An Analysis of the Level of Service of Unsignalized Intersections Along the Arterial Roads in the Heritage City of Vigan

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Abstract

This study aimed to look into the traffic situation of the unsignalized intersections relative to the level of service and the flow or volume of vehicles entering the arterial roads and going to the central business district of the heritage city of Vigan. Also, the mean speed of vehicles passing through the arterial road was determined through spot speed survey. The data is necessary in visiting the ordinances relative to the allowable speed as set by regulating the traffic flow at the intersections in order to reduce the conflicts of vehicles and pedestrians and ensure safety among motorists and pedestrians. The researchers recommend schemes to improve the traffic management practices of the city.

Introduction

Background of the Study

Unsignalized intersections are the most common fonns of intersection in the world. The modeling of traffic operations at unsignalized intersections is considered much more complex than the modeling of signalized intersections. At signalized intersections, right-of-way is clearly assigned by the sequencing of phases while at unsignalized intersections, individual driver behavior asserts itself in the interaction of two or more competing traffic streams in situations wherein the right-of-way is often not clearly defined.

Arterial or national roads are considered as vital access to municipalities and cities in the Philippines because they provide the framework for networks of collectors and local streets. Along these national roads are intersections. It cannot be denied that some

intersections along the arterial roads in the city of Vigan are suffering from congestion and sometimes, the safety of drivers and pedestrians are at risk.

Capacity and level of service of the road networks are deemed essential parameters in improving any urban transport systems planning. The capacity of a transport network indicates the maximum attainable throughput of the given network and hence provides important infonnation for efficient flow control and demand management. A good planner must consider the capacity and level of service that would enable road designers to predict how much additional demand a road network can accommodate.

Objectives

The study focused on the characterization and detenninants of the level of service of unsignalized intersections along the arterial roads in the heritage city of Vigan.

The specific objectives of the study are the following:

1. Characterize the intersections under study;
2. Detennine the traffic flow or volume of vehicles that traverse the intersections;
3. Identify the through car units;
4. Determine the level of service and the degree of saturation of the intersections under study; and
5. Describe the speed of vehicles plying the arterial roads.

Methodology

This research is exploratory in nature making use of spot speed survey and traffic volume count

The data on speed is determined through spot speed while vehicular volume or flow is determined through traffic volume count. Spot speed survey was made by employing 20 to 30 meters as the trap distance to determine the time to measure the speed of vehicles plying the arterial roads.

This study aimed to determine the levels of service of unsignalized intersections along the arterial roads in the heritage city of Vigan. This study considered the four-legged and unsignalized intersections located in the arterial roads of Vigan City.

The study is limited to the data obtained during the conduct of the traffic survey on August 23, 2006 from 7:00 A.M. to 5:00 P.M. and the spot speed field survey for one hour on July 26, 2006.During the conduct of the traffic volume count, there was an on-going geometric improvement along Quezon Avenue.

Traffic volume count was conducted to determine the peak-hour period, the flow of vehicles per hour, and the volume-capacity ratio to determine the level of service of unsignalized intersections in the city of Vigan, the location of the study as reflected in Figure 1.

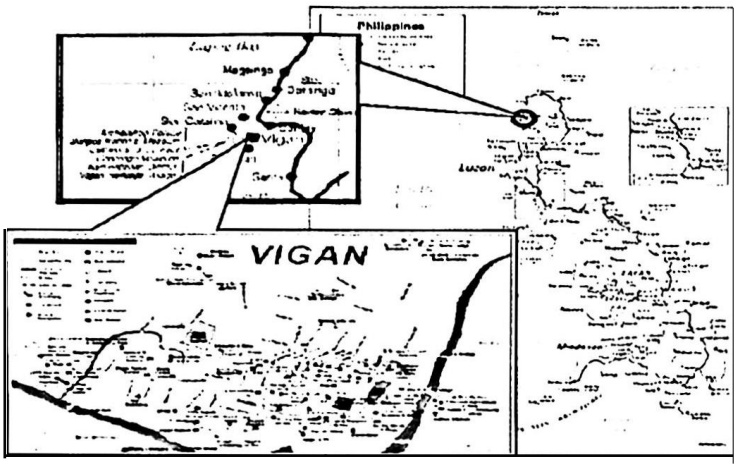


Figure 1. Location Map of Vigan City.

Source: Traffic Management in a City with U.N World Heritage Site by Franklyn .T. Amistad and Jose Regin F. Regidor

Related Literature

Studies Conducted by Other Researchers

According to Kyte (1999) in his analysis on the capacity of unsignalized intersections, capacity analysis is an important part of the process of evaluating the performance of a transportation facility. He also added that the transportation engineer is equipped with the information needed to determine how well the facility serves its purpose.

Yan et al. (1999) in their study on modeling the capacity of levels of service of urban transportation networks found out that for a given current origin-destination (O-D) demand patterns, links were considered for a flow pattern on the network through an appropriate equilibrium traffic assignment model. They tried to consider the different measures of maximum network flow.

Amistad (2006) on his study assessing the need for traffic signalization from the perspective of lccal government units discussed that the determined level of service of Mac Arthur Highway-Dagupan Asingan Intersection in Pangasinan, the study area, is F which is described to be forced flow which implies that the intersection is over saturated or over capacity, which usually results from queues of vehicles. He recommended an acquisition of right-of-way (ROW) to increase the capacity of the road because it decreases the degree of saturation flow by 30%. He further recommended the construction of new transportation facilities (e.g. traffic signalization, fly-over).

Amistad et al (2005) in their research work entitled "Traffic Management in a City with U.N. World Heritage Site" mentioned that the capacity of the links along the arterial roads of Vigan City, a world heritage site, is affected by the on-street parking and unregulated parking of vehicles like tricycles near the intersection as justified by a volume-capacity of 1.79 in the morning which is very high while in the afternoon it is around 1.0. These ratios indicate the onset of congestion and must be addressed immediately.

Concepts on Volume-Capacity Ratio and Level of Service

From the point of view of traffic engineers, the term volume or flow is considered as one of the primary measures of traffic condition or state, where the flow can be computed by the formula:

$$q = \frac{N}{T} \qquad \text{eq. 1}$$

where: N - number of vehicles traveling along a section of the road
T - time that a vehicle passes at a section of the road
q- flow or volume of vehicles per hour

The Traffic Engineering Center (TEC) used the procedures below in the computation and analysis of volume-capacity ratio (v/cap) which served as a basis in the formulation of the template for capacity analysis for planning and operational method is used by the said office in warranting intersections for signalization.

1. Convert Vehicle per Hour (VPH), Volume (@) in Through Car Units (TCUs);
2. Determine the lane width and phasing diagram
3. Determine the saturation flows using

S= 650 (w) TCUs/hour of effective green

4. Compute for the value of y for each phase

$$y = \frac{I}{s} \qquad \text{eq.2}$$

where Y is the total critical y value, Saturation flow
Yi is the individual y value

Table 1. Criteria for Y value Analysis.

Range of y value	Interpretation
Y < 0.75	Below capacity
0.75 <**y**<0.85	Near capacity
Y > 0.85	Oyer capacity

Calculate the cycle time (c) and the effective green time (g) using the Webster formula

$$C = \frac{1.5L + 5}{1 - Y} \qquad \text{eq.3}$$

$$g = \frac{y}{Y}(C - L) \qquad \text{eq.4}$$

Where L is the lost time

5. Compute for the (Volume/ Capacity) ratio (V/Cap)

$$r_{Cap} = \frac{g}{C} \qquad \text{eq. 5}$$

Note: Average Volume-Capacity Ratio (V/cap) indicates the degree of traffic congestion of the network or intersection.

The Level of Service and Volume-Capacity ratio for the traffic signal analysis, criteria for intersection used for Philippine Highways and prescribed by the Department of Public Works and Highways, is presented on Table 2.

Table 2. Traffic Signal Analysis Criteria for Intersection

Level of Service (LOS)	Vehicle/Capacity Ratio (V/Cap)	Description
A	Less than 0.20	Free flow traffic
B	0.21 to 0.50	Free flow traffic
C	0.51 to 0.70	Moderate traffic
D	0.71 to 0.85	Moderate heavy traffic
E	0.86 to 1.0	Heavy traffic
F	> 1.0	Force flow, Stop and go

Through Car Units (TCUs)

The conversion of through car units that is used in the template for capacity analysis for planning and operational method used by the Traffic Engineering Center, Metro Manila Development Authority and the Traffic Engineering and Management, Department of Public Works and Highways is presented on Table 3. Notice that tricycles and single motorcycles are not included but by practice of the said offices, tricycles are equivalent to cars while two single motorcycles are equivalent to car.

Table 3. Equivalent of Through Car Unit of Vehicles **by Movement**

Movement	Car	Jeepney	Bus/truck
Left-Turn	1.0	1.4	2.2
Through	1.0	.1.4	2.2
Right-Turn	1.4	2.0	2.8

Related Ordinances and Traffic Rules

Ordinance Number 9, series of 1999, known as the Vigan Traffic Management Ordinance 1995 which was enacted by the municipal council of Vigan includes the prohibition of right turns for north bound public utility buses, public utility jeepneys and trucks at Rizal Street to P. Burgos Street. In the same ordinance, it is stated that the speed limit of vehicles along any street in the poblacion of Vigan is 20 kilometers per hour and a prescribed speed limit of 15 kilometers per hour when approaching the world heritage marker located near the city hall.

Meanwhile, according to Republic Act 4136 on the traffic rule which has a restriction on the speed limit of any motor vehicle as presented on Table 4 shall not exceed the following:

Table 4. Allowable Speed Limit by Type of Vehicle

Maximum Allowable Speeds	Passenger Cars and Motorcycles	Motor Trucks and Buses
1. on open country roads, with no "blind corners" and not closely bordered by habitation.	80 km. per hour	50 km. per hour
2. on "through streets" or boulevards, clear traffic, with no "blind corners," when so designated.	40 km. per hour	30 km. per hour
3. on city and municipality streets, with light traffic, when not designated as "through streets".	30 km. per hour	30 km. per hour
4. through crowded streets, approaching intersections at "blind corners. " passing school zones, passing other vehicles which are stationery, or for similar dangerous circumstances.	20km. per hour	20 km. per hour

It is further stated in the rules on the speed limits which is uniform throughout the Philippines, that no provincial, city or municipal authority shall enact or enforce any ordinance or resolution specifying maximum allowable speeds other than those provided in this act.

Relative to the route of some vehicles from the terminal, the following are also included in the Vigan Traffic Management Ordinance of 1995:

a. PUJ should exit at Gov. A. Reyes Street straight to L. Florentino Street

b. PUB shall be exiting at Rivero Street, straight to Rizal Street going out of the Municipality.

c. Tricycles-for-hire going to Sta. Catalina shall follow the route from their parking area going west to Zamora Street turning North to P. Burgos Street.

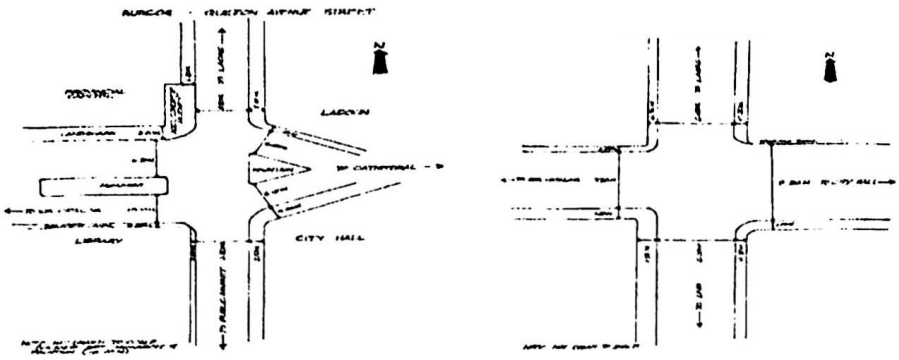
The ordinance also includes the provision of one-way streets in which Quezon Avenue starting at P. Burgos Street up to Liberation Boulevard is considered.

Results and Discussion

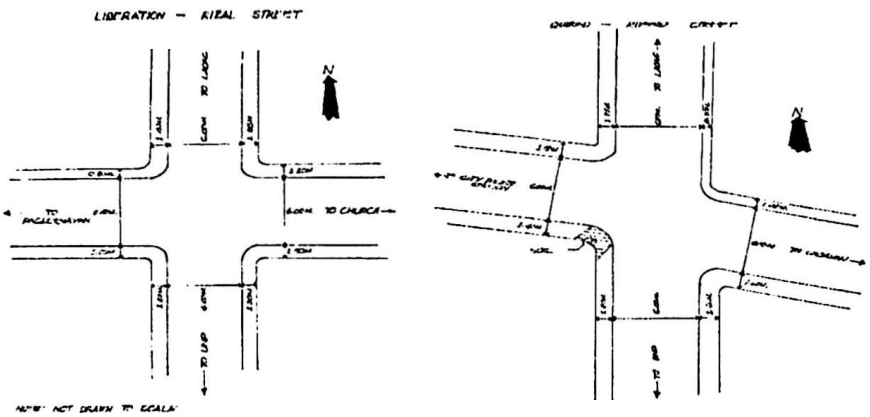
Characterizing the Intersection. The intersections under study are the intersections of Burgos Street-Rizal Street, Burgos Street-Quezon Avenue, Rizal Street-Liberation Boulevard, and Quirino Boulevard-Rivero Street. The said intersections are unsignalized and they are located along the arterial roads of the city. The intersections are believed to be the avenue to the central business district (CBD) and to the vital installations of the city (e.g. university, colleges, schools, churches, government offices). The intersections Burgos Street-Rizal, Rizal Street-Liberation Boulevard, and Quirino Boulevard-Rivero Street have 12 movements and have no traffic control devices such as lane markings, directional signs, stop signs, yield signs, and pedestrian lane lines. On the other hand, the intersection at Burgos Street-Quezon Avenue has nine movements and has lane markings and pedestrian lanes to direct the drivers and pedestrians. The intersections under study have good sight passing distances. Since the intersections are unsignalized, it regulates the drivers pedestrians to consider awareness and take the responsibility when crossing the intersections. Likewise, police officers are visible to control and man traffic along the intersections on a regular basis because there are unregulated stoppage of vehicles and loading and unloading near the intersections that cause the unstable flow. The traffic situation of the intersections are shown from Figures 2a to 2d.

Figure 2a. Quezon Avenue-Burgos Street Intersection (left) and Rizal Street-Burgos Street Intersection (right)

Figure 2b. Rizal Street-Liberation Boulevard Intersection (left) and Quirino Boulevard-Rivero Street Intersection (right)



2c. Sketch Plan of Quezon-Avenue-Burgos Street Intersection (left) and Rizal Street-Burgos Street Intersection (right)



2c. Sketch Plan of Rizal Street-Liberation Boulevard Intersection (left) and Quirino Boulevard-Rivero Street Intersection (right)

Traffic Flow. The distribution of vehicles that traversed the intersections during the ten (10) hour period is presented on Tables 5 to 7.

It is shown on Table 5 that tricycle is the most numbered type of vehicle that traverse the intersection of Quezon Avenue-Burgos Street with a total of about 46% (6670) of vehicles. Four thousand six hundred ninety five or 32% are single motorcycles; 2079 or 14% are cars, 389 or 3% are jeepneys, and about 662 or 5% are trucks and buses. It is indicative on the table that the peak hour is experienced at 9-10 and 1-2 for morning and afternoon, respectively. The traffic flow or volume of vehicles that traverse the Quezon Avenue-Burgos Street intersection is 1495 vehicles per hour.

Table 5. Distribution of Vehicles that Traversed Quezon Avenue-Burgos Street during the Ten (10) Hour Period.

TIME	VEHICLE CLASSIFICATION					TOTAL	%
	Tricycle	Slngle Motorcycle	Car	Jeepney	Busl Truck		
7.01-8.00	375	260	106	41	38	818	5.60
8.01-9.00	737	511	210	38	75	1571	10.76
9:01..10.00	76	568	210	40	85	1689	11.57
10.01-11.100	727	530	294	41	70	1662	11.39
11.01-12.00	722	508	236	36	70	1572	10.77
12.01-1.00	690	439	233	47	43	1452	9.95
1:01-2:00	808	525	234	38	75	1680	11.51
2.01:3.100	696	436	239	41	66	1478	10.13
301-4.00	606	441	188	33	73	1341	9.19
4.01-5.00	623	477	129	34	69	1332	9.13
TOTAL	6770	4695	2079	389	662	14595	100
%	46.39	32.17	14.24	2.67	4..54	100	

Table 6 presents the distribution of vehicles that traversed Burgos Street-Rizal Street intersection during the ten (I 0) hour period. It is noticed that more than sixty percent, which is 9,816 or 60% of the vehicles that cross the said intersection are tricycles. Three thousand two hundred ninety three or 20% are single motorcycles and less than 10 percent for each of the cars, jeepneys and buses or trucks. The observed peak hour period for this intersection are 8-9 and 1-2 for morning and afternoon, respectively. It is indicated on the table that the traffic flow is 1,569 vehicles per hour.

Table 6. Distribution of Vehicles that Traversed Burgos Street- Rizal Street during the Ten (10) Hour Period.

TIME	VEHICLE CLASSIFICATION					TOTAL	%
	Tdcycle	Single Motorcycle	Car	Jeepney	Busl Truck		
7.01-8.00	746	213	$9	9	51	II3	724
%O\-%.00	1199	451	135	99	65	1949	12.42
901-10.0	181	598	98	68	95	1940	t23
[0.01–1.00	1239	42	6	108	$3	1928	12.28
11.)–2.00	1217	321	157	$9	91	1875	11.95
I20I–:00	881	293	136	71	49	I>	9.1I
1:01-2.00	1053	322	//	56	80	1665	I0.61
1.01:3.00	873	338	lt	39	81	158	9.29
301-4:00	614	191	31	2	67	959	6.II
40)-5:00	883	214	139	39	7	1350	8.60
TOTAL	981	3293	1a	662	748	15690	1o
;a	625	20.99	7.4	4.22	4.77		

The d.stribution of vehicles that traversed Rizal Street-Liberation Boulevard intersection during the conduct of a ten hour traffic volume count is presented on Table 7. lt was observe.l that about 70% or 8,237 of the vehicles that traverse the intersections are tricycles. Almost 15% or 1,686 are single motorcycles, about 5% each for cars and jeepneys crossed Rizal Street-Liberation Boulevard: and 659 or almost 6 % of the vehicles are buses or trucks. There are 1,173 vehicles per hour that crossed the intersection of Rizal Street-Liberation Boulevard.

Table 7. Distribution of Vehicles that Traversed Rizal Street-Liberation Boulevard During the Ten (10) Hour Period.

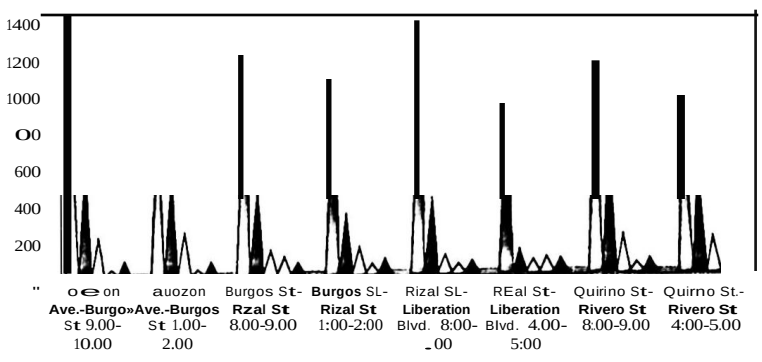
TIE	VEHICLE CLASSIFICATION					TOTAL	%
	1.3IY(E	SINGLE OTORCYLE	AI	JEEP.NEY	BS] TRI"(K		
7:01-8.00	514	121	49	t	51	762	6.50
:01-9.00	1389	402	101	53	67	2012	17.15
9.01-1EA)	8k8	3??	68	92	$2	1503	123l
10:0)–1:D	70)	13	42	6i	68	1021	8.0
11.01-12U	588	I	34	30	56	s22	7.41
12)-1:ad	748	102	39	$3	55	977	8.33
1:0/–2.00	773	98	51	53	1	105	9.0
201:3:t	843	105	48	2	69	1137	9.19
3:01-4.00	874	H	62	73	56	1175	10.12
4:01-5:00	913	!?:	7o	85	74	1265	10..8
T0/TL	$237	1686	54	51	659	1730	1%
%	70.22	1..37	4.8I	4.93	6.62	Io	

Table 8 exhibits the distribution of vehicles that traversed Quirino Boulevard-Rivero Street intersection during the ten-hour traffic volume count. Fifty five percent of the vehicles that crossed the mentioned intersection are tricycles, 29 percent or 9,324 are single motorcycles, 11 o/o or 1,847 are cars, and there are 2% or 339 and 3% or 465 are jeepneys and buses or trucks. respectively. The flow at the said intersection is 1,693 vehicles per hour.

Table 8. Distribution of Vehicles that Traversed Quirino Boulevard-Rivero Street During the Ten (10) Hour Period.

TillE	HIIILE LISSInICATION					TOTL	%
	TRI.TIE	SINGLE HOTORCY(IE	CIR	JEEPIE	BIS] TRIO		
7.01-8.00	II36	61	1i0	3	53	2030	12.05
8.:01.9.00	1158	655	201	53	73	2110	12.61
9.01-10.00	1001	605	211	48	55	1923	11.36
I0.01-11.00	813	680	215	40	58	I836	10.85
I1I-I2.00	886	451	180	29	31	15,	9.32
12.01-1.00	941	394	191	40	42	I6II	9.52
1.12.0	975	173	156	16	39	169	8.68
2:01:3:00	769	20	132	29	4	I251	7.1
301-1.00	60	408	198	I8	41	1325	7.83
4.01-5:00	955	561	187	20	29	1752	10.35
TOT.IL	9324	4951	I8I7	39	465	1692	100
ö	55.09	29.25	10.9I	2.00	25	100	

The distribution of vehicles that traversed the intersections during the peak hour period is exhibited in Figure 3. It is noticed that tricycles are the most numbered type of transportation mode that pass the intersections during the specified peak hour period. It is seen in the figure that Quezon Avenue-Burgos Street has the lowest number of vehicles among the types of transportation modes. The intersections Burgos Street-Rizal Street; Rizal Street-Liberation Boulevard, and Quirino Boulevard-Rivero Street have common peak hours in the morning which is 8-9; while Quezon Avenue-Burgos Street experienced peak hours in the morning at 9-10. With regards to the afternoon peak hour period, the intersections at Quezon Avenue-Burgos Street and Burgos Street-Rizal Street experienced traffic congestion at 1-2. The afternoon peak hour period of the intersections of Rizal Street-Liberation Boulevard and Quirino Boulevard-Rivero Street is being experienced at 4-5.



Through Car Units

The flow of vehicles in the intersection as affected by the through car units (TCUs) is presented on Table 9 to 12.

Table 9 exhibits the distribution of vehicles by movements during the peak hours that traversed Quezon Avenue-Burgos Street intersection by through car units. It is revealed that the TCUs for 9-10 in the morning is 1662 and 1675 TCUs for 1-2 in the afternoon. It was found out that there are no north-bound vehicles because Quezon Avenue is a one way street from 6:00 in the rooming to 6:00 in the evening. It was observed that cars have the greatest number compared to jeepneys and buses or trucks because of the counted tricycles and single motorcycles that traversed the intersection as shown on Table 5. Based on the table, east-bound vehicles have the highest number of TCUs for morning and afternoon peak hours as a result of the values 586 and 536, respectively.

Table 9. Distribution of Vehicles by Movements during Peak Hours that Traversed Quezon Avenue-Burgos Street Intersection by Through Car Units (TCU's)

OEt		I.IL. Peak llor 9-10) elile lassilication			Tar	P.MI. Peak llar (12) elicle lassilicatio			Id▾
		Car	Jeepey	us/Truek		Car	Jecpue	as/Truck	
	Lilt-Tum	0		0		U	0	0	
North	Through					!			0
bocnd	Right-Tun	0		0					0
Suh-tlal		0		0					
	let-Tun	3		2	57	3			4I
Soul	Through	209	29	I3	34	Io		30	2s7
bound	Niht-in	to;	0	;	I9	Is;	%	6	I8
Sul-tolI		3%	2	52	s70	311	18	3	499
	left-Ten	202	6	5	y	2\3	0		20
et	Throuh	183	0	13	212	2!		3	23
bond	kiht-Tun	50			7a	MI			209
Sub-total		135		I9	50	5.3			651
	left-Tun	203			30	':'o		15	II
Est	Through	I01		3	I8	23	10	I	t4
hour	Ni±:t-Tun	I73	0	2	248	Iu!			I
Sul-total		47		I	3	30	I7	13	53
Total		I28I	IO	8.i	1662	136	38	5	165
Perenl		91.10	2.¥	6.06		9203	249	5.29	
Prrat ltl				D				100	

Table 10 presents the distribution of vehicles by movement during the peak hours along Burgos Street-Rizal Street intersection by through car units. It is indicated that there are 1987 TCUs for 8-9 in the morning peak hour and 1733 TCUs for 1-2, afternoon peak hour period. It is observed that in the morning, there are 7 buses/trucks and 1 for P.M. moving north and turning to the right. These vehicles violate the ordinance prohibiting buses/trucks and PUJs to ply said direction. It was found out that there are 507 and 658 TCUs in the morning and afternoon, respectively. This **is a** positive effect of the high frequency of vehicles entering the city.

Table 10. Distribution of Vehicles by Movements during Peak Hours that Traversed Burgos Street-Rizal Street Intersection by Through Car Units (TCU's)

MO\ENET		L.MI. Peak Iour (&9) elide Issilication ar	leg	hs[Truck	1c	P.NL. Peak oar(12) lehide Ciiati ar	JI	bus/Trvd	Tu
	lei-Tur	90	9	4	Io;	85	I	2	91
North	Trap	30	18	I	366	193		15	236
bound	Hie-Tu	I05		7	IOI	4	0	I	64
Sb-toll		501	34	25	54	32	8	1	391
	Left-Tum	59	0		6I	9€	S		112
South	Throngl	280	30	1	36	z1	II	S	13
bound	ill-hu.	5¥	2		80	/.-	2	6	I
ut-toll		393	32	21	S07	479	l	46	658
	Lei+-hum	39	2	2	4	Ii		2	53
West	Through	20	8		230	I7		8	194
bound	ht.	I05	1		I0I	II	S	I	79
ul-total.		350	4	10	s7	252	5	1	326
	Left-Tum	106	3	3	1Iz	8§8	2	0	92
East	Tr	12	4		16	I5		I	I8
bond	kiht-un	7	2		7$	75		I	10
Sub-total		315	9		38	120	12	2	30
Toal		1559	99	4$	1987	I3	5	80	1733
Perel		90.49	5.74	17		90.92	1.3	$.35	
Percent Total				17				100	

The distribution of vehicles by movements during peak hour-periods along the intersection of Rizal Street-Liberation Boulevard by the effect of through car units is presented on Table I1. It is reflected on Table I1 as an effect of the turning movement of the different types of vehicles that TCUs for mommg and afternoon peak hour periods are 2100 and 1392, respectively. Vehicles moving north have a positive effect on the TCUs for 8-9 in the moming and 4-5 in the aftemoon of 752 and 579, respectively.

Table 11. Distribution of Vehicles by Movements dring Peak Hours that Traversed Rizal Street-Liberation Boulevard Intersection by Through Car Units (TCUs)

NO\TIT		L.. Peak llour 39) Vehicle [Issiliz ion			Tu,	P.I. teak llour (+-5) chi«le hassilication			TI'
		Car	Jeepney	bs/Ihuk		ar	Jeepney	Bus/Ilk	
korh bound	leit-hum	305	I3	4	330	300	12	8	334
	Tlrouch	27	1	18	338	I6I	I	8	20l
	Ili@ht–um	50	3	3	8l	23	3	2	4
Sulb-total		629	2	25	752	487	29	It	579
South hound	left-Tum	I0	0	I	5l	13	I	0	24
	Ihrouzh	231	13	II	280	12o	18	32	2l
	llig**l**–um	54	0	I	7$	29	1	0	13
Sul.tolal		334	Is	I	lo9	172	0	2	283
Test bound	If–Tum	I5	2	I	50	5l	4	3	63
	Trough	1.6	0	9	19	15	I	2	I5
	Riel+-Tum	43	2	4	7s	I	I	I	2
Sub-till		21	4	*I*	321	2I;	$	6	*2l*
East hound	Lt-Tin	28	0	I	30		I	0	8
	Throigh	153	3	3	I6!	128	*i*	7	153
	light-Tum	283	2	8	423	34	22	11	12
uh-al:l		41	5	12	47	I6)	3	IR	283
Toal		1691	5	67	2\00	10£5	I	74	1392
Perent		93.32	2.98	3.70		35.4	8.50	6.6	
Peret Total		100				100			

The distribution of vehicles that traversed the intersection of Quirino Boulevard-Rivero Street during peak hour periods by TCUs as affected by the movement are presented on Table 12. The table shows that there are 1749 and 1430 TCUs for morning and afternoon, respectively. It can be seen from the table that vehicles that are west-bound have the highest TCUs as affected by the movements of the vehicles which gives a value of 778 and 595 TCUs for morning and afternoon, respectively.

Table 12. Distribution of Vehicles by Movements during Peak Hours that Traverse Quirino Boulevard -Rivero Street Intersection by Through Car Units (TCUs)

IO\EVENT		A)I. Peak four (8.9) ebile Classification			TO	PM. Peak Hor (15) 'ebi«le lassliallln			1I
		ar	Jeepey	Bs/Iruk		ar	Jeepey	Busl Tr«lt	
North hound	Left-Tum	45	2	I	50	S3	4	3	45
	Through	I65	4	7	18	I00	0	5	111
	Nia-fur	20	I	2	38	4	0	0	6I
Sul-olal		130	7	I0	22	199	4	8	24I
South bound	Iei-Tam	27	3	3	248	233	2	6	249
	Through	I6	0	0	I6	28	0	0	2
	hight-Tum	5	I	I	83	2I	0	3	38
Sul-total		308	4	4	347	22	2	9	315
Test bound·	Left-Tum	I3	Ii	I6	2	:I0	6	I	4I
	Through	I9I	2	6	07	1O	3	2	II5
	Nie±-Tu	329	8	8	499	30£	I	2	439
Sul-tol1		513	27	30	78	440	13	5	595
tfl bound	Ieft-Tum	5	I	0	57	2I	0	3	28
	Through	I09	I	S	I	95	0	I	s7
	Right-Ium	99	7	6	I9	7	0	2	I55
Sih-total		264	t2	II	352	z3	0	6	280
Toal		I338	50	55	1749	I I	31	28	I39
Perent		92.	3.46	3.83		95.09	25	234	
Perceul Tola)		100				100			

Table I3 presents the comparative data on the level of service and the level of saturation of the different intersections in Vigan City. The table reflects that Quezon Avenue-Burgos Street intersection has a level of service of C for the morning and afternoon peak hour period. The said level of service is described as moderate traffic, thus the drivers can maneuver the vehicles with control. The same description is said to be suitable for urban places like the heritage city of Vigan. On the other hand, the level of saturation of Quezon Avenue-Burgos Street is described as below capacity which means that the intersection is wide enough for an urban area like Vigan City. Meanwhile, Burgos Street-Rizal Street, Rizal Street-Liberation Boulevard, and Quirino Boulevard-Rivero Street have levels of service of F described as forced flow and stoppages may occur which cause a delay of about 3 to 6 minutes or more and may result to a high density of vehicles queues. The level of saturation of these intersections is over capacity. This suggests that there is a need to improve the intersection and rerouting of some vehicles is needed.

Table 13. Comparative data on the Level of Service and Level of Saturation of the Intersections

Intersection	Time	/a	LOS	Remark	Level of Saturation	Remark
Quezon.fe.-	9.01-1000 4	0.42	t	olerate Tralic	0.38	Delos (apaily
IIrgos SL.	:01-2.00 7.I	0.6!	t	loderate Traffic	0.39	Delo apatily
lurges SL.- Rial	$.01-9.404.L.	1.30	F	Forced How	0.98	let apacily
s1.	1.0)-20 %.-	1.26	F	Forted How	0.87	Oer apaily
Ilinal SL.--	8:01-9%40 1.L.	1.13	F	Forced How	0.75	Jear Capaily
Liberation Id.	±01-5.00 P..	1.58	F	Fored [low	1.13	er apacily
(uirino Blvd.-	8.0)-900.\.I.	1.29	F	Forced Foy	0.92	Orr apacily
Riv«r SI.	401-5.00 E.I.	1.@1	F	Forced Flow	4.75	}ear apacily

Speed

The comparison of the speed of vehicles during the one hour survey on August 23, 2006 along the selected arterial roads in Vigan City is presented on Table 14. It is noticed that the mean speed of the 1773 vehicles ranges from 17.76 kilometers per hour (kph) to 30.14 kph. The mean speed of vehicles along Rizal Street is 17.58 kph; the mean speed of vehicles along Burgos Street is 20.03kph; 29.80kph for vehicles plying Quirino Boulevard; and 21.05kph for vehicles that traverse Rivero Street. The overall mean speed of the vehicles along the four arterial roads is 22.11 kph which is below the allowable speed limit of30kph on City as stated in Republic Act 4136 and nearly within the speed limit of20kph in the City of Vigan as included in the Vigan Traffic Management Ordinance of 1995. The very low mean speed of the vehicles may be due to the very high number of queues of vehicles along the approach of the intersections and the high level of service of the said intersections under study.

Table 14. Comparison of Speed of Vehicles along the Selected Arterial Roads (August 23, 2006)

Amo of Street	Morth Bound		So«th Bout		Jean Speed (kpb)	Mme of Street	ft Bond		Wes! Jound		lea Sped (kpb)
	Speed (kp»)	O. of Suple eliels	Syed (kpb)	No. of Sample ebides			Speed (cli)	lo. ol Sample Vehicles	Speed (kph)	No. o! Sample Vehicles	
Ri2) Street	/.-.	2!4	17.40	I56	17.58	Burgos Streel	20.48	197	19.38	;	20.03
9viino bsd.	30.11	254	29.45	302	29.80	Ruero Streel	21.47	ms;	20.63	19	21.05
Toll		478		I58				431		43	
Oer all Mean speed	2211 pl										

Common Resons for Traffic Congestion in the City

1. Fixed work hours resulting to rush in the city especially during peak hour periods.
2. Too many cars and tricycles on the narrow street of the city
3. Narrow width of streets in the city like those in the Central Business District
4. Bad driving habits
5. Too many single occupancy vehicles
6. Mxed land use activities in the City thereby attracting traffic
7. Too many intersections and narrow links or mid-blocks one way street with one lane on-street parking slots.

Table 15. Common Causes of Congestion along Intersections and the Suggested Typical Counter Measures.

Common Causes	**Menu Solutions**
Too many conflicts at intersections due to left-turns, right-turns and through movements	Minimize conflicts by banning low-volume turning movements at the intersection and transferring it elsewhere. (Strict implementation of the city ordinance prohibiting the right-turn of PUJ,PUB along Rizal Street to Burgos Street and implement rerouting among tricycles and cars, see Figure 4.)
Nan·ow street including the approaches of the intersection	Improve the geometries of the streets and intersections and acquire right-of-way (ROW) to increase the capacity of the roads and intersections, thus improve the level of service.
On-street parking	Ensure that the full capacity of the intersection can be achieved. The no parking, no loading, and unloading restriction at the approaches of the intersection should be implemented.
Physical inadequacies such as deteriorated pavements (e.g. Rizal Street-Burgos-Street)	Physical improvement
Counter productive driving pattern	Strict enforcement of road rules, regulations, laws (e.g. **R.A.** 4136, City ordinances

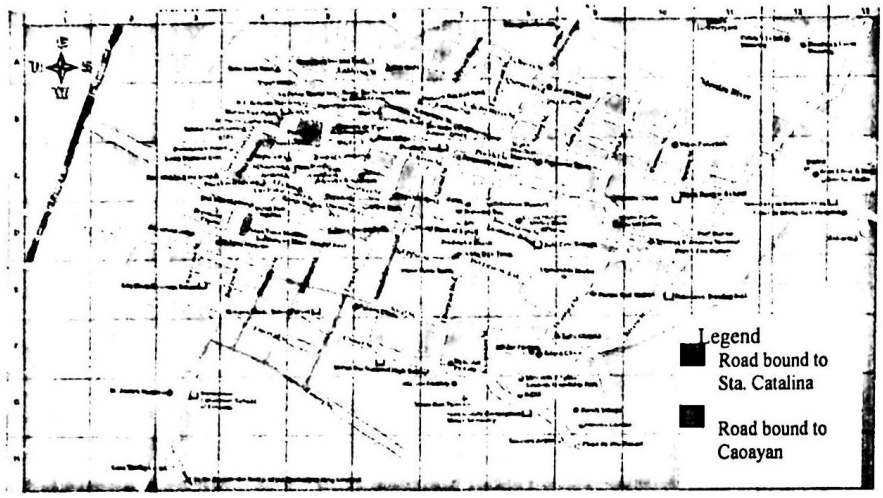


Figure 4. Map of Vigan showing the alternative roads bound to Sta. Catalina and Caoayan to Vigan City and vice versa.

It is noted in Figure 4 that tricycles bound for Sta. Catalina (West bound) shall use the Florentino Street turn right to Zamora Street and turn left to Burgos Street. Another alternative is the use of Bonifacio Street turning right to Zamora street then left to Burgos Street (see street in pink). Vehicles moving north bound from UNP and the southern part of Vigan and Caoayan shall use the street beside UNP going to Rizal Street extension. Vehicles from Beddeng, Vigan City, and other barangays therein shall turn right to Quirino Boulevard then turn left to Quema Street and move elsewhere as reflected in Figure 4.

Conclusion and Recommendations

I. The City of Vigan as a world heritage site which is new in its traffic management scheme and is traditionally focused on the use of regulation and enforcement. It is high time for the Planner to use the application of Traffic Engineering Principles to improve the traffic management practice in the city. Traffic control devices shall be used in the city to remind and direct the commuters. The LGU should revisit the implementation of the traffic rules, laws and regulations as written in Republic Act 4136 and consider the dissemination of the ordinances.

2. There are great numbers of vehicles that traverse the intersections and majority of them are cars and tricycles. Meanwhile, the number of buses and trucks that are plying the intersections studied will contribute a great effect on the through car units which is a

variable in the analysis of the capacity of the intersections. Thus, the LGU should visit the ordinance to regulate and limit the left or right turning vehicles.

3. The level of service of most of the intersections are F which is described as forced flow and a level of saturation as over capacity. These suggest that the Planners and LGUs should look into the possibility of acquiring right-of-way (ROW) to increase the capacity of the road and to improve the level of service of the intersections. The city administration should encourage Biguenos to use other transport modes that have larger occupancy for passengers.

4. The intersections with levels of service of "F" are recommended for traffic signalization. This is a medium solution to traffic congestion problems experienced in the city.

S. The planners should consider the implementation of the rehabilitation of barangay networks and new road cross-sections as included in the Vigan Master Plan. This will enable the easy access to the different barangays and give drivers an option to use other roads.

Because of the limitation of this study, other researchers should consider the attitudes towards the traffic management schemes of drivers plying Vigan City especially, the tricycles because it serves as the primary mode of transportation in Metro Vigan. Likewise, they should consider other factors that affect the level of service of the intersections. Further researches should also consider a study on the origin -destination of commuters. Other researchers should be encouraged to conduct a study on the variations of traffic flow by month, day and hour to establish an average daily traffic (ADT) in the heritage city of Vigan.

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