EFFECT OF THE MODIFIED BUS SEGREGATION SCHEME (MBSS) ON BUS OPERATION ALONG THE EPIFANIO DE LOS SANTOS AVENUE (EDSA)

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Abstract: ***The Modified Bus Segregation Scheme (MBSS) being implemented by the Metro Manila Development Authority (MMDA) to improve bus operations along EDSA was analyzed by taking bus samples before and after its implementation. To determine its effect on bus operations, such bus operating characteristics as travel and stop times, average travel and running speeds, and average passenger-kilometer performance were used as measures.***

Considering the segment of EDSA from Gil Puyat Extension to Aurora Boulevard, the result showed that in general, the average travel and stop time have increased after the implementation of the MBSS, although there was a noted decrease in stop time for a given value of travel time. It was also known that the average passenger-kilometer performance of the buses has not change after the implementation of the MBSS although their average travel and running speeds decreased. Also, no significant differences were noted in the operating performance of the numbered buses, although in the volume survey buses numbered one(1) in operation were quite few compared to buses numbered two(2) and three(3).

1. INTRODUCTION

Public utility buses operating along EDSA are considered one of the main causes of traffic congestion in the area, especially near bus stops. Congestion normally occur when they outmaneuver each other to get passengers thereby blocking adjacent lanes. Bottlenecks and constriction of traffic lanes used by other vehicles result as manifested by long vehicular queues before major bus stops. In addition, the MRT construction which occupies at least two lanes (one in each direction) of EDSA has farther reduced the available number of traffic lanes. For the time being, the lanes occupied by the MRT construction will remain while the project is ongoing. Being a priority project, it is expected that once the MRT system is operational, it will greatly improve commuter travel along EDSA. It is then imperative to introduce traffic management measures on bus operations to alleviate the traffic congestion.

Hence, the introduction of the bus segregation schemes (MBSS) to improve bus operational behavior along EDSA. While there were other traffic management measures introduced before, such as the yellow bus lane and the bus segregation scheme, there has been no schematic evaluation of whether the new scheme is an improvement of the previous scheme. However, going over the details of the new scheme, buses will still be using the segregated yellow lanes while also being allowed to use the under- and over-passes whenever possible and the two grouping of the previous bus segregation scheme have been expanded to three bus groupings. Further each grouping can only stop at 10 of the 22 designated bus stops along EDSA. This latter was done primarily to answer the bus congestion problem near major bus stops. At the very least these are the noted changes in and improvements of the modified bus segregation scheme.

This study aimed to determine the effect of the MBSS on bus operating characteristics along EDSA. Bus samples were taken before the MBSS was introduced in November 12, 1997 and additional samples were again taken after its implementation, since congestion along EDSA is worse during the peak hours (morning and afternoon), bus data were collected during these periods on weekdays. Data were gathered using the classical survey methods such as volume and boarding check surveys.

By concentrating the analysis on the Gil Puyat Extension to Aurora Boulevard segment of EDSA, being the segment used by all buses passing EDSA even though their origin and destination points are different, several interesting results were obtained. For one, the average passenger-kilometer performance of the buses has not changed after the implementation of the MBSS although their average travel and running speeds decreased. Also, significant differences were noted in the operating performance of the numbered buses, although buses numbered one(1) in operation are quite few compared to bus numbers two(2) and three(3).

This study, however limited, has evaluated one of the more economical measures of managing traffic congestion through public transportation system management. It is hoped that the current government should put more emphasis on this approach to solve traffic congestion especially with the limited infrastructure funds available.

2. THEORITICAL CONSIDERATION

Public bus journey time can be divided into three parts, namely: (1) Moving time; (2) traffic delays such as intersection delays; delay due to interaction with other vehicles; delay caused by embarking and disembarking passengers; and other related delays; and (3) turnaround time. Variability on moving time depends largely on the level of service of the road: the more vehicles the more conflict occur, resulting in slower overall speed of the traffic stream. Since city buses operating in Metro Manila have to compete with road space, it is expected that the incidence of traffic delay is high.

Service reliability is a concept frequently applied in measuring bus-operating performance. According to Jordan and Turnquist (1979), it reflects the degree to which buses provide regular or "on-time" service. Along the segment of EDSA, service reliability is quite high; a bus arrives approximately around 7 to 11 seconds in any direction during the peak hour. Hence, the problem of bus service performance lies more on the variability of moving time and actual time spent on bus stops waiting for passengers.

Several public bus transportation system improvement techniques are available to improve bus operation in the urban area (Tanaboriboon 1992). *This in with-flow bus lanes, contra-flow bus lanes, bus-only streets, bus ways, transit priority at traffic signal, bus priority for access to arterials by signal, and preferential treatment of the buses on freeways.* These techniques are currently being applied to improve bus operation. These were the following:

A. the EDSA Bus Lane Scheme (1990) which designated two of the outermost lanes among the six lanes in EDSA as bus lanes on weekdays and yellow lane marking was applied to separate the bus lanes from the ordinary lanes. Initially, the bus lane demarcation was enforced during morning and afternoon peak hours but was later changed to whole day, except on Saturdays, Sundays and holidays. However, confusion prevailed as to how the measure was to be followed and enforced between the drivers and traffic enforcers. The problems encountered included the misconception that the lanes can confine buses within and hence could not use the inner lanes and the rules for right turning vehicles were not clearly defined. Despite these shortcomings, the measure was officially hailed to have improved bus operations along EDSA; and

B. the Bus Stop Segregation Scheme which was intended to make the loading and unloading of passengers at bus stops more organized by dividing the buses plying EDSA into two groups based on their destinations. The bus stop area was delineated at different locations for each group with markings and signs indicating the group number. Buses were required to stop and load/unload passengers only at designated bus stops. The scheme was expected to enhance the convenience of public transportation.

The MBSS is the new version of the bus stop segregation scheme, and it was implemented starting November 12, 1997. Under the scheme, buses plying EDSA were divided into three groups, with each group allowed stop at no more than 10 of the 22 identified bus stop of EDSA from Mantrade to Balintawak. However, a bus may stop at any bus stop outside of the given limits or boundaries. The groups were numbered 1, 2, 3, and assigned with colors Tangerine, Yellow-Gold and Green, respectively. One-foot reflectorized stickers bearing the color-coded numbers, as manufactured and controlled by IMBOA (Integrated Metro Bus Operators Association), are placed at the right windshield to identify the buses. The same color-coded number is painted on the left side of the door. IMBOA is responsible for assigning bus stops and numbers and issuing stickers to buses. Non-IMBOA members have to communicate directly with IMBOA for their bus stops assignments and stickers. Signs were installed (just like the first bus stop segregation scheme) at the different bus stops to indicate which buses stop there and help commuters identify the buses they have to take.

An initial study done by the author, (Fillone, et. al 1998) showed that the average passenger-km performance of air-conditioned buses along the Gil Puyat Extension to Aurora Boulevard segment to EDSA did not change after the implementation although there were some noted decrease when the whole route system is considered. On the other hand, the average travel and running speeds decreased after the implementation although other extraneous factors such as the MRT construction and the pre-Christmas season traffic could have caused it.
With additional independent random sample gathered, bus data have to be tested for normally and variability in order that hypothesis testing regarding the changes in the means of these data after the implementation of the scheme can be performed. The F test, under the single-factor analysis of variance (ANOVA) model, is a preliminary statistic to be used between the alternatives is

$F^* = MSTR/MSE$

where,

MSTR = treatment mean square

$= SSTR/(r-1) = \sum_i ni(Yi.-Y..)^2/(r-1)$

MSE = error mean square

$= SSE/(n_T-r) = \sum \sum (Yij-Y..)^2/(n_T-r)$

$= \sum_i \sum_j e^2 ij/(n_T-r)$

And the appropriate decision rule to control the level of significance at EMBED Equation.α is:

If $F^* \leq F(1-\alpha; r-1, n_T-r)$, conclude H_o
If $F^* \geq F(1-\alpha; r-1, n_T-r)$, conclude H_a

where,
$F(1-\alpha; r-1; n_T-r)$ is the $(1-\alpha)100$ percentile of the appropriate F distribution.

A detailed analysis was undertaken to determine if the F test leads to the conclusion that the factor level means μi differ. These detailed analysis include:

A. Estimation of a factor level mean .μi

The confidence limits for μi with confidence coefficient
$1 - \alpha$ are:

$\overline{Y} \pm t(1-\alpha/2; n_T-r)s\{\overline{Yi}\}$

where
$t(1-\alpha/2; n_T-r)$the two sided t-

distribution
$s\{Yi.\}$ is the estimated standard deviation of the sampling distribution of Y (sample mean)

B. Turkey method multiple comparisons of factor level means

The Turkey method of multiple comparisons considers the set of all pairwise comparisons of factor level means which consists of estimates of all pairs $D = \mu_i - \mu_{i'}$. The family confidence coefficient of at least $1-\alpha$ are as follows:

$$\bar{D} \pm Ts\{\bar{D}\}$$

where,

$$\bar{D} = \bar{Y}_{i.} - \bar{Y}_{i.}$$

$$s^2\{\bar{D}\} = s^2\{\bar{Y}_i\} + s^2(\bar{Y}_{1.}) = MSE\{{}^1/_{ni} + {}^1/_{n}{}^1\}$$

$$T = ({}^1/_{\sqrt{2}})q(1-a;r;n_T-r)$$

When the distribution of the data depart from normality. The Kruskal-Wallis Rank Test can be used to test the whether the treatment means are equal. The test statistics of the Kruskal-Wallis Rank Test, X^2_{KW}, expressed as

$$X^2_{KW} = [({}^{12}/n_T(n_T-1))\sum_{i=1}^{r} n_i R^2_{i.}] - 3(n_T+1)$$

With n_i reasonably large (5 or more), X^2_{KW} is approximately a X^2 random variable with r-1 degrees of freedom and having the following hypothesis test:

$H_0: \mu_1 = \mu_2 = \ldots = \mu_r$

H_a: not all μ_i are equal

The appropriate decision rule for controlling the risk of making a Type I error at $\underline{\alpha}$ is:

If $X^2_{KW} \leq X^2(1-\alpha; r-1)$, conclude H_0

If $X^2_{KW} \geq X^2(1-\alpha; r-1)$, conclude H_a

3. METHODOLOGY

Since the primary objective of this study is to determine the effect of the MBSS on the operating characteristics, bus data were collected before and after the implementation of the scheme.

The primary bus data collection employed in this study are the following:

The boarding checks study. Most bus data were gathered using this data collection method. The data collector rode the bus being observed from the start of the route up to the end of its journey and collected the necessary data along the way. Giannopoulos (1989) discussed this method of determining the number of passengers inside the bus at various points of the route and also to determine passenger boarding and alighting.

To maintain the randomness of data, after identifying the bus service route to be surveyed at the beginning of the journey, the first bus to go was chosen as the sample. If possible, the surveyor should be the first passenger of the bus. Important data were listed down such as route serviced by the bus, time of start, seating capacity of the bus, and date of survey. As the bus stops to pick up and/or drop off passengers, the exact moment the bus stops and the time it moves afterwards were noted down to determine the time of passenger boarding and alighting. Other reasons for stopping such as obstruction caused by other vehicles and intersection delay were also noted down. At the end of the journey, the surveyor made it a point to be the last or part of the last group of passengers to disembark. The exact time the journey ended was then noted down. The last step was to subtract bus seat capacity by one (two) as this was occupied by the surveyor (two surveyors), usually the seat near the door.

This study was performed during the whole year of 1997 and up to June 1998. MBSS data were obtained after the scheme was implemented starting November 12, 1997.

Bus speed and delay studies. Data needed for computation of bus speed and delay were easily obtained by the surveyor by taking note of the time when the bus passes important road junctions or landmarks as well as the causes and duration of delays along the route. Distances were later obtained from a scaled map. Other important observations regarding bus interaction with other vehicles on the road as well as ongoing activities and land use along the route were also listed down.

Bus volume study. The primary purpose of this study is to determine the volume of buses passing through EDSA. The bus volume survey was conducted from 0630 to 0900 HRS in the morning and another one from 1630 to 1930 HRS in the evening. Three bus volume surveys were conducted during these periods: one in August 1997, November 1997, and in April 1998. Fifteen-minute intervals were used in determining the peak hour factor.

After processing the data collected, several bus service operating characteristics were obtained:

A. Average travel speed. Average travel speed is equal to the distance of the segment being studied divided by the total travel time (includes stop time and running time) expended on the segment.
B. Average running speed. Average running speed is equal to the distance of the segment being studied divided by the running time (or moving time) of the segment; and
C. Passenger-kilometer performance. All data regarding the computation of passenger-kilometer performance of buses were obtained with the surveyor on the bus. The computation process was as follows:

   (a) For the route segment of the study, every stop- and move-time of the bus was known. Since the distance of the segment was given, the average running speed could easily be computed as the distance of the segment divided by total running time within the segment.
   (b) Knowing the number of passengers inside the bus at all times, the passenger-

kilometer performance of the bus every time the bus moves along the segment can be easily obtained as follows

No. of Pax-Km = No. of passengers inside the bus
x the average running speed
x the running time

The average running speed for the whole segment was used since only the distance of the segment was known and it was quite difficult to obtain the bus location every time the bus stopped and moved along the segment for a detailed passenger-kilometer computation.

Statistical techniques were then used to analyze the data as discussed in the previous section to arrive on a set of conclusions.

4. PUBLIC BUS TRANSPORT ALONG EDSA

Metro Manila's PUBs. The public utility buses of Metro Manila are mostly imported. The buses are usually single-door types for air-conditioned unit and two-door types for non-air-conditioned units. The seating capacity of these buses range from 46 to 66, were the seats are usually arranged in fours or fives in a row, two-by-two or two-by-three facing the direction of motion. There are some modifications, however, like the removal of some of the seats near the door to improve movement of embarking and disembarking passengers, or to provide space for standing passengers. Bus fares are collected by a conductor/ conductress inside the bus.

Bus routes. The major street network of Metro Manila consists mostly radial and circumferential routes. The radial routes radiate from the city of Manila toward other urban and suburban areas while circumferential routes traverse these radial routes.Urban centers that attract most daily urban trips are the Ayala and Ortigas business districts. Figure 1 also shows the extent of bus route being studied with EDSA as the major segment of these route.

Urban bus service. Urban service in Metro Manila can be considered as local bus service since all stops along a route are being served. Along EDSA, buses stops on all bus stops and even on locations not designated as bus stops, although MBSS has modified this to some extent. With MBSS, the numbered buses can only stop in 10 of the 22 designated bus stops along EDSA. However, as observed, buses were still able to stop at any point along the route either to drop off or to pick up passengers especially when there were no traffic enforcers around.
Major bus stops along EDSA are either situated on the near side or far side of an intersection or at locations where there are major activity centers like shopping malls. Bus stops are also located near pedestrian overpasses for the convenience of the commuters. All bus stops are adjacent to the curb for direct and easy access by passengers.

Bus volume study. The ongoing Metro Manila Urban Transportation

Integration Study (MMUTIS 1996-1998) mentioned that the peak period in the morning occurs from 0700 to 1000 HRS, while the evening peak period occurs from 1600 to 1900 HRS. Three bus volume surveys were conducted during these periods: one in August 1997, November 1997, and in April 1998. Table 1 shows the average results of the first two surveys while Table 2 shows the bus volume survey in April 1998 with bus numbering fully in place. The peak hour volume has observed to occur within the specified peak periods. Not much different in bus traffic volume during the peak hour transpired after the implementation of the MBSS scheme. The data showed that

- The proportion of buses in the north-bound and south-bound directions has a difference of no more than 10 percent, with higher south-bound traffic during the morning peak hour and higher north-bound traffic in the afternoon peak hour
- The ratio of non-air-conditioned buses to air-conditioned buses is around 1:3
- The proportion of number 1 buses is quite low (9 to 10 percent) compared to numbers 2 and 3 buses (40 to 48 percent) of the total buses flow during the estimated peak hour
- With MBSS fully in place, the volume survey in April 1998 showed that around 1 to 2 percent of buses travelling during the peak hour did not have numbers; roughly the same proportion had signs too inconspicuous to be seen.

Table 1. Public bus transit volume survey

Morning Peak Hour	Air-conditioned		Non-airconditioned		Total	
	No. of Buses	%	No. of Buses	%	No. of Buses	%
North-bound	229	28.84	138	17.38	367	46.22
South-bound	296	37.28	131	16.50	427	53.78
Total	525	66.12	269	33.88	794	100
Afternoon Peak Hour	**Air-conditioned**		**Non-air-conditioned**		**Total**	
	No. of Buses	% No. of	Buses %	No. of	Buses	%
North-bound	228	32.66	117	16.76	345	49.43
South-bound	235	33.67	118	16.91	353	50.57
Total	463	66.33	235	33.67	698	100

Table 2. Public bus transit volume survey (April 1998)

Morning Peak Hour		North-bound		South-bound		Total	
		Frequency	%	Frequency	%	Frequency	%
Aircon	Bus#1	27	2.77	35	3.59	62	6.37
	Bus#2	108	11.09	117	12.01	225	23.10
	Bus#3	150	15.40	177	18.17	327	33.57
	None	3	0.31	4	0.41	7	0.72
Total		288	29.57	333	34.19	621	63.76
Non-aircon	Bus#1	26	2.67	21	2.16	47	4.83
	Bus#2	82	8.42	80	8.21	162	16.63
	Bus#3	64	6.57	76	7.80	140	14.37
	None	2	0.21	2	0.21	4	0.41
Total		174	17.86	179	18.38	353	36.24
Grand Total		462	47.43	512	52.57	974	100.00
Afternoon Peak Hour		**North-bound**		**South-bound**		**Total**	
		Frequency	%	Frequency	%	Frequency	%
Aircon	Bus#1	27	3.59	12	1.60	39	5.19
	Bus#2	124	16.49	102	13.56	226	30.05
	Bus#3	123	16.36	111	14.76	234	31.12
	None	1	0.13	6	0.80	7	0.93
Total		275	36.57	231	30.72	506	67.29
Non-aircon	Bus#1	16	2.13	14	1.86	30	3.99
	Bus#2	64	8.51	55	7.31	119	15.82
	Bus#3	53	7.05	38	5.05	91	12.10
	None	5	0.66	1	0.13	6	0.80
Total		138	18.35	108	14.36	246	32.71
Grand Total		413	54.92	339	45.08	752	100.00

5. BUS OPERATING CHARACTERISTICS FOR ANALYSIS OF THE MBSS EFFECT

The bus operating characteristics that were analyzed to measure the MBSS effect include travel and stop times, average travel and running speeds, and average passenger-kilometer performance.

Travel and stop times can provide facts about the effect of reduced number of stops on bus travel. Average travel and running speeds can provide information whether improvements in bus travel have resulted, while average passenger-kilometer performance can give insights into the revenue performance effect of the MBSS implementation on bus operators. The study gave emphasis on Gil Puyat Extension to Aurora Boulevard segment of EDSA. This segment is part of the routes being serviced by all buses passing EDSA regardless of their destination within Metro Manila.

Bus Travel Time and Delay. Table 3 shows the average travel (stop plus moving time) and stop time of air-conditioned buses before and after the implementation of the MBSS along the Gil Puyat Extension to Aurora Boulevard segment of EDSA. **Figure 2** shows the scatterplots of the travel time versus stop time. The following observations can be derived from the presentations:

A. In general, the average travel has became longer after the implementation of the MBSS by around 0.223 hr. (13.38 minutes) while average stop time increased by only around 0.07 hr (4.26 minutes).

B. The relationship between the travel and the stop times of buses as represented by the trendlines, has shifted upward after the implementation of the MBSS. The shift tells us that considering the same duration of time travel along the segment, travel time was equal to one hour before MBSS, while stop time was around 0.444 hr. (27 minutes). After MBSS, it was only around 0.344 hr. (21 minutes), or a savings of six minutes on a one-hour total travel time. This observation could be the result of reducing the number of major bus stops a bus can stop along the segment under MBSS.

Table 3. Average travel and stop times of air-conditioned buses

	Average Stop Time Hour (minutes)	Average Travel Time Hour (minute)
Before MBSS	0.291(17.46)	0.802(48.12)
After MBSS	0.361(21.66)	1.025(61.50

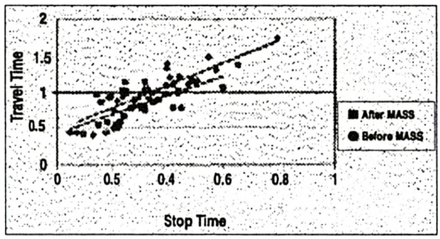

Figure 2. Stop versus travel time of air-conditioned buses along a segment of EDSA

Since in totality the average travel time and stop times have increased, MBSS was hardly a factor in improving air-conditioned bus movement along EDSA. However, the data showed that this scheme reduced average stop time by a few minutes per average total travel time.

ANOVA Model I was used to test the other operating characteristics. Using this method, the before-and-after MBSS situations as well as the bus numbering system were considered as factor levels and have probability distribution of responses (the independent variables). These responses are assumed normal and of the same variance (standard deviation) and observations are randomly obtained and are independent from observations of other factor levels. Hence, to start the analysis, the response variables such as the average travel and running speeds and the average passenger-kilometer performance of buses were tested concerning their probability distributions.

5.1 Test on the Distribution of Data

Table 4 shows the data regarding the average travel and running speeds and average passenger-kilometer performance of the 60 air-conditioned buses, 30 before and 30 after the implementation of the MBSS, surveyed. There are several available tests to determine whether the sample data came from a normal population. One of these is the normal probability plot wherein the actual residuals of the variable are plotted against its expected residuals. If the plot appears straight along the diagonal, the data can be considered as normal. **Figure 3** shows one of these plots using the residuals and expected residuals of the average passenger-kilometer of the air-conditioned buses sampled after implementation of the MBSS. To strengthen this normality proof further, the correlation between the actual residuals and the expected residuals were compared to a set of correlation values under normality as prepared by Looney and Gulledge, Jr. (1985). **Table 5** shows these correlation values of all variables studied were only the average running speed (before MBSS) and the average passenger-kilometer (after MBSS) of the buses passed the critical values. The average passenger-kilometer (before MBSS) was quite near the critical value and the rest of the variables were quite far off. Hence, the average passenger-kilometer for both cases (before and after) tend to behave normally.

Except for the average running speed (before MBSS), the other distribution of the average travel and running speeds were not near normal. Hence, the average and running speeds was not further analyzed with regard to their variability because they seemed have failed one major criteria for normality.

Table 4. Average travel and running speeds and average passenger-kilometer performance of air-conditioned buses

Before MBSS			After MBSS			
Average Travel Speed (kph)	Average Running Speed (kph)	Average Passenger-Km Performance	Bus No.	Average Travel Speed (kph)	Average Running Speed (kph)	Average Passenger-Km Performance (Pax-Km)
9.38	14.66	344.72	3	9.09	12.02	306.53
8.89	13.95	492.04	2	19.09	28.40	342.28
9.13	11.22	482.89	1	10.08	16.89	315.42
10.12	16.63	608.99	1	8.46	11.45	459.64
14.11	20.52	291.24	1	7.55	9.84	178.82
8.86	13.58	353.86	3	5.97	8.89	504.09
10.48	18.33	360.50	2	6.52	9.90	364.22
14.2	23.25	276.92	1	10.05	24.02	336.32
17.92	30.24	277.63	1	5.29	8.45	302.49
10.07	21.87	407.04	3	7.78	11.17	341.00
11.67	18.37	459.02	1	8.45	12.47	456.84
14.30	19.52	503.21	3	6.53	10.36	453.77
9.55	15.81	276.14	3	14.86	27.13	231.72
15.92	27.59	273.58	1	8.41	10.68	136.23
8.82	15.12	350.95	2	9.68	14.75	456.49
7.43	17.17	404.12	3	6.71	11.51	408.23
17.91	22.88	438.32	2	5.70	10.92	205.56
18.56	20.90	316.84	2	6.00	10.79	301.86
7.14	9.95	407.15	2	7.10	12.36	346.68
8.61	12.48	258.15	1	8.14	10.90	205.91
7.89	14.10	367.27	1	4.53	8.36	612.35
6.76	11.98	288.86	3	17.38	20.80	237.75
8.87	11.15	482.63	3	6.95	12.50	274.02
9.63	15.74	140.48	3	10.68	14.87	570.06
8.05	13.45	188.46	3	8.34	12.94	363.94
7.15	11.64	277.24	2	5.60	7.85	404.04

7.20	19.78	871.93	2	6.90	8.82	256.69
10.19	15.56	74.04	2	7.02	11.34	287.95
8.20	9.62	676.42	2	7.80	11.43	246.99
9.72	15.54	441.50	1	8.59	13.53	400.90

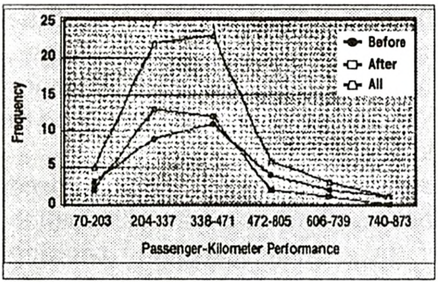

Figure 3. Plot of residuals vs. expected residuals of the average passenger-kilometer performance of air-conditioned buses after MBSS

Table 5. Test for normality using the coefficient of correlation of air-conditioned buses operating characteristics.

	Operating Characteristics	Coefficient of correction	Critical values α=0.05)	No. of Samples	Remarks
Before MBSS	Ave. Pax-Km	.955	.964	30	Fail
	Ave. Trvl. Speed	.918	.964	30	Fail
	Ave. Run. Speed	.970	.964	30	Pass
After MBSS	Ave. Pax-Km	.989	.964	30	Pass
	Ave. Trvl. Speed	.878	.964	30	Fail
	Ave. Run. Speed	.890	.964	30	Fail

Table 6. F-Test for variances of the average passenger-kilometer performance of air-conditioned buses before and after the implementation of the MBSS

	Before MBSS	*After MBSS*
Mean	379.738	343.626333
Variance	25048.4937	12923.3268
Observations	30	30
Df	29	29
F*	1.93823882	
P(F≥f) one tail	0.0399722	
F Critical one-tail	1.86081195	

The variances of the average passenger-kilometer were tested using the F-Test for equality of variance. Table 6 shows $F^* > _{critical,}$ therefore the variances of the average passenger-km performance of air-conditioned buses before and after the implementation of the MBSS somewhat differed. However, the value of F* is quite near the $F_{critical}$ which tells us that the variability was not that large. As Figure 4 would show, their frequency polygons were almost similar in shape with only some shifts near the center.

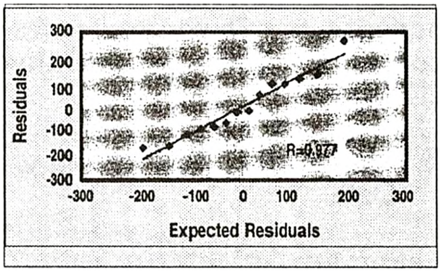

Figure 4 Frequency polygon of the average passenger-kilometer performance of air-conditioned buses

Similarly, for non-air-conditioned buses, the variables being studied are shown in Table 7 below. Again, the results in Table 8 show that the average passenger-kilometer garnered behave normally. Figure 5 presents the normal probability plot of the actual residuals versus the expected residuals of the average passenger-kilometer of non-air-conditioned buses sampled before the implementation of the MBSS.

Table 7. The average travel and running speeds and average passenger-kilometer performance of non-air-conditioned buses

Before MBSS			After MBSS		
Average Travel Speed (kph)	Average Running Speed (kph)	Average Passenger-Km Performance (Pax-Km)	Travel Speed (kph) Average	Running Speed (kph) Average	Passenger-Km Performance (Pax-Km) Average
16.34	25.99	509.41	9.46	13.69	344.767
14.11	20.44	352.41	14.83	19.90	319.514
15.62	23.94	262.00	10.73	15.65	299.903
23.58	28.19	682.23	18.95	27.41	634.668
15.77	23.54	549.95	12.44	29.03	705.711
9.87	11.99	331.57	13.22	18.21	463.765
9.94	12.74	247.43	12.65	17.86	452.464
9.94	11.95	378.83	9.67	13.64	263.728
6.44	10.98	261.80	9.66	13.47	276.221

8.42	12.89	400.21	10.76	14.77	841.648
8.57	11.88	587.88	10.75	15.16	845.577
8.57	13.64	496.28	10.61	13.84	327.319
8.32	11.59	305.66	10.74	14.87	314.780
10.40	15.26	507.91	10.76	14.57	835.068

Table 8. Test for normality using the coefficient of correlation of non-air-conditioned characteristics

	Operating Characteristics	Coefficient of correlation	Critical values (α=0.05)	No. of Samples	Remarks
Before MBSS	Ave. Pax-Km	.977	.935	14	Pass
	Ave. Trvl. Speed	.916	.935	14	Fail
	Ave. Run. Speed	.913	.935	14	Fail
After MBSS	Ave. Pax-Km	.936	.935	14	Pass
	Ave. Trvl. Speed	.871	.935	14	Fail
	Ave. Run. Speed	.857	.935	14	Fail

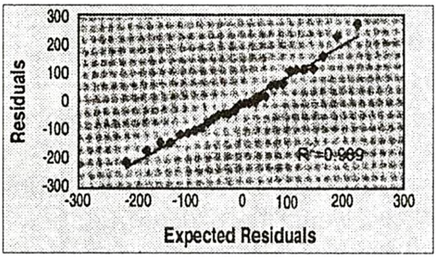

Figure 5. Normal probability plot of expected residuals vs. actual residuals of the average passenger-kilometer performance of non-air-conditioned buses before MBSS

In **Table 9** below, at α = .05, F* < $F_{critical}$. Therefore the variances of the ave. paxpkm performance of non-air-conditioned buses before and after the implementation of the MBSS did not differ.

Table 9. F-Test for variances of the average passenger-kilometer for non-air-conditioned buses before and after the implementation of the MBSS

	Before MBSS	After MBSS
Mean	409.6711	500.3666
Variance	15396.24	50457.18
Observations	14	14
Df	13	13
F*	0.305135	
P(F≥f) one tail	0.020519	
F Critical one-tail		0.388059

As determined, the sample data of the average pax-kilometer performance were quite normal and equal variability. With bus samples, the confidence interval range can now be obtained for the average pax-km and is shown in **Figure 6.** The confidence interval range for air-conditioned buses shifted a bit downward after the implementation of the MBSS while that for non-air-conditioned buses moved a bit upward The confidence range of the airconditioned buses is quite tight compared to non-air-conditioned buses because there were more samples taken (30 samples for air-conditioned buses, compared to 14 for non-air - conditioned buses for both before and after the MBSS) of the former.

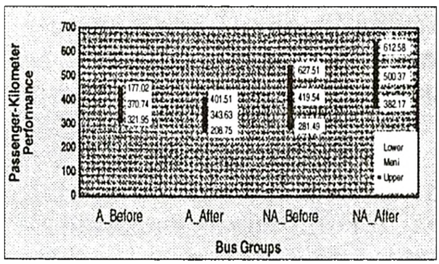

Figure 6. Estimated confidence interval ($\alpha = .05$) of the average passenger-kilometer perfomance of air-conditioned and non-air-conditioned buses before and after the implementation of the MBSS

A statistical tests showed, the average travel and running speeds of buses did not behave normally, hence we cannot assume that the distribution of these variables are normally distributed. Just to give some insights into the effect of the MBSS on these variables, the sample means of the average travel and running speeds for all bus types are given in the Table 10.

Table 10. Average travel and running speeds of buses before and after the implementation of the MBSS

Bus Type	No. of Sample	Before MBSS		After MBSS	
		Mean of Ave. Travel Speeds (kph)	Mean of Ave. Running Speeds	Mean of Ave. Travel Speeds (kph)	Mean of Ave. Running Speeds (kph)
Aircon	30	10.56	16.75	8.51	13.41
Non-aircon	14.	11.85	16.35	11.80	17.29

Through the average travel and running speeds were non-normal there are other non-parametric statistical tools available to determine the change in means of the sample such as the Kruskal - Wallis rank test.Applying Kruskal Wallis rank test to determined whether change in average travel and running speed occurred after the application of the MBSS for both air-conditioned and non-air-conditioned buses, **Table 11** gives the result. As shown, the average travel and running speeds of air-conditioned buses decreased after the application of the MBSS while that for the non-air-conditioned buses remain the same.

Table 11. Kruskal-Wallis Rank Test for changes in the average travel and running speeds

	Speed	Before R_1	After R_2	X^2_{KW}	$X^2_{critical}$	Remarks
Aircon	Ave. Travel Speed	37.567	23.433	9.824	3.841	$X^2_{KW} > X^2_{critical}$ Accept Ha
	Ave. Running Speed	37.533	23.467	9.731	3.841	$X^2_{KW} > X^2_{critical}$ Accept Ha
Non-aircon					3.841	$X^2_{KW} < X^2_{critical}$ Accept Ho
					3.841	$X^2_{KW} < X^2_{critical}$ Accept Ho

5.2 ANOVA MODEL I to Test the average Pax-Km Performance of the buses

Using ANOVA MODEL I, two tests were undertaken on the average passenger-kilometer performance of the buses. These are the following:

1. With two factor levels, (1) before MBSS, and (2) after MBSS, data on the average passenger-kilometers (the response variable) from the two studies were tested if changes occurred. This was done for both air-conditioned and non-air-conditioned buses.
2. With buses under MBSS grouped into three, we think of these groupings as factor levels. The test would like to determine how they have performed and whether anyone among the three groups got worse/ better off from the scheme. This was done only for air-conditioned numbered buses.

Assuming that we to control the risk of making Type I error at α= .05, $F_{critical}$ = 4.007 Since $F^* < F_{critical}$ we conclude H_0, that the mens of the average passenger -kilometer of air conditioned buses along the segment mentioned did not differ after the implementation of the MBSS.

Using the same test on non-air-conditioned buses, F* = 1.323 < F critical = 4.2252, we again conclude H_0, that the means were equal or that the means of the average passenger-kilometer performance of non-air-conditioned buses before and after MBSS did not differ.

Table 12. F-Test for variances of the average passenger-kilometer performance of air-conditioned buses

Source of Variation	SS	df	MS	F*	P-value	Fcrit
Between Groups	19560.79	1	19560.78704	1.030279	0.314309	4.006864
Within Groups	1101183	58	18985.91025			
Total	1120744	59				

Under the MBSS scheme, the buses were divided into three groups numbered 1, 2, and 3. It would be interesting to know how each group has been performing under the scheme. However, it was noted down that the assigning of bus numbers to buses were not done proportionately. This was observed from the volume survey in Table 3, where the No.1 buses are few (9-10%), compared to Nos. 2 and 3 (40-48%), of the total buses operating during the peak hour. Nevertheless, the same number of samples, 10 from each group, was taken which in the previous section totaled to 30 samples. Table 13 below shows the average passenger-km performance of the numbered buses under the MBSS. On the other hand, Table 14 shows the coefficient of correlation of the means of the average passenger-kilometer have passed the critical value showing that they tend to be normally distributed. These can be further bolstered by the frequency histogram shown in Figure 7 where the average passenger-kilometer performance of the majority of the samples tend to cluster in the middle.

Table 13. Average passenger-kilometer performance of air-conditioned numbered buses under the MBSS

Samples j	Bus Number, i		
	Bus#1 (kph)	Bus#2 (kph)	Bus#3 (kph)
1	315.42	306.53	342.28
2	459.64	364.22	504.09
3	178.82	456.49	341.00
4	336.32	205.56	453.77
5	302.49	301.86	231.72
6	456.84	346.68	408.23
7	136.23	404.04	237.75
8	205.91	256.69	274.02
9	612.35	246.99	570.06
10	400.90	287.95	363.94
Mean ($\bar{Y}_i$)	340.49	317.70	372.69
Mean ($\bar{Y}$)	343.63 (all samples)		

Table 14. Air-conditioned numbered buses test for normality

	Bus No.	Coefficient of Correlation	Critical value (α=.05)	No. of Samples	Remarks
Ave. Pax-Km	1	0.984	0.918	10	Pass
	2	0.989	0.918	10	Pass
	3	0.984	0.918	10	Pass

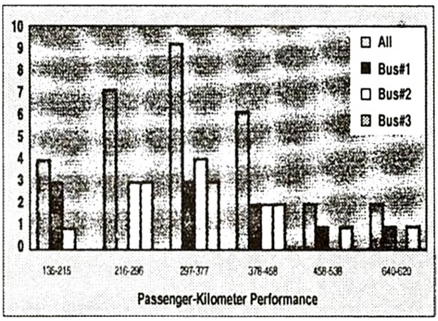

Figure 7. Sample frequency histogram of the average passenger-kilometer of numbered buses

Table 15. Comparison of the average passenger-kilometer variances between the numbered buses

Bus Number	Mean (kph)	Variance	Compared to					
			Bus#1		Bus#2		Bus#3	
			F*	Fcrit	F*	Fcrit	F*	F_{crit}
Bus#1	340.49	21,483.59	****	****	3.698	3.179	1.698	3.179
Bus#2	317.70	5,808.83	3.698	3.179	****	****	0.459	0.315
Bus#3	372.69	12,653.40	1.698	3.179	0.459	0.315	****	****

Table 15 above shows the F-Test for variances of the numbered buses. Only the variances of the buses 1 and 3 did not differ since the comparison passed the critical F-value. The other values being compared have F-values a little over near the F critical though they were expected to pass the critical F-values if only more samples are taken.

It is now desired to determine whether or not the means (μi) of the ave. pax-km of the number of equal. The alternative conclusions considered were : H_0: $\mu_1 = \mu_2 = \mu_3$ and Ha : not all μi are equal Since F·0.4597 <F_{crit} =3.4028, we concluded H_0 that the means of the average pax-km of three bus types are equal. This results tells us that there was no relation existing between the numbering of the buses and thier corresponding average passenger-kilometer performance.

Table 16. The result of the ANOVA for the three bus types

Source of Variation	SS	df	MS	F*	P-value	Fcrit
Between Groups	13576.6	2	6788.302	0.459718	0.636907	3.402832
Within Groups	354389.3	24	14766.22			
Total	367965.9	26				

Since it has been proven using the F-test that no relation exist between the levels (the numbering of buses) and the dependent variable (the ave. pax-km performance), detailed analysis of the factor level effects may not be necessary. However, additional analysis will be undertaken to show additional proof of what has just been proven. Further analysis include, (1) Normal probability plot of estimated means of the average pax-km of the numbered buses, and (2) The Tukey method of multiple comparison of the ave. pax-km means of the numbered buses (factor levels).

Normal Probability Plot of Estimated Factor Level Means. Since all sample sizes are equal (n_i=10), the normal probability plot can be used to determined factor level means. The expected value of the *i*th ordered estimate factor level means, if all factor level means μ_i were equal, is approximate as (See Neter, Wasserman,and Kutner, 1990:) Expected value =Y + z[(i - .375)/ (r .25) X Sqrt (MSE/N), where the square root term is the estimate standard deviation of Yi., i=1,2 and 3.

The estimated factor level means $\overline{Yi}$ is plotted against the normal percentiles. A linear pattern of the points was obtained since the expected values are a linear function of the percentiles. The expected values were also plotted to serve as a reference line whether how far the estimated mean $\overline{Yi}$ deviate from its expected value. The plots of the data are shown in Figure 8 below.

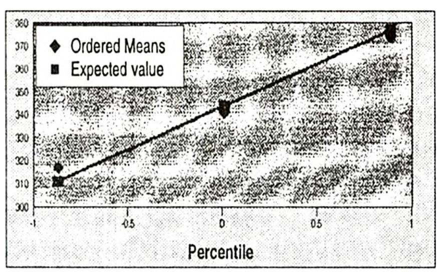

Figure 8. Normal probability plot of estimated means of passenger-kilometer performance of the three bus types

The fact that the points of the means of the ave. pax-km performance of the three numbered buses were close to the reference line (expected value), these suggest that all means μ_1 are reasonably equal In other words, result supported the F-Test conducted previously.

Multiple Comparison of factor level means (Turkey Method). To stimate all pairwise comparisons by means of the turkey procedure, a family confidence coeficient of 95 percent was used. From data, r = 3 and $(n_T - r) = 27$ which could give us the required percentile of the studentized range distribution q (.95;3,27) = 3.51. other necessary data were obtained as follows:

$T = (1/\sqrt{2})(2.496) = 2.482$ $s^2\{\bar{D}\} = 19060.66(1/9 + 1/9) = 2663.054$, resulting to $s\{D\} = 51.6048$; hence, $Ts\{D\} = 128.08$

The pairwise confidence interval with 95 percent family confidence coeffient therefore are:

$-105.29 = (340.49 - 317.70) - 128.08 \leq \mu_2 - \mu_1 \leq (340.49 - 317.70 + 128.08 = 150.87$

$-73.10 = (372.69 - 317.70) - 128.08 \leq \mu_1 - \mu_2 \leq (372.69 - 317.70) + 128.08 = 183.07$

$-95.89 = (372.69 - 340.49) - 128.08 \leq \mu_1 - \mu_1 \leq (372.69 - 128.08 = 160.28$

The pairwise comparisons indicate that the means of the average passenger-kilometer performance of buses along the segment mentioned did not differ from each other. Since the confidence intervals cover the value zero, all of the differences are statistically insignificant. No numbered bus type has gained singificantly form the bus numbering arrangement. This result against agrees with the earlier findings.

5.3 Kruskal-Wallis Rank Test for Average Travel and Running Speeds

Since it has been shown that the average travel and running speeds depart from normality, a nonparametric test called the Kruskal-Wallis Rank Test was employed to estimate possible changes in the means. The only assumption in the population distribution being studied using the Kruskal-Wallis test is that

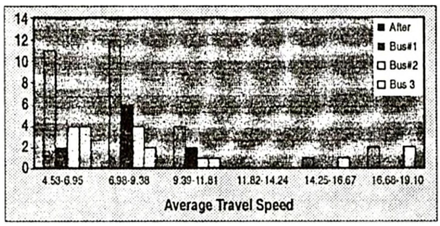

Figure 9. Average travel speed of air-conditioned numbered buses

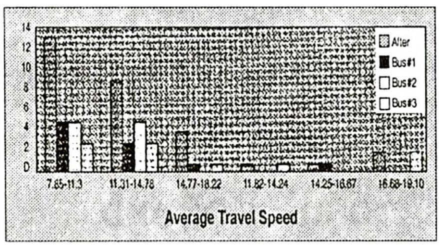

Figure 10. Average running speed of air-conditioned numbered busses

they should be continuous and of the same shape (Neter, et. al., 1990). As Figure 9 and 10 show, the frequency histograms of the average travel and running speeds of the air-conditioned buses are quite similar.

Using the data of Table 17 it can be shown that the B. Kruskal-Wallis test $X^2_{KW} = 3.672$ was lower than the $X^2 0.95,2) = 5.991$, hence we conclude H_0 that the mean of the average running speeds of the numbered buses did not differ. Doing the same process to the average travel speeds of the numbered buses, X^2_{KW}=2.7587 was lower than the X^2 0.95,2) = 5.991.

Table 17. Average running speed of numbered buses and their Kruskal-Wallis ranks

Bus Sample J (kph) Y_i	Bus Number					
	Bus#1		Bus#2		Bus#3	
	Run. Speed R_i	Rank (kph) Y_i	Run. Speed R_i	Rank (kph) Y_i	Run. Speed R_i	Rank
1	1689	26	1202	18	284	30
2	11.45	16	99	7	889	5
3	984	6	1475	24	11.17	13
4	2402	28	1092	12	1036	8
5	845	3	1079	10	2213	29
6	1247	20	1236	19	1151	17
7	1068	9	785	1	208	27
8	109	11	882	4	125	21
9	836	2	1134	14	1487	25
10	1353	23	1143	15	1294	22
Mean $\bar{R}_i$		144		124		197
Overal rank, R			155			

These results showed that non of the numbered buses got a better/worsedeal in their performance since the hypothesis that the means of their average travel and running were the same cannot be disproved.

6. CONCLUSION AND RECOMMENDATIONS

The study aimed to determine the effects of MBSS on bus operating performance along EDSA. Using the bus operating characteristics such as travel and stop times, average travel and running speeds, and average passenger-kilometer performance of buses along the Gil Puyat Extension to Aurora Boulevard segment of EDSA, the following conclusions were derived from the study:

A. In general, the mean of travel and stop times increased after the implementation of the MBSS, although there was a noted decrease in stop time for a given value of travel time may be attributed to the decrease in the number of stops the bus are allowed to stop;

B. One possible reason why average travel and running speeds do not behave normally is that due to MRT and other construction activities, closing of additional lanes sometimes occur in an unpredictable manner thereby causing bottlenecks and reducing average travel and running speeds. This is not true with respect to the average passenger-kilometer performance of the buses, which behaves normally, since daily bus passengers remain the same whether there is congestion or not along EDSA.

C. Using analysis of variance with a confidence level of α = .05, the average passenger-kilometer gained by both the air-conditioned and non-air-conditioned buses did not differ after the implementation of the MBSS. However, this may not be true of the average passenger-kilometer performance of the buses of the entire route they service or on daily basis;

D. Using analysis of variance with a confidence level α = .05, for the air-conditioned numbered buses, no group got better/worse off in terms of the average passenger-kilometer performance. However, as the volume survey would show, there were quite a small percentage of number 1 buses in operation. Since one of the primary purposes of the scheme is the decongest bus stops, equal assignment of buses to each group should be done. In the present situation, if equal proportion of buses is considered, number 1 buses will be disadvantaged. Hence, a reassignment of bus stops to the three bus groups should be looked into before equal proportioning of buses is done.

E. Using Kruskal-Wallis Rank test, the average travel and running speeds of air-conditioned buses decreased after the implementation of the MBSS while that for the non-air-conditioned buses did not differ. Also, for the air-conditioned numbered buses, no differences among the groups were noted in terms of their average travel and running speeds.

This study only considered the effect of the MBSS on bus operating characteristics. However, there are other stakeholders involved whose interests are as important as the buses and bus operators, such as the bus riding public and other vehicles using EDSA. With buses limited to fewer stops than before, waiting time for bus commuters certainly became longer. It would also be interesting to know how traffic flow on the point of view of private vehicles has changed after the MBSS implementation.

ACKNOWLEDGEMENT

The author would like to acknowledge the support provided by the University Research Coordination Office of DLSU for providing the necessary funds for the research on air-conditioned buses. The author would also like to acknowledge Mr. Lawrence Alcon, Mr. Rommel Icasiano, and Mr. Virgilio S. Vinzon II, all DLSU civil engineering students, for sharing with the author their data on non-air-conditioned buses.

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