Re-evaluation of Signal Parameters in Metro Manila

by:

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Abstract :

Traffic Signal Control is an important element in the traffic management of road transportation system since it involve allocation of road space to road users. The signal controller will does the allocation of green time for every phase or the cycle time. This form of control can be obtained either through automatic control or by Police direction (manual control). In order to maximize the ability of the intersection to move traffic, the allocation of green time or the cycle time should be optimized under the prevailing traffic demand. This will minimize the road user's discomfort, frustration, loss of travel time and high fuel consumption. Thus, a re-evaluation of signal parameters is necessary to deal with and perhaps improve the deplorable traffic situation in the Metropolis.

I Background :

The operation of intersections is often the critical factor in determining the over-all capacity and performance of the road network. Traffic Engineers are continually faced with the problem of controlling flows at intersections in order to improve the road network performance. Because of continuing increase of population and ownership of cars in the Metropolis, the Government urgently needs to provide the increasing demand for intersection facilities to facilitate and control traffic movements. Metro Manila adopted the Area Signal Control System starting 1980. Since then, the government is continually trying to solve this problem of facilitating the flow of traffic at the intersections of major thoroughfares. Inspite of the bad economic situation in the country the Government is doing its best to ease the road user's discomfort, frustration, lost of travel time and high fuel consumption, brought by the deplorable traffic situation in the Metropolis.

At present, there is now a Computerized Control System in Metro Manila, as part of the Government's program to solve the traffic congestion problem especially at intersections. Approximately there are 427 signalized intersections in Metro Manila, 94 sub-areas consisting of 367 intersections and 80 Intersections which are often use Manual Control Operation. A sub-area is a group of intersections consisting of one or more intersections and has a prescribed range of cycle time which will be used by each intersection that belongs to the particular sub-area. All intersections in the sub-area are linked to the central computer (controller) at the Traffic Engineering Center (TEC) for the purpose of ; coordination of adjacent intersections, to make the traffic signal responsive only for intersections which has detectors at the approaches and for monitoring purposes. Those intersections which are not included in the sub-area are called Isolated Signals in a way that they are not linked to the central controller. They use a predetermined cycle time and green time allocation for the time of day.

The ability of these Signalized Intersections to move traffic is determined by the roadway, traffic and signalization condition of the intersection. Traffic Signal Control is an important element in the traffic management of road transportation system since it involved allocation of road space to road users. This form of control can be obtained either through automatic control or by Police direction (manual control). Because of continuing increase of road users, there will be an increase of traffic demand in intersections, as it needs evaluation of the signal parameters used, under the prevailing traffic demand.

In this study, it was aimed to reveal the current situation of signal setting in Metro Manila. For this purpose a field survey of traffic volume and signal setting were conducted for 9 intersections which were selected as typical intersections in Metro Manila. This paper focused only on signal parameters, namely; cycle time, phase length and phase pattern, which the signalization condition of the intersection is greatly dependent on.

II Observation :

2.1 Selection of Observation site

Before the field survey, a set of criteria for the selection of the intersection to be observed was established. The purpose of this selection is to pick up intersections which can be considered as typical intersection based on several criteria.

Criterion 1) Classification of Intersections :

2.1.1.1 Big Intersection
2.1.1.2 Big-Minor Intersection
2.1.1.3 Minor Intersection

Definition (Classification of Intersections) :

Approaches	>= 6 lanes	< 6 lanes
>= 6 lanes	Big Intersections	Big-minor intersections
< 6 lanes		Minor Intersection

Criterion 2) Number of Approaches/Leg

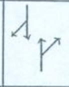
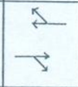
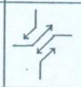
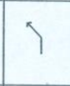
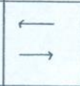
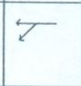
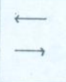
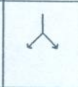
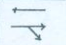
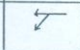
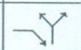
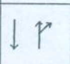
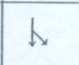
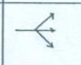
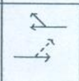
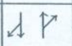
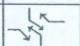
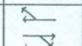
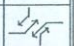
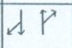
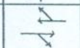
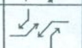
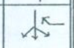
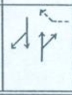
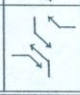
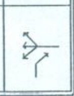
Criterion 3) Representative of the Sub-area :
- the key intersection along major thoroughfares in Metro Manila, based on the Map by Sub-areas of Signalized Intersections in Metro Manila (See annexes).

Criterion 4) Traffic Volume (vehicle composition) :
- based from the Traffic Flow Map made by TEC in 1992 (See annexes).

2.2 Location of Observed Signalized Intersections :

- as shown in Metro Manila Map (See annexes).

Table 1 : Observed Signalized Intersections

Sub-area no.	Int. no.	Name of Intersection	No. of legs	Type of control	Classifi-cation	Phase Pattern			
						Phase I	Phase II	Phase III	Phase IV
008	153	TAFT AVE.-PRES QUIRINO	5	Automatic traffic actuated signal	Big				
131	873	ELLIPTICAL ROAD-COMMONWEALTH AVE.	3	Automatic traffic actuated signal	Big				
003	266	P. BURGOS-FINANCE ROAD	3	Automatic traffic actuated signal	Big-minor				
125	132	E. RODRIGUEZ-T. MORATO	3	Automatic	Big-Minor				
003	258	U.N AVE.-MABINI (one-way along Mabini)	4	Automatic	minor				
116	239	AURORA BLVD.-GILMORE (one-way along Gilmore)	4	Automatic	Minor				
136	652	DONA J. VARGAS-MERALCO	4	Automatic	Big				
013	235	AURORA BLVD.-ARANETA	4	Manual	Big				
201	478	EDSA-AYALA	4	Using Manual and Automatic	Big				

NOTE : Actuated traffic signal are for left-turn movement only.

Intersection number - is the identification number of the intersection given by the TEC

Sub-area number. - is the identification number of an intersection or group of intersections classified by TEC .

The dotted direction is the filtering movement of vehicle

III Data Collection :

During the field survey the traffic volume was recorded every 15 minute interval for every movement coming from the approaches of the intersection. The observation period started from 6:00 a.m. to 1:00 p.m.. The green time allocations for every phase or the cycle time were recorded as possible as the time recorder can record for the whole observation period. In the case of automatic control, the green time allocation for every phase includes the yellow (amber) time, the same for manual control where traffic light signal indication was used. In the case of manual signal it is difficult to determine the amber and all-red indication. The green time indication was considered when the first vehicle moved from the stop line until the last vehicle that stopped at the stop line and the all-red indication was just assumed to be the same as it was automatically operated.

All vehicles were classified into car, jeepney, bus and truck. The traffic volume was converted to equivalent passenger car unit (pcu) using the conversion factor used by the TEC, as shown below.

Conversion Factors :

movement	Car	PUJ (jeepney)	Bus/Truck
left-turn	1.00	1.4	2.2
through	1.00	1.4	2.2
right-turn	1.4	2	2.8

III Results :

3.1 Cycle time indications for different types of signal control :

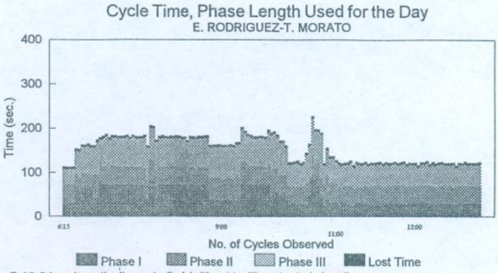
3.1.1 Automatic Signal:

3.1.1.1 Automatic Signal without traffic actuated control:

As shown in Fig. 1, 2, 3 & 4, in these intersections there is no abrupt fluctuation of cycle time indication as it shows almost uniform indication for every time of the day. Most of the automatic signal without traffic actuated control has a smaller standard deviation of the cycle time indicated compared to the signal which has traffic actuated control, except the intersection of E. RODRIGUEZ-T. MORATO.

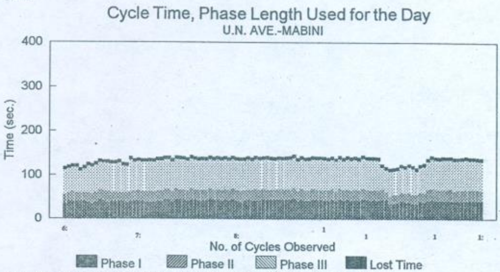
In Fig. 1, the intersection of AURORA BLVD.-GILMORE, there was a long lost time indicated in the graph. Actually an all-red indication of 22 sec. is used for the filtering movement of left-turning vehicle coming from Aurora going to Gilmore. According to the TEC, the traffic management is using it because the signal lantern in the intersection has no left-turn signal, and left-turn movement is allowed.

Fig. 1



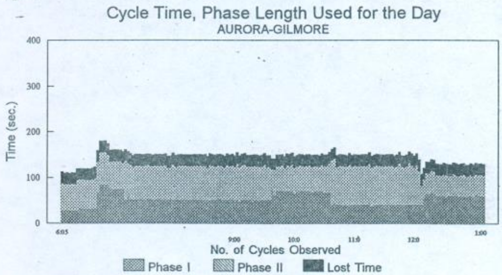
5-18-94, automatically controlled (without traffic actuated signal)
Observation time from 6:00 a.m. to 1:00 p.m.

Fig. 2



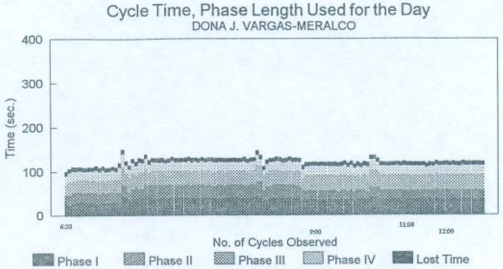
6-8-94, automatically contolled (without traffic actuated signal control)
Observation time from 6:00 a.m. to 1:00 p.m.

Fig. 3



5-17-94, automatically controlled (without traffic actuated signal contol)
Observation time from 6:00 a.m. to 1:00 p.m.

Fig. 4



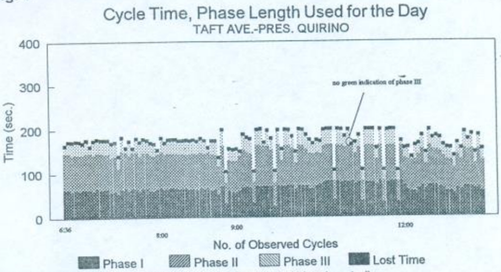
6-15-94, automatically conteolled (without traffic actuated signal control)
Observation time from 6:00 a.m. to 1:00 p.m.

3.1.1.2 Traffic Actuated Signal: (left-turning movement only)

The movement which has the traffic actuation are TAFT AVE.-PRES. QUIRINO, ELLIPTICAL ROAD-COMMONWEALTH AVE. and P. BURGOS-FINANCE ROAD the phase III, phase III and phase II, respectively. In Fig. 5 & 6, the cycle time keep on changing as the green time allocation of this phase responds to the traffic demand, but it has a predetermined maximum indication such that when it reaches at that point, it acts as a fixed cycle time and the minimum indication will extend up to the point of omitting the allocation of the green time for that movement as in TAFT AVE.-PRES. QUIRINO, phase III, as shown in Fig. 5.

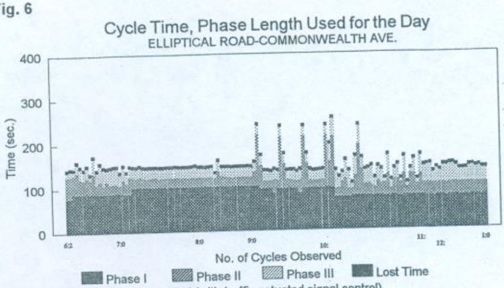
In Fig. 5 & 6, there was an abrupt fluctuation of cycle time especially in TAFT AVE.-PRES. QUIRINO and ELLIPTICAL ROAD-COMMONWEALTH AVE.. According to TEC, it sometimes happened in some intersections but the central computer (controller) which monitor the operation of intersections (for those intersections that are linked to the central computer) will respond accordingly to set the cycle time back to the normal indication as shown in Fig. 6 . When comparing these three intersections P. BURGOS-FINANCE ROAD has the smallest standard deviation of cycle time than the other two intersections, as shown in Table 2.

Fig. 5



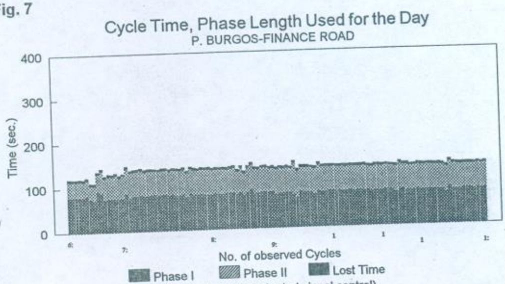
6-7-94, automatically controlled (with traffic actuated signal control)
Observation time from 6:00 a.m. to 1:00 p.m.

Fig. 6



6-16-94, automatically controlled (with traffic actuated signal control)
Observation time from 6:00 a.m. to 1:00 p.m.

Fig. 7



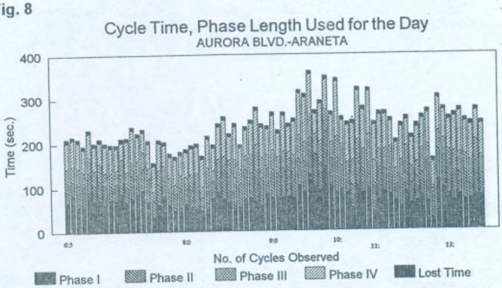
6-9-94, automatically controlled (with traffic actuated signal control)
Observation time from 6:00 a.m. to 1:00 p.m.

3.1.2 Manual Signal Control:

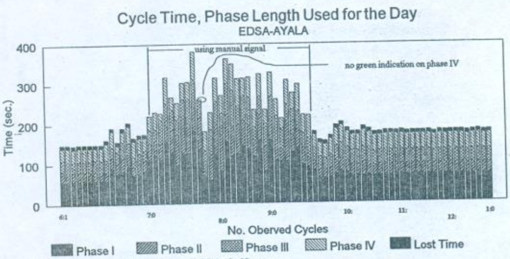
In manual Signal Control the cycle time keeps on changing. As shown in Fig. 8 & 9, an abrupt change of cycle time can be observed most on every cycle time indication. The cycle time indications were very long. In the intersection of AURORA BLVD.-ARANETA, as shown in Fig. 8, the traffic enforcer used manual control for the whole observation period, where he used a device to control the traffic light or the signal indication.

In the intersection of EDSA-AYALA, the traffic enforcer shut-off the traffic light and used the manual signal from 7:00 a.m. to 9:46 a.m.. At that time it was difficult to determine the amber time and the all-red indication. The traffic enforcer omitted one movement, for one cycle indication, he did not allocate a green time for phase IV, as shown in Fig. 9. From table 2, the standard deviation of the cycle time in AURORA BLVD.-ARANETA which uses manual control for the whole observation period was smaller than the manual control operation used on a certain period within the observation time.

Fig. 8



6-16-94, manually controlled
Observation time from 6:56 a.m. to 12:31 p.m.



6-14-94, using manual signal from 7:00 to 9:46 a.m.
Observation time from 6:00 a.m. to 1:00 p.m.

3.1.3 Comparison of Automatic and Manual Control

Table 2

Name of Intersection	Type of Control	Observed cycle time (sec.)			
		std. dev. σ	Mean	Max.	Min.
TAFT AVE.-PRES. QUIRINO	Automatic traffic actuated signal	22.95	174.37	203.57	107.44
ELLIPTICAL ROAD-COMMONWEALTH	Automatic traffic actuated signal	25.96	153.09	258.04	141.32
P. BURGOS-FINANCE ROAD	Automatic traffic actuated signal	6.53	137.98	141.95	109.97
E. RODRIGUEZ-T. MORATO	Automatic	29.77	153.24	227.45	112
U.N. AVE.-MABINI	Automatic	9.52	133.97	146.68	117.52
AURORA BLVD.-GILMORE	Automatic	13.13	145.36	180.22	109.07
DONA J. VARGAS-MERALCO	Automatic	8.34	123.35	138.01	100
AURORA BLVD.-ARANETA	Manual	43.82	241.51	362.59	171.17
EDSA-AYALA	Using Manual and Automatic	63.21	216.1	389.11	147.82

Note : All actuated traffic signal are for left-turn movement only.

Table 2 shows that the manual signal control has a higher standard deviation compared to automatic signal control. The manual control indicates very much higher cycle time than that prescribed by the TEC. The maximum cycle time prescribed by TEC is 200 sec. But when manual control was used the cycle time will reach as high as 380 sec., as we can observe in the intersection of EDSA-AYALA, shown in Fig. 9.

3.2 Evaluation of green time using traffic volume :

The critical volume of vehicle in terms of pcu/lane/phase and the total green time allocation of that particular phase were taken in every hour in the following intersections, DONA J. VARGAS and EDSA-AYALA, as shown below. Also, the degree of saturation was computed based from the observed data ;

$X=(C*Y)/g$ where :

- X = degree of saturation,
- C = average of the observed cycle time,
- Y = is the sum of the critical volume-saturation flow ratio in every phase,
- g = C - lost time, lost time is the total lost time of every cycle which is equal to all-red (2.0 sec.) plus the starting loss (assumed to be 2.0 sec.) times the number of phases.

Table 3 : DONA J. VARGAS-MERALCO (automatically controlled) :

Time	Y (value)	X	Volume & Green Time every 1 hour							
			Phase I		Phase II		Phase III		Phase IV	
			Vol. pcu	Green time hr.	Vol. pcu	Green time hr.	Vol. pcu	Green time hr.	Vol. pcu	Green time hr.
6:00-7:00	0.44	0.51	278	0.280678	150	0.199556	245	0.260613	188	0.188087
7:00-8:00	1.04	1.19	368	0.321631	490	0.216928	593	0.252564	536	0.155228
8:00-9:00	0.99	1.13	375	0.314247	497	0.217722	532	0.252503	448	0.150014
9:00-10:00	0.89	1.03	473	0.307504	417	0.164659	483	0.292659	312	0.168408
10:00-11:00	0.87	1.00	453	0.314357	383	0.16558	500	0.288546	331	0.166388
11:00-12:00	0.89	1.02	452	0.314087	449	0.159417	470	0.290647	318	0.169387
12:00-1:00	0.90	1.04	419	0.315616	555	0.168189	466	0.287827	275	0.161841

Table 4 : EDSA-AYALA (using manual signal from 7:00 to 9:46 a.m.) :

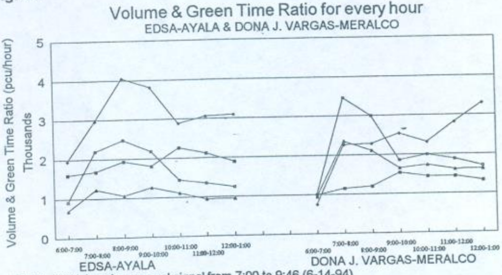
Time	Y (value)	X	Volume & Green Time every 1 hour							
			Phase I		Phase II		Phase III		phase IV	
			Vol. pcu	Green time hr.	Vol. pcu	Green time hr.	Vol. pcu	Green time hr.	Vol. pcu	Green time hr.
6:00-7:00	0.66	0.73	619	0.3869	268	0.137514	111	0.160715	173	0.189591
7:00-8:00	0.96	1.02	723	0.431117	632	0.2135	199	0.161736	329	0.149761
8:00-9:00	1.10	1.16	756	0.391583	848	0.209752	197	0.185476	415	0.167882
9:00-10:00	1.12	1.19	830	0.45878	698	0.183169	254	0.200188	439	0.200733
10:00-11:00	0.97	1.06	916	0.405243	468	0.162309	229	0.20709	342	0.238285
11:00-12:00	0.92	1.01	823	0.389525	460	0.150387	180	0.19102	304	0.224781
12:00-1:00	1.01	1.11	851	0.449291	525	0.170204	207	0.218125	317	0.254771

The volume-green time ratio were computed in every phase per hour to determine the allocated green time in every vehicle per hour per phase, in the two intersections ,namely ; DONA J. VARGAS-MERALCO and EDSA-AYALA which are operated automatically and using manual signal (from 7:00 to 9:46 a.m.) respectively. Fig. 10 shows that the lower the volume-green time ratio the longer the green time allocation with respect to its traffic volume. The higher the volume-green time ratio the shorter the green time allocation with respect its traffic volume. For Both intersections, the volume-green time ratio keep on changing due to the variation of traffic demand in every movement in each phase and signal parameters used, either by predetermined or manual signal.

In Table 3 & 4 the two intersections, DONA J. VARGAS-MERALCO and EDSA-AYALA, were both oversaturated during the peak-hour period. This period had resulted to long queuing of vehicle waiting for many changes of signal before passing through, especially at EDSA-AYALA along EDSA. At this period the apportionment of green time in every phase should be optimum to maximize the total number of vehicles that can pass through the intersection within the given cycle time indication.

Fig. 10 shows that the band width of the points of volume-green time ratio in every phase are sometimes thin and sometimes wide in the whole observation period. This means, that the apportionment of green time in every phase was not optimized, where the long green time was allocated to smaller traffic volume or short green time was allocated to bigger traffic volume or the green time was not fully utilized or there were lost of green time in every cycle. This will happen when the green time is not well proportioned to its traffic demand. When comparing the two intersections, both has a wide band during peak-hour. EDSA-AYALA has a wider band width than DONA J. VARGAS-MERALCO, even if manual signal was used compared to DONA J. VARGAS-MERALCO which automatically controlled.

Fig.-10



EDSA-AYALA, using manual signal from 7:00 to 9:46 (6-14-94)
DONA J. VARGAS-MERALCO, automatically controlled (6-15-94)

IV Conclusion :

In the intersection of DONA J. VARGAS-MERALCO and EDSA-AYALA, during the oversaturated period, the wider the band width of the points of the volume-green time ratio in every phase the greater the un-utilized green time or the volume of vehicle that had moved in the intersection was not maximized. The wider the band width, the green time was not well proportioned to its traffic demand or the utilization of green time was not optimized. When comparing signal control, the automatic has smaller band width than the manual signal or the automatic signal control has smaller un-utilized green time than the manual signal.

A traffic signal can carry a maximum number of vehicles during cycle which results in the absolute capacity and this occurs when the signal is greatly overloaded or the intersection is oversaturated. The number of vehicles that can pass through the intersection can be maximized when there is well apportionment of green time in every phase or the signal parameters used are optimum, not just having a long indication of cycle time.

V Acknowledgement

The authors would like to thank ; *Dr. Ricardo G. Sigua*, Associate Professor, National Transportation Studies (NCTS), U.P., Diliman, Quezon City, *Ms. Lucy Castello*, Assistant Chief, Planning Division, Traffic Engineering Center, Sta. Mesa, Manila City, who shared their ideas and made advises in the researched.

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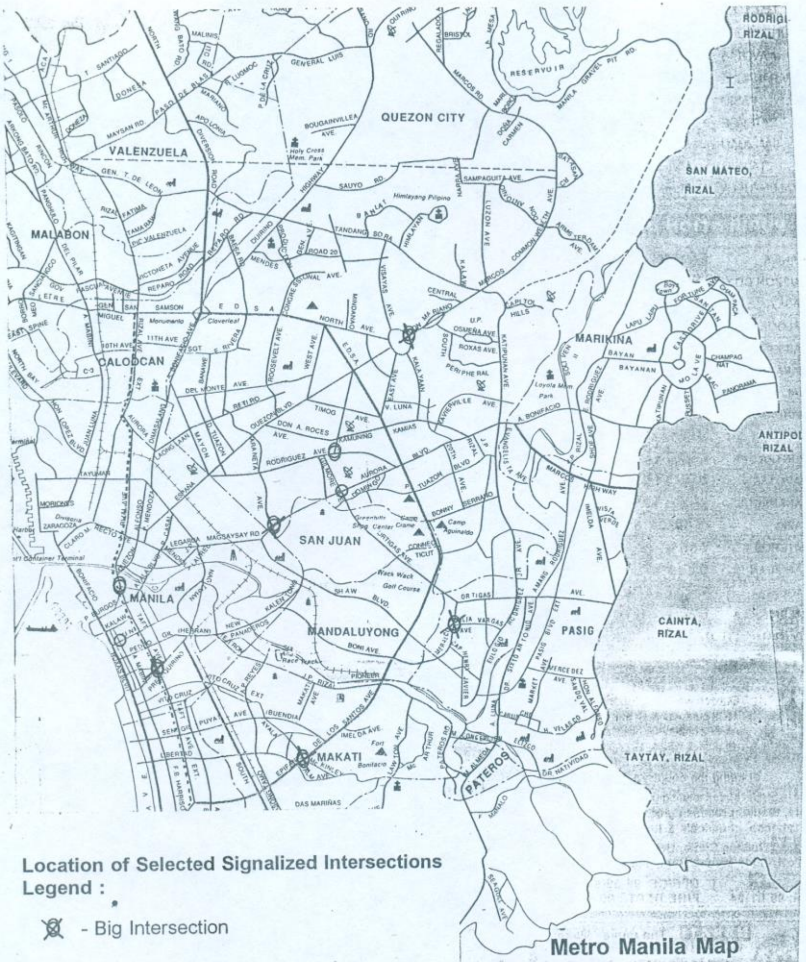
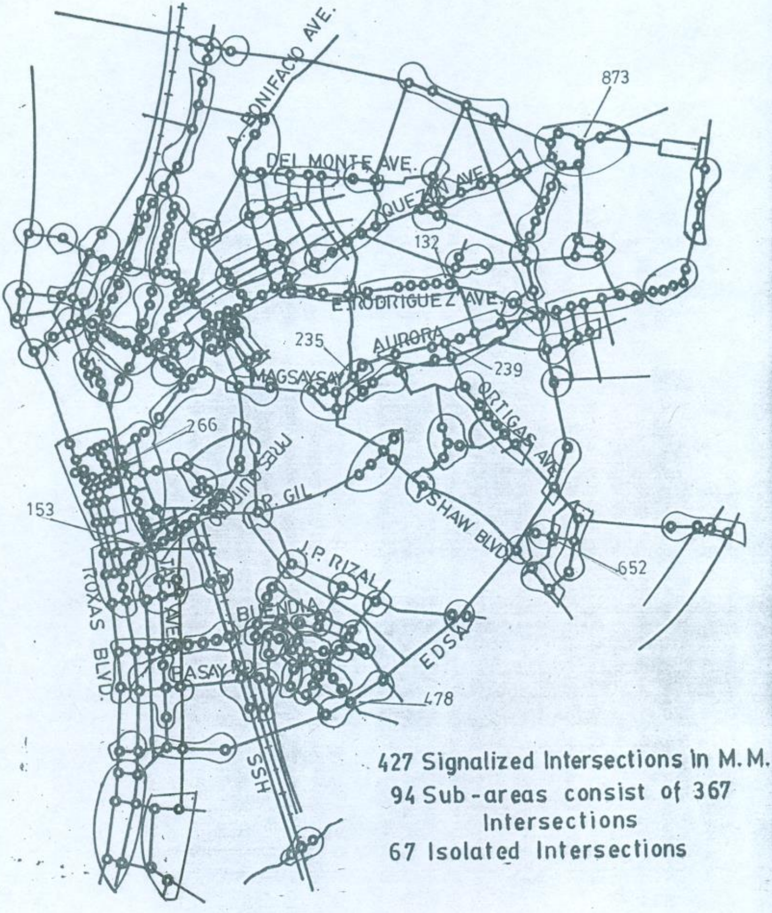


Location of Selected Signalized Intersections

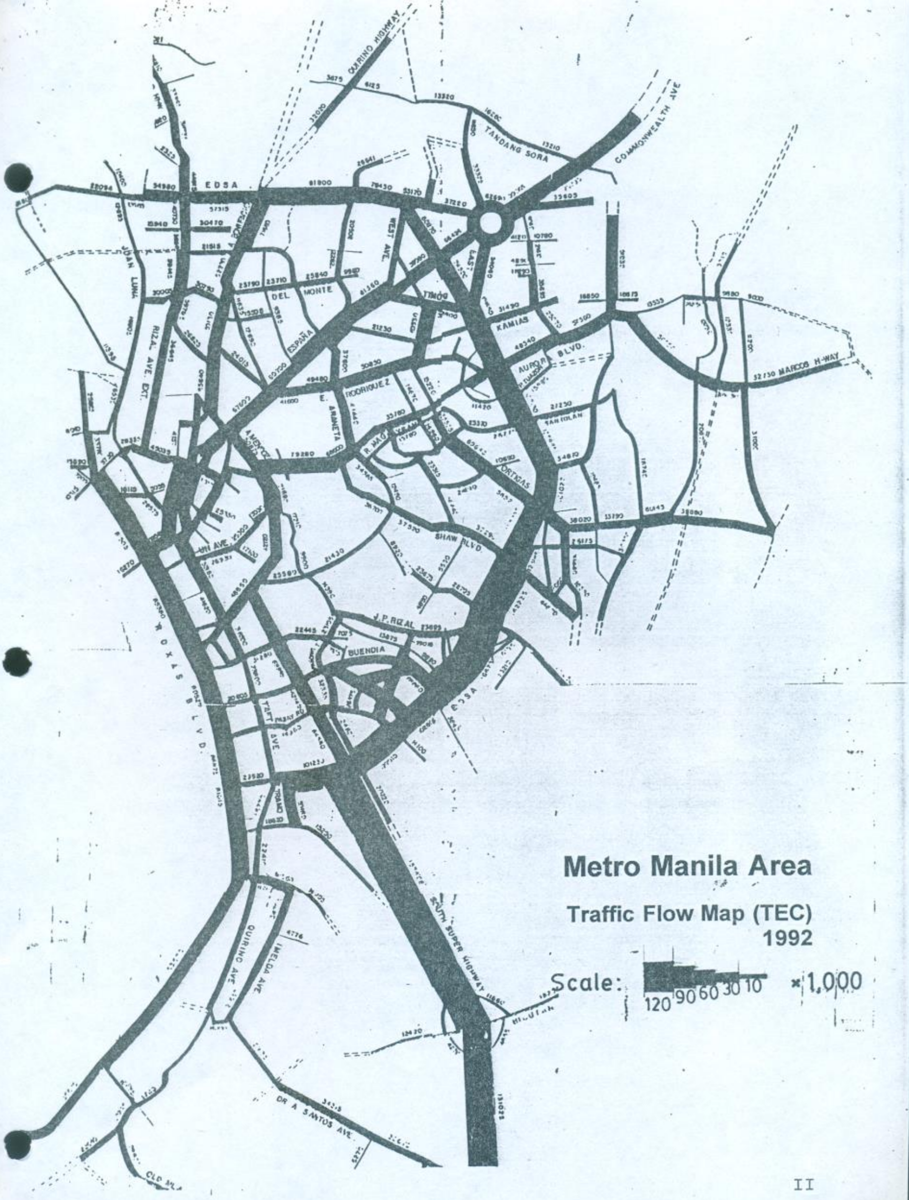
Legend :

- Big Intersection
- Big-Minor Intersection
- Minor Intersection

Metro Manila Map



MAP OF SUB-AREAS OF SIGNALIZED INTERSECTIONS IN METRO MANILA



Metro Manila Area

Traffic Flow Map (TEC)
1992

Scale: 120 90 60 30 10 ×1,000