS	Evaluation Category	Remark
a.Storage Queue Length	01 Heavy	Over 500m
	02 Medium	Over 300m – 500m
	03 Light	Over 100m – 300m
	04 None	
b.Vehicle Queue Length	01 Heavy	Over 500m
	02 Medium	Over 300m – 500m
	03 Light	Over 100m – 300m
	04 None	
c.Blocked by intersecting traffic flow	01 Heavy	Almost every signal timing
	02 Medium	A quarter of signal timing
	03 Light	A few during observation
	04 None	
d.Spill over from downstream intersection	01 Heavy	Almost every signal timing
	02 Medium	A quarter of signal timing
	03 Light	A few during observation
	04 None	
e.Risky or Dangerous maneuver of Vehicle	01 Heavy	Almost every time
	02 Medium	A frequently happen (more than 4)
	03 Light	A few times happen (2-3 times)
	04 None	
f.Risky or Dangerous maneuver of Motorcycle	01 Heavy	Almost every time
	02 Medium	A frequently happen (more than 4)
	03 Light	A few times happen (2-3 times)
	04 None	
g.Jay Walking	01 Heavy	Almost every time
	02 Medium	A frequently happen (more than 4)
	03 Light	A few times happen (2-3 times)
	04 None	
h.Loading / Unloading at intersection	01 Heavy	Almost every time
	02 Medium	A frequently happen (more than 4)
	03 Light	A few times happen (2-3 times)
	04 None	
i.Illegal Parking	01 Heavy	A long time and many vehicles
	02 Medium	In short time and a frequently
	03 Light	In short time and a few vehicles
	04 None	
j.Pedestrian Traffic Volume (in 5minutes)	01 Heavy	More than 100 pedestrians / 5 min
	02 Medium	More than 20 pedestrians / 5 min
	03 Light	A few pedestrians per 5 minutes
	04 None	

Major Cause of Traffic Queue			Comments of Traffic Issues at the point for Vehicle and Pedestrian
A. decrease of number of lanes (width of road) B. inappropriate traffic signaling C. railroad crossing D. hindrance by left turn vehicle E. hindrance by right turn vehicle F. hindrance by heavy (large) vehicle G. hindrance by motorcycles H. hindrance by passengers	I. parking vehicles J. construction K. accidents L. hindrance by roadside vendors M. hindrance by stoppage of buses and Jeeps N. hindrance by inflow/efflux from/to roadside O. hindrance by U-Turn slot vehicles P. No traffic signaling at intersection	Q. Inappropriate road geometry R. Inappropriate intersection geometry S. Congestion beyond intersection T. Insufficient road capacity U. Insufficient intersection capacity V. Lane Behavior resulting to delay and queue	

Source: Google/ JPT

Figure 2.3: Site Survey Sheet (sample)

Based on the data collected and site observations, improvement measures were developed which include intersection geometry modification, pavement marking modification, signal phasing and timing parameter optimization, traffic control device, and other traffic engineering measures. Multiple scenarios were prepared for each location to compare the effects of different countermeasures.

Microscopic traffic simulation was conducted using Vissim, a simulation software. It simulates the movement of each vehicle in the area and signal operation based on various parameters. The program produces evaluation parameters such as average speed and delay. However, Vissim cannot simulate non-engineering measures such as the strict application of traffic rules.

Once the effectiveness of the countermeasures is confirmed, the cost was estimated based on standard unit costs adopted by MMDA. Finally, the countermeasures were compiled into a proposal.

2.2 Roxas Boulevard–MIA Road Intersection

1) Area Profile

The intersection of Roxas Boulevard–MIA Road is a four-legged intersection and falls under the jurisdiction of Parañaque City (see Figure 2.4). The southern leg of the intersection is enforced by the Public Estates Authority Tollway Corporation (PEATC). It is a government corporation and subsidiary of the Public Estates Authority, a government agency under the Office of the president, and is operated by CAVITEX Infrastructure Corporation, a unit of Philippine-based company Metro Pacific Investment Corporation (MPIC). The remaining legs of the intersection are managed by the MMDA.

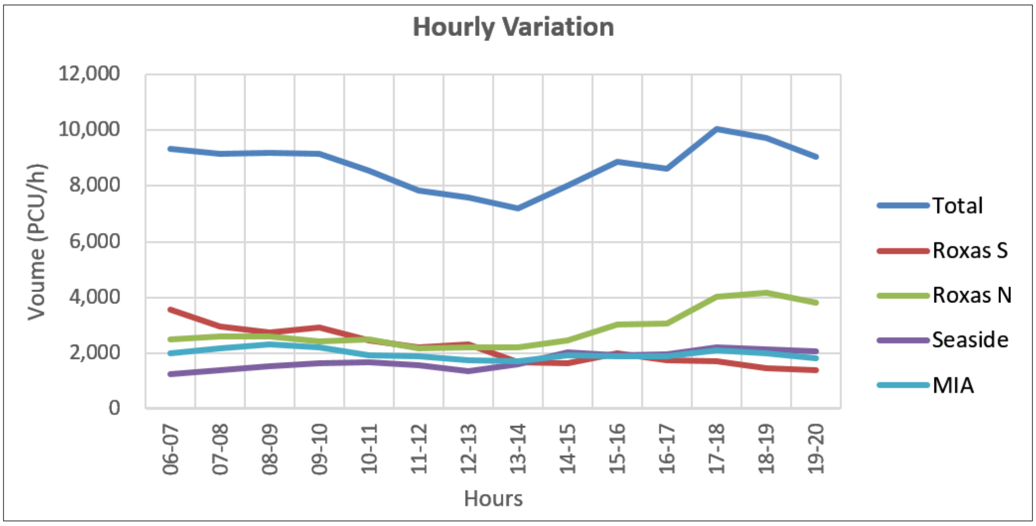
This intersection serves as a gateway for the vehicles coming from the province of Cavite going to Metro Manila. Roxas Boulevard is an 8- to 10-lane divided road, while MIA Road and Seaside Drive are both 8-lane divided roads. Although there is a flyover above the intersection, the Ninoy Aquino International Airport Expressway (NAIAX), the intersection (Roxas Boulevard–MIA Rd.) is one of the busiest intersections in Metro Manila with an average of 10,000 to 11,000 private cars and motorcycles per hour. The intersection is also a part of the route for city buses coming and going to the Parañaque Integrated Terminal Exchange (PITX). PITX, which serves as a hub for provincial buses, city buses, PUJs, and other public utility vehicles, is located southwest of the intersection. Its operation started on 5 November 2018.

Source: MMDA.

Figure 2.4: Roxas Boulevard–MIA Road Intersection

2) Traffic Characteristics

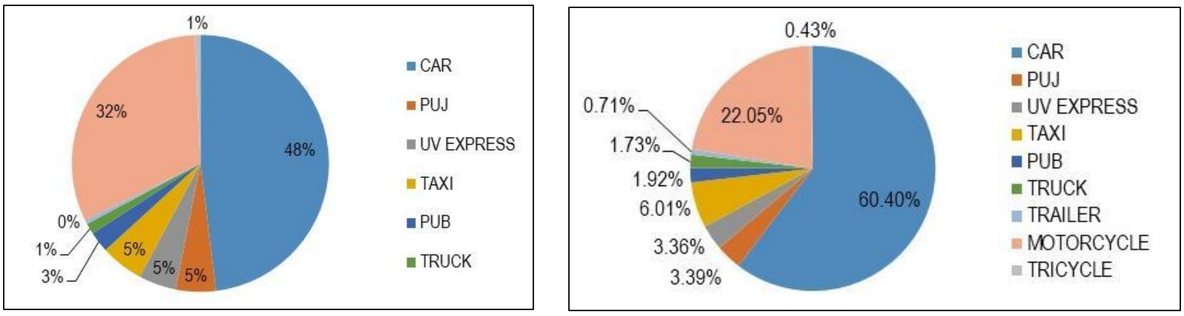
Hourly traffic volume variation in PCU by approach and total is shown below. The graph indicates a tidal flow of traffic; inbound in the morning and outbound in the afternoon for Roxas Boulevard north and south approaches, while MIA Road and Seaside Drive had a nearly flat traffic volume throughout the survey period.



Source: MMDA.

Figure 2.5: Hourly Traffic Volume Variation in PCU at Roxas Boulevard–MIA Road IS (11 Jul 2019)

Vehicle composition during the AM and PM peak hours is shown in Figure 2.6. Cars accounted for a large portion of traffic, followed by motorcycles.



AM Peak (08:00-09:00) PM Peak (17:00-18:00)

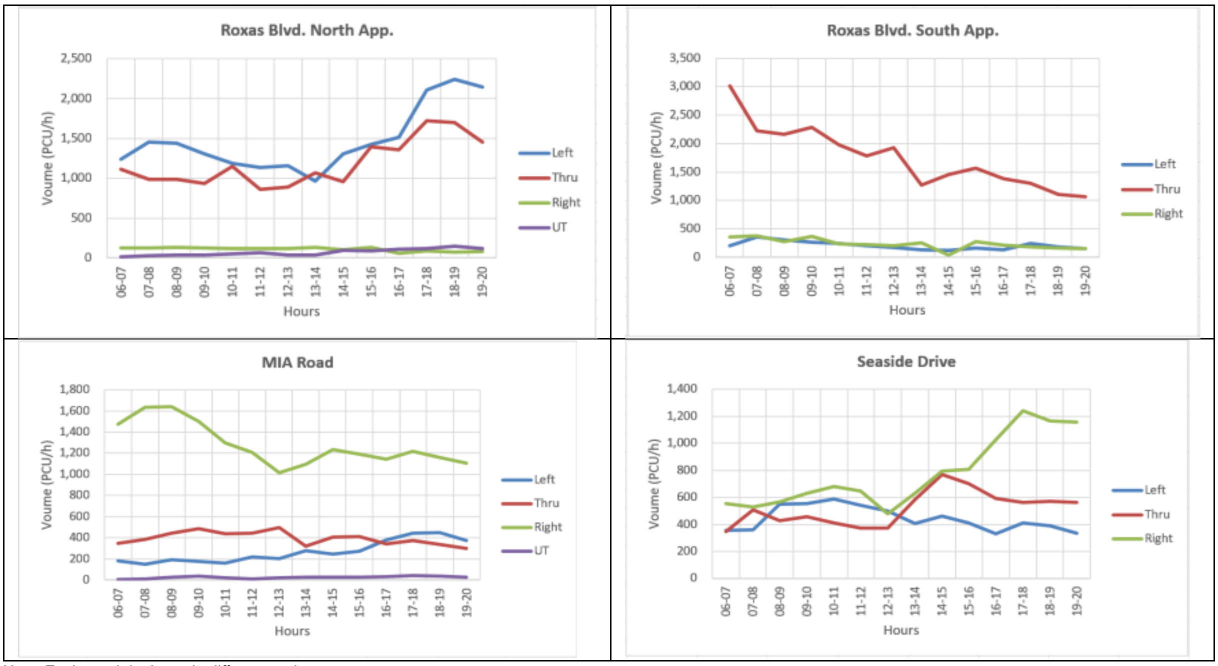
Source: JPT

Figure 2.6: Vehicle Composition at Roxas Boulevard–MIA Road IS (11 Jul 2019)

3) Turning Movement Count

Turning movement count indicates the complexity of movements at an intersection. If the left-turn volume that conflicts with the through traffic on the opposite approach is high, the intersection is generally more congested than the case where there is little to no left-turn movements. The volume of left-turn traffic also affects the signal phase design.

Turning movement counts on 11 July 2019 are shown in Figure 2.7. The data of the intersection turning movement show the following feature of traffic during peak hours at this intersection.



Note: Each graph is drawn in different scale.
Source: MMDA.

Figure 2.7: Hourly Variation in Turning Movement in PCU (11 Jul 2019)

(i) Traffic on Roxas Boulevard shows a typical tidal pattern. Inbound traffic was much larger than outbound traffic during the AM peak, while outbound traffic was more than double of inbound traffic during the PM peak;

(ii) More than half of traffic from Roxas Boulevard's north approach turned left onto MIA Road during both peak hours. Some headed for NAIA, while most of them were bound for Parañaque;

(iii) Majority of traffic on MIA Road (73% in the AM peak and 59% in the PM peak) turned right onto Roxas Boulevard;

(iv) Half of the traffic from Seaside Drive turned right onto CAVITEX; and

(v) Corner islands are provided at all four corners of the intersection, so that right turns are possible all the time regardless of traffic signal indication.

4) Peak Hour Turning Movement Count

Peak hour volume in PCU and ratio of turning movements are shown for AM and PM peak hours (see Figure 2.8). The AM peak is 6:00AM–7:00AM, while the PM peak is 5:00PM–6:00PM.

The data of the intersection turning movement show the following features of traffic during peak hours on 11 July 2019 at this intersection:

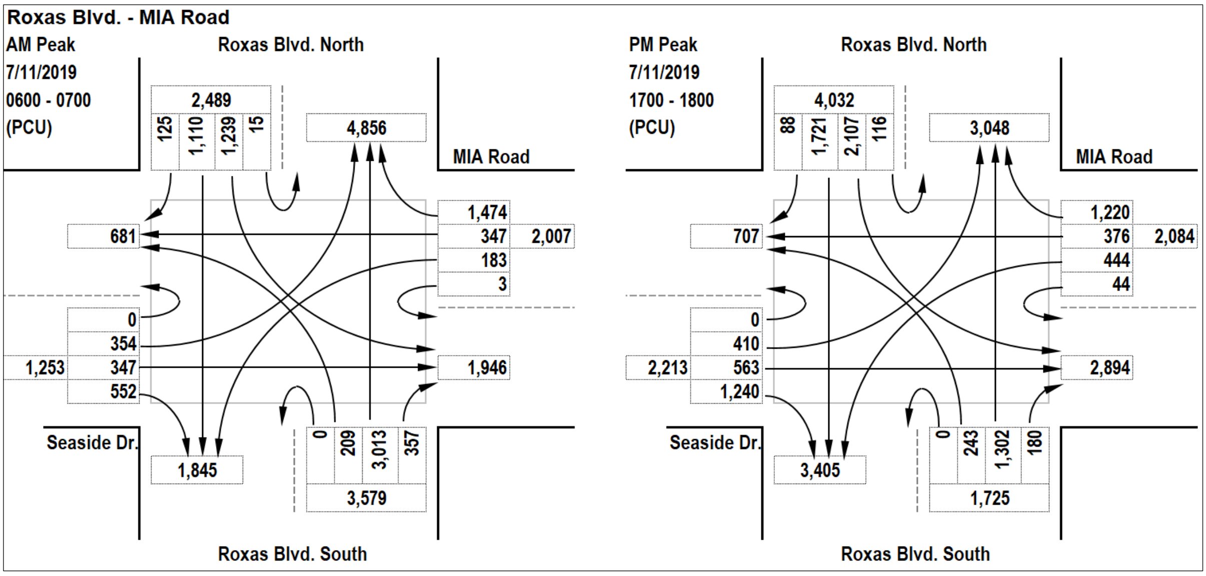
(i) More than half of the traffic from Roxas Boulevard's north approach turned left onto MIA Road during both peak hours.

(ii) Majority of traffic on MIA Road (73% in the AM peak and 59% in the PM peak) turned right onto Roxas Boulevard;

(iii) About half of the traffic from Seaside Drive turned right onto Roxas Blvd. going to CAVITEX;

(iv) Higher volume of vehicle comes from the south at AM peak and from north at PM peak; and

(v) Corner islands are provided at all four corners of the intersection so that right turns are possible all the time regardless of traffic signal indication.



Source: Metropolitan Manila Development Authority

Figure 2.8: Peak Hour Traffic Volume in PCU (11 Jul 2019)

5) Traffic Management Issues

The various physical and operational traffic management problems were identified through the review of data and site visit. The main problems are shown in Figure 2.9 and explained below.

(i) There is a mismatch between the approach and exit widths and misalignment between CAVITEX's south approach and Roxas Boulevard's north exit; b, e

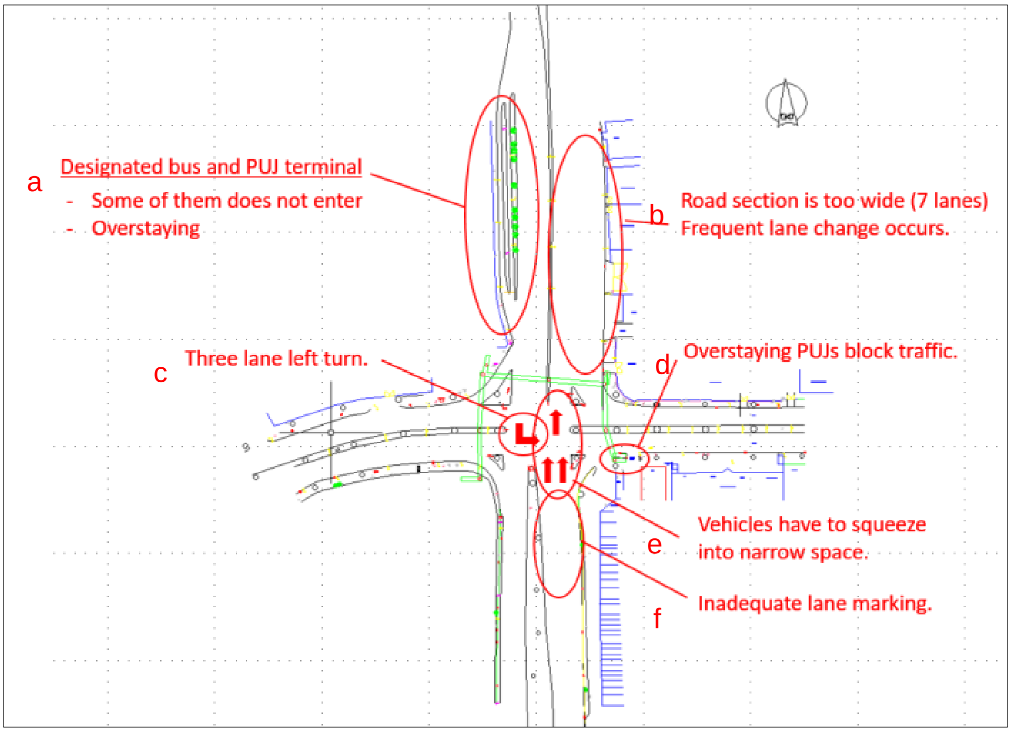
(ii) Roxas Boulevard's north exit is too wide, resulting in excessive lane change maneuver;

(iii) There is an inadequate bus operation on Roxas Boulevard's north approach and boarding/alighting outside of the designated bus terminal; a, d

(iv) Due to the high volume of left turns from Roxas Boulevard's north approach, left-turning vehicles occupied more lanes, causing unnecessary merging at MIA Road's east exit; c

(v) Lack of pedestrian crossing across CAVITEX's south exit; and f

(vi) Inadequate signal timing plan due to the lack of periodic signal timing review and malfunctioning vehicle detector.



Source: Metropolitan Manila Development Authority/ JPT

Figure 2.9: Major Problem at Roxas Boulevard–MIA Road Intersection

6) Proposed Improvement Measures

The proposed improvement measures are simple to implement and have minimal costs. However, they are all at concept level, and further study and detailed design, including simulation and site visits, are necessary before its implementation.

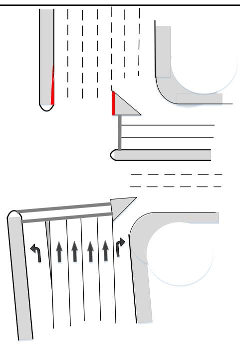
(i) Widening of north exit of Roxas Boulevard as much as possible (Figure 2.10);

(ii) Construction of a separator with slot along Roxas Boulevard north exit to regulate traffic flow on the main road and side road (Figure 2.11);

(iii) Provision of a “no boarding/ alighting zone” pavement marking in conspicuous color (Figure 2.12);

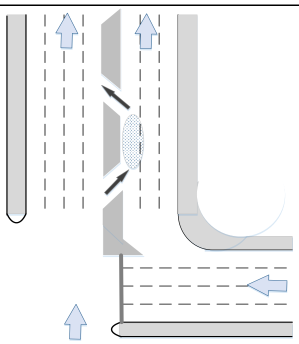
(iv) Provision of double left-turning guidelines inside the intersection to regulate the left-turning flow (Figure 2.13); and

(v) Banning of left turns from south approach to provide more green time for left-turning movement from Roxas Boulevard’s north approach (Figure 2.14).



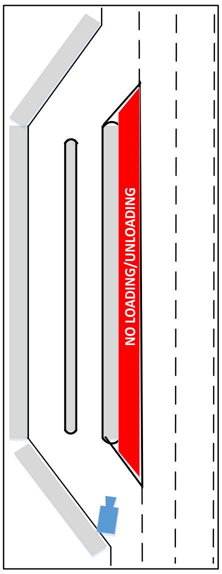
Source: JPT

Figure 2.10: Widening of North Exit



Source: JPT

Figure 2.11: Separator on North Exit

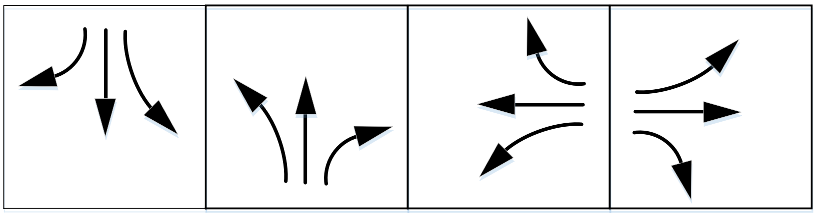


Source: JPT

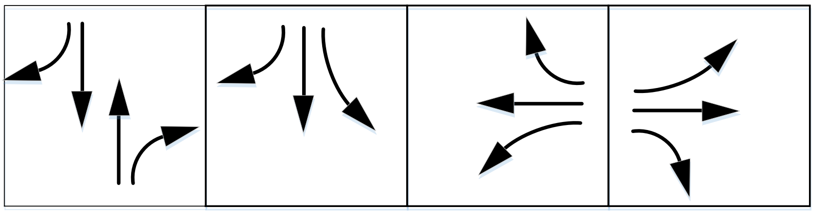
Figure 2.12: No Boarding / Alighting Zone Marking

Source: JPT

Figure 2.13: Left Turn Guidelines and Arrow Symbol



Current Signal Phasing



Proposed Signal Phasing

Source: JPT

Figure 2.14: Proposed Changes in Signal Phasing

7) Assessment of Measures by Simulation

The measures proposed above were examined using Vissim, a microscopic simulation program, to assess their effectiveness. Three scenarios shown below were simulated.

Table 2.1: Scenarios Evaluated

Scenario	Measure
0	Current condition, no measures implemented.
1	All measures proposed except banning of left turn from Roxas Boulevard south approach.
2	Banning of left turns from CAVITEX south approach.
3	Combination of 1 and 2.

Source: JPT

Source: JPT

Figure 2.15: Screenshot of the Simulation

8) Cost Estimates

Cost estimation was made for all three scenarios, and the cost summary is shown in Table 2.2. The costs of the three (3) scenarios are not that different from each other.

Table 2.2: Summary of Cost Estimates

Item	Scenario 1	Scenario 2	Scenario 3
1. Pavement Marking Works	994,588.00	798,928.00	994,588.00
2. Traffic Road Signs (High intensity Type)	0.00	0.00	0.00
3. Geometric Improvement Works	571,322.20	571,322.20	618,466.20
4. Safety Facilities (Fence)	260,080.00	260,080.00	204,813.00
Total Direct Cost	1,825,990.20	1,630,330.20	1,817,867.20
Indirect Cost (25% Mark-up)	456,497.55	407,582.55	454,466.80
Total VAT	273,898.53	244,549.53	272,680.08
Total Cost Estimated	2,556,386.28	2,282,462.28	2,545,014.08

Source: JPT

9) Results of Analysis

The simulation results are summarized below. The figures in percentage indicate the increase average speed and decrease in total delay and average time as compared with the exiting case (do-nothing case).

The significant improvements in performance are mainly due to the streamlining of the traffic at Roxas Boulevard's north exit, where a separator is constructed. It should be noted, however, that the boarding /alighting area for buses and jeepneys is relocated away from the intersection, resulting to an inconvenience for public transportation users.

Table 2.3: Summary of Simulation Results

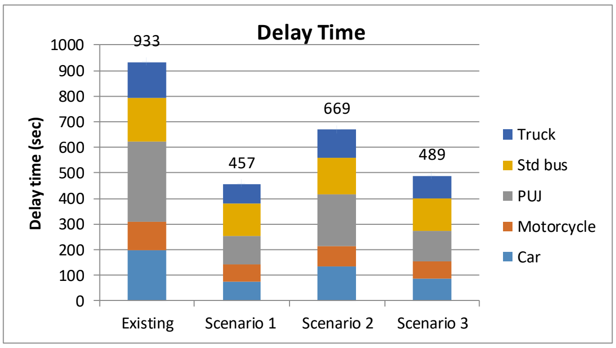
Indicator	Scenario 1	Scenario 2	Scenario 3
Average Speed (%)	+ 68	+ 13	+ 54
Total Delay (%)	- 51	- 28	- 48
Average Travel Time (%)	- 39	- 15	- 33

Note: Average Speed, Total Delay, Average Travel Time are calculated in micro simulation network area
Source: JPT

The results of analysis for the existing situation and three (3) scenarios are shown in terms of delay, travel time, travel speed, and benefit (Figure 2.17). As expected, scenario 3, which applies all improvement measures, produced the largest benefits.

Total Delay Time (Average) second per vehicle

	Existing	Scenario 1	Scenario 2	Scenario 3
Car	199.24	73.35	134.43	85.58
Motorcycle	109.82	69.38	79.54	67
PUJ	311.6	110.74	201.72	121.75
Std bus	173.76	128.68	144.22	127.01
Truck	138.26	75.11	109.39	88.08
Total	933	457	669	489



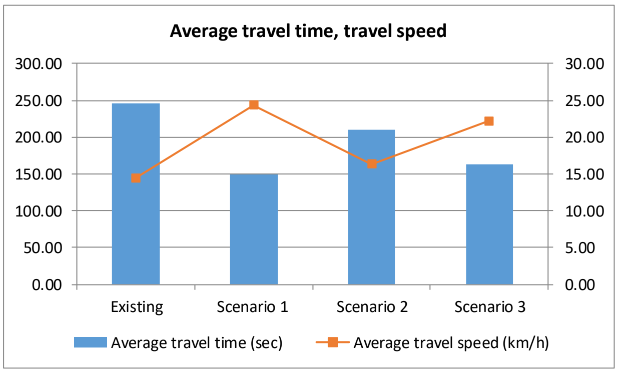
Source: JPT

Figure 2.16: Average Delay by Scenario

	Existing	Scenario 1	Scenario 2	Scenario 3
Average travel time (sec)	245.90	149.16	209.59	163.49
Average travel speed (km/h)	14.46	24.34	16.33	22.21

Time Saving (min) :(Exiting delay time - Scheme delay time)*number of vehicle

		Ex-S1	Ex-S2	Ex-S3
Car		10,478	5,411	9,208
Motorcycle		1,713	1,288	1,701
PUJ		1,644	866	1,538
Std bus		206	135	0
Truck		121	56	96



Source: JPT

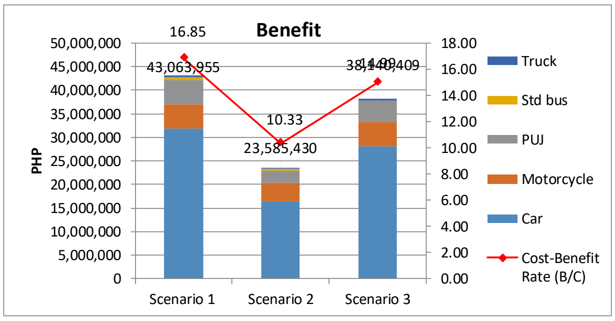
Figure 2.17: Average Travel Time and Travel Speed by Scenario

Benefit (Time Saving * Time Value *4hours**No. Passenger* (**365-8*12**)

		Scenario 1	Scenario 2	Scenario 3
Car		31,861,994	16,452,285	28,000,543
Motorcycle		5,209,786	3,917,778	5,171,349
PUJ		4,998,137	2,633,983	4,676,060
Std bus		625,990	410,199	0
Truck		368,048	171,185	292,457
		43,063,955	23,585,430	38,140,409

peak hours 4

		Scenario 1	Scenario 2	Scenario 3
Cost		2,556,386	2,282,462	2,545,014
Cost-Benefit Rate (B/C)		**16.85**	**10.33**	**14.99**



Source: JPT

Figure 2.18: Benefit by Scenario

10) Recommendations

The simulation results showed that significant improvements are possible by implementing the measures proposed. On the other hand, the proposed measures cost about PHP2.5 million for each of the three (3) scenarios. Considering the large number of vehicles (more than 130,000 vehicles per 14 hours), the cost is about PHP20 per vehicle.

2.3 EDSA–Taft Avenue Intersection

1) Area Profile

The intersection of EDSA–Taft Avenue is a four-legged intersection and falls under the jurisdiction of Pasay City. The intersection is enforced both by the MMDA and Pasay City.

The prevailing land uses around the intersection are characterized by a vastly evolving commercial–residential core. The perimeter of the site comprises of different land uses like malls, hotels, railway stations, various commercial and office buildings, and Bus and PUJ terminals.

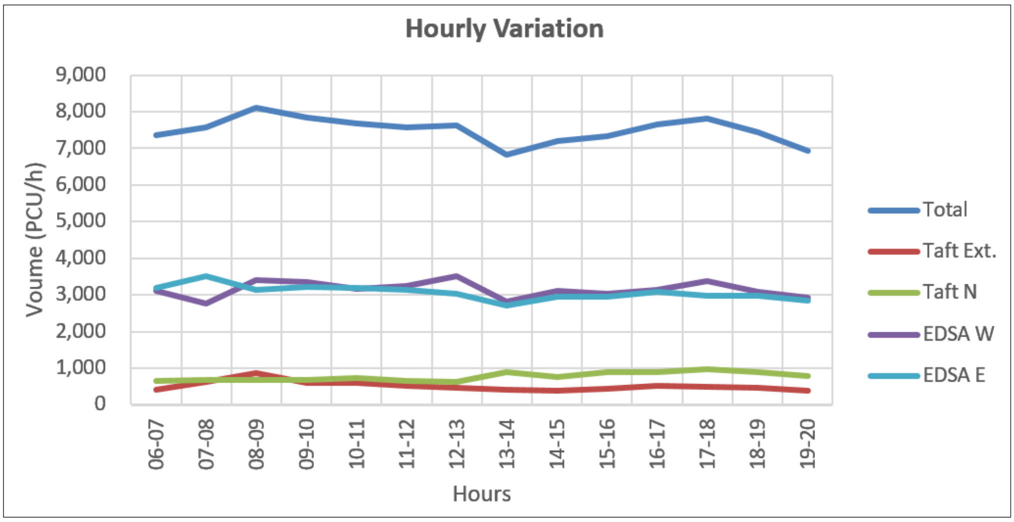
There are existing bus routes traversing EDSA corridor from end to end. Jeepney routes are also available along with other vehicle types like tricycles and e-trikes. Due to the presence of several modes of transportation in the vicinity of the intersection, the area becomes a major transportation hub and highly functions as a transfer site. As a result, pedestrian activity in the area is very high. As an intervention, elevated pedestrian walkways are provided across EDSA and Taft Avenue.

Source: MMDA.

Figure 2.19: EDSA–Taft Avenue Intersection

2) Traffic Characteristics

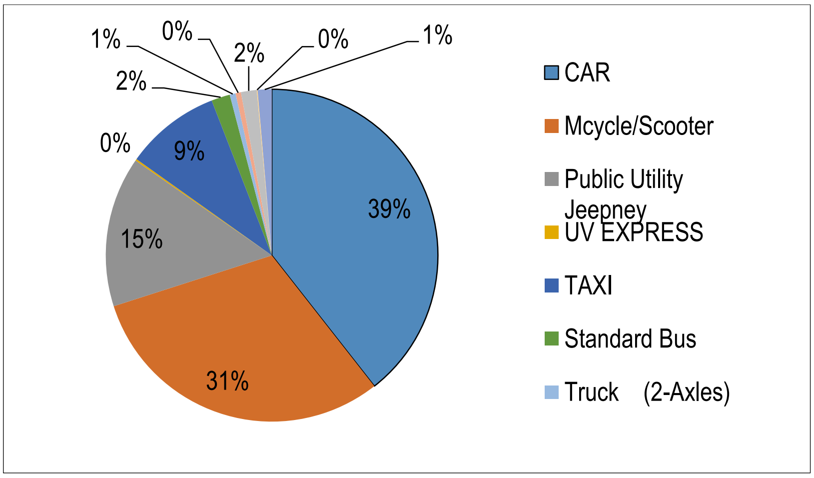
Hourly traffic volume variation in PCU by approach and total is shown below. The graph indicates that the traffic at the intersection was dominated by a large traffic volume along EDSA. There was no clear peak during daytime.



Source: Metropolitan Manila Development Authority

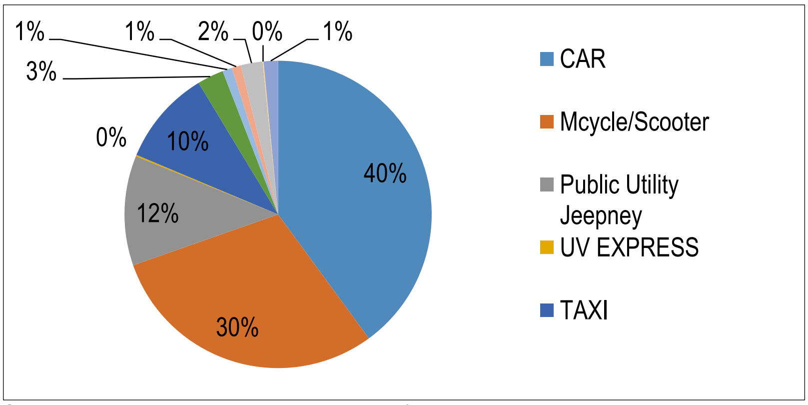
Figure 2.20: Hourly Variation in Traffic Volume in PCU at EDSA–Taft Avenue IS (4 September 2019)

Vehicle composition during the AM and PM peak hours is shown in Figure 2.21 and Figure 2.22, respectively. As compared with the vehicle composition at Roxas Boulevard–MIA Road IS, the share of motorcycles and PUVs are higher. The difference could be attributed to the longer trip length of vehicles at Roxas Boulevard–MIA Road IS.



Source: Metropolitan Manila Development Authority/ JPT

Figure 2.21: Vehicle Composition at EDSA–Taft Avenue IS (4 September 2019, AM Peak)



Source: Metropolitan Manila Development Authority/ JPT

Figure 2.22: Traffic Composition at EDSA–Taft Avenue IS (4 September 2019, PM Peak)

3) Turning Movement Count

The hourly variation of the turning movement counts during the survey time are shown in Figure 2.23, and peak hour traffic volume is shown in Figure 2.24. It should be noted that graphs shown use different scales. Traffic volume along EDSA was much higher than that along Taft Avenue. It shows the number of vehicles that went through, turned right, or turned left during the survey period. The turning movement count data indicates the following facts:

(a) **Taft Avenue Ext. Approach (South Approach):** Right turn traffic volume was higher compared with the through traffic. There was no left turn traffic because it was prohibited.

(b) **Taft Avenue Approach (North Approach):** Through and right turn traffic volume were comparable throughout the survey period. They gradually increased in the afternoon. There was no left turn traffic because it was prohibited.

(c) **EDSA West Approach:** Through traffic volume was dominant and high at around 1,000 PCU/hour throughout the survey period. Other directional traffic was almost negligible.

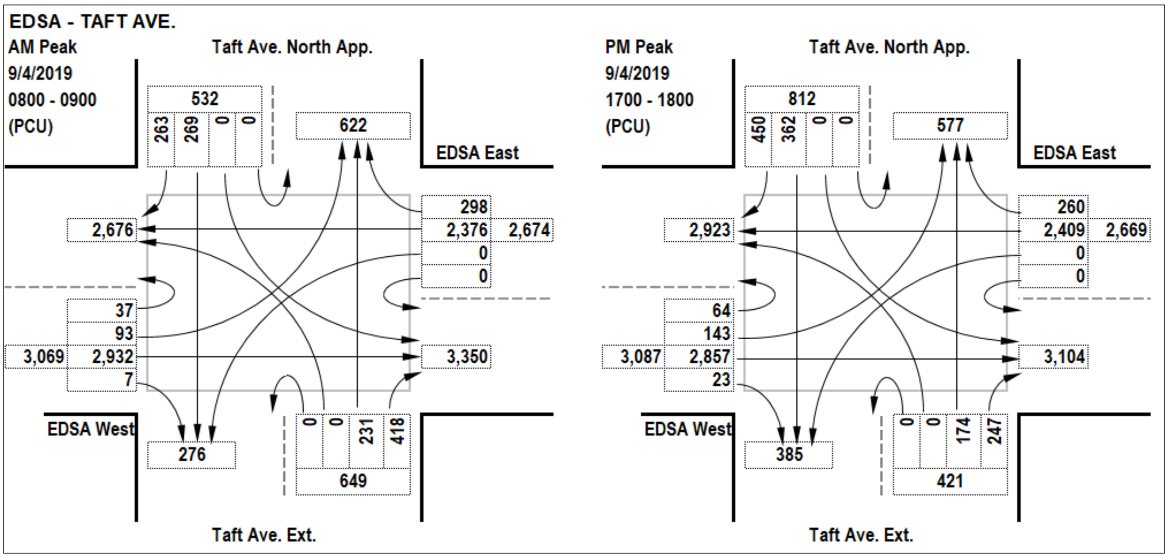
(d) **EDSA East Approach:** Through traffic volume was dominant throughout the survey period but not similar with EDSA west approach due to the right turning traffic. About 10% of traffic turned right onto Taft Avenue northbound.

Source: Metropolitan Manila Development Authority

Figure 2.23: Hourly Variation in Turning Movement Count in PCU (4 September 2019)

4) Peak Hour Turning Movement Count

Figure 2.24 shows the turning movement counts at the intersection during the AM and PM peak hours. It can be observed that flows during AM and PM peak hours along EDSA are balanced in terms of PCU volume. The left turns from Taft Avenue south were prohibited as of 4 September 2019 when the traffic count was conducted, so that no left turn volume was counted.



Source: Metropolitan Manila Development Authority

Figure 2.24: Peak Hour Traffic Volume in PCU (4September 2019)

5) Traffic Management Issues

The observation of traffic and the overall situation at the intersection revealed the following:

(i) Queue length of over 500m was observed on both approaches of EDSA; and

(ii) Heavy boarding and alighting activities occurred around the intersection as the stations of both LRT and MRT are located at the legs of the intersection.

The major causes of congestion are identified as follows:

(i) Decrease in the number of lanes (width of road) on the east side of EDSA as compared with the west side;

(ii) Hindrance of through traffic on EDSA east approach by right-turning vehicles from EDSA west approach toward Taft Avenue;

(iii) Hindrance by and unscrupulous movement of motorcycles in and around the intersection;

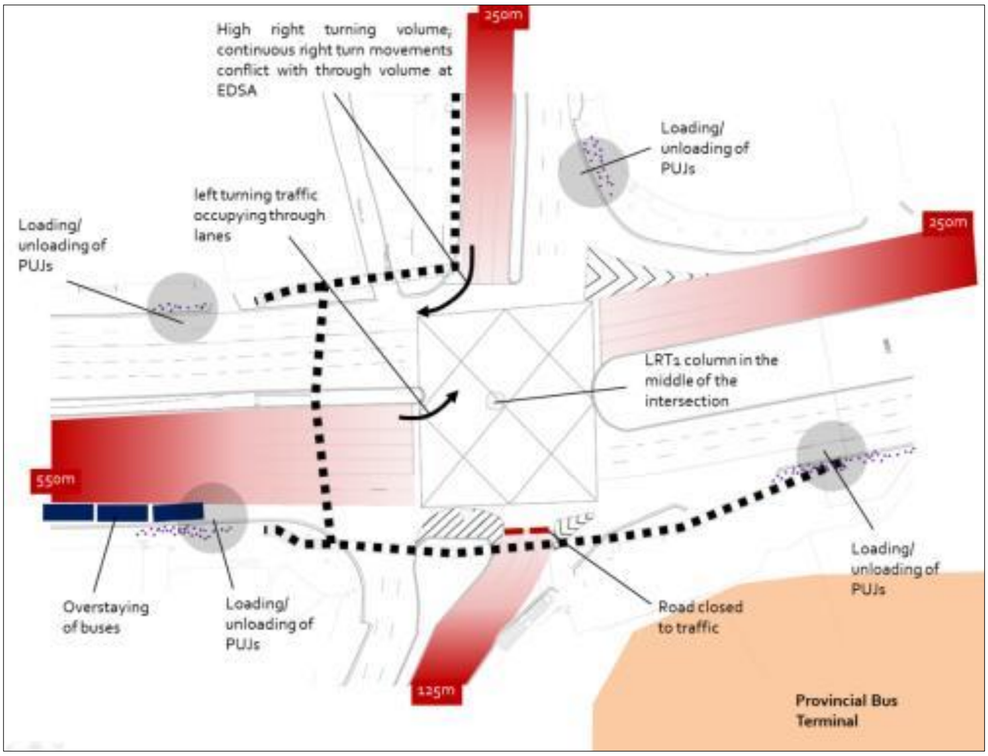
(iv) Accidents;

(v) Street vendors occupy both sides and the median island of Taft Avenue Extension. They were removed as of January 2020, but there were still several vendors hindering the traffic; and

(vi) As the intersection functions as a bus stop and jeepney terminal, the PUVs stay within the vicinity of the intersection to get more passengers, thereby obstructing traffic. In addition, boarding and alighting from taxis was also frequently observed.

6) Proposed Improvement Measures

The proposed improvement measures are simple and cost-effective. However, they are all at concept level, and further study and detailed design, including simulation and site visits, are necessary before their implementation.



Source: JPT

Figure 2.25: Identified Issues at EDSA–Taft Avenue Intersection

(i) Clearing of street vendors south of the intersection (Completed); and

(ii) Intersection layout to be modified together with the movement restriction for vehicles coming from Taft Avenue Ext. (south approach) and signal phase modification. The intersection geometry will be modified depending on the movements allowed from the south approach.

Based on the on-site observation and analysis of vehicle and pedestrian movements, it was found that treatment of the traffic from Taft Avenue Ext. (south approach) is key to improving the traffic condition at the site. In order to compare the possible regulation on the traffic from the south approach, three (3) scenarios were prepared for simulation:

(a) **Scenario 1:** Through and right turn with minor improvements of intersection geometry.

(b) **Scenario 2:** Right turn only from south approach with minor improvements of intersection geometry.

(c) **Scenario 3:** Through and right turn + modification of island + replace and rebuild a footbridge.

In each scenario, signal timing was also adjusted to the traffic movements at the intersection.

7) Assessment of Measures by Simulation

The three scenarios proposed above were simulated using Vissim to examine their effectiveness. The simulation results are summarized in Table 2.4. All scenarios showed positive results, and there was notable differences in the scale of improvement among scenarios. However, it should be noted that scenario 2 restricts the through traffic from the south approach, forcing it to take other routes. Changes in routes were not considered in the evaluation.

Table 2.4: Summary of Simulation Result

Indicator	Scenario 1	Scenario 2	Scenario 3
Average Speed (%)	+ 50	+ 77	+ 83
Total Delay (%)	- 67	- 58	- 57
Average Travel Time (%)	- 32	- 41	- 44

Source: JPT

8) Cost Estimates

Cost estimates were prepared for all of three scenarios, and the cost summary is shown in Table 2.5. Scenario 3 includes the reconstruction of the pedestrian bridge. For this reason, its cost is much higher than that of the other scenarios.

9) Results of Analysis

The results of analysis for the existing situation and three (3) scenarios are shown in terms of delay, travel time, travel speed, and benefit (figures 2.26 to 2.28).

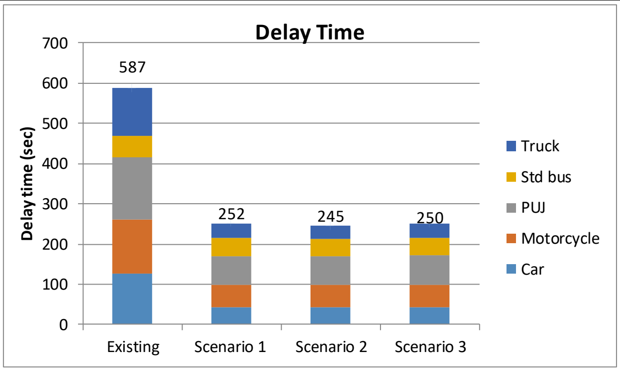
Table 2.5: Summary of Cost Estimates

Item	Scenario 1	Scenario 2	Scenario 3
1. Pavement Marking Works	542,379.00	582,253.00	559,412.00
2. Traffic Road Signs (High intensity Type)	0.00	0.00	0.00
3. Geometric Improvement Works	339,330.30	0.00	162,570.60
4. Safety Facilities (Fence)	70,000.00	0.00	0.00
5. Modification of Existing Footbridge	0.00	0.00	1,100,000.00
Total Direct Cost	951,709.30	582,253.00	1,821,982.60
Indirect Cost (25% Mark-up)	237,927.33	145,563.25	685,804.00
Total VAT	142,756.39	87,337.95	246,462.40
Total Cost Estimated	1,332,393.02	815,156.20	2,545,017.08

Source: JPT

Total Delay Time (Average) second per vehicle

	Existing	Scenario 1	Scenario 2	Scenario 3
Car	127.35	43.43	44.04	43.66
Motorcycle	134.81	54.53	55.46	54.09
PUJ	154.11	72.12	69.55	74.31
Std bus	52.27	46.3	43.51	44.39
Truck	118.8	35.42	32.74	33.89
Total	587	252	245	250



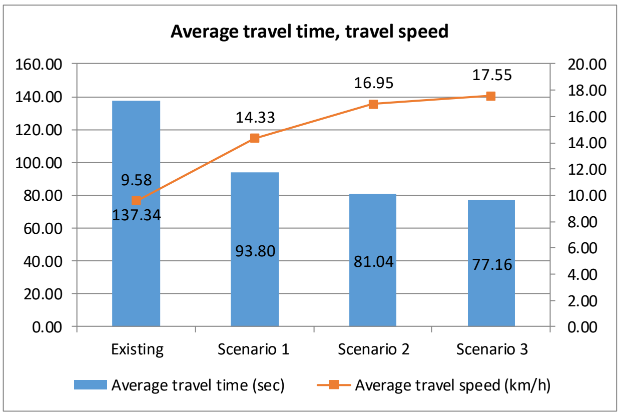
Source: JPT

Figure 2.26: Average Delay by Scenario

	Existing	Scenario 1	Scenario 2	Scenario 3
Average travel time (sec)	137.34	93.80	81.04	77.16
Average travel speed (km/h)	9.58	14.33	16.95	17.55

Time Saving (min) :(Existing delay time - Scheme delay time)*number of vehicle

		Ex-S1	Ex-S2	Ex-S3
Car		5718	5834	5662
Motorcycle		3172	3325	3131
PUJ		1602	1762	1532
Std bus		16	24	21
Truck		113	118	113



Source: JPT

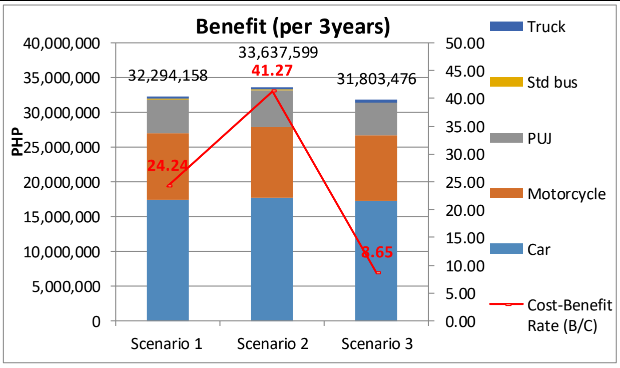
Figure 2.27: Average Travel Time and Travel Speed by Scenario

Benefit (Time Saving * Time Value *4hours**No. Passenger* (365-8*12)

		Scenario 1	Scenario 2	Scenario 3
Car		17,386,395	17,741,338	17,215,744
Motorcycle		9,646,552	10,109,866	9,519,425
PUJ		4,869,918	5,356,834	4,658,955
Std bus		49,014	71,920	65,095
Truck		342,279	357,642	344,256
Total / years		32,294,158	33,637,599	31,803,476

peak hours 4
years 1

		Scenario 1	Scenario 2	Scenario 3
Cost		1,332,393	815,154	3,675,502
Cost-Benefit Rate (B/C)		**24.24**	**41.27**	**8.65**



Source: JPT

Figure 2.28: Benefit by Scenario

10) Recommendations

Based on the observation at site, simulation results, and cost estimates, scenario 2 seems to be the most cost-efficient and can be implemented relatively easily. The final decision must be made, however, after considering other factors, such as impact on traffic at neighborhood streets and convenience of pedestrians and passengers.

2.4 EDSA–Shaw Boulevard

1) Area Profile

The intersection of EDSA–Shaw Boulevard is a four-legged intersection and falls under the jurisdiction of Mandaluyong City. Traffic at the intersection is enforced by MMDA and Mandaluyong City.

The intersection is grade-separated by an underpass along EDSA and an overpass along Shaw Boulevard for through traffic. Grade separation is helpful in reducing traffic that crosses each other at intersections. However, Buses are required to take at-grade roads for passenger boarding and alighting.

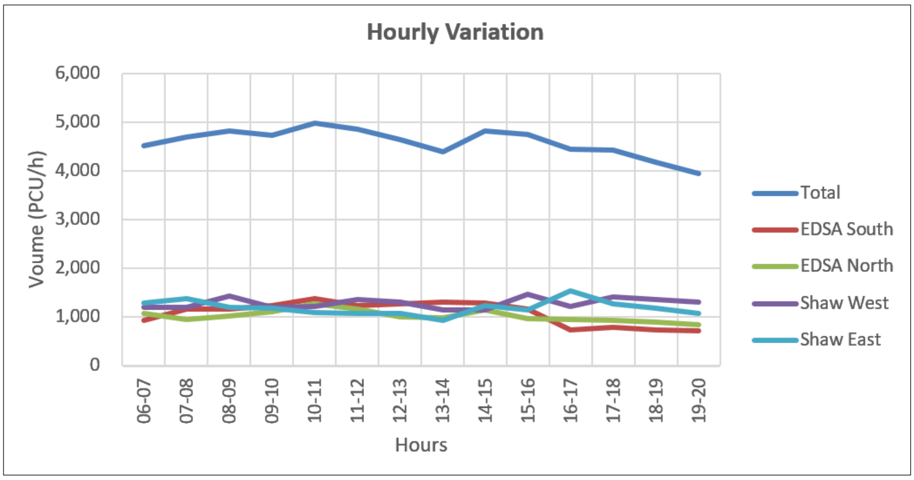
Like the EDSA–Taft Avenue intersection, the EDSA–Shaw Boulevard intersection is also a major transportation hub. The intersection is a major transfer point for commuters taking other forms of transportation, such as buses, taxis and jeepneys. Three major PUJ and UV Express (air-conditioned vehicles) terminals are located near the intersection. Buses that run along EDSA may be boarded at the boarding / alighting bays near the intersection. For buses heading to Quezon City and areas in the north, passengers may board in front of EDSA Central Mall. Passengers heading to Makati and areas in the south may board buses in front of Starmall (near the PUJ terminal). Since the intersection is surrounded by malls and other business establishments, it is also considered one of the busiest intersections in Metro Manila.

Source: MMDA.

Figure 2.29: EDSA–Shaw Boulevard Intersection

2) Traffic Characteristics

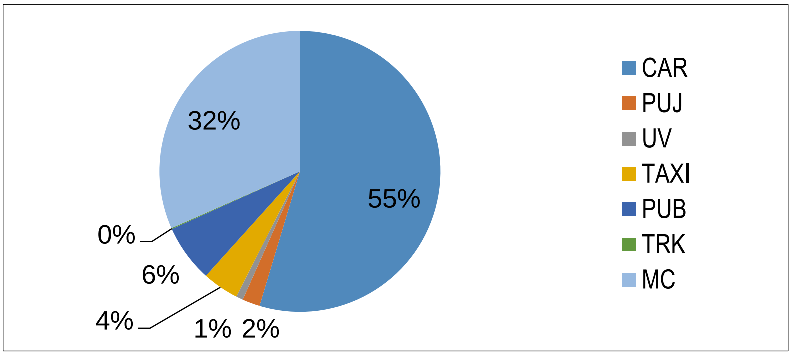
The hourly traffic volume variation in PCU by approach for 25 September 2019 is shown below. The graph indicates that the traffic volume was at a high level throughout the day and had indistinct peak from 10:00AM–11:00AM and from 2:00PM–3:00PM. The traffic volume on all four (4) approaches was at the same level. The intersection is grade-separated for the north–south direction (EDSA) and the east–west direction (Shaw Boulevard), and traffic volume refers to the number of vehicles at the grade level.



Source: Metropolitan Manila Development Authority

Figure 2.30: Hourly Traffic Volume Variation in PCU at EDSA–Shaw Boulevard IS (25 September 2019)

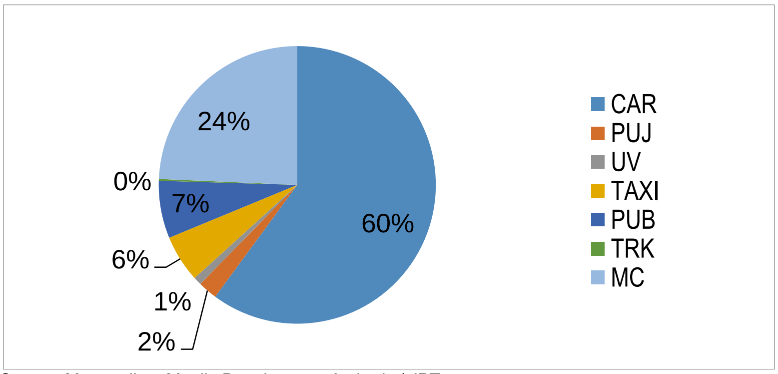
Figure 2.31 shows the composition of vehicles utilizing the intersection during the AM peak. Private cars comprise more than half of the vehicles with a total of 55%, followed by motorcycles with a total of 32%, and buses with a total of 6%.



Source: Metropolitan Manila Development Authority/ JPT

Figure 2.31: Vehicle Composition at EDSA–Shaw Boulevard IS (25 September 2019, AM Peak)

Figure 2.32 shows the composition of vehicles utilizing the intersection during PM peak. Private cars made up 60% of the vehicles, followed by motorcycles with a total of 24%, which was smaller than the AM peak, and buses at 7%.



Source: Metropolitan Manila Development Authority/ JPT

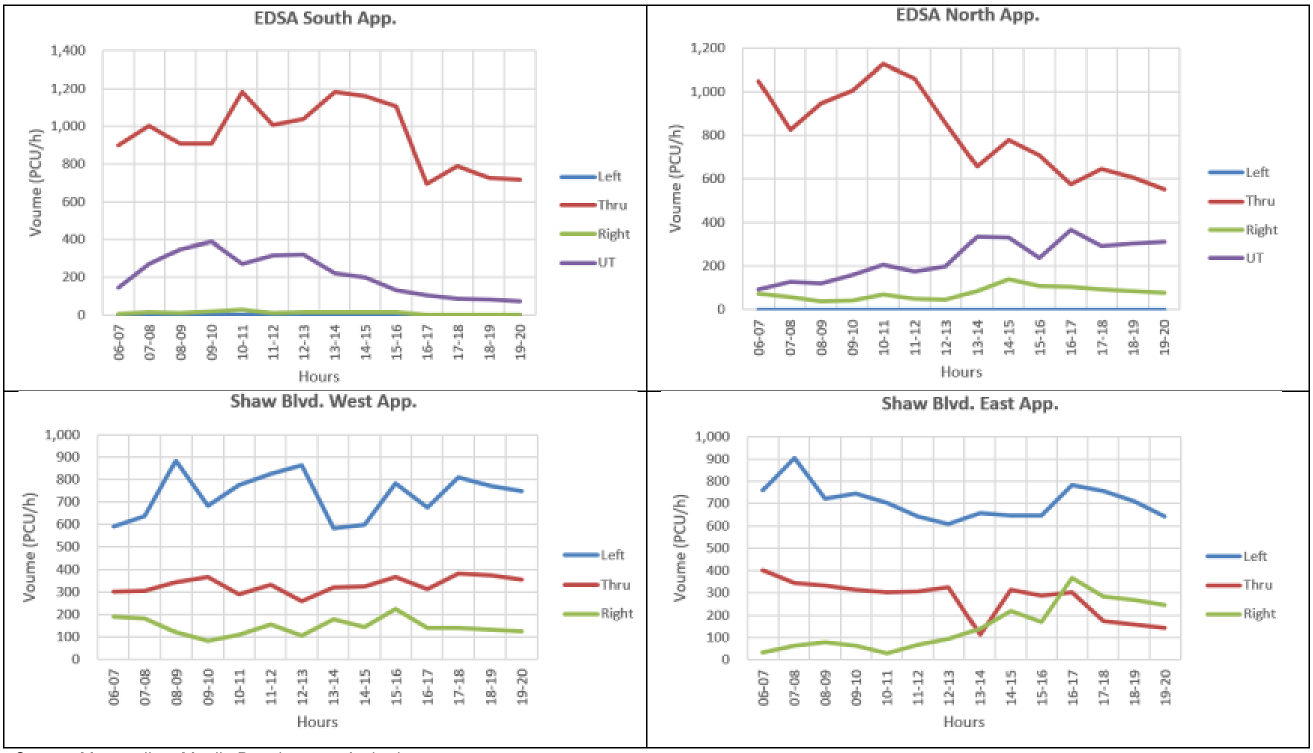
Figure 2.32: Vehicle Composition at EDSA–Shaw Boulevard IS (25 September 2019, PM Peak)

3) Turning Movement Count

Figure 2.33 shows the turning movements at the EDSA–Shaw intersection. Despite the underpass on Shaw Boulevard, the through traffic is higher than turning volume because busses use the at-grade road. The U-turn volume was second largest after the through traffic. The hourly traffic volumes did not show clear AM and PM peaks. During the AM peak, the southbound traffic volume is higher than the northbound traffic.

Along Shaw Boulevard, the left-turning volume was much higher than through and right-turning traffic throughout a day. On the west approach, the volume of through traffic was higher than right-turning traffic going north on the west approach, while the through traffic volume was comparable with right-turning traffic going south on the east approach in the afternoon.

A large volume of U-turning traffic on EDSA approaches and on Shaw Boulevard approaches required non-standard signal phase pattern to accommodate large turning volumes.



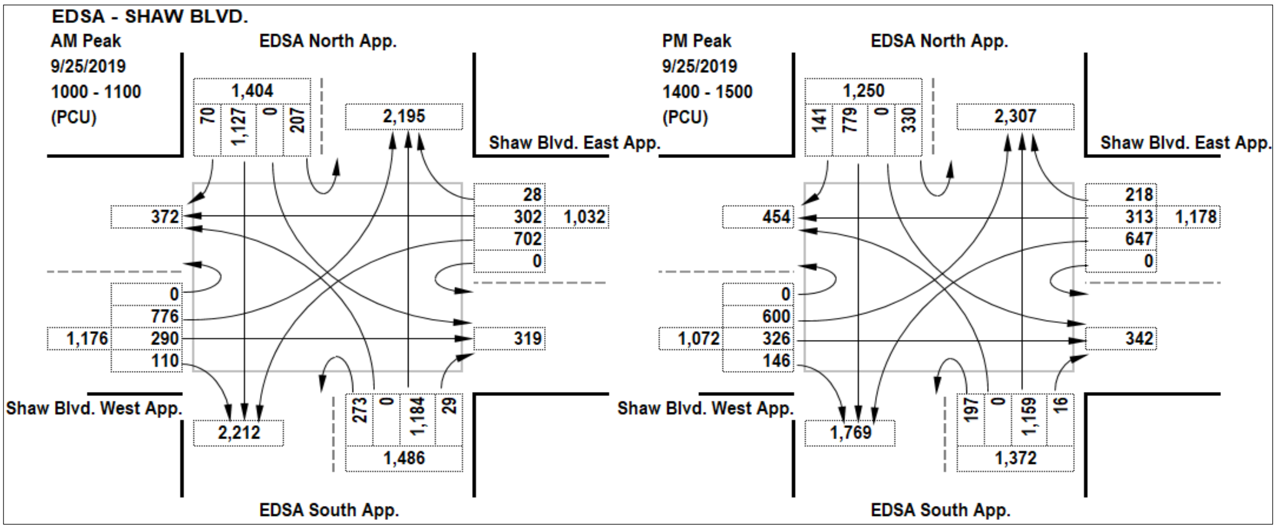
Source: Metropolitan Manila Development Authority

Figure 2.33: Hourly Variation in Turning Movement in PCU (25 September 2019)

4) Peak Hour Turning Movement Count

Peak hour volume in PCU is shown for AM and PM peak hours (Figure 2.34). The AM peak was 10:00–11:00, while the PM peak was 14:00–15:00.

As stated above, U-turn volume along EDSA was high due to the long span between intersections along EDSA.



Source: Metropolitan Manila Development Authority

Figure 2.34: Peak Hour Traffic Volume in PCU (25 September 2019)

5) Traffic Management Issues

The following traffic management issues were identified:

(i) A medium queue length (over 300–500m) was observed at the inflow direction on EDSA;

(ii) A heavy queue length (over 500m) was observed at the inflow direction on Shaw Boulevard;

(iii) Heavy boarding/ alighting at the intersection occurred along the EDSA corridor;

(iv) Light jaywalking was observed around the intersection; and

(v) Heavy pedestrian traffic volume was observed around the intersection.

Major causes of traffic management issues were observed, as follows: obstruction caused by left-turning vehicles, motorcycles, buses/taxis stopping, and vehicles entering/exiting the roadside; and inappropriate intersection geometry.

The major causes of traffic congestion at the EDSA–Shaw Boulevard intersection are as follows:

(i) Pedestrian overflow on the north approach;

(ii) Overstaying buses;

(iii) Conflict with merging vehicles;

(iv) High volume of jaywalkers on Shaw Boulevard;

(v) U-turning vehicles coming out of the establishments and obstructing through traffic; and

(vi) Dark intersection area.

6) Proposed Improvement Measures

Possible improvement measures are proposed here.

(i) Improvement of bus management (wage system, schedule, dispatch, segregation scheme, etc.) to eliminate bus waiting at bus bay for a long time;

(ii) Installation of pavement marking for turning movements to serve heavy volume of turning movements;

(iii) Provision of street lighting for better visibility under the flyover and MRT station; and

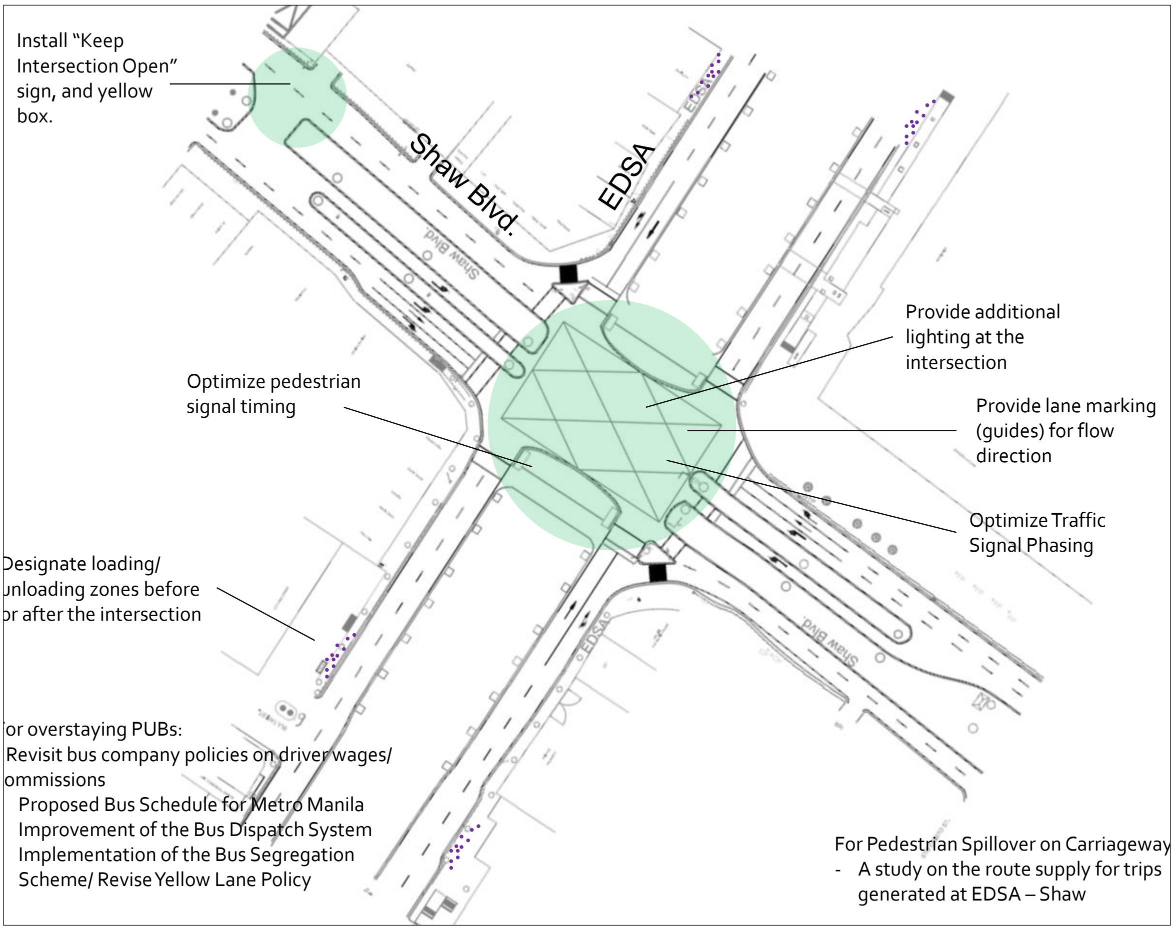
(iv) Review and update of signal timing.

7) Assessment of Measures

The largest issue at this intersection is the bus operation at bus bays, entry/exit of PUJs at terminals near the intersection, entry/exit of cars at shopping malls nearby, and overflowing pedestrians, for which traffic engineering measures were not applied. For this reason, no microscopic simulation was carried out.

8) Recommendations

The most effective way to improve the traffic condition at this intersection is to improve the bus operation around the intersection.



Source: JPT

Figure 2.35: Proposed Improvement Measures

2.5 Summary

Each case study intersection had its own geometric and traffic characteristics. As a result, there are different types of traffic management issues as shown in the table below. The category of issues was the same in two intersections although the nature and extent of the issues are not necessarily similar.

Countermeasures were developed and evaluated for two intersections (Roxas Boulevard–MIA Road and EDSA–Taft Avenue). For Roxas Boulevard–MIA Road IS, the countermeasures are expected to be relatively easy to implement and do not require large funds. While the issues and solutions for EDSA–Taft Avenue intersection are more of the operational nature, and implementation requires careful consideration and coordination among road users.

Table 2.6: Types of Traffic Management Issues at Case Study 1 Intersections

Intersection	Intersection Geometry	Pavement Marking	Excessive Traffic	Turning Movement	Signal Phase / Timing	Bus / Jeepney Operation	Pedestrian Movements	Roadside Activities	Street Lighting
Roxas Boulevard–MIA Road	✓	✓	✓	✓	✓	✓			
EDSA–Taft Avenue	✓	✓	✓		✓	✓	✓	✓	
EDSA–Shaw Boulevard		✓		✓	✓	✓	✓	✓	✓

Source: JPT.

Improvement measures vary depending on the type and extent of the problems. Thus, no categorization is made. Improvement measures specific to the location must be developed after analyzing the issues.

The case study of three intersections on major roads presents the procedure to take to identify the causes of congestion and to develop improvement measures. It also shows the evaluation method in terms of costs and benefits. This procedure can be established as congestion mitigation process and can be applied to other locations where congestion is a problem.

3 CASE STUDY 2: IMPROVEMENT OF A SEGMENT BOTTLENECK ALONG A CORRIDOR

3.1 Background

1) Objectives

Traffic congestion at an intersection affects adjacent intersections as traffic volume in the affected intersection flows from the upstream of connecting roads. Therefore, case study 2, which focuses on the corridor between Santolan and Connecticut intersections along Ortigas Avenue, was carried out to consider the improvement of travel speed along this segment.

Case study 2 aims to achieve the following:

(i) To smoothen traffic flow and ensure road safety along the corridor;

(i) To evaluate the effectiveness of the improvement measures proposed by the project team using microsimulation;

(ii) To identify and settle any hindrance that may occur during the implementation, and

(iii) To enhance the implementation capacity of MMDA in traffic management.

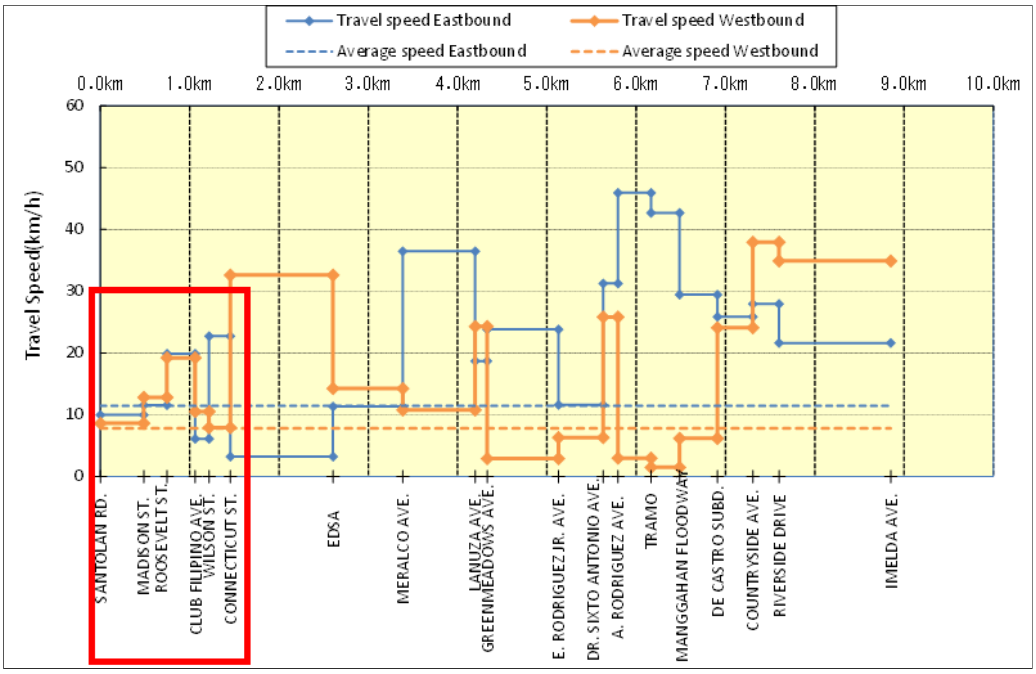
2) Project Area

The case study is located along the corridor of Ortigas Avenue having three (3) lanes per direction and covers six (6) intersections, as indicated in Figure 3.1.

Source: JPT

Figure 3.1: Project Area

These locations were identified in the MMDA travel time survey (Figure 3.2) to be the sections where travel speed was significantly low during the AM peak hours. Based on Waze data, these were also the sections where congestion was most frequent and had been identified by LGUs and MMDA as traffic bottleneck points in a study.



Source: JPT based on MMDA travel speed survey.

Figure 3.2: MMDA's Travel Speed Survey along Ortigas Corridor

Source: JPT based on Waze data.

Figure 3.3: Travel Speed Data from Waze

3) Overall Approach

The overall approach of the case study is shown in Figure 3.4. First, to understand the traffic situation, it was necessary to collect traffic count data, travel speed data, traffic signal phasing, and CAD inventory data. By site observation and data analysis, traffic situation could be understood, and bottleneck points and other causes of congestion could be identified. In response to the causes of congestion, multiple solutions were considered, and combined to create alternative scenarios. Then, the implementation cost of each proposed scenario was estimated. At the same time, micro-simulation model with calibration and validation was developed to match existing traffic conditions, after which the proposed scenarios were added to the model. By comparing the various scenarios in term of KPIs and conducting economic evaluation, the best scenario was selected in conjunction with other elements.

Source: JPT

Figure 3.4: Workflow for Case Study 2

3.2 Existing Traffic Conditions

1) Daily Traffic Volume

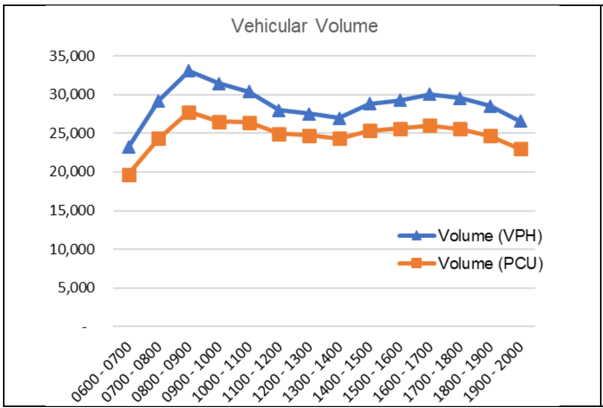
The peak hours were identified by summing up the traffic volumes of all the incoming movements of the six intersections counted in 2019. In summary, there was a total of 33,072 vehicles (equivalent to 27,745 PCU) during the AM peak hour which was from 8:00AM to 9:00AM. Also, there were 30,043 vehicles (or 25,983 PCU) during the PM peak hour at 4:00PM to 5:00PM. Meanwhile, the least number of vehicles was recorded at 6:00AM to 7:00AM. Table 3.1 and Figure 3.5 show the traffic volume in vehicles per hour and PCU per hour. The counts were gathered by MMDA in 2018 and 2019 from 6:00AM to 8:00PM.

As shown in Figure 3.6, most vehicles, which traversed the six intersections in 2019, were cars at 60%, followed by motorcycles at 32%. The share of PUJs, UVEs, taxis, buses, trucks, trailers, tricycles, and bicycles ranged from 0% to 4%.

Table 3.1: Hourly Traffic Volume in Vehicle No. and PCU in 2019

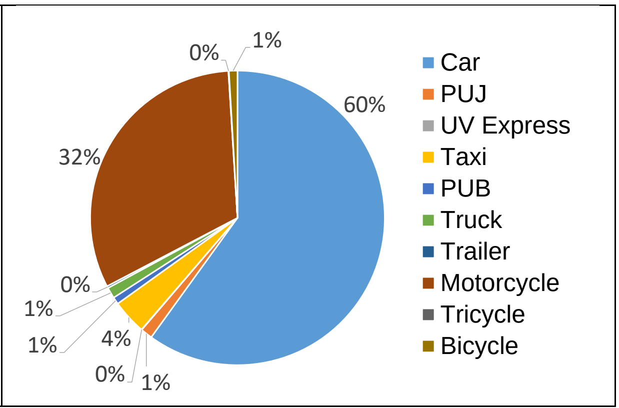
Time of Day	Volume (vehicle/hour)	Volume (PCU/hour)
0600 - 0700	23,194	19,670
0700 - 0800	29,209	24,331
0800 - 0900	33,072	27,745
0900 - 1000	31,451	26,523
1000 - 1100	30,391	26,413
1100 - 1200	27,987	24,918
1200 - 1300	27,539	24,738
1300 - 1400	26,965	24,345
1400 - 1500	28,804	25,321
1500 - 1600	29,254	25,633
1600 - 1700	30,043	25,983
1700 - 1800	29,543	25,549
1800 - 1900	28,550	24,656
1900 - 2000	26,583	23,004
Total	402,585	348,829

Source: MMDA



Source: MMDA

Figure 3.5: Hourly Traffic Volume in Vehicle No. and PCU in 2019



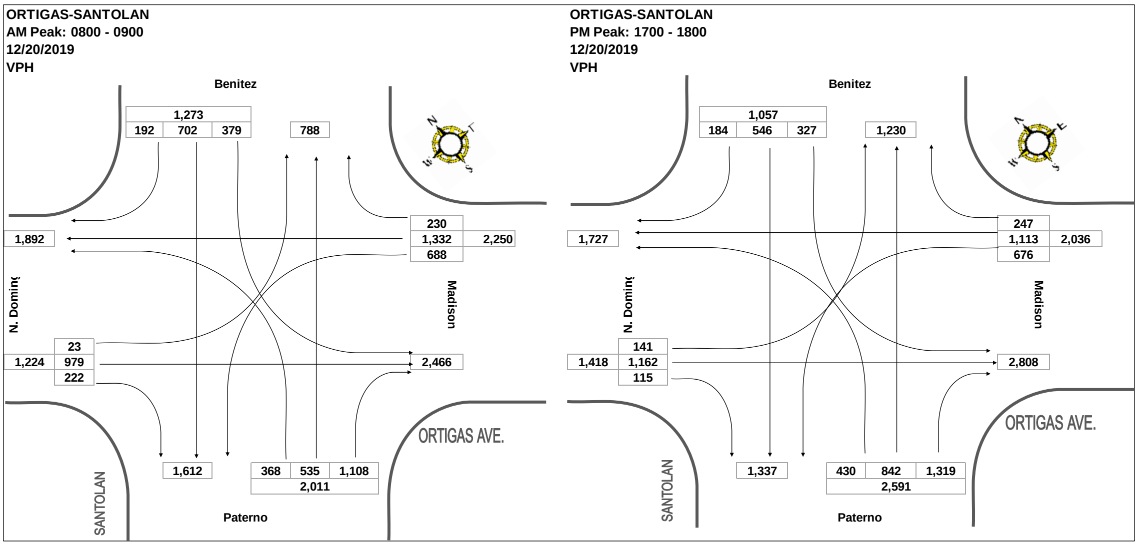
Source: MMDA

Figure 3.6 Vehicle Composition of the Study Area

2) Current Peak Hour Traffic Volume and Turning Movements

The current peak hour traffic volume and turning movements at the three major intersections along the corridor are described below.

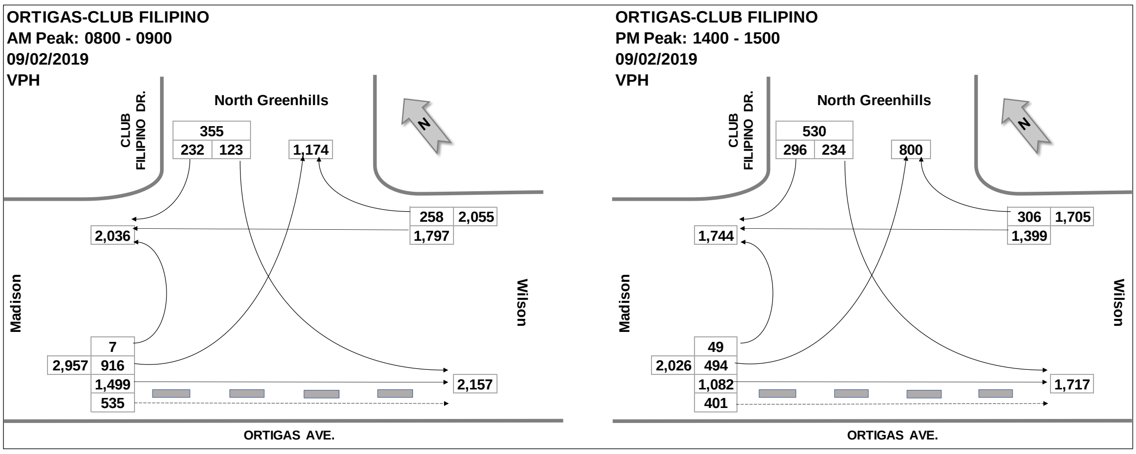
(a) **Ortigas Avenue–Santolan Road IS:** MMDA conducted a survey for the traffic volume count at Ortigas–Santolan intersection on 20 December 2019. According to the survey, the AM peak hour occurred at 8:00AM to 9:00AM, while the PM peak hour occurred at 5:00PM to 6:00PM. The highest traffic volume was observed at the east approach of the intersection during the AM peak hour, while the highest volume was recorded at the south approach of the intersection during the PM peak hour, as shown in Figure 3.7. The turning movement with highest percentage was the through movement from N. Domingo to Madison streets at 80%, while the movement with the lowest percentage was the left turn movement from N. Domingo to Benitez streets at 2% during the AM peak hour.



Source: MMDA

Figure 3.7: Peak Hour Traffic Volume at Ortigas Avenue–Santolan Road IS (20 Dec 2019)

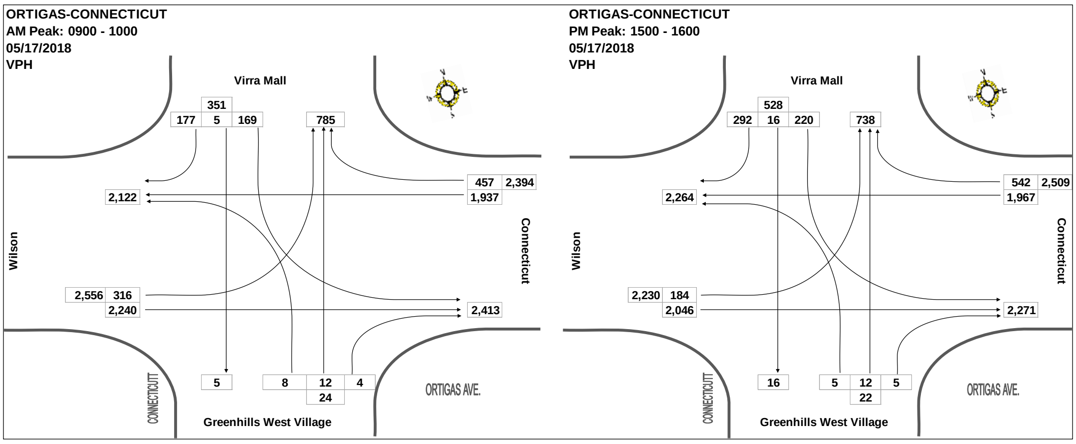
(b) **Ortigas Avenue–Club Filipino Drive IS:** Based on the survey conducted by MMDA at the Ortigas–Club Filipino intersection on 02 September 2019, the AM peak hour was from 8:00AM to 9:00AM and PM peak hour was from 2:00PM to 3:00PM. The highest traffic volume was recorded at the west approach with 2,957 and 2,026 vehicles during the AM and PM peak hours, respectively, as shown in Figure 3.8. Only 20% of eastbound vehicles used the service road present at the Ortigas–Club Filipino IS compared to the 50% that used the main road.



Source: MMDA

Figure 3.8: Peak Hour Traffic Volume at Ortigas Avenue–Club Filipino Drive IS (02 September 2019)

(c) **Ortigas Avenue–Connecticut Street IS:** The survey at the Ortigas-Connecticut intersection was conducted on 17 May 2018. During this time, the AM peak hour was from 9:00AM to 10:00AM, while the PM peak hour was from 3:00PM to 4:00PM, as shown in Figure 3.9. The highest number of vehicles was recorded at the west leg during the AM peak hour, while it was recorded at the east leg during the PM peak hour. The through movement along the Ortigas corridor had the highest rate among the other movements.



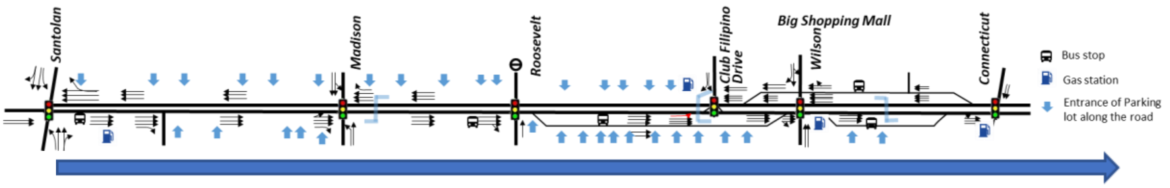
Source: MMDA

Figure 3.9: Peak Hour Traffic Volume at Ortigas-Connecticut (17 May 2018)

3) Travel Speed

The travel speed was obtained using the average travel speed data collected by Waze during weekdays. Figure 3.10 shows the average travel speeds for the AM peak hour (8:00AM–9:00AM) and PM peak hour (4:00PM–5:00PM) in 20-minute intervals on the eastbound direction. Cells in red represent slower speeds, while cells in green represent faster speeds. For the AM peak hour, faster speeds were recorded at the start of Santolan, ranging from 26.74kph to 34.15kph which are represented by green-shaded cells. The speed slowed from the middle of Santolan and Madison until before entering the Wilson intersection, with speeds ranging from 14.36kph to 19.4kph as marked by the red-shaded cells. Upon entering Wilson, the speed increased (32.54kph–35.31kph) and slowed down at the Connecticut intersection (14.79kph–20.26kph). Meanwhile, for the PM peak hour, slightly higher speeds were recorded from the middle of Santolan and Madison until Roosevelt (18.16kph–23.11kph). Slightly higher speeds were also observed at Connecticut (24.94kph–29.32kph), showing that the traffic bottleneck at eastbound was located between Wilson and Club Filipino intersections and served as the start of the long queue of traffic congestion.

Figure 3.10 shows the range of the speeds experienced along the Ortigas corridor during the AM peak hour (8:00AM–9:00AM) and PM peak hour (4:00PM–5:00PM) in 20-minute intervals on the westbound direction. During the AM peak hour, faster speeds were experienced before Connecticut, with speeds ranging from 29.81 to 35.20 kph. Congestion was experienced after passing through Connecticut while going to Wilson as presented by the light red cells (19.55kph–20.95 kph). Slower speeds were continuously experienced from Wilson until after Roosevelt, with speeds ranging from 17.85kph to 20.88kph. Speeds started to increase after Roosevelt until Santolan (23.57kph–27.51kph). Meanwhile, for the PM peak hour, lower speeds were recorded before the start of Connecticut until Wilson (20.27kph–35.20kph). Travel speeds worsened from Wilson until Santolan, as illustrated by the red shaded cells, with the speeds ranging from 12.18 to 16.01kph.



AM Peak Hour

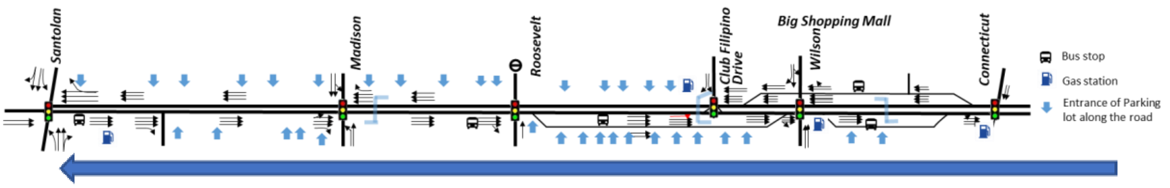
Time	Santolan					Madison			Roosevelt			Club Filipino		Wilson				Connecticut	
8:00	32.82	27.43	17.46	16.91	16.54	17.38	17.38	17.06	15.63	15.57	15.57	15.16	17.25	34.16	33.27	33.17	33.84	20.26	20.00
8:20	31.91	26.74	17.11	16.53	16.25	16.96	16.96	16.69	14.72	14.63	14.63	14.36	16.25	35.31	33.89	33.72	34.26	18.02	17.69
8:40	34.15	30.78	19.04	18.37	18.15	18.68	18.68	18.25	16.18	16.09	16.10	15.60	17.80	34.43	32.72	32.54	33.19	15.11	14.79

PM Peak Hour

Time	Santolan					Madison			Roosevelt			Club Filipino		Wilson				Connecticut	
16:00	29.54	26.48	20.85	20.32	19.63	21.62	21.62	21.11	15.69	15.43	15.43	14.68	17.08	34.22	33.86	33.83	34.39	29.32	29.18
16:20	30.36	26.00	19.59	19.08	18.16	19.98	19.97	19.42	14.83	14.63	14.63	14.05	16.10	32.97	31.80	31.77	32.44	25.89	25.77
16:40	35.19	32.90	23.11	22.34	21.66	22.71	22.71	21.84	16.15	15.90	15.91	15.22	17.56	32.88	31.32	31.18	31.74	25.05	24.94

Source: JPT based on Waze data.

Figure 3.10: Average Travel Speeds for Eastbound Direction from Waze Data



AM Peak Hour

Time	Santolan					Madison			Roosevelt			Club Filipino		Wilson			Connecticut		
8:00	25.88	25.63	26.14	27.25	27.26	23.95	24.30	20.88	19.74	19.74	19.74	18.08	18.16	20.09	20.95	30.44	35.20	30.12	30.09
8:20	25.79	25.54	25.98	27.00	27.01	23.99	24.10	20.43	19.28	19.28	19.28	17.88	17.98	19.61	20.43	30.18	35.20	30.20	30.16
8:40	26.28	26.01	26.52	27.50	27.51	23.83	23.57	20.20	19.18	19.18	19.18	17.85	17.96	19.55	20.32	30.27	35.20	29.84	29.81

PM Peak Hour

Time	Santolan					Madison			Roosevelt			Club Filipino		Wilson			Connecticut		
16:00	15.46	15.07	15.36	15.99	16.01	14.03	13.68	13.45	13.35	13.35	13.37	12.79	13.08	21.17	21.76	27.76	35.20	19.82	19.75
16:20	13.00	12.72	13.14	14.13	14.14	13.47	13.09	12.90	12.83	12.83	12.85	12.51	12.77	20.27	20.82	26.04	35.20	22.35	22.22
16:40	13.14	12.89	13.22	14.04	14.05	13.28	12.93	12.71	12.64	12.64	12.66	12.18	12.45	20.36	20.86	25.31	35.20	25.97	25.87

Source: JPT based on Waze data.

Figure 3.11: Average Travel Speeds for Westbound Direction from Waze Data

3.3 Identification of Issues and Alternative Solutions

1) Causes of Traffic Congestion

Based on the collected data and understanding the traffic situation, the following traffic problems and issues causing traffic congestion were identified:

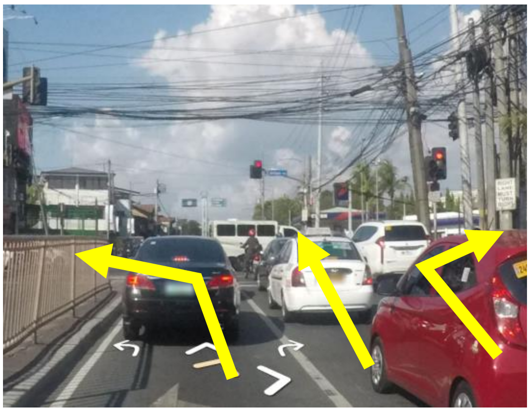
(a) **Traffic Bottleneck Intersection (Geometry Issue):** Based on the travel speed data from Waze, the traffic bottleneck at eastbound seemed to be located between Wilson and Club Filipino intersections, and the long queue of traffic congestion started there. There is a traffic island that separates the left-turning from through vehicles, but there is not enough road width for vehicles to pass through because of the island. Geometry improvement is required to smoothen the traffic.

Source: JPT

Figure 3.12: Geometric Issue at Ortigas Avenue-Club Filipino Drive IS

(b) **Vague Lane Configuration on Santolan Road Northbound (NB):** Based on site observations, queues usually form at this part of the intersection due to the large vehicular volume passing through the Ortigas–Santolan intersection. The south approach of Ortigas–Santolan has three lanes: the innermost lane for the left turn movement, the middle lane for the through movement, and the outermost lane for the right turn movement, which is always allowed. Based on the survey of the current traffic count, since the rate of left turning and through movements from Paterno Street was 18% and 27%, respectively, the option of sharing the innermost lane with both left turn and through movements was considered. Figure 3.13 shows the lane configuration on Santolan Road northbound (NB).

(c) **Inadequate Signal Timing and Signal Coordination:** Traffic signal parameters at all intersections in the study area were set to adjust the traffic volume before the signal implementation by MMDA. However, since the traffic flow has changed gradually, the signals have not been optimized. In addition, while the signal coordinating system (ATC system) has been applied to this section, the function is not used well resulting in inadequate offset between signals. Therefore, the optimization and coordination of the signal timing parameters were proposed for the Ortigas corridor.



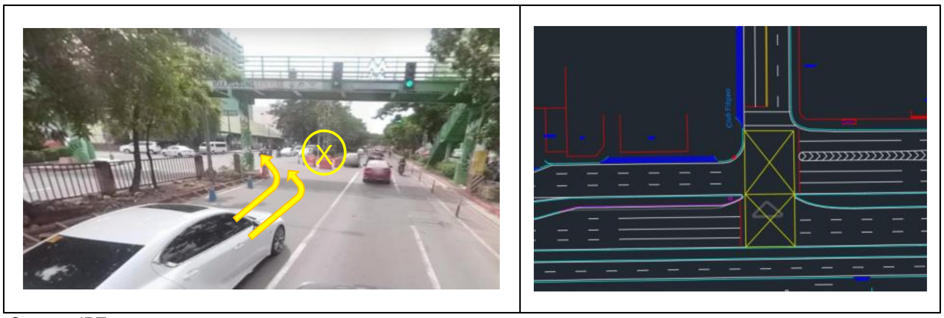
Source: JPT

Figure 3.13: Current Lane Configuration at Ortigas–Santolan

2) Consideration of Alternative Solutions

Based on the causes of congestion, the following solutions were proposed:

(a) **Geometric Improvement:** In Ortigas–Club Filipino, it was observed that around 30% of the volume from the west approach turned left. In the existing condition, only a passenger car and a motorcycle could turn left given the road width. Due to this geometric issue, vehicles waited for their turns, and queues started to form affecting the level of service (LOS) of the intersection. Thus, it was proposed to remove the triangular median island to provide an additional lane for left turning vehicles. This geometric improvement is illustrated Figure 3.13.



Source: JPT

Figure 3.14: Geometric Improvement at Ortigas–Club Filipino

(b) **Review of Lane Configuration on Santolan Road NB:** It was proposed that the innermost lane be shared between left-turning and through movements to ease the queues forming at the approach. This proposal provided two options for the lane assignment at the south approach: the first option was for the innermost lane to be a shared lane for left-turning and through movements, and the second option was for the innermost lane to be for left-turn movements only. These options are shown in Figure 3.15.

First Option | Second Option

Source: JPT

Figure 3.15: Geometric Improvement at Ortigas Avenue–Santolan Road IS

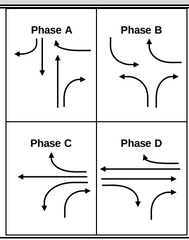
(c) **Optimization of Signal Phasing and Revision of Offset Timing:** One of the issues presented earlier was the signal timing parameters and the coordination among the intersections in the study area. In response to this, two signal timing parameters were provided which were computed using capacity analysis.

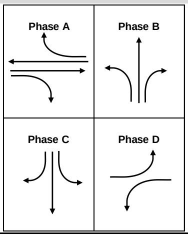
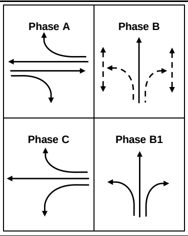
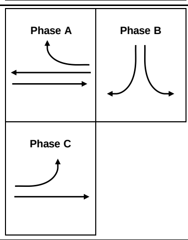
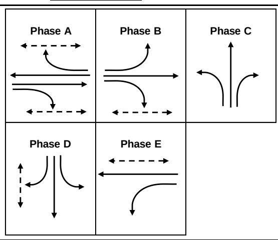
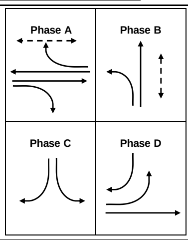
(i) **Phase Pattern:** The phasing diagrams for all intersections are illustrated in Table 3.2 and Table 3.3. There are two sets of phasing diagrams: one set used with the existing offset, and another used with the revised offset. The sequence of the phasing diagrams was modified for the revised offset since the phase should start with the direction that was given priority in the computation of the offset, which was the eastbound direction. The phasing at Ortigas–Santolan was revised as this contributes to the improvement of the LOS in the said intersection. One of the modifications done in the phasing diagram at Ortigas–Santolan was the prohibition of the left turn movement from the west approach. Instead of turning left, the vehicles would proceed straight to Ortigas-Madison and take a U-turn at the intersection.

(ii) **Signal Timing Parameter:** The signal timing parameters were computed using capacity analysis. The first signal timing parameters consist of an optimum cycle length of 130 seconds, while the second signal timing parameters consist of an optimum cycle length of 135 seconds.

The two sets of signal timing parameters will be used with either the existing offset or the revised offset. The signal timing parameters that will be used together with the existing offset are detailed in Table 3.2, while the signal timing parameters to be used with the revised offset are detailed in Table 3.3.

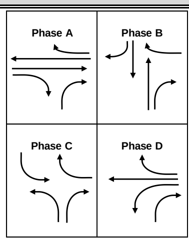
Table 3.2: Signal Timing Parameters and Phasing Diagram to be Used with the Existing Offset

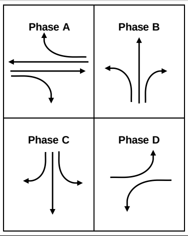
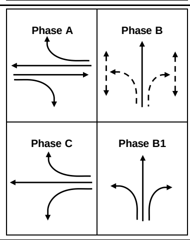
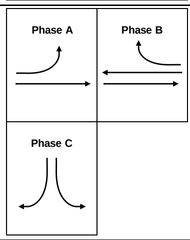
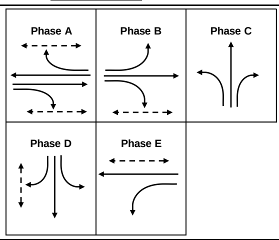
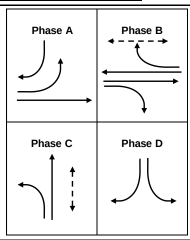
Intersection	Phase		Cycle Length of 130 sec	Cycle Length of 135 sec
			Split (sec)	Split (sec)
Ortigas–Santolan		A	27	29
		B	25	29
		C	47	41
		D	31	36
		Cycle	**130**	**135**
Ortigas–Madison		A	66	68
		B	30	31

Intersection	Phase		Cycle Length of 130 sec Split (sec)	Cycle Length of 135 sec Split (sec)
		C	18	19
		D	16	17
		Cycle	**130**	**135**
Ortigas–Roosevelt		A	90	94
		B	19	20
		C	21	21
		Cycle	**130**	**135**
Ortigas–Club Filipino		A	49	51
		B	36	37
		C	45	47
		Cycle	**130**	**135**
Ortigas–Wilson		A	31	33
		B	14	14
		C	34	36
		D	18	18
		E	33	34
		Cycle	**130**	**135**
Ortigas–Connecticut		A	61	63
		B	14	15
		C	30	31
		D	25	26
		Cycle	**130**	**135**

Source: JPT

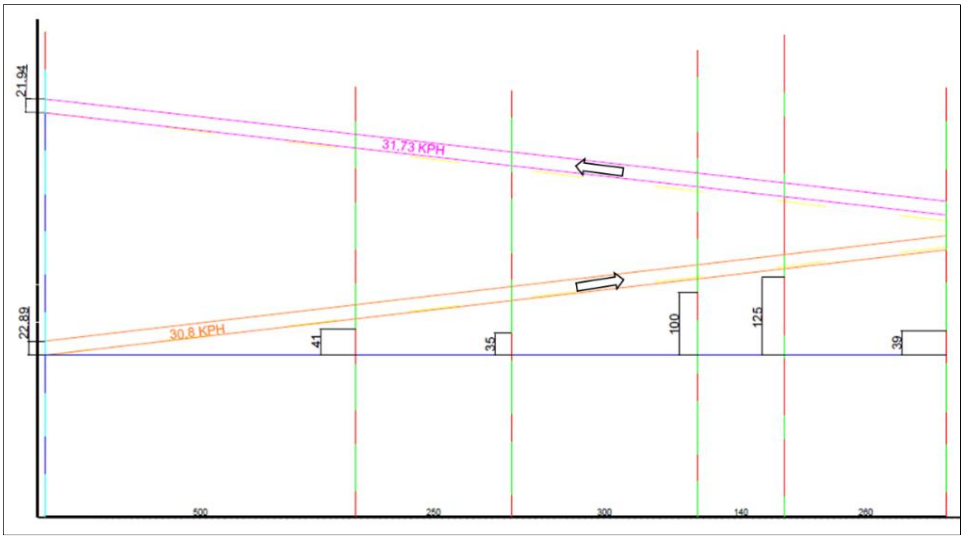
Table 3.3: Signal Timing Parameters and Phasing Diagram to be Used with the Revised Offset

Intersection	Phase		Cycle Length of 130 sec Split (sec)	Cycle Length of 135 sec Split (sec)
Ortigas–Santolan		A	31	36
		B	27	29
		C	25	29
		D	47	41
		Cycle	**130**	**135**
Ortigas–Madison		A	66	68
		B	30	31

Intersection	Phase		Cycle Length of 130 sec Split (sec)	Cycle Length of 135 sec Split (sec)
		C	18	19
		D	16	17
		Cycle	**130**	**135**
Ortigas–Roosevelt		A	90	94
		B	19	20
		C	21	21
		Cycle	**130**	**135**
Ortigas–Club Filipino		A	45	47
		B	49	51
		C	36	37
		Cycle	**130**	**135**
Ortigas–Club Wilson		A	31	33
		B	14	14
		C	34	36
		D	18	18
		E	33	34
		Cycle	**130**	**135**
Ortigas–Connecticut		A	25	26
		B	61	63
		C	14	15
		D	30	31
		Cycle	**130**	**135**

Source: JPT

(iii) **Offset Timing:** Meanwhile, in the coordination aspect, the offset (in seconds) was recomputed through a graphical method making use of the time-distance diagram. In the preparation of the time-distance diagram, the eastbound direction was chosen as the priority direction, which means that the movement of eastbound vehicles were given priority over the westbound vehicles. The offset was determined through the time-distance diagram which is shown in Figure 3.16. The revised offset is presented in Table 3.4.



Source: JPT

Figure 3.16: Time-Distance Diagram to Determine the Revised Offset

Table 3.4: Revised Offset for Each Intersection

Intersection	Offset (sec)	Intersection	Offset (sec)
Santolan	0	Club Filipino	100
Madison	41	Wilson	125
Roosevelt	35	Connecticut	39

Source: JPT

3.4 Evaluation

1) Methodology of Traffic Analysis

(a) **Micro Simulation using Vissim:** Modeling alternative scenarios is less expensive, faster, and safer to obtain results as inputs to decision making. PTV Vissim is a microscopic simulation program used for multimodal transport operations. PTV Vissim is capable of modeling urban and rural traffic as well as pedestrian flows when managing scenarios from current to future alternatives. KPIs such as volume count, travel time, travel speed, and travel delay, among other data, can be generated using the software.

(b) **Model Development:** Inputs such as volume counts and traffic signal control were necessary in modeling the current scenario realistically during the AM peak hour (8:00AM–9:00AM). With the help of MMDA, certain parameters for urban road network were provided. Geometric data, traffic flows, vehicle composition, turning movements, and traffic signal phases/times were collected through the surveys to develop the model in Vissim. As for further details about the model development.

(c) **Model Calibration:** Driving behavior parameters were modified to mirror the space-oriented urban setting along Ortigas corridor. By these adjustments, unique vehicle types, such as motorcycles, can maneuver easier in between larger vehicles. Moreover, private cars, trucks, and other PUVs can maximize the effective carriageway as observed on the field.

2) Validation

Geoffrey E. Havers' (GEH) formula was used to measure the goodness-of-fit of a model. It considers the absolute and percentage difference between the modeled and actual traffic volume. Computed GEH values must be less than 5.0 to be considered an acceptable match. Moreover, 85% of all the links or movements must meet the GEH criteria. Computed GEH statistics from the base scenario ranged from 0.0 to 7.44. The results show that 95.24% of the total number of turning movements had a GEH statistic of less than 5.0. This indicates that the model is validated and suitable for testing.

$$GEH = \sqrt{\frac{2(m-c)^2}{m+c}}$$

Where: m –simulation volume (veh), c – actual traffic volume (veh)

3.5 Proposed Scenarios

The JPT and the MMDA CPT came up with eight scenarios combining the alternative solutions, composed of the geometric improvements and traffic signal control. The geometric improvements consist of removing the triangular median island to allocate an additional lane for left turning vehicles at the west approach of Ortigas–Club Filipino and left turn movement only at innermost lane at the south approach of Ortigas–Santolan. On the other hand, four sets of signal timing data were provided, and the offset was recalculated for better coordination of the intersections for traffic signal control.

A summary of the proposed scenarios is shown in Table 3.5. A check mark in the box means that the alternative solution is applied to the scenario.

Table 3.5: Summary of Proposed Scenarios

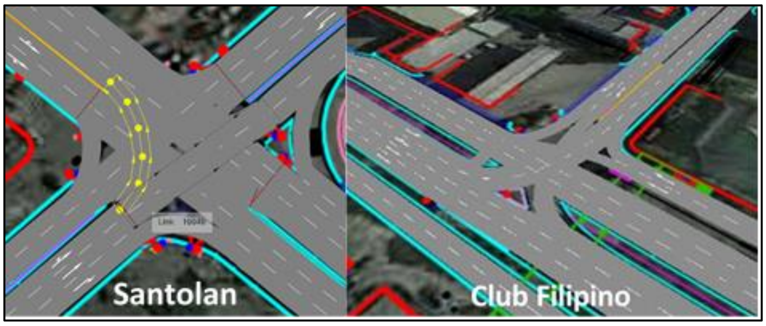
Alternative Solution		Scenario							
		1A	1B	2A	2B	3A	3B	4A	4B
Geometric Improvements									
A	2 lanes for left turn at Club Filipino (modified triangle) + Shared lane (thru and left turn) at innermost lane at Santolan NB	✓		✓		✓		✓	
B	2 lanes for left turn at Club Filipino (modified triangle) + Left turn only at innermost lane at Santolan NB		✓		✓		✓		✓
Traffic Signal Control Option									
1	Adjusted Signal Timing (130 secs) using existing offset	✓	✓						
2	Adjusted Signal Timing (130 secs) using revised offset			✓	✓				
3	Adjusted Signal Timing (135 secs) using existing offset					✓	✓		
4	Adjusted Signal Timing (135 secs) using revised offset							✓	✓

Source: JPT

3.6 Scenario Management

The scenario management function in PTV Vissim was used in creating multiple related networks in a single file. This function also provides easier workflow in evaluating the difference between the base scenario and other alternatives. Varying signal timing and offsets using capacity analysis were applied to signal control parameters to test the best signal program for each scenario.

(a) **Scenario A:** A base scenario was replicated to apply geometric improvements. In this scenario, two lanes were assigned for through movement at the south leg of Santolan intersection, one of which is shared with the left-turning movement. Moreover, the triangle island at Club Filipino was taken down, and one lane was added for left-turning vehicles coming from the west leg. Figure 3.17 shows the changes made in the network.



Source: JPT

Figure 3.17: Scenario A Modifications

(b) **Scenario B:** Scenario A was duplicated to test the effect of turning left lane of the south leg of Santolan intersection into a dedicated left turn lane. Improvements from Club Filipino intersection were still carried in this scenario. Shown in Figure 3.18 are the modifications for scenario B.

Source: JPT

Figure 3.18: Scenario B Modifications

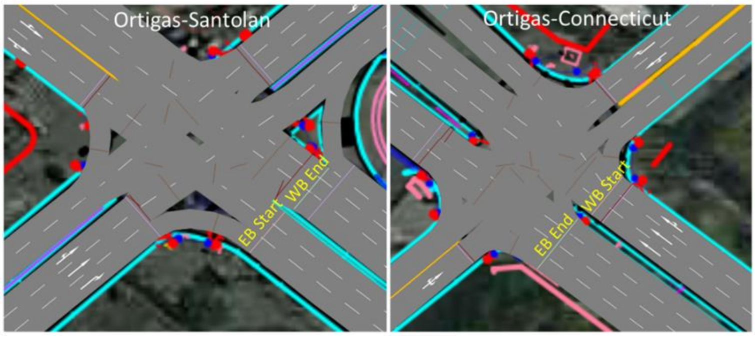
3.7 KPIs and Evaluation

KPIs shown in Table 3.6 were defined to evaluate the condition of the corridor and the efficiency of the proposed alternatives. KPI counters were placed northwest of Santolan IS and southeast of Connecticut IS, as shown in Figure 3.19. Vehicles with origins and destinations outside the study area but passing through it—both along the main road and service roads—were also recorded. The selected KPIs are shown below.

Table 3.6: Key Performance Indicators

KPI	Description
Average Travel Time (sec)	The average travel time of all vehicles passing from Santolan to Connecticut and vice versa.
Average Delay (sec)	The difference between the theoretical free flow travel time and the simulated travel time of all vehicles passing from Santolan to Connecticut and vice versa.
Average Travel Speed (kph)	The distance between Santolan and Connecticut (1.43km) over the average travel time of vehicles passing through the eastbound and west bound directions starting and ending in Santolan and Connecticut.
Average Queue Length at Approach (m)	The average queue length from all the eastbound and westbound approaches.
Vehicle Volume (veh)	Used in computing for the weighted average of travel time, delay, and travel speed.

Source: JPT



Source: JPT

Figure 3.19: KPI Counters

3.8 Results of Vissim Simulation

Table 3.7 compares the results of KPIs measured from the base scenario and proposed alternatives. The warmest color (red) indicates the worst scenario, while green signifies the best scenario for a specific indicator.

Table 3.7: KPI Results

Key Performance Indicator	Direction	Base	1A	1B	2A	2B	3A	3B	4A	4B
Average Travel Time (sec)	EB	538	389	379	440	436	399	425	477	479
	WB	291	247	248	187	188	251	249	191	192
	Ave. EB & WB	457	341	336	352	351	350	366	378	380
Average Delay (sec)	EB	443	294	284	345	342	304	330	382	384
	WB	194	147	149	89	91	152	150	94	95
	Ave. EB & WB	361	245	239	256	256	254	270	282	285
Average Travel Speed (kph) Distance of 1.43 km	EB	9.6	13.2	13.6	11.7	11.8	12.9	12.1	10.8	10.8
	WB	17.7	20.9	20.7	27.6	27.3	20.5	20.7	26.9	26.8
	Ave. EB & WB	12.2	15.8	16.0	17.2	17.1	15.4	15.0	16.4	16.3
Average Queue Length at approach (m)	EB	98.0	95.3	93.2	104.0	104.2	79.5	81.2	93.2	91.6
	WB	43.9	28.8	29.5	26.8	26.7	32.1	31.2	28.4	29.6
	Ave. EB & WB	70.9	62.0	61.3	65.4	65.5	55.8	56.2	60.8	60.6
Model Vehicle Volume (veh)	EB	1243	1233	1255	1186	1186	1269	1248	1177	1189
	WB	609	627	626	629	619	622	629	623	624
	Ave. EB & WB	926	930	941	908	903	946	939	900	907

Source: JPT

Since there are no countermeasures, the base scenario has the highest travel time, delay, queue length, and lowest travel speed. Although the offset optimization prioritized the eastbound direction, there were higher improvements in the westbound direction, as shown in columns 2A, 2B, 4A, and 4B (scenarios with optimized offset). This may be caused by the higher design speed in the westbound direction (31.73kph) than the eastbound direction (30.8kph) in the time-space diagram when optimizing the offset timing.

Weighted averages of travel time, delay and speed follows the following formula:

$$Weighted\ Average = \frac{\mathrm{KPIeb(Voleb) + KPIwb(Volwb)}}{\mathrm{Voleb + Volwb}}$$

Scenario 1B was found to be the best scenario when considering average travel time and average delay. However, scenarios 2A and 2B have produced the highest average travel speed at 17.2kph and 17.1kph, respectively. Generally, when considering the average travel speed, optimizing the offset timing improves the corridor (columns 2A, 2B, 4A, and 4B). Scenario 3A, on the other hand, had the lowest average queue length along the east-west approach. The number of vehicles on the eastbound and westbound direction from these scenarios might be affecting these results since the scenario with the lowest travel time did not necessarily become the one with the highest travel speed.

3.9 Cost Estimation

The MMDA CPT assisted in estimating the total cost for scenarios A and B. The slight cost increase is observable in scenario B mainly because of the difference in supply and the installation of standard traffic road sign costs. A summary of the estimated costs is presented in Table 3.8.

Table 3.8: Total Estimated Costs

Estimated Cost	A (Php)	B (Php)
Total Cost	869,449	877,593
Indirect Cost (25% Mark-up)	217,362	219,398
Total VAT	115,417	116,639
Total Est. Cost	1,202,229	1,213,630
Rounded Total Estimated Cost	1,203,000	1,214,000

Source: JPT

3.10 Economic Evaluation

Comparing the differences in travel time between the base scenario and the alternatives, the benefits from travel time savings were estimated. Benefits in this study refer to the function of time value, number of days, passenger factor, and travel time savings from different vehicle types. Time values and passenger factors as shown in Table 3.9 and Table 3.10, respectively, were from relative studies, namely, Capacity Development on Transportation Planning and Database Management: Urban Transport Planning and MUCEP 2015.

Table 3.9: Time Value per Vehicle Type

Vehicle Type	PHP/min
MC	1.11
Car	1.8
Taxi	1.54
Jeepney	0.92
Bus	1.18
HOV	1.41
Truck	1.18
Pedicab	0.63
Walk	0.72
Other Land Transport	0.77
Railway	1.28
Water Transport	0.60
Air Transport	1.93
Others	1

Source: JICA MUCEP

Travel time savings for the first and third year were computed as follows:

*Benefit (at year 1) = Σ [(TTbase - TTalternative) * Time Value * Passenger factor * peak hours (3) * weekdays * evaluation year (1)]*

*Benefit (at year 3) = Benefit (at year 1) * ((1-(1+0.12)^(1-3))/0.12+1))*

Benefits from the AM peak hour were doubled to account for the PM peak. An discount rate of 12% was assumed. Moreover, no operation and maintenance costs were expected. The net benefits were computed by getting the difference between the cost and the total benefit. On the other hand, benefit-cost ratios (BCR) were computed by dividing the benefits by the cost. Desirable alternatives should have BCR higher than 1.5.

Based on Table 3.11, scenario 2B had the highest benefit over cost with a value of 14.1.

Table 3.10: Passenger Factors per Vehicle Type

Vehicle Type	24 hr	Peak hr
Standard Bus	34.19	44.63
Minibus	1.63	3.56
Jeepney	8.84	8.96
Tricycle	0.94	1.24
Pedicab	0.14	0.34
Car	1.58	1.57
Taxi	0.81	0.88
HOV Taxi	6.06	5.35
Utility Vehicle		
Truck/Trailer	2.17	2.17
Private Bus	11.28	5.96

Vehicle Type	24 hr	Peak hr
MC/Bicycle	1.2	1.19
Others	2.67	2.43

Source: JICA MUCEP.

Table 3.11: Cost-Benefit Analysis

Scenarios	First Year						At Year 3				
	Benefit		Cost		Benefit-Cost Ratio (B/C)	Net Benefits (Php)	Benefit	Cost		Benefit-Cost Ratio (B/C) at Year 3	Net Benefits at Year 3 (Php)
	Time Saving (Php/year)	Total Benefits (Php/year)	First Cost (Php)	Total Cost (Php/year)			Cummulative Benefit (PHP) at Year 3	First Cost (Php)	Total Cummulative Cost (Php) at Year 3		
Base	-	-	-	-	-	-	-	-	-	-	-
SC1A	14,682,000	14,682,000	1,203,000	1,203,000	**12.2**	**13,479,000**	39,496,000	1,203,000	1,203,000	**32.8**	**38,293,000**
SC1B	15,606,000	15,606,000	1,214,000	1,214,000	**12.9**	**14,392,000**	41,981,000	1,214,000	1,214,000	**34.6**	**40,767,000**
SC2A	16,784,000	16,784,000	1,203,000	1,203,000	**14.0**	**15,581,000**	45,150,000	1,203,000	1,203,000	**37.5**	**43,947,000**
SC2B	17,164,000	17,164,000	1,214,000	1,214,000	**14.1**	**15,950,000**	46,173,000	1,214,000	1,214,000	**38.0**	**44,959,000**
SC3A	13,908,000	13,908,000	1,203,000	1,203,000	**11.6**	**12,705,000**	37,414,000	1,203,000	1,203,000	**31.1**	**36,211,000**
SC3B	11,486,000	11,486,000	1,214,000	1,214,000	**9.5**	**10,272,000**	30,898,000	1,214,000	1,214,000	**25.5**	**29,684,000**
SC4A	13,764,000	13,764,000	1,203,000	1,203,000	**11.4**	**12,561,000**	37,026,000	1,203,000	1,203,000	**30.8**	**35,823,000**
SC4B	13,472,000	13,472,000	1,214,000	1,214,000	**11.1**	**12,258,000**	36,241,000	1,214,000	1,214,000	**29.9**	**35,027,000**

Source: JPT

3.11 Conclusion and Findings

1) Conclusion

The traffic situation along the Ortigas corridor segment (consisting of six intersections) was evaluated. Traffic-related issues were identified beforehand, and alternative solutions were proposed. These solutions were combined and formed different scenarios that were assessed using a microsimulation software called Vissim.

During the hourly volume analysis, it was found that the AM peak hour from the 14-hour count was 8:00AM to 9:00AM. In the base scenario, it was obvious from the simulation results that the corridor's LOS was under forced flow with an average delay of 361 seconds per vehicle during the AM peak. During this period, the queue from the west leg of Ortigas-Wilson intersection spilled to the next eastbound approach which made the queue length from the west approach of Ortigas–Club Filipino intersection the longest at 175m.

Based on the KPI results and cost-benefit analysis, modifying the innermost lane at the Santolan south approach to serve left turns only and optimizing the cycle length (130 seconds) and offset timing provided the most desirable alternative. Removing the existing concrete island at Ortigas–Club Filipino intersection provided additional capacity for left turning vehicles from Ortigas Avenue to Club Filipino.

2) Findings (Lessons for Scaling Up in Metro Manila)

The salient findings from case study 2 are as follows:

(i) Improvement of traffic flow helps mitigate traffic congestion along corridors; and

(ii) Coordination among signals reduce travel time and mitigate congestion on corridors.

4 CASE STUDY 3: IMPROVEMENT OF INTERSECTION BOTTLENECKS ON LOCAL ROADS

4.1 Background

The 1st joint meeting of the Joint Coordinating Committee (JCC) and the Technical Working Group (TWG) held on 11 June 2019 gave importance to the involvement of the LGUs in coming up with a good and comprehensive traffic management plan for Metro Manila. Anticipating this, the JPT earlier requested MMDA and the LGUs to identify the bottlenecks on the roads they separately and jointly manage, as well as the severity and causes of congestion in such bottlenecks.

The JPT studied one intersection in each of the pilot LGUs together with the counterpart project teams (CPTs) from MMDA and the pilot LGUs. This was to make the CTMP Project counterparts from MMDA and the LGUs knowledgeable about the scientific method of identifying, analyzing, and unblocking bottlenecks.

4.2 Selection of Case Study Sites

On 21 October 2019, all Metro Manila LGUs were invited for a discussion on the scope of the case study on LGU-identified traffic bottlenecks in Metro Manila. All the LGUs, except for the city of Manila, sent representatives to the meeting where the attendees agreed on the need for an integrated and coordinated approach to traffic management due to the following reasons:

(i) Many traffic bottlenecks identified by the MMDA and LGUs in the surveys conducted at the start of the project affect each other;

(ii) There is a need to distinguish intercity (metropolitan) traffic from local traffic; and

(iii) Policies on issues, such as traffic management, institutions, and funding, need to be set at metropolitan level and local level.

In this meeting, the LGU representatives selected the five pilot LGUs for the case study. The relevant LGUs listed down the intersection they deemed problematic. The LGU representatives considered unsignalized intersections, intersections with high pedestrian volumes, intersections with mixed traffic, and dense areas. After subsequent meetings with these five pilot LGUs, one intersection in each was chosen. Traffic flow in these intersections is managed by the LGUs. Table 4.1 and Figure 4.1 show the final intersection bottlenecks studied by the LGU CPTs, together with the MMDA CPT and the JPT.

Table 4.1: Intersection Bottlenecks for Case Study

LGU	Intersection	Description
1. Caloocan	Samson Road–New Abbey Road Intersection	Samson Rd. is a 2-lane-per-direction road connecting to EDSA. While, New Abbey Rd. is a 1-lane-per-direction road leading the barangay roads to the main road. Institutional establishments cover the northern portion, and the residential and commercial establishments are located south of the intersection.
2. Mandaluyong	F. Martinez Avenue–San Rafael Street Intersection	F. Martinez Ave. is a a 2-lane-per-direction road which gives access to Shaw Blvd. and Maysilo Circle. While, San Rafael St. has a one-way scheme on the west leg (2 lanes) and two-way scheme of the east leg (1 lane per direction). The intersection is surrounded by commercial establishments.
3. Paranaque[1]	E. Rodriguez Avenue–Doña Soledad Avenue–East Rodriguez Street–St. Francis Street Intersection	All the legs in this intersection surrounded by commercial establishments have 1 lane per direction.
4. Pasay	A. Arnaiz Avenue–Zamora Street–Burgos Street Intersection	A. Arnaiz Ave. is a 2-lane-per-direction road connecting Roxas Blvd., Taft Ave., and Osmeña Hwy. On the other hand, Burgos St. (north leg) is a one-way road with 4 lanes and Zamora St. (south leg) is a two-way road with 2 lanes per direction. The intersection houses commercial establishments and 2 tricycle terminals.
5. Pasig	Pasig Boulevard Rotonda (Pasig Boulevard Extension–Dr. Sixto Antonio Avenue–C. Raymundo Avenue–Dr. Maldo del Rosario Street)	Pasig Blvd. Rotonda is not a typical roundabout: three roads form a triangle with a counter clockwise flow. Pasig Blvd. Ext. has varying directional schemes depending on the peak hours. It is mostly surrounded by commercial and residential buildings.

[1] Parañaque was unable to finish the case study.
Source: JPT

Source: Google Maps

Figure 4.1: Location of Final Case Study Sites

4.3 Technical Approach for the Case Study

Once the case study sites were finalized, the project team followed the process mentioned below.

(1) Identification of Issues

The LGU CPTs showed the physical conditions of their respective case study intersections and the issues present in the site. Video footage of traffic was shown, whenever available.

(2) Data Collection

Available data on traffic volumes for the intersection and video footage of traffic at the sites were collected from MMDA and the LGUs.

(3) Conduct of Field Surveys

Traffic count surveys were conducted at site either by the MMDA survey team with the LGU CPTs or only by the LGU themselves.

(4) Analysis of Intersection Capacity

The intersections' LOS were analyzed, with the worst movement in the intersection determining the overall performance of the intersection. The table below describes various LOS categories based on reserve capacity.

Table 4.2: Levels of Service of Intersections

Reserve Capacity (pcu/h)		LOS	Description
	>600	A	Free flow, no traffic delay
251	600	B	Stable flow, very short traffic delay
176	250	C	Stable flow, short traffic delay
126	175	C to D	Approaching unstable flow, average traffic delay
76	125	D	Long traffic delay
0	75	E	Unstable flow, very long traffic delay
	<0	F	Forced flow, congestion

Source: Sigua, R.G. (2008). Fundamentals of Traffic Engineering. The University of the Philippines Press. University of the Philippines Diliman

(5) Formulation of Alternative Solutions

Several traffic management (TM) measures comprising geometric improvements, traffic regulations, and application of traffic control devices, including signal control, were grouped into alternative scenarios.

(6) Micro Simulation of TM Scenarios

Due to the complexity of the problems at intersections, a micro-simulation program was used in assessing the impacts and performance of each proposed alternative scenario. PTV Vissim is a time-step-oriented and behavior-based, microscopic simulation software capable of modeling urban and rural traffic, as well as pedestrian flows, when managing scenarios from current to future alternatives. The key performance indicators (KPIs), namely, volume counts, travel time, travel speed, and travel delay, among others, can be generated using this software.

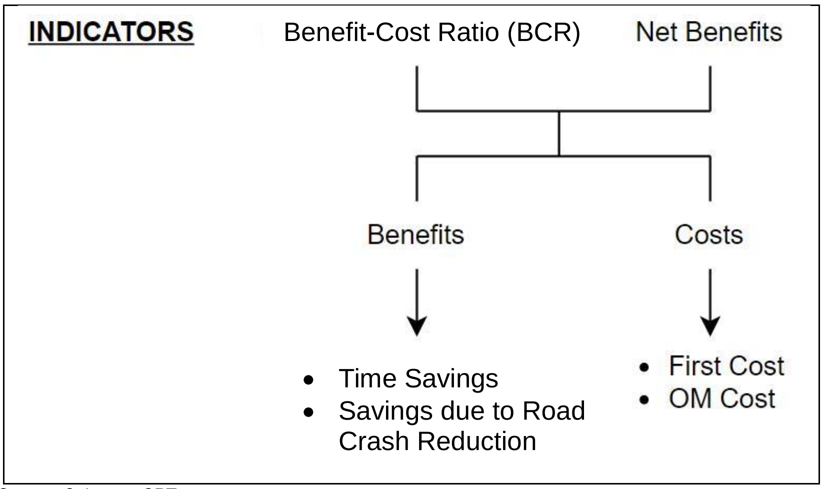
The first step in the simulation was to recreate and model the current conditions, i.e., 2019 and 2020 situation prior to the pandemic, based on geometric data, traffic flows, vehicle composition, turning movements, and traffic signal parameters (cycle length, phase pattern, green time allocation or split). The resulting model was then adjusted to mirror the driving behavior of vehicle users. Geoffrey E. Havers' (GEH) formula was then used to compare the traffic volumes generated by the model and those from the traffic counts. Once the GEH values are acceptable, TM scenarios were then simulated to determine their respective KPIs, namely, average travel time, average delay, average travel speed, average queue length, and vehicle volume.

(7) Estimation of Improvement Costs

MMDA's unit prices were adopted to estimate the respective costs of all the scenarios.

(8) Economic Evaluation

The key indicators of the economic evaluation of the scenarios are the BCR and net benefits, which will be based on the total Benefits and Costs. Figure 4.2 provides a framework of the steps involved in the economic evaluation.



Source: Caloocan CPT

Figure 4.2: Framework of the Economic Evaluation

1) Benefits

The benefits side is comprised of the time savings of the trip makers and savings due to road crash reduction. Time saving is the difference between the travel time of the base scenario and alternative scenario.

Time Savings S is computed as follows:

$$S_n = \sum S_{n,m,o}$$

For an approach o,

$$S_{n,m} = NC_{n,m} - NC_{1,m}$$

where S_n is the savings of the nth scenario

$S_{n,m}$ is the savings of vehicle m in the nth scenario

$NC_{n,m}$ is the normalized cost of vehicle m in the nth scenario

Normalized cost NC is computed as follows:

$$NC_{n,m} = TC_{n,m} \times \frac{V_{field}}{V_{sim,n}}$$

where $TC_{n,m}$ is the travel cost of vehicle m in the nth scenario

V_{field} is the field volume of the hour considered (i.e. AM or PM peak, Average)

$V_{sim,n}$ is the simulation volume of the nth scenario

Travel cost TC is computed as follows:

$$TC_{n,m} = TT_{n,m} \times V_{sim,n} \times D_{m,o} \times PF_m \times TV_m$$

where $TT_{n,m}$ is the average travel time of vehicle m in the nth scenario

$D_{m,o}$ is the distribution of vehicle m in the field for approach o (i.e., EB, WB, NB, SB)

PF_m is the passenger factor of vehicle m

TV_m is the time value of vehicle m

The time values of trip makers used in the evaluation are shown in Table 4.3.

Table 4.3: Time Values of Trip Makers per Person

Vehicle Type	PHP/min
1. MC	1.11
2. Car	1.80
3. Taxi	1.54
4. Jeepney	0.92
5. Bus	1.18
6. HOV	1.41
7. Truck	1.18

Vehicle Type	PHP/min
8. Pedicab	0.63
9. Walk	0.72
10. Other Land Transport	0.77
11. Railway	1.28
12. Water Transport	0.60
13. Air Transport	1.93
14. Others	1.00

Source: JICA MUCEP (Part 3: Project Evaluation)

Time values were estimated using income approach using the trip information and individual income on MUCEP database. Income approach computes time value by dividing individual income per month over the assumed working time. Philippine Statistics Authority supplied the estimate for average working hours in a week (40.9 hours) for 2014.

(a) **Savings due to Road Crash Reduction:** To account for the increased safety of pedestrians due to the introduced interventions, savings due to fewer road crashes SC were calculated as follows:

$$SC = AC \times RF$$

where AC is the total annual accident cost (PHP/year)

RF is a reduction factor

The reduction factor is the rate of effectiveness of an intervention (i.e., $RF = 65.6\%$ according to a study by Kentucky Transport Center for signalization, and $RF = 100\%$ for the addition of a footbridge). These values are only simplifications to estimate the savings due to road crash reduction.

The total annual accident cost AC was calculated as follows:

$$AC = AR \times V_{ped} \times AC_{ave}$$

where AR is the accident rate (incidents/year)

V_{ped} is the annual volume of pedestrians (pedestrians-year)

AC_{ave} is the average accident cost (PHP/incident)

The accident rate per million AR was calculated as follows:

$$AR = \frac{No\ of\ incidents}{Time\ Period\ \times AADT} \times 10^6$$

Metro Manila Accident Reporting and Analysis System (MMARAS) data from 2017 to 2019 were used to identify the number of incidents. MMARAS is a Excel-based system that MMDA uses to register accident data from the police. The time period considered is three (3) years. AADT was estimated using the 14-hr count which was converted to a 24-hr count using a factor of 1.3 as per MMDA.

The average accident cost AC_{ave} was calculated as follows:

$$AC_{ave} = \frac{Total\ Accident\ Cost}{No\ of\ incidents}$$

Table 4.4 contains accident cost estimates in 2005, which were applied with a 12% discount rate to obtain their present worth (year 2020). For zero incidents, a conservative assumption of 0.01 was applied.

Table 4.4: Accident Cost Estimates

Item	Damage to Property	Injury		Total
		Non-Fatal	Fatal	
1. Unit Cost 2005 (PHP/accident)	55,000.00	350,000.00	2,273,000.00	2,678,000.00
2. Unit Cost 2020 (PHP/accident)	301,046.12	1,915,748.02	12,441,414.97	14,658,209.10

Source: Sigua, R.G. (2008). Fundamentals of Traffic Engineering. The University of the Philippines Press. University of the Philippines Diliman

2) Costs

The cost comprises the Initial Investment Cost and the operation and maintenance (O&M) cost.

(a) **Initial Investment Cost:** This is the sum of the initial expenditures involved in implementing a project and includes items such as materials, installation, and other related costs.

(b) **O&M Cost:** The O&M cost of the alternatives is assumed to be 10% of the Initial Investment Cost in addition to other known O&M expenses such as salaries of traffic enforcers.

3) Evaluation

The net benefits and benefit-cost ratio were calculated using the project's present worth (PW). The present worth PW_n of scenario n at year t with interest i is computed as shown. This assumes that the project started at year 1. Also, assuming that the accident cost is constant per year, the present worth of accident cost $PW\ AC_n$ is calculated using the same formula.

$$PW_n = S_n\left(\frac{1-(1+i)^{-t+1}}{i} + 1\right)$$

The present worth of O&M Cost $PW\ OM_n$ of scenario n with frequency f at year t is calculated as:

$$PW\ OM_n = OM_n \times \frac{1-(1+i)^{-t}}{(1+i)^f - 1} \times (1+i)^{-t}$$

Total Cost of scenario n is $C_n = FC_n + PW\ OM_n + PW\ AC_n$

Net Benefits of scenario n is $NPV_n = PW_n - C_n$.

Benefit-cost ratio is $BC_n = {}^{PW_n}/_{C_n}$.

(a) **Decision Rules:** The rules indicated below are applied in the evaluation (Boardman et al, 1996).

If $BC_n > 1$, then scenario n is beneficial.

If two or more scenario n has $BC_n > 1$, then get the scenario with $\max NPV_n$.

If the percent difference of two NPV_n is less than 5% (assumed), then get the scenario with $\min C_n$.

4.4 Timeline of the Case Study 3 Activities

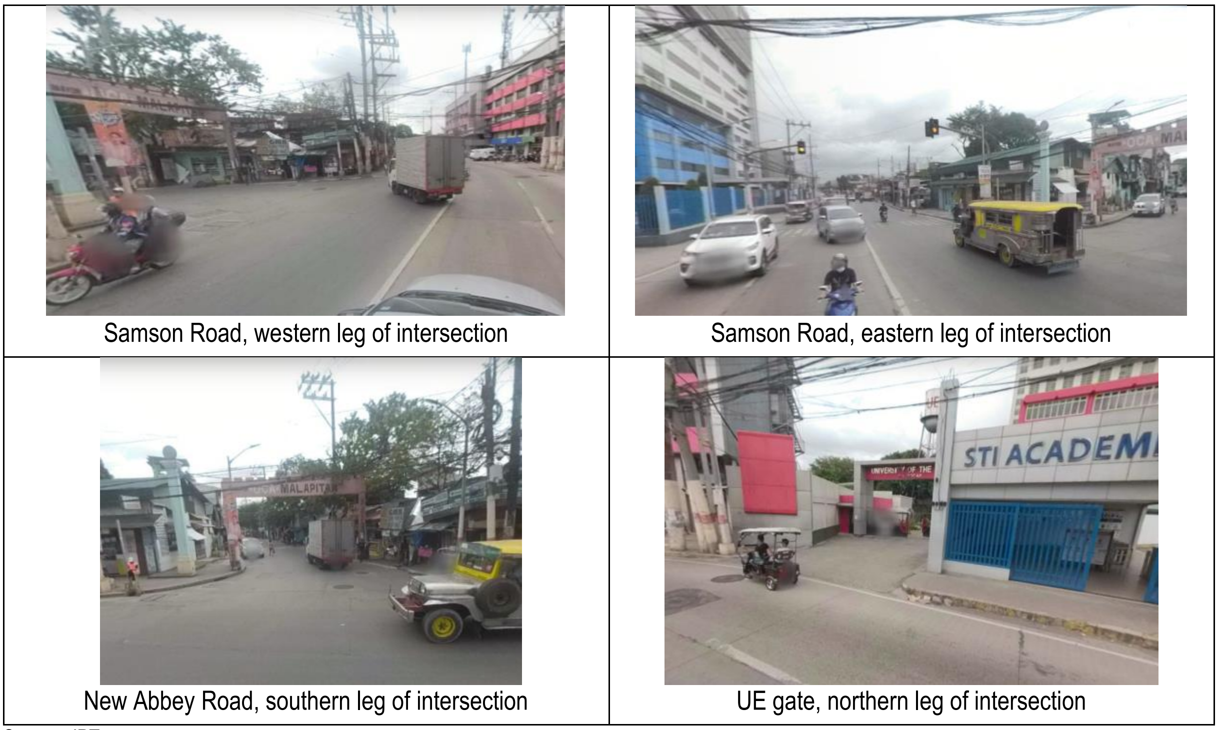
The case studies started in November 2019 and finished in September 2020.

Table 4.5: Timeline of Case Study 3 Activities

Pilot LGU	Activity	2019		2020								
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1. Caloocan	Identification of issues and concerns											
	Planning and data collection											
	Field surveys											
	Intersection capacity analysis											
	Formulation of alternative solutions											
	Evaluation of impact, effectiveness thru											
	Estimation of cost of improvements											
2. Mandaluyong	Identification of issues and concerns											
	Planning and data collection											
	Field surveys											
	Intersection capacity analysis											
	Formulation of alternative solutions											
	Evaluation of impact and effectiveness											
	Estimation of cost of improvements											
3. Pasay	Identification of issues and concerns											
	Planning and data collection											
	Field surveys											
	Intersection capacity analysis											
	Formulation of alternative solutions											
	Evaluation of impact, effectiveness thru											
	Estimation of cost of improvements											
4. Pasig	Identification of issues and concerns											
	Planning and data collection											
	Field surveys											
	Intersection capacity analysis											
	Formulation of alternative solutions											
	Evaluation of impact, effectiveness thru											
	Estimation of cost of improvements											

Source: JPT.

4.5 Caloocan City: Samson Road–New Abbey Road Intersection



Samson Road, western leg of intersection

Samson Road, eastern leg of intersection

New Abbey Road, southern leg of intersection

UE gate, northern leg of intersection

Source: JPT

Figure 4.3: Samson Road–New Abbey Road Intersection

1) Traffic Volumes

A 14-hour traffic count and travel time and delay survey were conducted on 26 February 2020. Peak hour volumes are shown in Table 4.6. Most of the vehicles in the distribution were motorcycles (MCs), as shown in the pie chart (see Figure 4.4).

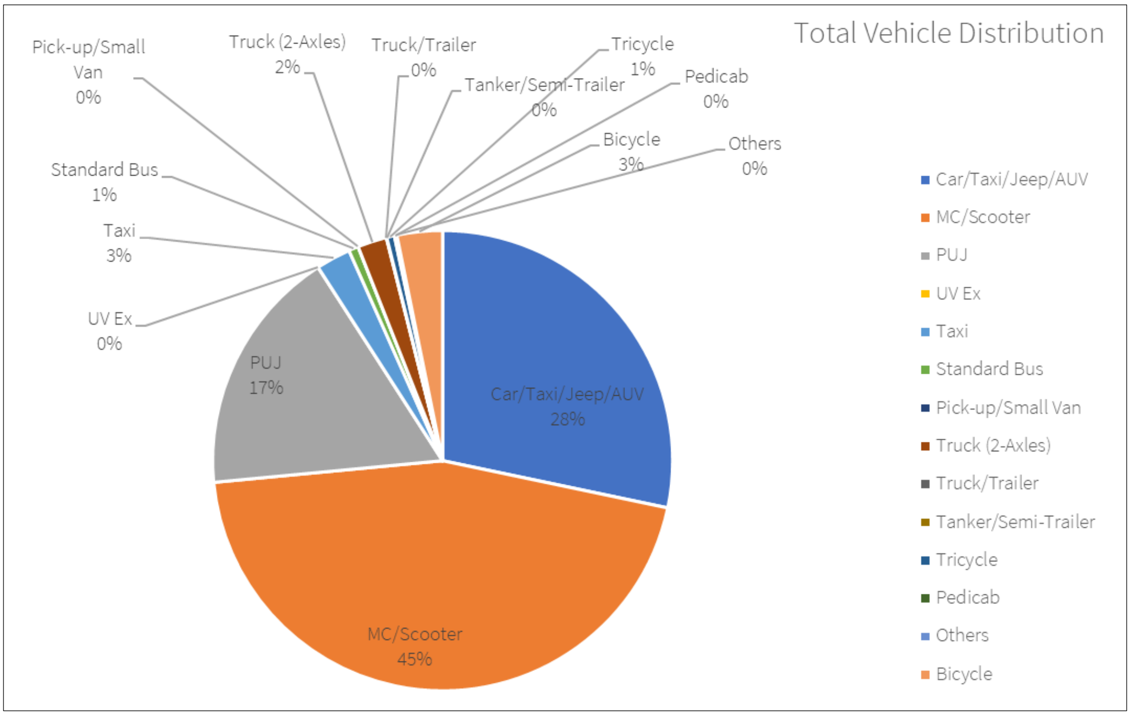
Table 4.6: Peak Hour Volumes for AM and PM

Movement	Approach	Turn	AM Peak (7:00AM - 8:00AM)		PM Peak (5:00PM – 6:00PM)	
			veh/h	pcu/h	veh/h	pcu/h
M1	West	LT	0	0	0	0
M2		TH	1919	1845	1064	1103
M3		RT	306	277	221	213
M4	South	LT	206	188	230	223
M5		TH	10	8	4	4
M6		RT	71	64	179	184
M7	East	LT	85	79	85	76
M8		TH	1289	1349	1736	1698
M9		RT	15	13	5	5
M10	North	LT	30	28	32	29
M11		TH	17	16	20	18
M12		RT	33	30	8	7

Source: Caloocan CPT based on MMDA data.

2) Intersection Capacity Analysis

The unsignalized intersection was assessed as LOS F.



Source: Caloocan CPT.

Figure 4.4: Vehicle Volume Distribution

3) Signal Operation

The Samson Road–New Abbey Road intersection has signal control equipment installed which were not operational during the case study. Instead, traffic enforcers managed the traffic flow during the day.

4) Causes of Congestion

(i) Jeepneys and buses were observed to stop less than 30 meters from the intersection on both sides and from both directions along Samson Road. This resulted in blockage of turning movements and reduction in capacity.

(ii) Because the signal control was damaged and non-operational, there were no clear phase pattern or sequence to manage the flow from different approaches.

(iii) Given a heavy flow of vehicles on the eastbound and westbound direction, conflicts between turning vehicles generated delay.

(iv) The Systems Technology Institute (STI) gate is less than 20 m from the intersection. Even with small ingress and egress trips during peak hours, additional delay occurred when going in or out of the establishment.

(v) Pedestrians crossed from all directions on all the legs of the intersection, causing delay because motorists were forced to give way to them.

No clear priority at the intersection

Pedestrians crossing anytime

Source: JPT

Figure 4.5: Causes of Congestion

5) Proposed Traffic Management Scenarios

To improve the operational performance of the intersection, several alternatives or improvements in the intersection were proposed. Table 4.7 lists observed problems proposed improvements, and their impacts.

Table 4.7: Proposed Improvements for the Intersection and Their Impacts

Problem	Improvement	Impact
1. Jeepneys stop before and after the intersection that cause delays.	• Place public transport (PT) stops after the intersection.	• Delays caused by public transport vehicles such as jeepneys and buses stopping before and after the intersection previously are reduced.
		• Pedestrians would have to walk much further if their destinations are far from the stops.
2. Bus stop is located before the intersection.		• The reduced PT stop length may need to be compensated, unless otherwise, proven unnecessary by analysis.
3. Movement conflicts in the intersection causes delay.	• Reroute left-turning vehicle to reduce conflicts.	• Delays at the intersection will be reduced because of restricted left turn movements.
		• Delays at the roads where vehicles are rerouted will increase. Whether the rerouting has significant unfavorable impacts to the roads in question has yet to be determined because of the lack of data.
		• A portion of New Abbey Rd will be one-way.
4. There are too many pedestrians crossing at different places in the intersection causing conflict	• Place median barriers at the west approach to prohibit pedestrians from crossing.	• Pedestrians will be prohibited to cross from the south to the north via the west leg to reduce delay.
		• When combined with placing PT stops after the intersection, the pedestrians unloaded at the west leg would have to circle around the intersection.
	• Place a footbridge in the area.	• Pedestrians will be safer since they will not be exposed to vehicle hazards.
		• The existing sidewalk with little space (around 1.2 m-width) will be occupied by the footbridge.

Problem	Improvement	Impact
		• Installing the footbridge may require land acquisition (and thus be costly) because of insufficient space at the sidewalk.
5. The intersection experiences heavy delays due to large vehicle volumes and uncontrolled foot traffic.	• Signalize the intersection.	• The delays will be minimized. • Foot traffic will be more orderly.

Source: JPT, Caloocan CPT, MMDA CPT.

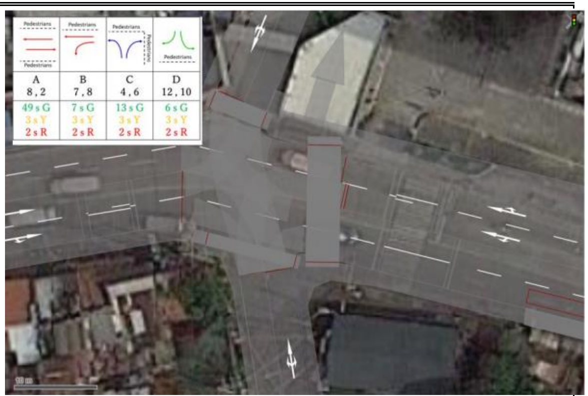
The improvements were combined to form alternative scenarios, as listed in Table 4.8. These scenarios were simulated to determine the most viable combination. Figure 4.6 shows the proposed interventions.

Table 4.8: Alternative Scenarios for the Samson Road–New Abbey Road Intersection

Scenario	Description
1	Do nothing
2	PT stops after the intersection + Traffic signal
3	PT stops after the intersection + Traffic signal + Rerouting
4	PT stops after the intersection + Rerouting + Median
5	PT stops after the intersection + Traffic signal + Rerouting + Median
6	PT stops after the intersection + Traffic signal + Rerouting + Median + Footbridge

Source: JPT, Caloocan CPT, MMDA CPT.

Scenario 1: Do Nothing

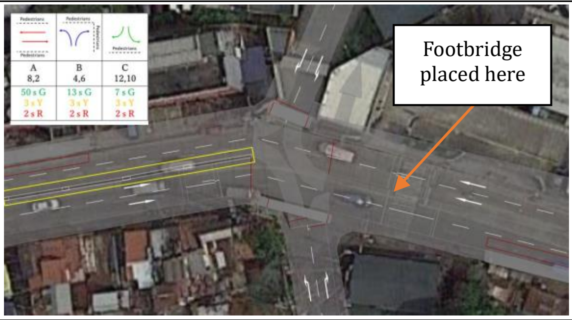


Scenario 2: PT Stops after the Intersection + Traffic Signal

Scenario 3: PT Stops after the Intersection + Traffic Signal + Rerouting

Scenario 4: PT Stops after the Intersection + Rerouting + Median

Scenario 5: PT Stops after the Intersection + Traffic Signal + Rerouting + Median



Scenario 6: PT Stops after the Intersection + Traffic Signal + Rerouting + Median + Footbridge

Source: JPT based on CPT meetings agreements.

Figure 4.6: Alternative Scenarios for Samson Road–New Abbey Road Intersection

PT stops are represented by red boxes in the simulation, while grey rectangles parallel the PT stops are the platforms where pedestrians board and alight. Alternative scenarios with traffic signals were provided signal lines represented by the red lines to mark where vehicles will stop during the all-stop phase. On the other hand, alternative scenarios with a rerouting component modifies New Abbey Rd. and STI Rd. as a one-way road with two (2) lanes of approach. Ingress trips to New Abbey Rd and STI. shall be redirected to Heroes del 95 Rd. and Caimito Rd., respectively. Moreover, to simplify the model of the last alternative scenario, the footbridge was not reflected. Instead, pedestrian activity along Samson Rd. was omitted.

6) Microsimulation of Traffic Management Scenarios

The base case and alternative scenarios were simulated using Vissim. Results shown in Table 4.9 show that scenario 2 worsened the situation and increased the delay by 36%. Scenarios 3 and 6 best improved the intersection producing LOS B from LOS F. Scenario 6 is the best scenario based on the parameters shown, i.e., overall delay (reduced by 72%) and weighted mean speed (improved by 68%). However, it should be noted that the costs of the scenarios differ significantly. Thus, the scenarios must undergo economic evaluation.

7) Economic Evaluation

Time savings were calculated from the simulation results to estimate the benefits coming from the alternative scenarios. Savings due to road crash reduction were computed using data obtained from MMARAS. The volume of pedestrians was obtained via video recording of over an hour at the intersection.

Table 4.9: Simulation Results by Scenario

KPI	Unit	Scenario					
		1	2	3	4	5	6
1. Total Volume (Field Data)*	veh	3,981	3,981	3,896	3,896	3,896	3,896
2. Total Volume (Simulation)	veh	3,758	3,706	4,255	4,059	4,251	4,244
3. Average Travel Time	sec	113.50	113.39	44.88	63.35	47.13	39.69
4. Average Queue Length	m	39.85	92.94	12.91	47.12	13.42	11.06
5. Overall Delay	sec	62.74	85.38	19.71	47.59	20.06	17.35
6. LOS (Intersection Delay)	LOS	LOS_F	LOS_F	LOS_B	LOS_E	LOS_C	LOS_B
7. Speed (EB)	km/h	9.01	8.18	14.35	8.34	14.39	15.01
8. Speed (WB)	km/h	10.62	7.51	17.08	15.43	16.93	17.05
9. Speed (NB)	km/h	1.87	2.62	6.94	4.69	6.51	7.46
10. Speed (SB)	km/h	2.33	2.23	6.90	5.15	6.28	9.24
11. Weighted Average Speed	km/h	9.00	7.56	14.67	10.58	14.60	15.10

KPI	Unit	Scenario					
		1	2	3	4	5	6
12. Total CO	gram	13,271.74	9,859.01	3,621.45	11,048.99	3,609.92	3,236.61
13. Total NOx	gram	2,582.20	1,918.20	704.60	2,149.73	702.36	629.73
14. Total VOC	gram	3,075.85	2,284.92	839.31	2,560.71	836.63	750.12
15. Total Fuel Consumption	gallon	189.87	141.04	51.81	158.07	51.64	46.30

Note: * Total Volume (Field Data) for Scenario 3-6 decreased because rerouted trips were omitted.
Source: JPT based on Vissim.

8) Estimation of Costs

(a) **Initial Investment Cost:** The Initial Investment Costs of the scenarios FC_n are shown in Table 4.10. Scenario 6 has the highest Initial Investment Cost because of the footbridge. The cost of the footbridge may be underestimated because of unaccounted-for land acquisition costs. Land acquisition may be needed because of the insufficient space in the current location. Scenario 1 has zero Initial Investment Cost but has an O&M cost of PHP465,600 per year for employing traffic enforcers.

Table 4.10: Initial Investment Costs by Scenario

Item	Scenario					
	1	2	3	4	5	6
1. Total Direct Cost (PHP)	-	2,960,715.39	2,981,619.39	1,055,709.63	3,184,839.39	6,341,982.25
2. Indirect Cost (25% Mark-up) (PHP)	-	740,178.85	745,404.85	263,927.41	3,184,839.39	1,585,495.56
3. Total VAT (PHP)	-	444,107.31	447,242.91	158,356.44	477,725.91	951,297.34
4. Total Estimated Cost (PHP)	-	4,145,001.54	4,174,267.14	1,477,993.48	4,458,775.14	8,878,775.14

Source: MMDA CPT.

(b) **O&M Cost:** It was assumed that scenarios 1 and 4 would employ traffic enforcers because of the lack of traffic signals.

9) Evaluation Results

Table 4.11 to Table 4.13 Table 4.16 show the results of the calculation for the economic evaluation using the average, AM peak, and PM peak volumes and distributions, respectively, under a three-year period. Meanwhile, Tables Table 4.14 to Table 4.16 show the results of the calculation for the economic evaluation using the average, AM peak, and PM peak volumes and distributions, respectively, under a six-year period. The study period is in multiples of three to coincide with the terms of the local chief executive.

For the three-year period, the best scenario is scenario 3 because it showed the highest net benefit among the scenarios with positive BCR. Meanwhile, the best scenario is scenario 6 for the six-year period. Since the alternative scenarios are mutually exclusive and have a positive and linear impact, the do-maximum approach is more favorable.

Table 4.11: Results of Economic Evaluation using Average Volume and Distribution at Year 3

Scenario	Description	Cost (PHP mil.)	Benefit (PHP mil.)	Net Benefit (PHP mil.)	BCR
1	Do nothing	1.26	-	(1.26)	-
2	PT stops after Int + Traffic Signal	4.85	0.69	(4.17)	0.14
3	PT stops after Int + Rerouting + Traffic Signal	4.89	111.21	106.32	22.75
4	PT stops after Int + Rerouting + Median	1.73	39.90	38.17	23.05
5	PT stops after Int + Rerouting + Traffic Signal + Median	5.22	108.38	103.16	20.76
6	PT stops after Int + Rerouting + Traffic Signal + Median + Footbridge	10.40	114.91	104.51	11.05
Best Case Scenario: S3					

Source: Caloocan CPT.

Table 4.12: Results of Economic Evaluation using AM Peak Volume and Distribution at Year 3

Scenario	Description	Cost (PHP mil.)	Benefit (PHP mil.)	Net Benefit (PHP mil.)	BCR
1	Do nothing	1.26	-	(1.26)	-
2	PT stops after Int + Traffic Signal	4.85	0.69	(4.17)	0.14
3	PT stops after Int + Rerouting + Traffic Signal	4.89	124.19	119.30	25.41
4	PT stops after Int + Rerouting + Median	1.73	39.74	38.01	22.96
5	PT stops after Int + Rerouting + Traffic Signal + Median	5.22	121.01	115.79	23.18
6	PT stops after Int + Rerouting + Traffic Signal + Median + Footbridge	10.40	128.82	118.42	12.39
Best Case Scenario: S3					

Source: Caloocan CPT.

Table 4.13: Results of Economic Evaluation using PM Peak Volume and Distribution at Year 3

Scenario	Description	Cost (PHP mil.)	Benefit (PHP mil.)	Net Benefit (PHP mil.)	BCR
1	Do nothing	1.26	-	(1.26)	-
2	PT stops after Int + Traffic Signal	4.85	0.69	(4.17)	0.14
3	PT stops after Int + Rerouting + Traffic Signal	4.89	118.91	114.03	24.33
4	PT stops after Int + Rerouting + Median	1.73	49.18	47.45	28.41
5	PT stops after Int + Rerouting + Traffic Signal + Median	5.22	115.53	110.31	22.13
6	PT stops after Int + Rerouting + Traffic Signal + Median + Footbridge	10.40	122.61	112.21	11.79
Best Case Scenario: S3					

Source: Caloocan CPT.

Table 4.14: Results of Economic Evaluation using Average Volume and Distribution at Year 6

Scenario	Description	Cost (PHP mil.)	Benefit (PHP mil.)	Net Benefit (PHP mil.)	BCR
1	Do nothing	1.44	-	(1.44)	-
2	PT stops after Int + Traffic Signal	5.01	1.17	(3.84)	0.23
3	PT stops after Int + Rerouting + Traffic Signal	5.04	190.37	185.33	37.74
4	PT stops after Int + Rerouting + Median	1.79	68.3	66.51	38.24
5	PT stops after Int + Rerouting + Traffic Signal + Median	5.39	185.53	180.14	34.44
6	PT stops after Int + Rerouting + Traffic Signal + Median + Footbridge	10.73	196.69	185.97	18.33
Best Case Scenario: S6					

Source: Caloocan CPT.

Table 4.15: Results of Economic Evaluation using AM Peak Volume and Distribution at Year 6

Scenario	Description	Cost (PHP mil.)	Benefit (PHP mil.)	Net Benefit (PHP mil.)	BCR
1	Do nothing	1.44	-	(1.44)	-
2	PT stops after Int + Traffic Signal	5.01	1.17	(3.84)	0.23
3	PT stops after Int + Rerouting + Traffic Signal	5.04	212.58	207.53	42.15
4	PT stops after Int + Rerouting + Median	1.79	68.03	66.24	38.09
5	PT stops after Int + Rerouting + Traffic Signal + Median	5.39	207.15	201.76	38.45
6	PT stops after Int + Rerouting + Traffic Signal + Median + Footbridge	10.73	220.51	209.78	20.55
Best Case Scenario: S6					

Source: Caloocan CPT.

Table 4.16: Results of Economic Evaluation using PM Peak Volume and Distribution at Year 6

Scenario	Description	Cost (PHP mil.)	Benefit (PHP mil.)	Net Benefit (PHP mil.)	BCR
1	Do nothing	1.44	-	(1.44)	-
2	PT stops after Int + Traffic Signal	5.01	1.17	(3.84)	0.23
3	PT stops after Int + Rerouting + Traffic Signal	5.04	203.55	198.51	40.36
4	PT stops after Int + Rerouting + Median	1.79	84.18	82.39	47.14

Scenario	Description	Cost (PHP mil.)	Benefit (PHP mil.)	Net Benefit (PHP mil.)	BCR
5	PT stops after Int + Rerouting + Traffic Signal + Median	5.39	197.76	192.38	36.71
6	PT stops after Int + Rerouting + Traffic Signal + Median + Footbridge	10.73	209.88	199.15	19.56
Best Case Scenario: S6					

Source: Caloocan CPT.

The most economical alternative in terms of the BCR and net benefits is scenario 6 considering a study period of six (6) years and an discount rate of 12%. This scenario will improve the LOS of the intersection from F to B, reduce delay by 72%, and increase the weighted mean speed of vehicles by 68%.

The results of the economic evaluation critically hinged on the assumptions listed below.

(a) **Foot Traffic per Hour:** In the study, it was assumed to be 500 pedestrians per hour. Higher values of foot traffic will increase accident costs and would further increase the BCR and net benefits of scenario 6.

(b) **Land Acquisition Cost for the Footbridge:** The cost of the footbridge does not include land acquisition, which may be required under scenario 6. The land acquisition cost has higher land value because the area is situated in a commercial zone. If this cost is included, the BCR and net benefits will decrease. However, there is no sufficient data that the result of the evaluation would change.

(c) **O&M Cost:** The O&M cost is assumed to be 10% of the Initial Investment Cost. If this cost can be broken down in even more detail, then the evaluation would become more reliable.

(d) **Time Period considered in Accident Rate Calculation:** The time period adopted to calculate the accident rate was short and may overestimate the accident rate.

4.6 Mandaluyong City: F. Martinez Avenue–San Rafael Street Intersection

F. Martinez Avenue, northern leg of intersection

F. Martinez Avenue, southern leg of intersection

San Rafael Street, western leg of intersection

San Rafael Street, eastern leg of intersection

Source: Mandaluyong CPT and JPT

Figure 4.7: F. Martinez Avenue–San Rafael Street Intersection

1) Traffic Volumes

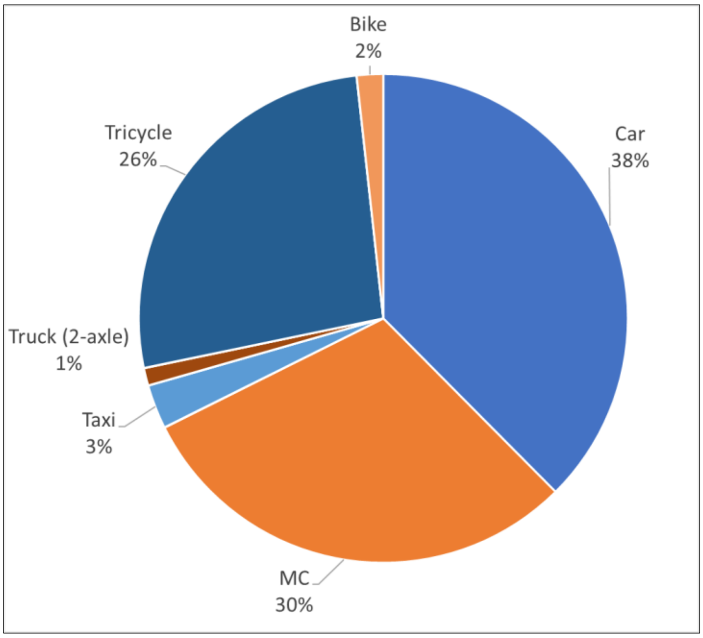
A 14-hour volume count survey was conducted on 12 February 2020, Wednesday, at F. Martinez Avenue–San Rafael Street. It was found that the AM and PM peak hours were 8:00AM–9:00AM and 3:00PM–4:00PM, respectively.

Table 4.17: Hourly Volume Count by Vehicle Classification

Time of the Day	Car	Motor cycle	Jeep	UV	Taxi	Pub lic Bus	Small Van	Truck (2-Axle)	Truck/ Trailer	Tanker/ Semi Tanker	Tricycle	Pedicab	Other	Bike	Total
06:00–07:00	1106	1009	7	0	136	1	0	48	0	0	947	0	0	149	3403
07:00–08:00	1464	1366	0	1	108	2	0	26	1	0	1263	1	0	220	4452
08:00–09:00	1424	1626	0	0	105	0	0	31	0	0	1198	0	0	118	4502
09:00–10:00	1538	1333	1	0	131	1	0	51	0	0	1156	0	0	65	4276
10:00–11:00	1573	1401	0	1	148	0	0	64	3	0	1129	0	0	54	4373
11:00–12:00	1652	1348	0	0	134	0	0	77	2	0	1014	0	0	34	4261
12:00–13:00	1449	1175	0	0	127	0	0	53	1	0	823	0	0	35	3663
13:00–14:00	1346	877	1	1	87	0	0	48	1	0	930	0	0	39	3330
14:00–15:00	1723	1231	0	0	135	0	0	46	1	0	1152	3	0	52	4343
15:00–16:00	1760	1237	0	0	132	1	0	72	1	0	1236	2	0	54	4495
16:00–17:00	1521	1117	0	0	119	0	0	42	0	0	1020	0	0	47	3866
17:00–18:00	1620	1129	0	0	101	0	0	38	0	0	1042	0	0	57	3987
18:00–19:00	1589	1091	0	0	104	0	0	33	0	0	1090	0	0	36	3943
19:00–20:00	1404	1001	0	0	79	0	0	22	0	0	937	0	0	21	3464
Total	21169	16941	9	3	1646	5		651	10	0	14937	6	0	981	56358

Source: JPT based on MMDA data.

In the intersection, private cars dominated the vehicular distribution at 38%, followed by motorcycles with a 30% share. Tricycles had a significant share of 28%, while that of other vehicle types ranged from 0% to 3%.



Source: JPT based on MMDA data.

Figure 4.8: Vehicle Volume Distribution

2) Intersection Capacity Analysis

The F. Martinez Avenue–San Rafael Street intersection is unsignalized and was assessed as LOS F.

3) Signal Operation

There were no signal control facilities at the F. Martinez Avenue–San Rafael Street intersection. Traffic enforcers managed the traffic manually. As traffic from the east approach passed at the same time as that from the north approach, traffic enforcers alternately signaled “go” to the north and then south approaches.

4) Causes of Congestion

(i) Traffic enforcers prioritized the pedestrians crossing F. Martinez Avenue, causing delay for the northbound and southbound movements. There was no pedestrian crossing near the intersection. The absence of pedestrian lanes on both San Rafael and Martinez streets forced pedestrians to walk on carriageways. Pedestrians also simultaneously crossed the road along with the vehicles;

Source: Mandaluyong CPT

Figure 4.9: Pedestrians Crossing Along F. Martinez Ave.

(ii) Tricycles passing through from San Rafael Street east approach caused conflict, while the high volume of tricycles sometimes blocked other vehicles;

Source: Mandaluyong CPT

Figure 4.10: Tricycles Passing from San Rafael St.

(iii) There was inadequate manual control of vehicles and pedestrians; and

(iv) The four-lane F. Martinez Street could not accommodate the high volume of vehicles. Many motorists took this street to avoid heavy traffic congestion on EDSA. Stalled vehicles extend past the next intersection, i.e., F. Martinez Avenue–Fabella Road, which is about 100 to 200 meters from the case study intersection.

5) Proposed Traffic Management Scenarios

Improvements were proposed to ease the delay and make the intersection safer for pedestrians. Issues and countermeasures are presented in the table below, together with the impacts of each improvement measure.

Table 4.18: Proposed Improvements for F. Martinez Avenue–San Rafael Street Intersection

Problem	Improvement	Impact
1. Impedance caused by pedestrian crossing	• Lane markings and pedestrian facility modification	• Pedestrians are only allowed to cross the south leg of F. Martinez Avenue.
2. Flow approaching capacity due to large traffic demand		
3. Inadequate manual control of vehicles and pedestrians	• Multiprogram signal control	• Intersection delay slightly increased because of the addition of a dedicated green time for pedestrians crossing F. Martinez Avenue.

Source: JPT.

The base and alternative scenarios are described and shown in Table 4.19 and エラー! 参照元が見つかりません。, respectively. Multi-program signal controls are presented in Figure 4.11 Alternative Scenarios for F. Martinez Avenue–San Rafael Street Intersection

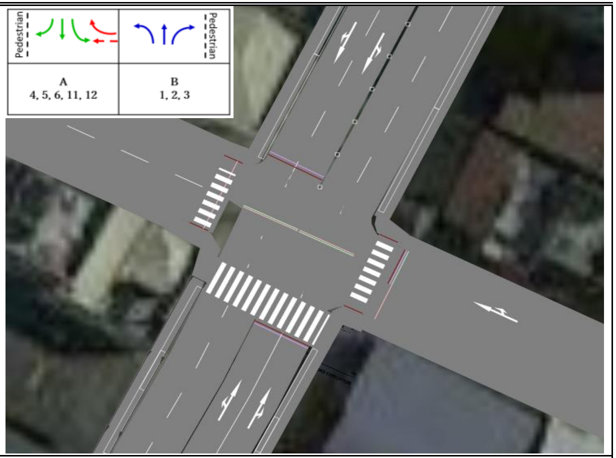
Table 4.20 and Table 4.21.

Table 4.19: Proposed Scenarios for F. Martinez Avenue–San Rafael Street Intersection

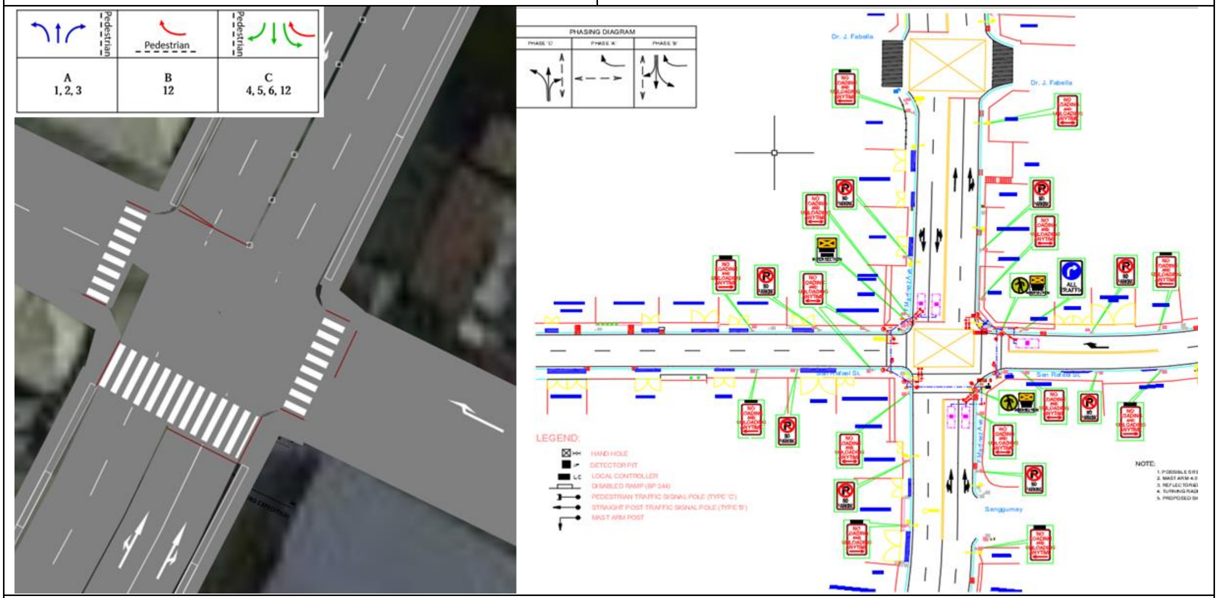
Scenario	Description
1. Base Scenario	• 2-phase signal control based on observed manual traffic management.
2. Lane Markings and Pedestrian Facility Modification	• Signal control same as Base Scenario. Estrella bridge is operational and shall reduce 30% of NB and SB thru movement volume.
3. Lane Markings and Pedestrian Facility Modification + Optimized 3-Phase Signal	• Aside from the impact of opening Estrella bridge, one phase was added to give way to pedestrian crossing F. Martinez Avenue and right turning from San Rafael Street Green time allocation was optimized using Webster's formula.

Source: JPT, Mandaluyong CPT, MMDA CPT.

Scenario 1: Base Scenario



Scenario 2: Lane Markings and Pedestrian Facility Modification



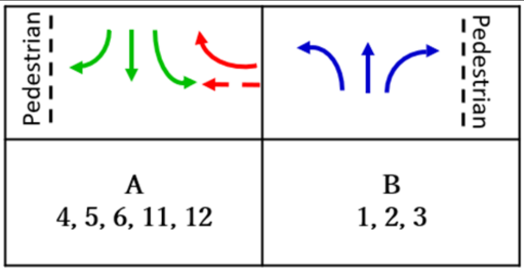
Scenario 3: Lane Markings and Pedestrian Facility Modification + Optimized 3-Phase Signal

Source: JPT.

Figure 4.11: Alternative Scenarios for F. Martinez Avenue–San Rafael Street Intersection

Table 4.20: Scenario 1 and Scenario 2 Signal Program

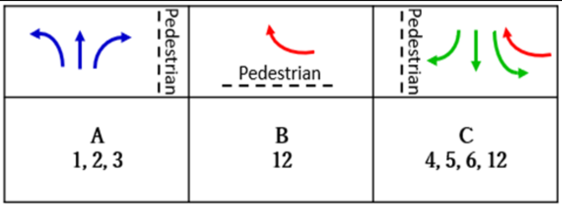
Item	Split		
	AM Peak	Off Peak	PM Peak
Phase A	79	41	72
Phase B	40	34	47
Cycle Length	119	75	119



Source: JPT.

Table 4.21: Scenario 3 Signal Program

Item	Split		
	AM Peak	Off Peak	PM Peak
Phase A	47	42	78
Phase B	20	20	20
Phase C	93	38	87
Cycle Length	160	100	185
Volume/Saturation Flow Rate	0.855	0.740	0.875



Source: JPT.

6) Microsimulation of Traffic Management Scenarios

The model for the base scenario was validated by GEH statistics. Values from all movements from the three study periods varied from 0.1 to 3.47, which met the GEH criterion (i.e., at least 85% of the movements should have GEH < 5.0).

Table 4.22 summarizes the results of the simulations for the AM peak (8:00AM–9:00 AM), off-peak (1:00PM–2:00PM), and PM peak hours (3:00PM–4:00PM). There was an 11% to 17% decrease in total volume due to the reduction of northbound and southbound thru movement volumes. It may be deduced from scenario 2 column that average queue decreased to 71%, 22%, and 60% during the AM peak, off-peak, and PM peak. On the other hand, improvements from scenario 3 caused longer average queues during the off-peak. Considering scenario 2, delay decreased from 13% during off-peak to about 37% during the AM and PM peak hours. However, adding a dedicated phase for pedestrians in scenario 3 resulted in a 3% increase in delay during AM and PM peaks and 35% increase during the off-peak. Weighted average speed from scenario 2 yielded 3% to 8% improvement. Meanwhile, there were varied changes in the weighted average speeds in scenario 3: the AM peak improved by 2%, but off-peak and PM peak decreased the speeds by 24% and 16%, respectively.

Table 4.22: Simulation Results by Scenario

AM Peak Hour	Unit	Scenario 1	Scenario 2	Scenario 3
KPI		Base Scenario AM 119 CL	LM and Pedestrian Facility Modification 119 CL	LM and Pedestrian Facility Modification + Opt. Signal 160 CL 3-Phase
1. Total Volume (Field Data)	veh	4,502	3,846	3,846
2. Total Volume (Simulation)	veh	4,232	3,764	3,691
3. Average Queue Length	m	87.30	25.22	57.10
4. Overall Delay	sec	58.65	36.95	60.26
5. LOS (Intersection Delay)	LOS	E	D	E
6. Weighted Average Speed	km/h	16.14	17.49	16.44

Off-peak Hour	Unit	Scenario 1	Scenario 2	Scenario 3
KPI		Base Scenario Off Peak 75 CL	LM and Pedestrian Facility Modification 75 CL	LM and Pedestrian Facility Modification + Opt. Signal 100 CL 3-Phase
1. Total Volume (Field Data)	veh	3,327	2,772	2,772
2. Total Volume (Simulation)	veh	3,241	2,726	2,714
3. Average Queue Length	m	12.41	9.65	16.77

Off-peak Hour	Unit	Scenario 1	Scenario 2	Scenario 3
KPI		Base Scenario Off Peak 75 CL	LM and Pedestrian Facility Modification 75 CL	LM and Pedestrian Facility Modification + Opt. Signal 100 CL 3-Phase
4. Overall Delay	sec	22.08	19.21	33.81
5. LOS (Intersection Delay)	LOS	C	B	C
6. Weighted Average Speed	km/h	19.31	19.91	14.60

PM Peak Hour	Unit	Scenario 1	Scenario 2	Scenario 3
KPI		Base Scenario PM 119 CL	LM and Pedestrian Facility Modification 119 CL	LM and Pedestrian Facility Modification + Opt. Signal 185 CL 3-Phase
1. Total Volume (Field Data)	veh	4,473	3,799	3,799
2. Total Volume (Simulation)	veh	4,305	3,712	3,665
3. Average Queue Length	m	67.12	26.48	65.86
4. Overall Delay	sec	58.77	37.40	60.54
5. LOS (Intersection Delay)	LOS	E	D	E
6. Weighted Average Speed	km/h	16.53	17.92	13.89

Source: JPT

7) Economic Evaluation

Benefits from time savings from AM and PM peak hours are shown in Table 4.23, while benefits from savings due to road crash reduction are presented in Table 4.24.

Table 4.23: Time Savings at AM and PM Peak Hours by Scenario

Item	Veh. Type/ Scenario	Scenario		
		Base	2	3
1. AM Benefits from Time Savings (PHP/year)	Car	0	1,401,209.29	933,687.72
	Motorcycle	0	715,263.59	486,264.24
	Truck	0	37,960.06	28,173.61
	Bike	0	32,943.13	25,142.74
	Tricycle	0	510,206.12	387,026.76
	Total	0	2,697,582.19	1,860,295.08
2. PM Benefits from Time Savings (PHP/year)	Car	0	1,663,328.55	1,326,639.32
	Motorcycle	0	414,447.15	309,948.35
	Truck	0	65,682.07	55,208.39
	Bike	0	8,416.90	5,345.26
	Tricycle	0	252,482.97	173,990.22
	Total	0	2,404,357.62	1,871,131.54

Source: JPT.

Table 4.24: Savings from Road Crash Reduction due to Traffic Signalization

Item		Damage to Property	Injury		Total
			Non-Fatal	Fatal	
1. Unit Cost 2005 (PHP/year)		55,000	350,000	2,273,000.00	2,678,000
2. Unit Cost 2020 (PHP/year)		301,046.12	1,915,748.02	12,441,414.97	14,658,209
3. No. of Accidents	2017	6	0	0	6
	2018	10	1	0	11
	2019	4	2	0	6
	Average	7	1	0	8
4. Reduced Accidents (65.6%)		4.592	0.656	0	
5. Benefits Carried by Signalization (PHP)		1,382,403.77	1,256,730.70	-	2,639,134.47

Source: JPT.

8) Estimation of Costs

(a) **Initial Investment Cost:** The proposed work for scenario 2 includes the application of reflectorized thermoplastic markings, installation of standard traffic road signs, and supply and construction of geometric improvements. Scenario 3 includes the supply and installation of traffic signals. Table 4.25 lists the Initial Investment Costs of the alternative scenarios.

Table 4.25: Initial Investment Costs by Scenario

Cost	Scenario 2	Scenario 3
1. Total Direct Cost (PHP)	743,876.00	3,367,147.00
2. Indirect Cost (25% Mark-up) (PHP)	185,969.00	841,786.75
3. Total VAT (PHP)	111,581.40	505,072.05
4. Total Estimated Cost (PHP)	1,041,426.40	4,714,005.80

Source: MMDA CPT.

(b) **O&M Cost:** Considering two shifts a day and a monthly pay of PHP12,000.00 per enforcer, the total O&M cost is estimated to be PHP576,000.00 per year.

9) Evaluation Results

Table 4.26 and Table 4.27 summarize the total benefits and cost, as well as the BCR and net benefits of the two alternative scenarios at year 1 and 3, respectively. Savings from road crash reduction were only added to scenario 3 because of its dedicated signal phase for pedestrians. In Figure 4.12, it may be noticed that approximately 50% of the total benefits comprise savings from road crash reduction. While scenario 3 yielded a BCR lower than 1.5 units, it is expected to have a 3.1 BCR at year 3. Scenario 3 is also the more desirable option because it prioritizes pedestrian safety.

Table 4.26: Results of Cost-Benefit Analysis of Proposed Scenarios at Year 1

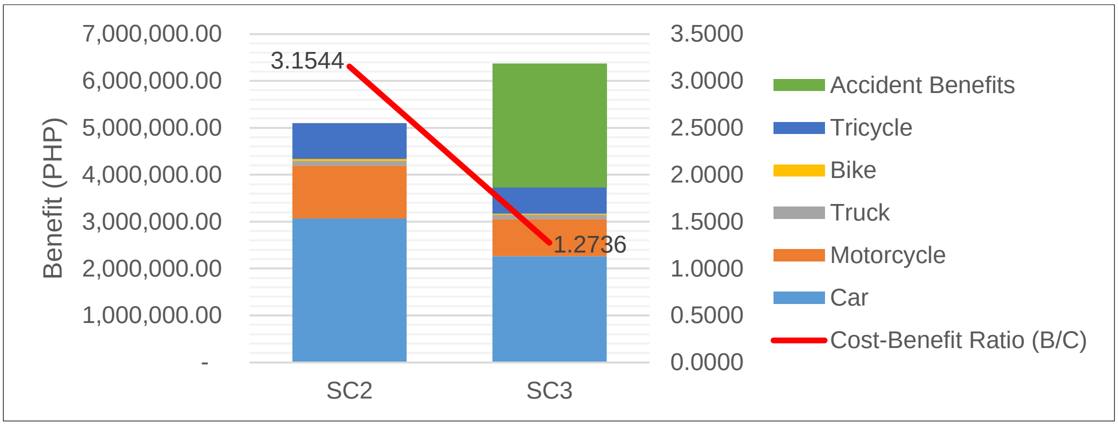
Scenario	First Year							
	Benefit			Cost			BCR	Net Benefit (PHP)
	Time Saving (PHP/year)	Accident Saving (PHP/year)	Total Benefits (PHP/year)	Initial Investment Cost (PHP)	O&M Cost (PHP/year)	Total Cost (PHP/year)		
2	5,101,939.81		5,101,939.81	1,041,426.40	576,000.00	1,617,426.40	3.2	3,484,513.4128
3	3,731,426.62	2,639,134.47	6,370,561.09	4,714,005.80	5,002,005.80	5,002,005.80	1.3	1,368,555.29

Source: JPT.

Table 4.27: Results of Cost-Benefit Analysis of Proposed Scenarios at Year 3

Scenario	Benefit	Cost			BCR at Year 3	Net Benefit at Year 3 (PHP)
	Cumulative Benefit at Year 3 (PHP)	Initial Investment Cost (PHP)	Cumulative O&M at Year 3 (PHP)	Total Cumulative Cost at Year 3 (PHP)		
2	13,724,478.40	1,041,426.40	1,728,000.00	2,769,426.40	4.9557	,955,052.00
3	17,137,134.36	4,714,005.80	864,000.00	5,578,005.80	3.0723	,559,128.56

Source: JPT.

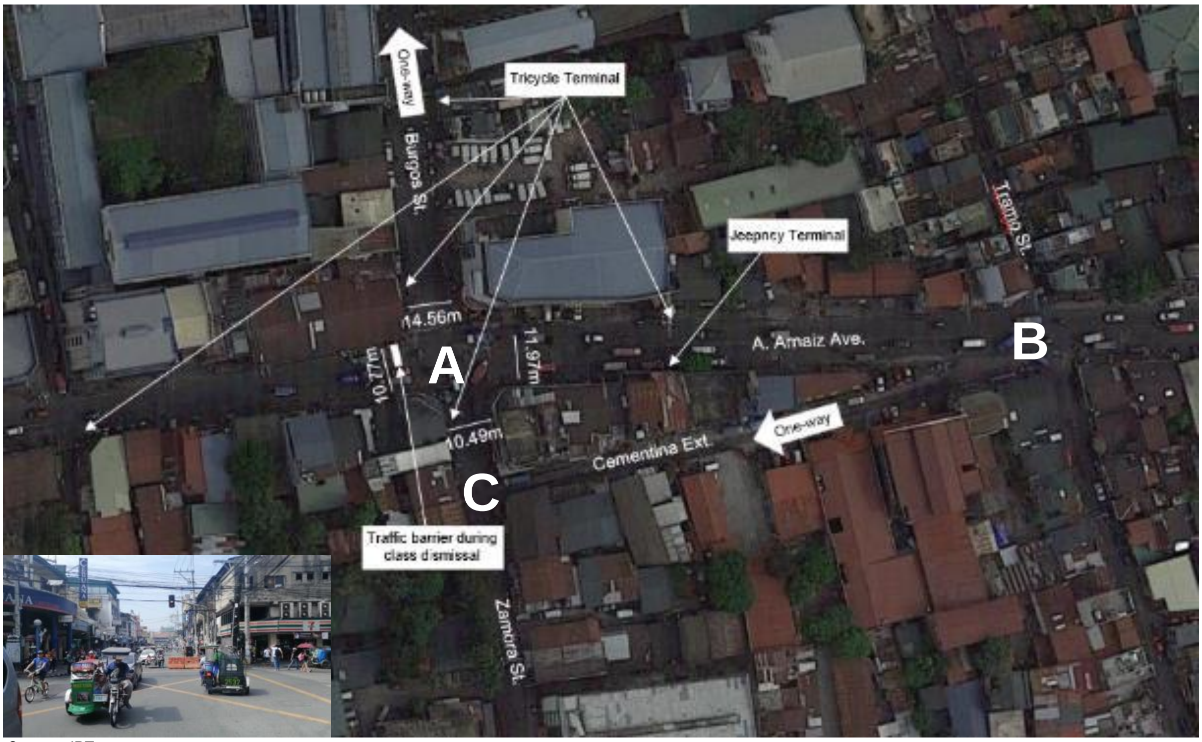


Source: JPT

Figure 4.12: Benefits from Proposed Scenarios at Year 1

4.7 Pasay City: A. Arnaiz Avenue–P. Burgos Street–P. Zamora Street Intersection

Besides the target intersection (A), two other intersections were included in the case study due to the effect of the former has on these two intersections, which are A. Arnaiz Avenue–Cementina Extension–Tramo Street (B) and Zamora Street–Cementina Extension (C).



Source: JPT

Figure 4.13: Studied Intersections in Pasay City

1) Traffic Volumes

Pasay City provided a peak hour count (10:00AM–11:00AM) which was conducted on 17 February 2021 as vehicle input for the simulation. The traffic count at Intersection A was also used to estimate the counts for Intersection B. Only right turning jeepneys from Intersection A were assumed to exit Cementina Extension at Intersection C. The classified vehicle counts during the AM peak hour are shown in Table 4.28: Traffic Counts at Intersections A and B during AM Peak Hour by Mode.

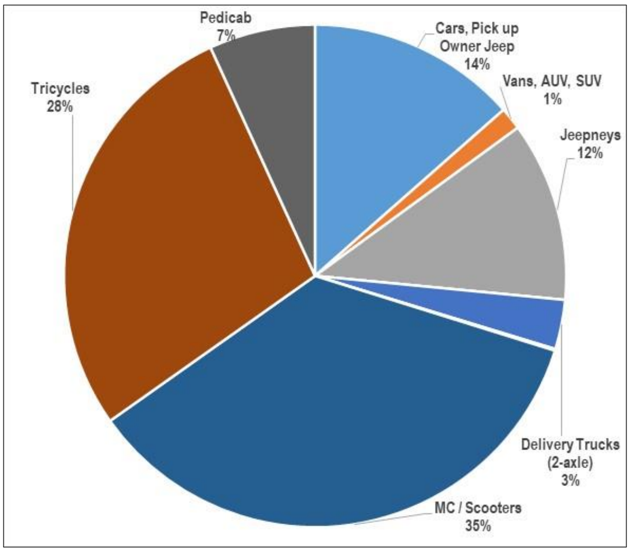
Table 4.28: Traffic Counts at Intersections A and B during AM Peak Hour by Mode

Inter-section	Move-ment	Car, Pickup Owner Jeep	Van, AUV, SUV	PUJ	PUB	Delivery Truck (2-axle)	Truck (>3 axles)	Motorcycle / Scooter	Tricycle	Pedicab	Total	PCU
A	M1	35	0	58	0	4	0	65	88	18	268	248
	M2	13	2	71	0	9	0	23	14	0	132	163
	M3	0	0	4	0	0	0	278	218	70	570	376
	M4	155	0	124	0	40	0	119	61	24	523	549
	M5	11	2	16	0	3	1	20	21	3	77	75
	M6	119	27	3	0	20	4	245	185	45	648	507
	M7	1	0	0	0	0	0	22	30	7	60	42
	Total	334	31	276	0	76	5	772	617	167	2,278	1,960
B	M1	0	0	63	0	0	0	0	0	0	63	95

Inter-section	Move-ment	Car, Pickup Owner Jeep	Van, AUV, SUV	PUJ	PUB	Delivery Truck (2-axle)	Truck (>3 axles)	Motorcycle / Scooter	Tricycle	Pedicab	Total	PCU
	M2	1	2	1	0	0	0	78	56	5	143	93
	M3	10	3	3	0	1	0	43	65	2	127	95
	M4	2	0	0	0	0	0	15	17	2	36	25
	M5	5	1	0	0	1	0	33	30	3	73	51
	M6	4	1	0	0	0	0	30	20	2	57	38
	M7	3	2	0	0	0	0	40	18	3	66	42
	M8	109	22	71	0	33	0	173	133	30	571	521
	M9	20	5	3	0	0	0	55	48	12	143	105
	M10	0	0	71	0	0	0	0	0	0	71	107
	M10a	2	2	1	0	1	0	40	33	6	85	59
	M11	151	0	61	0	39	0	371	259	92	973	787
	M12	1	0	0	0	0	0	33	33	1	68	45
	Total	308	38	274	0	75	0	911	712	158	2,476	2,063

Source: JPT based on Pasay City data.

As shown in Figure 4.14, motorcycles and tricycles dominate the vehicle composition with 35% and 28% mode share, respectively. Private cars make up only 14%, while PUJs are at 12%. Trucks, pedicabs, and SUVs contribute a total of 10%.



Source: JPT

Figure 4.14: Vehicle Composition

2) Intersection Capacity Analysis

The unsignalized intersections of B and C were assessed to have LOS of F and B, the latter due to low traffic coming from Cementina Extension.

3) Signal Operation

Although Intersection A is a signalized intersection, traffic enforcers could be seen managing the traffic along A. Arnaiz Avenue.

4) Causes of Congestion

(i) High volume of people fetching their children from school together with counterflowing;

(ii) Illegal parking, road construction, ambulant vendors occupying the carriageway, boarding and alighting by PUJs and motorcycles;

(iii) PUJ and tricycle terminals had their terminals on the carriageway and sidewalk, blocking parts of the roads;

(iv) Enforcers installed roadblocks or cones on the road; and

(v) The signal program at Intersection A was not optimized so traffic enforcers had to manage traffic when long queues occurred.

Source: JPT

Figure 4.15: Causes of Congestion

5) Proposed Traffic Management Scenarios

The Arnaiz Avenue–Zamora Street–Burgos Street (A) intersection was initially selected as the only intersection to be analyzed. However, certain proposed improvements would directly affect B and C intersections. Problems and improvements are enumerated in Table 4.29, while the impacts of the proposed alternatives are shown in Table 4.30.

Table 4.29: Proposed Improvements for the Intersections

Problem	Improvement
1. Permissive left turn at intersection A west approach.	• Modify the existing traffic signal. • Reconfigure lane along Arnaiz Avenue.
2. Lack of necessary pavement markings and traffic signage.	• Repaint pavement markings and install traffic signages.
3. Unregulated boarding/ alighting	• Regulate PT.
4. Tricycle and jeepney terminals encroaching on carriageway.	• Relocate tricycle and PUJ terminals.
5. Queue at intersection B west approach because of PUJs entering Cementina Extension.	• Allow counter clockwise flow at Arnaiz Avenue-Zamora Street-Cementina Extension.

Source: JPT

Table 4.30: Impacts of Proposed Improvements

Improvement	Impact
1. Optimize Signals at Intersection A	• Decrease in average delay. • Reduction in vehicle conflicts.
2. Signalize Intersection B	
3. Reconfigure Lane along Arnaiz Avenue	• Increase in road capacity.
4. Regulate PT	• Decrease in delay due to encroaching PUVs. Tricycle and PUJ terminals are farther from the intersections.
5. Change Traffic Flow along Cementina Extension	• Right-turning vehicles from Arnaiz Avenue at Intersection B will have possible conflicts with vehicles coming from Cementina Extension. Approximately 60 vehicles need to be rerouted.
6. Restrict On-street Parking along Burgos St.	• Increase in road capacity.

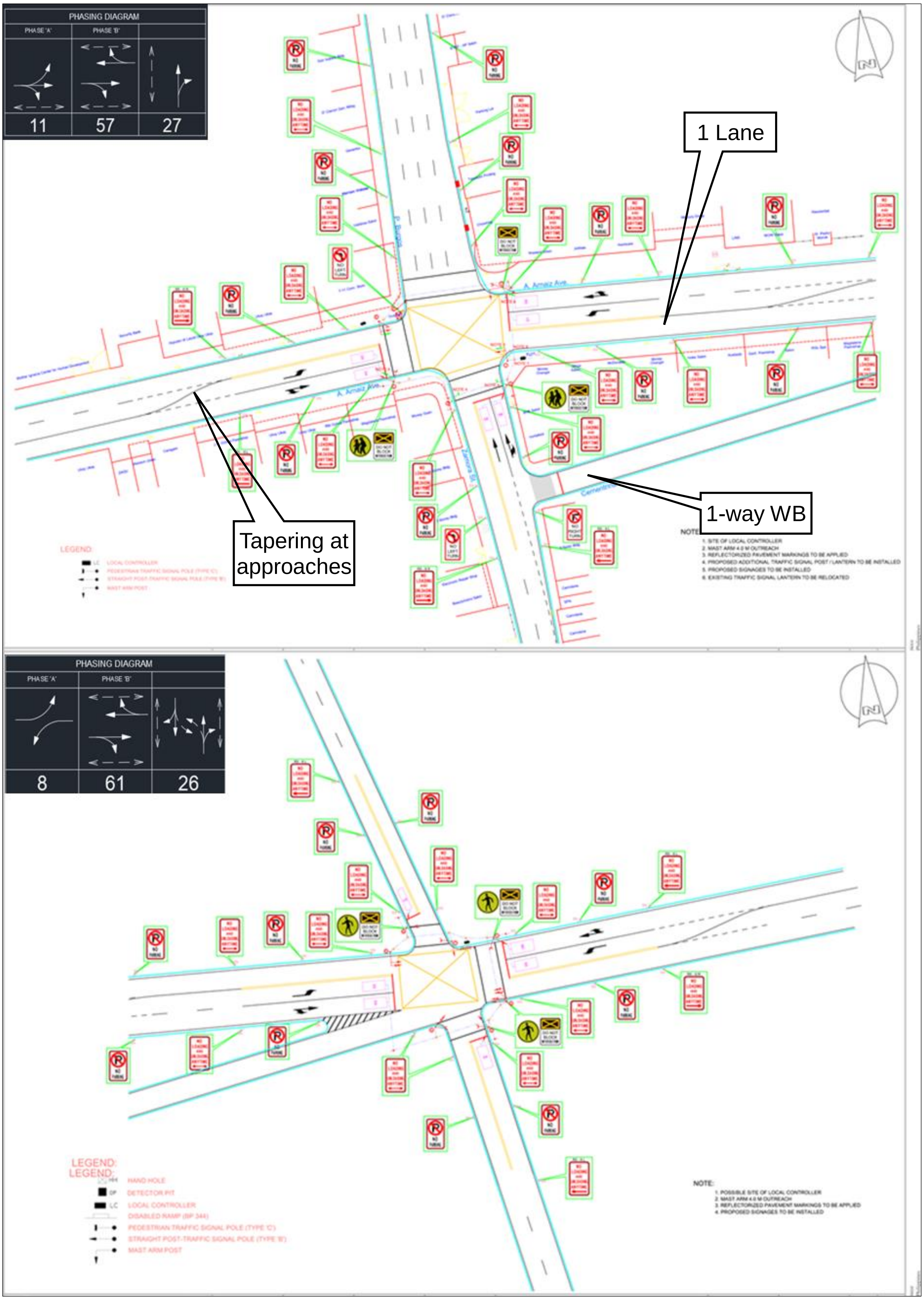
Source: JPT

The proposed scenarios and their components are shown in Table 4.31. Moreover, Figure 4.16 to Figure 4.18 show the proposed alternative scenarios.

Table 4.31: Proposed Improvement Measures under Scenario 2

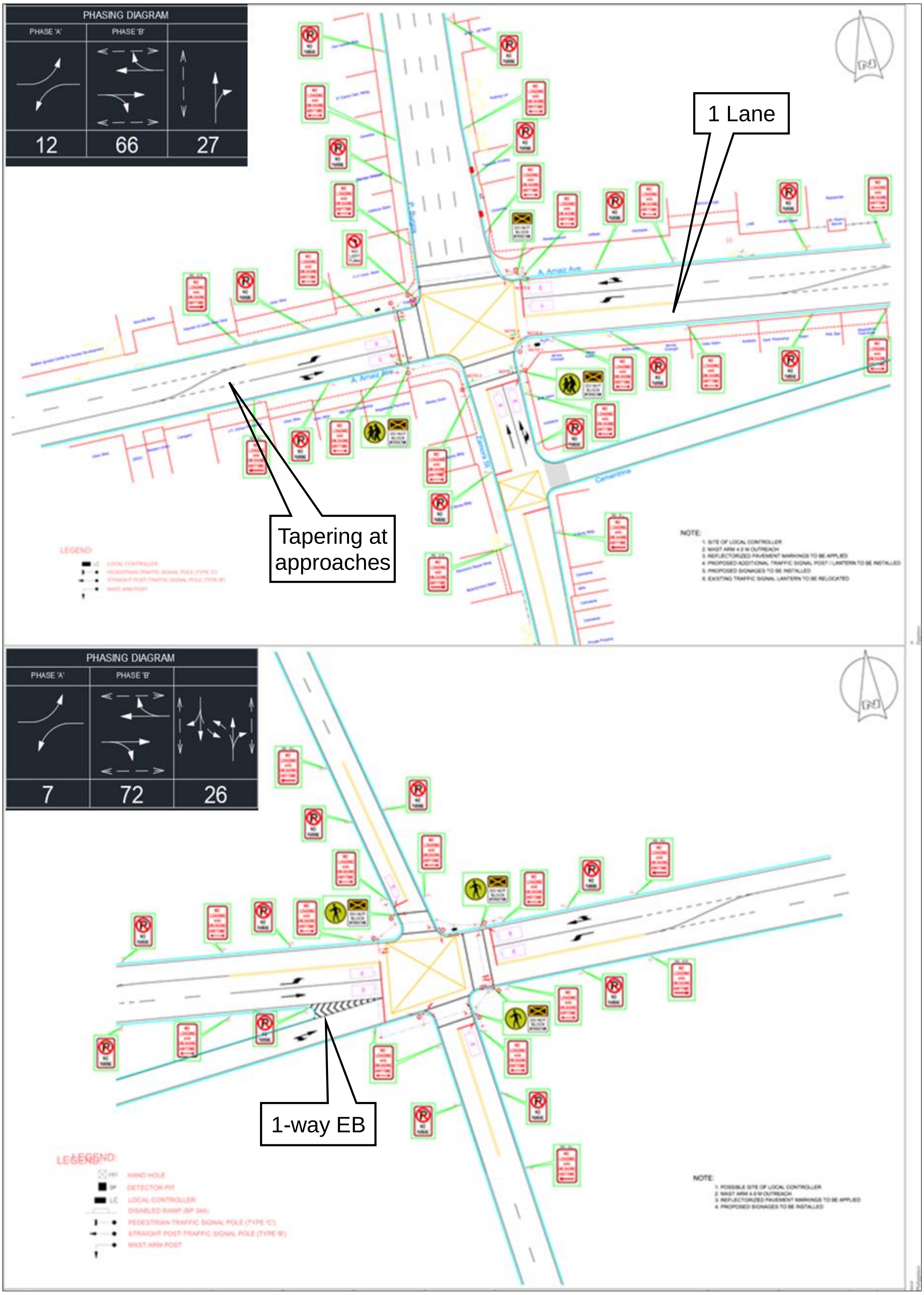
Improvement Measure		Scenario 2		
		A	B	C
1. Modification of Existing Traffic Signal at Intersection A		X	X	X
2. Proposed Traffic Signal at Intersection B		X	X	X
3. Repainting Pavement Markings		X	X	X
4. Lane Configuration along Arnaiz Avenue	a. Additional 2 Lanes from Burgos/Zamora to Tramo			X
	b. Tapering	X	X	
5. Installation of Traffic Signages		X	X	X
6. PT Regulation	a. Relocation of Tricycle and Jeepney Terminals	X	X	X
	b. No boarding and Alighting Areas	X	X	X
7. Change in Traffic Flow along Cementina Extension			X	
8. Restriction of On-street Parking along Burgos Street		X	X	X

Source: JPT and MMDA CPT



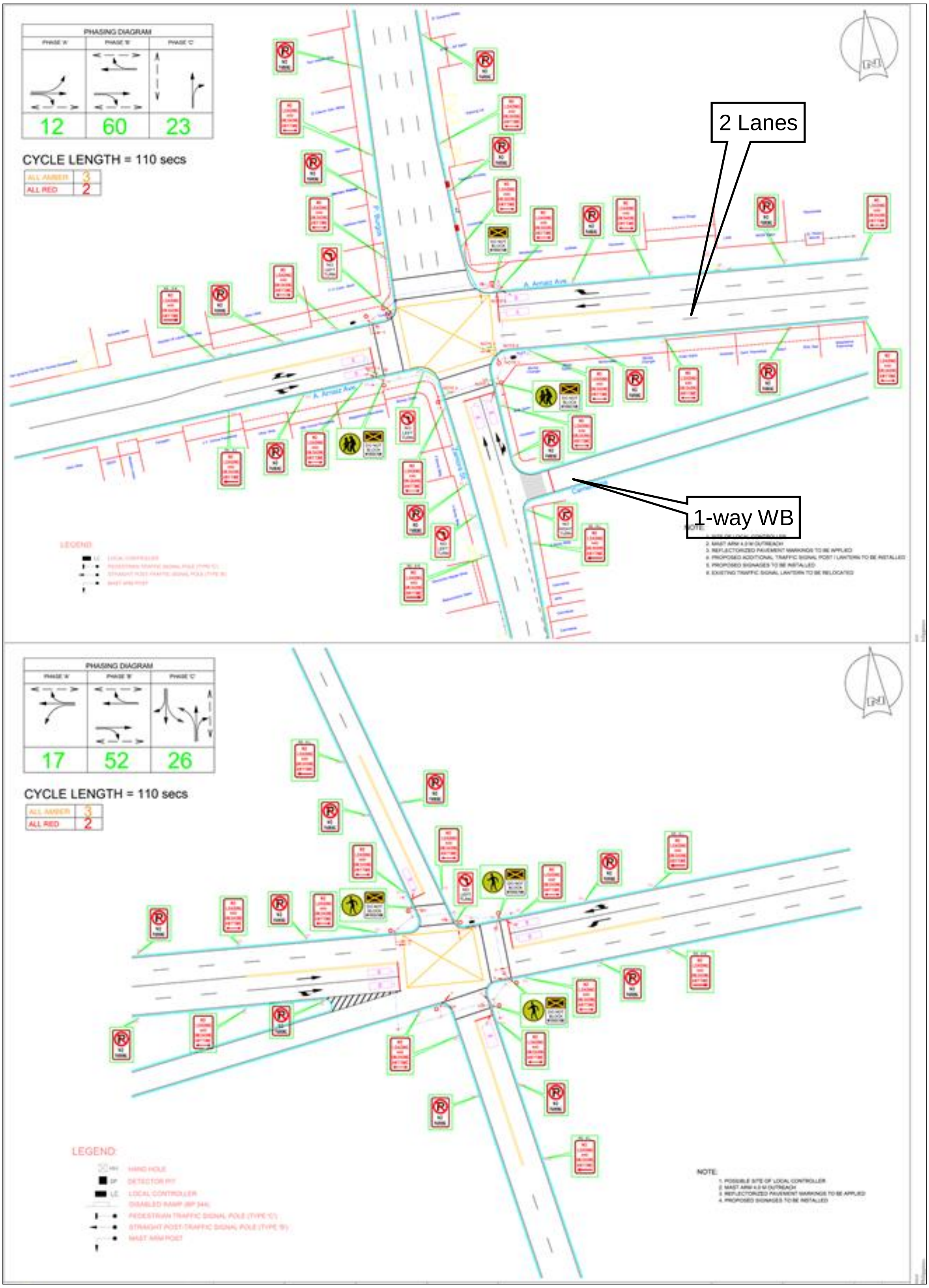
Source: MMDA CPT

Figure 4.16: Scenario 2A



Source: MMDA CPT

Figure 4.17: Scenario 2B



Source: MMDA CPT

Figure 4.18: Scenario 2C

6) Microsimulation of Traffic Management Scenarios

The base model was validated by GEH statistics. Values from all 23 movements in the AM peak varied from 0.0 to 4.71, which passed the GEH criterion (i.e., at least 85% of the movements should have GEH < 5.0).

Table 4.32 summarizes the results of the simulations of the AM peak (10:00–11:00AM). All proposed alternative scenarios resulted in a decrease in total network delay. Scenario 2C yielded the highest decrease at 35.93%. Consequently, it had the highest average network travel speed with 35.09% increase from the base scenario. Although there were improvements in the network delay, scenarios 2A and 2B (counterclockwise flow along Cementina Extension) created longer queues and longer intersection delays at Intersection B. Overall, the best alternative is scenario 2C.

Table 4.32: Simulation Results for Scenario 2 at AM Peak Hour

KPI	Unit	Base	Scenario 2		
			A	B	C
1. Total Network Delay	sec	417,540.5	349,574.7	328,221.8	267,503.7
2. Average Network Delay	sec	155.0	138.6	133.4	102.9
3. Average Network Travel Speed	km/h	5.7	6.2	6.4	7.7
4. Vehicle Count (model)	veh	2545	2388	2339	2492
5. Weighted Speed (km/h)	A	4.1	4.6	4.8	6.7
	B	4.8	3.6	3.8	7.0
	C	4.9	14.0	11.0	16.5
6. Average Queue (m)	A	50.0	29.0	33.6	24.5
	B	38.7	43.6	45.8	27.7
	C	22.3	2.3	2.9	1.2
7. Intersection Delay (s)	A	79.5	63.0	64.9	48.6
	B	68.6	94.8	90.6	67.5
	C	202.2	16.0	10.2	18.8
8. Level of Service (LOS)	A	E	E	E	D
	B	F	F	F	E
	C	F	C	A	C

Source: JPT

7) Economic Evaluation

Time savings from the AM peak were doubled to account for the PM peak, as shown in Table 4.33. Tapering lane configuration along A. Arnaiz Avenue in scenario 2A yielded negative time savings from almost all vehicle types except PUJs. Savings from road crash reduction (Table 4.34) were added to time savings to estimate the total benefits for each alternative. Scenario 2C has the highest total benefits of PHP12, 013,626.14.

Table 4.33: Time Savings at AM and PM Peak Hours under Scenario 2

Item	Veh. Type\ Scenario	Base	Scenario 2		
			A	B	C
1. AM Benefits from Time Savings (PHP/year)	Car	0	-357,690.01	309,041.84	890,943.38
	UV	0	-70,188.12	43,368.68	123,301.62
	Jeepney	0	1,086,816.21	487,461.39	1,674,756.41
	Truck	0	-110,620.29	50,900.44	134,560.11
	Motorcycle	0	-563,649.07	528,136.26	613,648.28
	Tricycle	0	-420,517.66	494,808.06	520,718.63
	Pedicab		-15,798.93	18,640.29	2,208.93
	Total	0	-451,647.89	1,932,356.96	3,960,137.36

Item	Veh. Type\ Scenario	Base	Scenario 2		
			A	B	C
2. PM Benefits from Time Savings (PHP/year)	Car	0	-357,690.01	309,041.84	890,943.38
	UV	0	-70,188.12	43,368.68	123,301.62
	Jeepney	0	1,086,816.21	487,461.39	1,674,756.41
	Truck	0	-110,620.29	50,900.44	134,560.11
	Motorcycle	0	-563,649.07	528,136.26	613,648.28
	Tricycle	0	-420,517.66	494,808.06	520,718.63
	Pedicab		-15,798.93	18,640.29	2,208.93
	Total	0	-451,647.89	1,932,356.96	3,960,137.36

Source: JPT

Table 4.34: Savings from Road Crash Reduction Due to Traffic Signalization

Item		Damage to Property	Injury		Total
			Non-Fatal	Fatal	
1. Unit Cost 2005 (PHP/year)		55,000	350,000	2,273,000.00	2,678,000
2. Unit Cost 2020 (PHP/year)		301,046.12	1,915,748.02	12,441,414.97	14,658,209
3. No. of Accidents	2017	6	1	0	7
	2018	10	1	0	11
	2019	6	2	0	8
	Average	8	2	0	10
4. Reduced Accidents (65.6%)		5.248	1.312	0	
5. Benefits Carried by Signalization (Warrant: Volume & Crashes) (PHP)		1,579,890.02	2,513,461.40	0.00	4,093,351.42

Source: JPT

8) Estimation of Costs

(a) **Initial Investment Cost:** The proposed work for all scenarios included the supply and installation of reflectorized thermoplastic markings, as well as the installation of standard traffic road signs and traffic signals at intersections A and B. Table 4.35 enumerates the costs of the alternative scenarios.

Table 4.35: Initial Investment Costs by Scenario

Cost	Scenario 2		
	A	B	C
Total Direct Cost (PHP)	5,197,157.08	5,252,821.08	5,219,959.08
Indirect Cost (20% Mark-Up) (PHP)	1,039,431.42	1,050,564.22	1,043,991.82
Total VAT (PHP)	777,904.74	787,922.49	781,325.4
Total Estimated Cost (PHP)	7,014,493.24	7,091,307.79	7,045,275.94

Source: JPT

(b) **O&M Cost:** Considering two shifts a day and a monthly pay of PHP12,000.00 per enforcer, the total O&M cost is estimated to be PHP576,000.00 per year.

9) Evaluation Results

Table 4.36 and Table 4.37 summarize the total benefits and cost, as well as the BCR and net benefits, of the three (3) alternative scenarios at year 1 and 3, respectively. Figure 4.19 reflects the negative time savings from scenario 2A with a benefit-cost ratio of 0.42. On the other hand, scenario 2C had the highest total benefits and the most beneficial among all proposed alternatives.

Table 4.36: Results of Cost-Benefit Analysis of Scenario 2 at Year 1

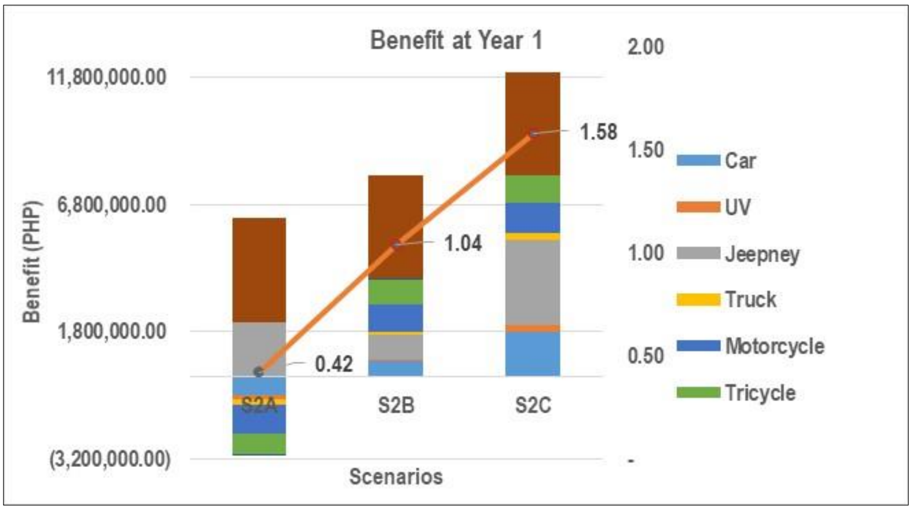
Scenario 2	Benefit			Cost			B/C Ratio at Year 1	Net Benefits at Year 1 (PHP)
	Time Saving (PHP/year)	Accident Saving (PHP/year)	Total Benefit (PHP/year)	Initial Investment Cost (PHP)	O&M Cost (PHP)	Total Cost (PHP/year)		
A	(903,295.77)	4,093,351.42	3,190,055.65	7,014,493.24	576,000.00	7,590,493.24	0.42	(4,400,437.59)
B	3,864,713.92	4,093,351.42	7,958,065.34	7,091,307.79	576,000.00	7,667,307.79	1.40	290,757.55
C	7,920,274.73	4,093,351.42	12,013,626.14	7,045,275.94	576,000.00	7,621,275.94	1.58	4,392,350.21

Source: JPT

Table 4.37: Results of Cost-Benefit Analysis of Scenario 2 at Year 3

Scenario 2	Benefit	Cost			B/C Ratio at Year 3	Net Benefits at Year 3 (PHP)
	Cumulative Benefit (PHP) at Year 3	Initial Investment Cost (PHP)	Cumulative O&M Cost (PHP) at Year 3	Total Cumulative Cost (PHP) at Year 3		
A	8,581,412.45	7,014,493.24	1,728,000.00	8,742,493.24	0.98	161,080.79
B	21,407,601.78	7,091,307.79	1,728,000.00	8,819,307.79	2.43	12,588,293.99
C	32,317,267.27	7,045,275.94	1,728,000.00	8,773,275.94	3.68	23,543,991.33

Source: JPT



Source: JPT

Figure 4.19: Benefits from Scenario 2 at Year 1

4.8 Pasig City: Pasig Boulevard Rotonda (Pasig Boulevard Extension–Dr. Sixto Antonio Avenue–C. Raymundo Avenue Intersection–Dr. Maldo del Rosario Street)

Pasig Boulevard Rotonda is composed of three intersections, namely, Pasig Blvd. Ext.–Dr. Sixto Antonio Avenue (A), Dr. Maldo del Rosario Street–Dr. Sixto Antonio Avenue (B), and C. Raymundo Avenue–Pasig Blvd. Ext. (C).

Source: Pasig CPT.

Figure 4.20: Pasig Boulevard Rotonda

1) Traffic Volumes

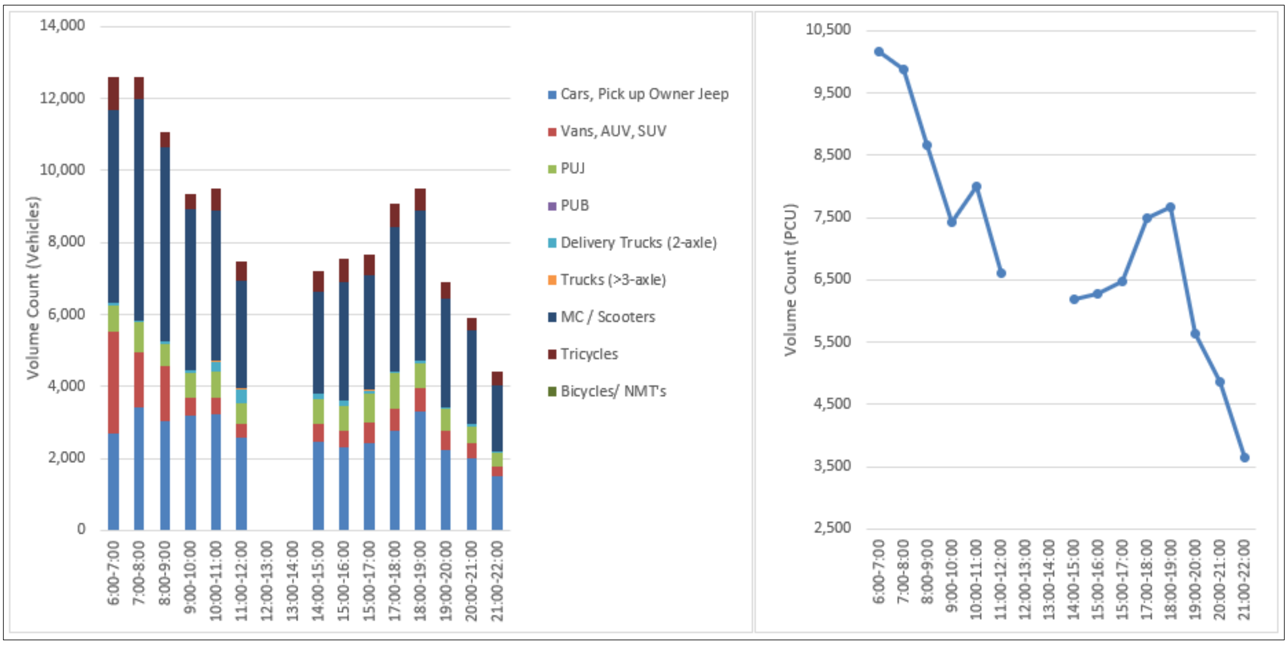
Intersection surveys were on 15 January 2020 (Wed) for intersections B and C and on 27 January 2020 (Mon) for Intersection A. Both intersections A and C were counted from 6:00AM to 12:00PM and from 2:00PM- to 10:00PM, but intersection B was surveyed only during the first half. Volume counts at intersection B during the afternoon were forecast using the modal share percentages at B and then combined the hourly volume percentages of A and C. The computed peak hours were 7:00AM to 8:00AM and 6:00AM to 7:00PM.

Table 4.38: Hourly Volume Count at Pasig Boulevard Rotonda by Vehicle Type

Time of Day	Mode									Total
	Car, Pickup, Owner Jeep	Van, AUV, SUV	PUJ	PUB	Delivery Truck (2-axle)	Truck (3-Axle)	MC/ Scooter	Tricycle	Bicycle/ NMT	
06:00–07:00	2,707	2,818	739	0	46	0	5,352	948	0	12,610
07:00–08:00	3,432	1,517	855	0	36	0	6,131	646	0	12,617
08:00–09:00	3,024	1,526	645	0	64	0	5,401	394	0	11,054
09:00–10:00	3,205	496	664	0	71	1	4,482	436	0	9,355
10:00–11:00	3,239	437	743	0	280	29	4,171	621	0	9,520
11:00–12:00	2,573	383	590	0	364	50	2,993	534	0	7,487
12:00–13:00										
13:00–14:00										

Time of Day	Mode									Total
	Car, Pickup, Owner Jeep	Van, AUV, SUV	PUJ	PUB	Delivery Truck (2-axle)	Truck (3-Axle)	MC/ Scooter	Tricycle	Bicycle/ NMT	
14:00–15:00	2,450	498	686	0	162	14	2,828	551	0	7,189
15:00–16:00	2,328	435	681	0	152	5	3,283	665	0	7,549
16:00–17:00	2,436	549	808	0	103	11	3,186	572	0	7,665
17:00–18:00	2,766	635	969	0	58	3	4,007	632	0	9,070
18:00–19:00	3,305	668	666	0	65	4	4,198	583	0	9,489
19:00–20:00	2,220	546	626	0	25	1	3,018	465	0	6,901
20:00–21:00	2,020	395	485	0	59	4	2,594	365	0	5,922
21:00–22:00	1,515	246	380	0	45	4	1,861	354	0	4,405
Total	37,220	11,149	9,537	0	1,530	126	53,505	7,766	0	120,833

Source: JPT based on Pasig City traffic counts.



Source: JPT based on MMDA data.

Figure 4.21: Hourly Volume Count by Intersection

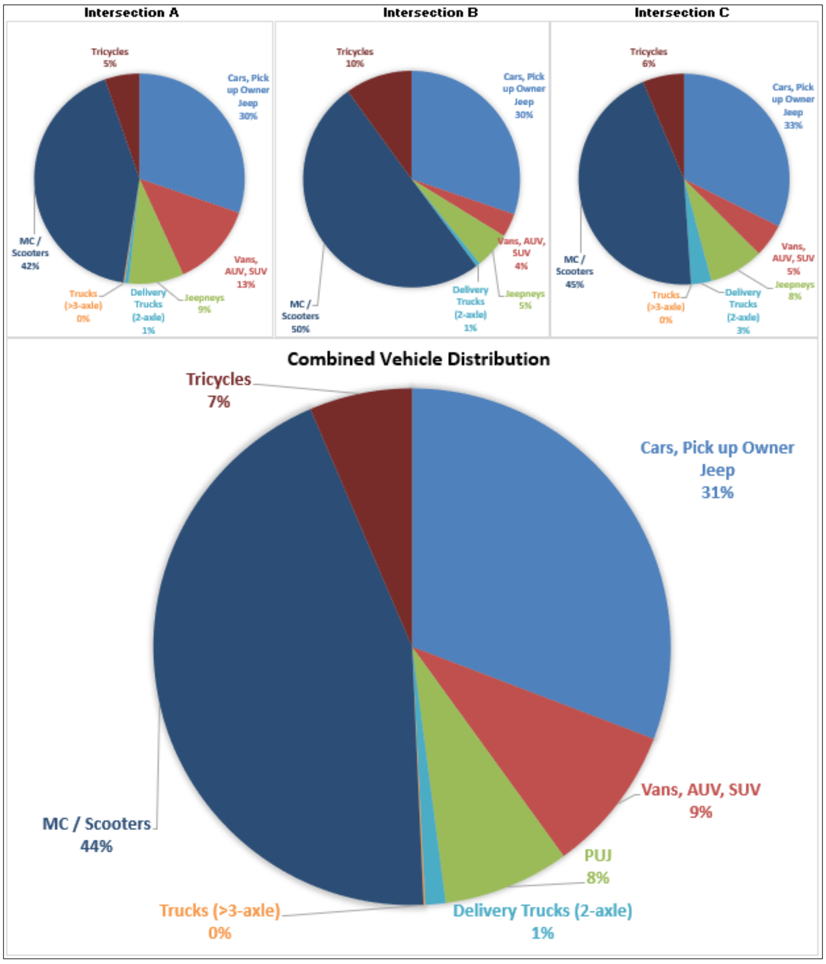
Table 4.38 sums up the traffic volume for all intersections per vehicle type and per hour. It showed that motorcycles had the largest modal share at 44%, followed by private cars at 31%. Public utility vehicles comprised 24% of the volume counts, while trucks only accounted for less than 2%.

2) Intersection Capacity Analysis

Using reserve capacity analysis, level of service was computed for unsignalized intersections within the rotunda. Intersections B and C had LOS rating of F during the AM peak hour, while intersection B south leg had an LOS A in the PM peak hour because of the two-way scheme along C. Raymundo Avenue.

(1) Signal Operation

Both intersections B and C are unsignalized intersections. And while traffic signals are present at Intersection A, they are not operational. Traffic enforcers manage the vehicles from morning to night.



Source: JPT.

Figure 4.22: Vehicle Volume Distribution

(2) Causes of Congestion

(i) In the morning, the east leg at Intersection A is given another lane, thereby allowing traffic counter flow which reduces the lanes for left-turning traffic;

(ii) Vehicles queue because of traffic from the establishments around the intersection;

(iii) Large volume of foot traffic causes delay;

(iv) There is illegal boarding and alighting along C. Raymundo Avenue;

(v) Queue on Julia Vargas Bridge from C5 service road decreases capacity of the west leg exit lanes; and

(vi) Inadequate manual control of vehicles and pedestrians.

Source: Pasig LGU

Figure 4.23: Causes of Congestion

(3) Proposed Traffic Management Scenarios

Improvements were proposed to ease delay and make the intersections safer for pedestrians. Issues and countermeasures are presented in Table 4.39. Also, impacts of the respective improvements are enumerated in Table 4.40.

Table 4.39: Proposed Improvements for the Intersections

Problem	Improvement
1. Inadequate manual control of vehicles and pedestrians	• Optimize signals at Intersection A.
2. Flow approaching capacity due to large traffic demand	• Implement geometric improvements.
3. Illegal boarding and alighting	• Regulate PT.
4. Changing traffic schemes	• Choose appropriate flow for the whole day.

Source: JPT.

Table 4.40: Impacts of Proposed Improvements

Improvement	Impact
1. Signal Optimization at Intersection A	• Decrease in average network delay.
2. Geometric Improvements	• Increase in capacity.
3. Public Transport Regulation	• Decrease in delay at Intersection A west leg.
4. One-way Flow at C. Raymundo Avenue	• Higher delay during PM Peak because larger demand goes eastbound.
5. Two-way Flow at C. Raymundo Avenue	• Higher delay during AM Peak because larger demand goes westbound.
6. Footbridge at Intersection A east leg	• Safer pedestrian crossing. Additional cost for sidewalk clearing or land acquisition.

Source: JPT.

Described in Table 4.41 are the base scenario and the alternative scenarios. The base scenario has one-way flow along C. Raymundo Avenue during the AM peak hour and a two-way flow during the PM peak hour.

Table 4.41: Proposed Improvement Measures under Scenarios 2 and 3

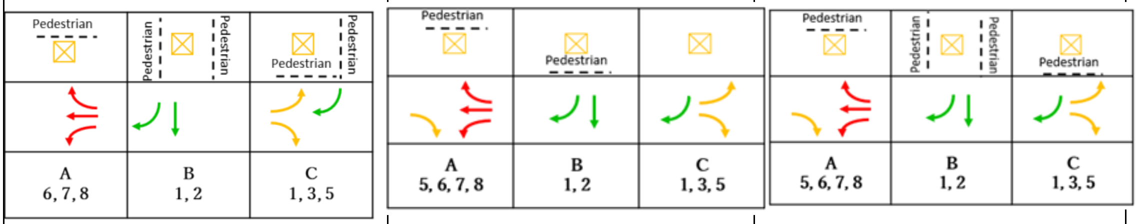
<table>
<tr><th colspan="2" rowspan="3">Improvement Measure</th><th colspan="5">Scenario</th></tr>
<tr><th rowspan="2">Base</th><th colspan="2">2</th><th colspan="2">3</th></tr>
<tr><th>A</th><th>C</th><th>A</th><th>C</th></tr>
<tr><td rowspan="2">1. Signal Optimization</td><td>With Footbridge</td><td></td><td>x</td><td></td><td>x</td><td></td></tr>
<tr><td>Shared Right Turn w/ Pedestrian</td><td></td><td></td><td>x</td><td></td><td>x</td></tr>
<tr><td rowspan="2">2. Geometric Improvement</td><td>Lane Configuration (Intersection A)</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td>North Approach at 4.7 m (Intersection A)</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td colspan="2">3. Prohibit 1 PT stop before Intersection A</td><td></td><td>x</td><td>x</td><td>x</td><td>x</td></tr>
<tr><td colspan="2">4. One-way flow along C. Raymundo Avenue</td><td>AM</td><td>x</td><td>x</td><td></td><td></td></tr>
<tr><td colspan="2">5. Two-way flow along C. Raymundo Avenue</td><td>PM</td><td></td><td></td><td>x</td><td>x</td></tr>
</table>

Source: JPT.

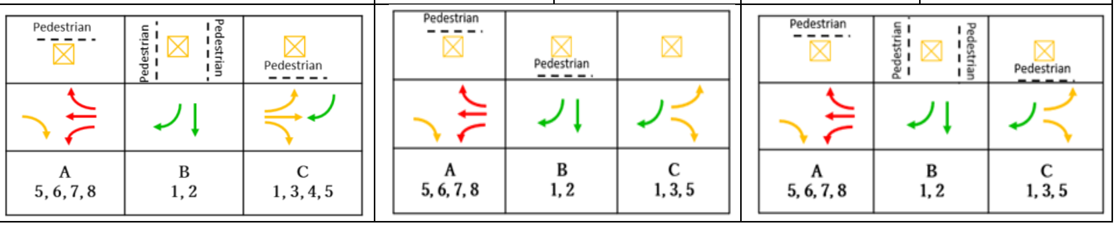
The base scenario was assumed to be managed by traffic enforcers; thus, the split time is only comprised of a green time and a two-second all-red time. The alternative scenarios, on the other hand, have a three-second amber and a two-second all-red time.

Table 4.42: Signal Program by Scenario

AM	Scenario				
	Base	2A	3A	2C	3C
Phase A	59	68	94	94	94
Phase B	77	61	79	85	79
Phase C	64	16	27	21	27

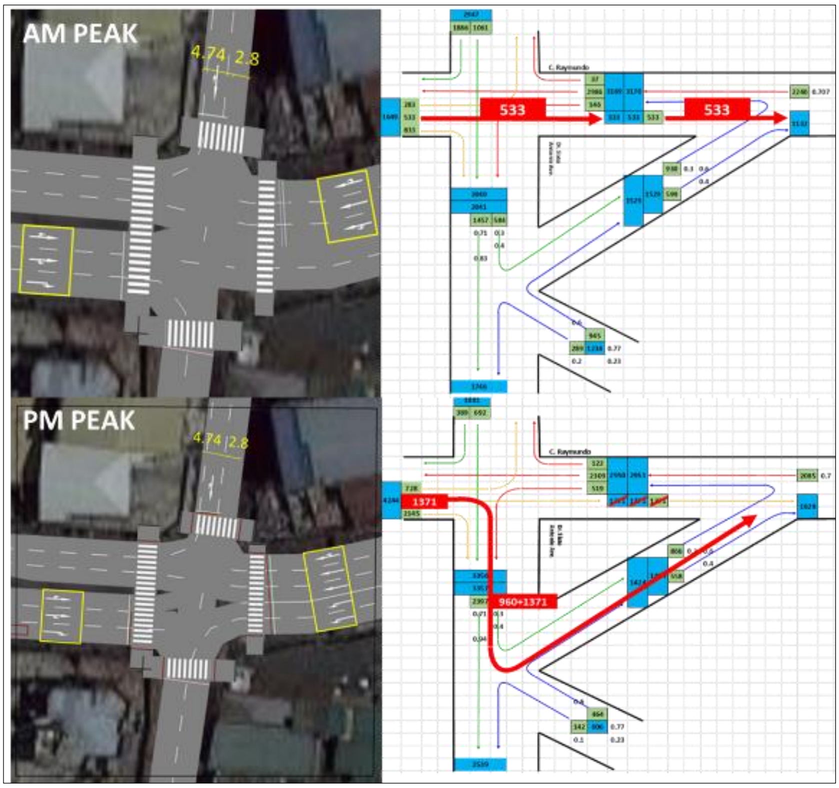


PM	Scenario				
	Base	2A	3A	2C	3C
Phase A	72	85	45	86	88
Phase B	38	45	48	45	51
Phase C	90	65	57	69	61



Source: JPT.

Other elements of the alternative scenarios, such as geometric improvements and change in traffic flow, are illustrated in Figure 4.24.



Source: JPT.

Figure 4.24: Geometric Improvements + Change in Traffic Flow

(4) Microsimulation of Traffic Management Scenarios

The base model was validated using GEH statistics. Values from the AM peak hour GEH computation varies from 0.9 to 14.1, with 85.7% passing out of 14 movements. Moreover, 87.5% passed the GEH statistics from the PM peak simulation. This means that the models from both time periods passed the GEH criterion (i.e., at least 85% of the movements should have GEH < 5.0).

Table 4.43 summarizes the results of the simulations. During the AM peak hour, a large improvement could be seen in scenarios 2A and 2C (one-way scheme). Although all the alternatives had lower average network delays, a one-way flow is more favorable because of the large demand of vehicles in the westbound direction. On the other hand, during the PM peak hour, at first glance, there was an increase in the average network delay in alternative scenarios. However, it may be observed that delays at individual intersections were distributed especially in scenarios 2A, 2C, and 3C.

Table 4.43: Simulation Results for AM and PM Peak Hours by Scenario

AM Peak Hour

KPI	Unit/ Phase	Scenario				
		Base	2		3	
			A	C	A	C
1. Total Network Delay	sec	1,424,805.8	803,079.2	814,585.3	1,562,335.7	1,480,020.0
2. Average Network Delay	sec	172.2	83.2	86.0	161.8	158.7
3. Average Network Travel Speed	km/h	10.7	17.5	17.6	11.3	11.8
4. Vehicle Count (model)	veh	13,100	15,105	14,687	14,107	14,046
5. Weighted Speed (kph)	Phase A	4.2	7.9	7.2	6.3	6.2
	B	27.1	34.0	35.0	31.5	32.9
	C	8.9	40.6	31.0	30.7	30.1
6. Average Queue (m)	A	172.7	70.0	71.5	187.4	180.0
	B	2.8	0.8	0.6	0.3	0.2
	C	118.8	56.9	67.4	64.5	68.6
7. Intersection Delay (s)	A		52.1	55.1	73.9	72.8
	B	8.8	5.0	4.5	3.8	3.3
	C	70.7	13.8	21.0	21.8	22.1
8. Level of Service	A		D	E	E	E
	B	A	A	A	A	A
	C	E	B	C	C	C

PM Peak Hour

KPI	Unit/ Phase	Scenario				
		Base	2		3	
			A	C	A	C
1. Total Network Delay	sec	1,210,913.3	1,158,586.6	1,313,239.1	1,119,298.1	1,311,129.4
2. Average Network Delay	sec	130.0	138.2	139.9	137.3	152.7
3. Average Network Travel Speed	km/h	13.9	15.0	13.3	14.2	12.1
4. Vehicle Count (model)	veh	15,683	17,244	16,752	14,942	15,461
5. Weighted Speed (kph)	A	6.9	6.4	6.0	6.0	6.1
	B	34.5	29.1	29.4	33.3	33.2
	C	14.0	48.7	47.1	14.2	26.1
6. Average Queue (m)	A	145.6	174.6	180.0	142.4	185.8
	B	0.2	4.3	3.5	0.2	0.1
	C	92.6	66.7	70.4	111.8	73.0
7. Intersection Delay (s)	A	59.8	58.9	63.3	64.3	58.1
	B	3.2	7.0	6.5	3.1	2.8
	C	38.3	14.6	16.7	38.0	23.5
8. Level of Service	A	E	E	E	E	E
	B	A	A	A	A	A
	C	D	B	B	D	C

Source: JPT.

(5) Economic Evaluation

The sum of time savings from the three intersections and savings from signalization and footbridge construction was calculated to estimate the benefits from each alternative. One-way traffic flow at C. Raymundo Avenue offers the highest time savings during the AM peak hour, while a two-way flow provides higher time savings during the PM peak hour. Furthermore, scenario 3C has the highest total time savings at PHP13, 019,154.77.

Table 4.44: Time Savings at AM and PM Peak Hours by Scenario

Item	Veh. Type / Scenario	Base	Scenario 2 A	Scenario 2 C	Scenario 3 A	Scenario 3 C
1. AM Benefits from Time Savings (PHP/year)	Car	0	3,564,305.54	3,170,195.33	2,531,664.23	2,705,608.36
	Truck	0	19,526.92	16,383.36	21,848.98	19,122.82
	Motorcycle	0	3,385,550.90	3,296,041.19	2,602,799.60	2,560,935.48
	Tricycle	0	314,623.97	271,583.11	208,442.73	245,284.33
	Jeepney	0	2,800,994.49	2,637,639.08	2,421,662.27	2,353,771.67
	SUV	0	1,610,633.97	1,554,081.20	1,310,866.24	1,287,546.35
	Total	0	11,695,635.80	10,945,923.28	9,097,284.05	9,172,269.02
2. PM Benefits from Time Savings (PHP/year)	Car	0	6,150.94	(147,130.44)	199,460.18	981,485.19
	Truck	0	6,213.40	5,230.11	(4,864.64)	16,666.97
	Motorcycle	0	(17,009.48)	(25,366.32)	(284,585.64)	1,680,274.42
	Tricycle	0	110,307.90	84,846.28	130,042.38	109,912.85
	Jeepney	0	483,188.49	269,432.87	908,257.75	2,244,022.66
	SUV	0	(114,718.51)	(149,844.37)	(383,076.53)	(203,991.16)
	Total	-	467,981.79	184,298.59	365,773.31	3,846,885.74

Source: JPT.

Only 65.6% of savings due to road crash reduction was considered to be the result of traffic signalization, while 74.9% was from the utilization of the footbridge (proportional to the decrease in pedestrian volume along zebra crossing). Savings from traffic signalization and utilization of footbridge were averaged to get 70.25% as a combined effect.

Table 4.45: Savings from Road Crash Reduction due to Traffic Signalization

Item		Damage to Property	Injury Non-Fatal	Injury Fatal	Total
1. Unit Cost 2005 (PHP/year)		55,000	350,000	2,273,000.00	2,678,000
2. Unit Cost 2020 (PHP/year)		301,046.12	1,915,748.02	12,441,414.97	14,658,209
3. No. of Accidents	2017	7	1	0	8
	2018	6	0	0	6
	2019	10	1	0	11
	Average	8	1	0	9
4. Reduced Accidents (65.6%)		5.248	0.656	0	
5. Benefits Carried by Signalization (Warrant: Volume & Crashes) (PHP)		1,579,890.02	1,256,730.70	-	2,836,620.72

Source: JPT.

Table 4.46: Savings from Road Crash Reduction Due to Traffic Signalization and Footbridge Utilization

Item		Damage to Property	Injury Non-Fatal	Injury Fatal	Total
1. Unit Cost 2005 (PHP/year)		55,000	350,000	2,273,000.00	2,678,000
2. Unit Cost 2020 (PHP/year)		301,046.12	1,915,748.02	12,441,414.97	14,658,209
3. No. of Accidents	2017	1	0	8	8
	2018	0	0	6	6

Item		Damage to Property	Injury		Total
			Non-Fatal	Fatal	
	2019	1	0	11	11
	Average	1	0	9	9
4. Reduced Accidents (70.25%)		5.620	0.702	0	
5. Benefits Carried by Signalization and Footbridge (PHP)		1,691,830.65	1,345,774.38	-	3,037,605.4

Source: JPT

(6) Estimation of Costs

(a) **Initial Investment Cost:** The proposed work for scenarios 2A and 3A includes supply and application of reflectorized thermoplastic markings, standard traffic road signs, traffic signals, construction of footbridge, and land acquisition. While SC2C and SC3C have the same proposed works but without the construction of footbridge and land acquisition. Table 4.47 enumerates the cost per alternative scenario.

Table 4.47: Initial Investment Costs by Scenario

Cost	Scenario			
	2		3	
	A	C	A	C
1. Total Direct Cost (PHP)	9,964,022.62	5,219,920.50	9,803,073.62	5,157,612.50
2. Indirect Cost (25% Markup) (PHP)	1,650,225.52	952,279.88	1,618,035.72	936,702.88
3. Total VAT (PHP)	1,188,162.38	571,367.93	1,164,985.72	562,021.73
4. Total Estimated Cost (PHP)	11,089,515.52	5,332,767.30	10,873,200.06	5,245,536.10

Source: JPT

(b) **O&M Cost:** Considering two (2) shifts a day with six (6) persons/shift and PHP12,000.00 monthly pay per enforcer, the total O&M cost is estimated to be PHP1,728,000.00 per year.

(7) Evaluation Results

Table 4.48 and Table 4.49 summarize the total benefits and cost, as well as the BCR and net benefits of the four alternative scenarios at years 1 and 3, respectively. The respective savings due to road crash reduction whether with or without the footbridge were added to time savings to get the total benefits. In Figure 4.25, it may be noticed that alternatives without the footbridge have higher BCR than those with the footbridge. This can be explained by the difference of PHP5 million in total cost. Scenario 3C has the highest total benefits and lowest total cost, thus, having the highest BCR.

Table 4.48: Results of Cost-Benefit Analysis at Year 1

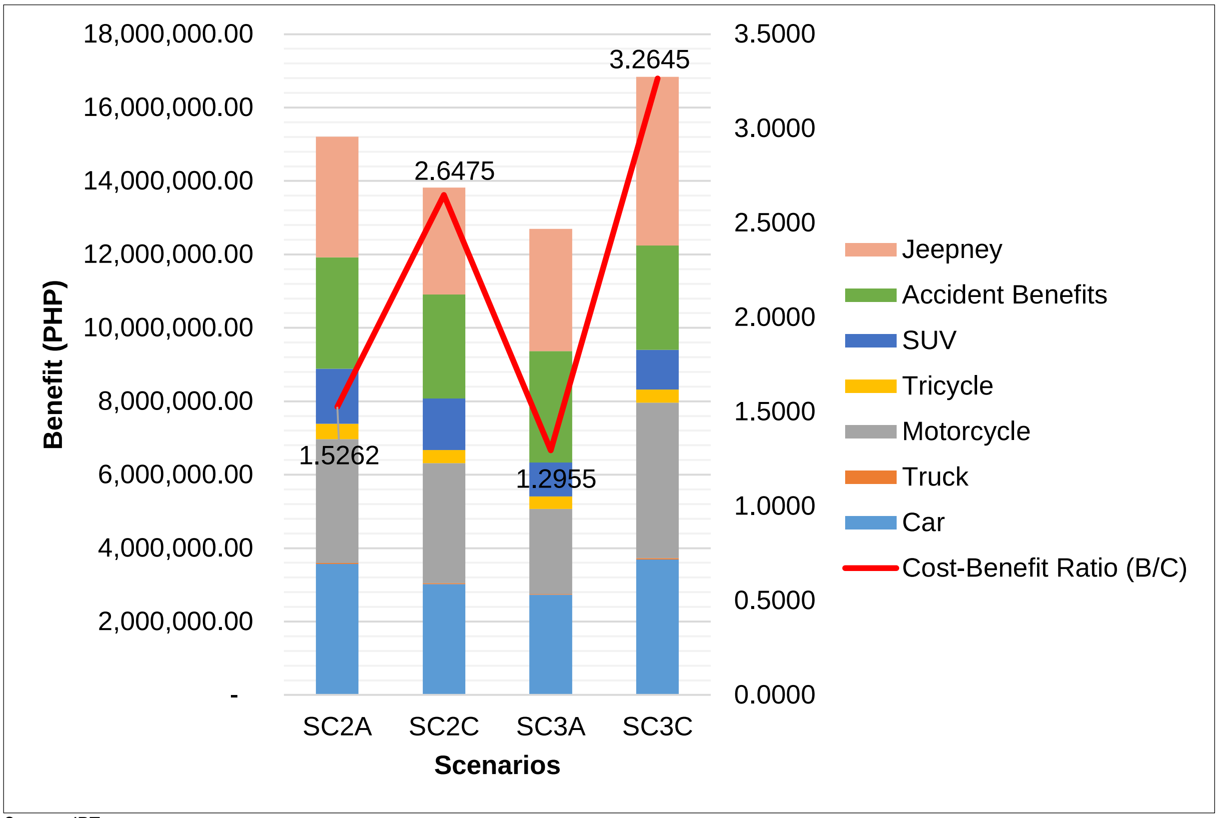
Scenario	Benefit			Cost			BCR	Net Benefit (PHP)
	Time Saving (PHP/year)	Savings from Fewer Crashes (PHP/year)	Total Benefits (PHP/year)	Initial Investment Cost (PHP)	O&M Cost (PHP/year)	Total Cost (PHP/year)		
2A	12,169,768.53	3,037,605.04	15,207,373.56	8,236,022.62	1,728,000.00	9,964,022.62	1.526	5,243,350.95
2C	10,983,091.42	2,836,620.72	13,819,712.14	3,491,920.50	1,728,000.00	5,219,920.50	2.648	8,599,791.64
3A	9,662,517.53	3,037,605.04	12,700,122.57	8,075,073.62	1,728,000.00	9,803,073.62	1.296	2,897,048.95
3C	14,000,639.96	2,836,620.72	16,837,260.68	3,429,612.50	1,728,000.00	5,157,612.50	3.265	11,679,648.18

Source: JPT

Table 4.49: Results of Cost-Benefit Analysis of Proposed Scenarios at Year 3

Scenario	Benefit	Cost			BCR at Year 3	Net Benefit at Year 3 (PHP)
	Cumulative Benefit at Year 3 (PHP)	Initial Investment Cost (PHP)	Cumulative O&M Cost at Year 3 (PHP)	Total Cumulative Cost at Year 3 (PHP)		
2A	40,908,610.77	8,236,022.62	5,184,000.00	13,420,022.62	3.048	27,488,588.16
2C	37,175,730.74	3,491,920.50	5,184,000.00	8,675,920.50	4.285	28,499,810.24
3A	34,163,977.67	8,075,073.62	5,184,000.00	13,259,073.62	2.577	20,904,904.06
3C	45,293,090.27	3,429,612.50	5,184,000.00	8,613,612.50	5.258	36,679,477.77

Source: JPT



Source: JPT

Figure 4.25: Benefits from Proposed Scenarios at Year 1

4.9 Conclusion and Recommendations

1) Conclusion

The nine-month duration of case study 3 was carried out partly before the pandemic and partly during the various permutations of the lockdown in Metro Manila. From November 2019 to March 2020, weekly CPT meetings were done in person in the project office, while from April to September 2020, the JPT and the MMDA, as well as LGU, counterparts met via Skype weekly with online technical meetings in between.

Based on the Project Team members' (JPT, MMDA CPT, and LGU CPT) experience of carrying out and participating in the case studies, some observations are discussed below.

(a) **Willingness to Participate:** The conduct of case study 3 was a learning experience for the project team members, LGU CPTs, and MMDA CPTs. Each member of the JPT had a key role in completing the tasks in coming up with a viable solution to the traffic problems of the selected LGU locations. The LGU CPTs provided information as they were supposed to know the extent of the problems of their selected site and were therefore expected to give inputs on each step of the process. The MMDA CPTs provided support in terms of providing manpower for collecting data through traffic volume counts when the LGU had no staff to undertake such activity. The MMDA CPT also helped LGU CPTs do the simulation runs of alternative scenarios towards finding the most feasible one. The JPTs provided the guidance in each step, sharing better practices along the way. Overall, the interaction through discussions of alternative scenarios among the three groups was informative and the sharing of ideas was appreciated by every member of the study team.

(b) **Constraints to Participation:** The completion of each case study took much longer than expected. The lockdown due to COVID-19 pandemic was a key factor as work had to be temporary suspended for a time in March and April. The face to face meetings/discussions were replaced by online meetings which appeared to be more constraining than the face to face meetings. Another factor is the level of knowhow as this varies widely from one LGU to another. This was observed during the meetings even before the pandemic. Some of the young members were inhibited to give their ideas than the others. Moreover, while some LGUs are much equipped with learning tools due to their exposure to previous trainings and doing practical/actual work, some LGUs would highly depend on in-house consultants to do the work for them.

(c) **Basic Knowledge and Understanding of Topics:** The presence or absence of technical staff in each LGU may be factor. The LGUs with qualified technical staff were able to complete the case studies much faster than the others. However, some LGU CPT members managed to finish the case studies even with little prior experience. Looking at the composition of some LGU CPTs who had difficulty in conducting the case studies, it was observed that the members sent by LGU were mostly traffic enforcers. One LGU, which eventually stopped participating, sent novice members.

Regarding the varying level of knowhow of each LGU CPT, this was remedied by providing them a training program during the course of case study 3 which could equip them with the appropriate tools in tackling traffic problems in their localities. It is recognized though that it may take some time before they get used to these tools, but it is expected that as they continue to follow the systematic way of doing things, they would be able to use such tools without difficulty.

(d) **Relevance of the Case Study to Tasks:** Despite the challenges experienced in the implementation of case study 3, it has successfully provided the LGU CPTs with the opportunity to go through the process of solving problems in their locality. One LGU counterpart commented that the case studies taught them the following: (i) how to assess the traffic characteristics of problematic intersections through observation and quantitative analysis; (ii) what tools and techniques to apply in their data collection activities under the roads and transportation sector; and (iii) additional knowledge on traffic management and traffic engineering such as in gathering traffic data, conducting traffic surveys, and using traffic simulation tools. Another counterpart said that the case study was an enlightening for them. Their long-held solution for their target intersection was to assign additional traffic enforcers during peak hours, aside from asking the MMDA to signalize the said intersection. With the case study, they realized that the faster and simpler solution is controlling pedestrian movement. Another counterpart from another LGU said the case study gave them a chance to learn new skills, one of which is the hands-on training in economic evaluation, and this made their group appreciate the study even more.

2) Recommendations

Based on the observations, the JPT has the following recommendations:

(a) **Produce/Revise Guidebook on Analyzing Congested Intersections:** The case studies of selected 4 LGU bottlenecks as documented in this report could very well reflect the nature of the problems of many bottlenecks all over Metro Manila. It is recommended that the process presented in this report be fully documented and produced as a guidebook for all LGUs. Alternatively, the SSTRIMM guidebook developed in 2000 can be revised or updated based on the output of this report. The guidebook will also be very useful for other LGUs experiencing traffic problems all over the country.

(b) **Replicate Training in Other LGUs:** The training programs conducted during case study 3 which benefited the selected LGUs should be shared with other LGUs. Better still, the content of the training program must be enhanced to address the needs of the different LGUs with regard to their transportation and traffic problems and also the level of knowhow of their technical staff.

(c) **Provide LGUs with Tools:** Equipping the LGUs with tools for analyzing traffic problems is recommended as this was found lacking in almost all LGUs. Much of the analytical tools described in the report, such as intersection analysis, capacity analysis, economic evaluation, etc., have been simplified and are available using spreadsheets. Each LGU will have to invest in other softwares like traffic simulation, as it proves to be very useful in analyzing complex problems and running several scenarios.

(d) **Strengthen Institutional Capacity of LGUs and Individual Capacity of Personnel:** Considering the technical requirements to undertake serious traffic studies in each LGU, it is recommended that a mix of staff with planning, engineering, management/ enforcement background is necessary. Relying solely on enforcement will not be able to do the task effectively. It is recommended that a dedicated office such as Traffic Engineering and Management (TEAM) be created in each LGU, rather than having an ad-hoc committee, as the severity of the traffic issues and concerns continue to worsen year by year.

5 LESSONS LEARNED FROM THE CASE STUDIES

1) Major Factors of Congestion in Metro Manila

Through the case studies, the major factors of congestion observed are briefly explained below. Traffic congestion was caused by two major reasons. First, the traffic demand exceeds road capacity. And second, road capacity decreases because of poor road infrastructure, road-side friction, and unoptimized traffic signals.

(1) Major Road Intersections/ Segments along the Corridor

Table 5.1 and Figure 5.1 show the factors of congestion at major road intersections and a corridor segment as observed during case studies 1 and 2. Two or more of these causes are sometimes present in each of the studied intersection/segment.

Table 5.1: Factors of Congestion at Major Road Intersections/ Corridor Segments based on Case Studies

Aspect	Factor of Congestion
Road Infrastructure	Inadequate geometric design of roads restricts vehicular movements in some degree.
Traffic Regulation/ Control	Mismatched traffic flow and regulation means poor prioritization of movements based on vehicle volume.
	Inadequate signal phasing or timing leads to insufficient green time allocation.
	Unreliable offset timing at intersections (inadequate signal coordination) generates a spill-over effect to the next intersection
	Traffic conflicts caused by undisciplined drivers involve sudden decrease in speeds or stops near or at the intersection.
Traffic Situation	Reduced lanes caused by pedestrians waiting or walking on carriageway is also a safety hazard.
Roadside Environment	Improper PUJ/Bus operation involves disorderly boarding and alighting.
Traffic Demand	Lack of road infrastructures and facilities (concentration of traffic flow on limited roads/intersections due to missing links)

Source: JPT.

Inadequate geometric layout (e.g., traffic islands block flow, insufficient left-turning lanes)

Mismatched traffic flow and regulation (e.g., two left turn lanes for low demand)

Inadequate traffic control by traffic signals without coordination (i.e., long phasing time for one direction)

Traffic conflicts caused by undisciplined drivers (e.g., vehicles suddenly changing lanes).

Reduced lanes caused by PUVs picking up and dropping off passengers at prohibited areas.

Reduced lanes caused by passengers waiting on carriageway for a ride.

Source: JPT

Figure 5.1: Factors of Congestion at Major Road Intersections/ Corridor Segments based on Case Studies

(2) Local Road Intersections in Area

Table 5.2 and Figure 5.2 show the factors of congestion at local road intersections observed during case study 3. They are almost the same factors as those observed at major road intersections, but they are more complicated.

Table 5.2: Factors of Congestion at Local Road Intersections based on Case Studies

Aspect	Factor of Congestion
Road Infrastructure	Poor geometric layout causes impedance to turning movements.
Traffic Regulation/ Control	Unsignalized intersections not only does not properly prioritizes traffic flows but are also unsafe for pedestrians.
	Inadequate signal control involves poor phasing and green time allocation.
	Violating traffic rules and regulations
	Inadequate traffic control by traffic enforcers without coordination with nearby intersections
Traffic Situation	Mixed traffic and high pedestrian volume
	Street vendors occupying the road reduces road capacity.
Roadside Environment	Boarding and alighting from PUJs near traffic bottleneck impedes through traffic.
	On-street parking reduces road capacity.
Traffic Demand	Concentrated traffic demand caused by limited road widths and PT routes

Source: JPT

Poor layout at unsignalized intersection (i.e., no road markings, sidewalk/crossing, and bike lane)

Conflict caused by drivers not respecting traffic rules, often occurring at unsignalized intersections, sometimes resulting in gridlocks.

No coordination among traffic enforcers managing adjacent intersections.

No space to accommodate high pedestrian volume and mixed traffic esp. near schools.

Reduced lanes caused to presence of street vendors.

Reduced lanes caused by PUVs picking up/dropping off passengers.

Reduced lanes caused by on-street parking

Concentrated traffic demand due to limited road widths and PT routes.

Source: JPT

Figure 5.2: Factors of Traffic Congestion on Local Roads based on Case Studies

2) Findings from Case Studies and Recommendations for the Five-year Comprehensive Traffic Management Action Plan

Results of the three (3) types of case studies conducted in 2019 and 2020 provided the following lessons:

(1) Need to Identify Factors of Congestion from Traffic Engineering Viewpoint

Traffic congestion in Metro Manila is caused by two major reasons: uncontrollable increase in traffic demand or a decrease in road capacity. It is essential to observe the traffic situation and road environment to identify the factors carefully, particularly the factors disturbing traffic flow which occur frequently.

(2) Need to Combine Measures to Match Factors and Site of Congestion

For the above-mentioned reasons, congestion countermeasures should be a combination of engineering improvement, operation, and management of traffic signals and traffic control to resolve several causes. In addition, when traffic congestion affects several intersections, the causes at sections/segments along the corridor should be identified and solved. Furthermore, areas with a concentration of bottlenecks and/or that experience persistent congestion should be dealt with using a combination of solutions that can be applied area-wide such as traffic rerouting. The following points are found as important considerations:

(i) Improvement of intersections, especially maximizing traffic signal capabilities as the most critical component;

(ii) Traffic improvement at corridor and network level using traffic signal coordination and proper PUV stops;

(iii) Maximizing capacity of existing local roads through advancement of public transport and elimination of road-side friction; and

(iv) Improvements in hardware (infrastructure and facilities), software (operation and management), and human-ware (behavior of road users).

(3) Need for Clear Demarcation of Responsibilities and Coordination among All Stakeholders

In Metro Manila, the scope of responsibility of each agency is not clearly set. The LGUs manage the roads within their city or municipality, while DPWH construct and maintain national roads. MMDA help in implementing traffic policies and maintaining other roads besides from national roads. But the problem occurs when there are overlaps or gray areas in their scopes of responsibility. For example, cities in Metro Manila with abundant funds install and manages their own traffic signals without coordination with the MMDA who manages most of the traffic signals. This results to poor network flow between signalized intersections. On the other hand, there are some cases in which the MMDA, LGUs, LTO, and other related agencies work together in an inter-agency council for traffic (IACT).

The traffic bottlenecks studied in the three types of case studies are interconnected as a road network. Several traffic administrators (MMDA and LGUs) monitor facilities such as traffic signals and signs at traffic bottlenecks and their surrounding areas. MMDA and the LGUs should have a clear demarcation of responsibilities over their assigned areas or road class, and to coordinate traffic signal and enforcement for effective traffic management. Also, it is necessary to coordinate among all stakeholders (including the private sector) covering all imaginable causes of congestion.

(4) Need to Assess Impact of Measures Before Implementation

Based on the case studies, there is always more than one solution to bottlenecks. It is also essential to consider which scenario is cost-effective. While it is possible to solve traffic congestion in one intersection or area, it may possibly create unexpected issues elsewhere. The effectiveness of a traffic management measure should be double checked before implementation so that resources are used efficiently.

(5) Need to Build Capacity of LGUs in Traffic Management

To ease traffic congestion in Metro Manila, it is necessary to adopt traffic management procedures done in the case studies such as data collection and analysis, simulation, and economic evaluation while strengthening the traffic management capacity of LGUs. Through case study 3, several recommendations are listed below (see Section 1.4 for details). Based on these recommendations, the JPT proposed the capacity building of the LGUs as Pilot Project 2, and this was approved at the JCC meeting on 19 November 2020.

(i) Produce/Revise guidebook on analyzing congested intersections;

(ii) Replicate training in other LGUs;

(iii) Provide LGUs with tools; and

(iv) Strengthen institutional capacity of LGUs and individual capacity of personnel.