AN INVESTIGATION OF BUS TRAVEL TIME COMPARING WITH PRIVATE CAR TRAVEL TIME

Moe Myint Mo[1], Kyaing[1], Yoshihide Sekimoto[2], Ko Ko Lwin[2]
[1]Yangon Technological University
Insein Road, Gyogone, Insein 11101, Yangon, Myanmar.
Email: moemyintmo.555@gmail.com; kyaingkyaing63@gamail.com
[2]Institute of Industrial Science, The University of Tokyo
Komaba 4-6-1, Meguro Ku, Japan.
Email: sekimoto@ii.u-tokyo.ac.jp; kokolwin@iis.u-tokyo.ac.jp

KEY WORDS: Private Car operation, GPS, Predicted Bus Travel time, Multi-Linear Regression Model

ABSTRACT: In Yangon, bus users are faced many traffic congestion problems such as not having substantial bus operation system, variance of headway is so different every time and day .The result is directly affected to bus travel time and reliability of bus operation . Bus drivers in Myanmar control their bus speed according to the passenger demand and they take long holding times at the bus-stops. The objective of this study is to control the bus like as the private car operation that is speed and travel time, and then rebuild reliable bus operation. Passenger boarding time, number of bus-stops and traffic signal time must be constant in this study. The field survey data, Global Positioning System (GPS) and Geographic Information System (GIS) were used to estimate the actual bus travel time and the result that can apply on predicting bus travel time under free flow condition. The multi-linear regression model of bus travel time was developed as a function of car traffic time rate, number of traffic signals time and number of bus stop accounted. The conclusion was that bus travel time in mixed traffic under free flow condition were used to reduce the actual bus travel time and can support bus–only shoulder polices, stops consolidation, serving major streets with fewer traffic signal time and removing bus stands which are near to signalized intersection.

1. INTRODUCTION

People in Yangon are faced traffic congestion every days and everywhere they travel. According to the government data, 66 percent of country’s vehicle are driven in Yangon. The roadway network in Yangon currently operates at or above its desired capacity at everywhere during the peak periods. Particularly, unique operational characteristics in Yangon are found: non-fixed daily schedule, incomplete data, short station spacing, and congested road network. Small increase in traffic volume will lead to cause significant increases in traffic delay and bus. Also, buses are not equipped with both in-vehicle global positioning system (GPS) and Automatic Fare Collection (AFC). Currently some agencies are looking forward increased implementation of faster services such as Bus Rapid Transit (BRT) services but these buses are running without having bus lane priority. So buses in Yangon operate almost exclusively in mixed traffic and share with private car, taxi and other transport vehicles. Therefore, congestion will have an impact not only on automobile drivers and passenger but also on bus riders. Moreover, buses under very congested condition can effect on low speed of the stream of the traffic and also give interference to other vehicles when moving in and out of the stream of traffic at bus stops.

Nowadays, there are about 6300 buses operating on many bus routes in the city, carrying over 4.4 million passengers a day in Yangon.All the buses are travelled in mixed traffic so bus travel time and speed are also decreased and the result can also affect reliable service to passenger.A reliable service to passenger is the service that can be easily accessed to origin and destination ,arrive in time, has a short travel time/run time(similar or better than private vehicle time), and low variance in travel (Furth and Muller 2006,2007;Koenig 1980;Murray and Wu 2003;Turnquist 1978;Welding 1957).Travel time, or run time, is the amount of time it takes for a bus to travel along its route or along a specified segment .Abkowitz and Engelstein(1984) found that mean run time affected by route width, passenger activity , and number of signalized intersection .

The purpose of this research was to quantify the impact of congestion on bus travel time in Yangon. The basic approach involved in developing a model based on GPS data and field survey that estimated bus travel time as a function of overall car travel time. The model was then used to estimate the proportion of bus travel time due to increase in traffic time over free flow condition The main goal of this research is to control the bus like as the private car operation that is speed and travel time and then rebuild reliable bus operation. In particular, the model presented in this paper lend to support bus–only shoulder polices, stops consolidation, serving major streets with fewer traffic signal time and removing bus stands which are near to the signalized intersections.

2. LITERATURE REVIEW

Most researchers agreed on the basic factor affecting bus run time (John Hourdos,2009;Abkowitz and Engelstein,1984).Table 1 contain a summary of known factors affecting run times which is related in Yangon City.

Table 1. Factor Affecting Transit Travel Time

Variables	Description
Distance	Segment length
Intersection	Number of signalized intersection
Bus stops	Number of bus stop
Boarding	Number of passenger boarding
Alighting	Number of passenger alighting
Time	Time period
Driver	Driver experience
Departure delay	Observed departure time minus scheduled
Direction	Inbound or outbound service
Weather	Weather-related conditions
Road	Road characteristics

Since bus travel with regular traffic, they are affected by overall dynamics of the transportation system, where changes occur on both regular (i.e. peak hour traffic congestion) and random (i.e. road construction, accidents, special events) bases. These changes influence the amount of time it takes for a bus to travel from one stop to another and the level of service it provides to passengers.

Heavy traffic cause additional delay (McKnight and Paaswell, 1997) because of a variety of situations, such as double and triple–packed cars, vehicle queues waiting to make right or left turns, taxi making sudden stops or turns to pick up passengers, and long signal time. The impact of these situation was often exacerbated for buses because of the need for buses to have frequent access to the curb lane at bus stops.

3. DATA COLLECTION

The goal of this research is to relate bus travel time to floating bus along study route and to model bus travel time rates in term of car travel time. The data were collected on bus route (blue line 1) which is connected with 15 roads (see in Figure 1.). There are about 84 bus-stops and the current bus system starts operating from Naung Pin (main bus station) at 07:00 a.m. and back at Naung Pin at 20:00 p.m. The distance of 45.319481km is traveled three time a day during weekdays (Monday, Tuesday, Wednesday, Thursday, and Friday) and congested on bus route. If the bus route is not congested, the bus travels four times a day mostly during weekends (Saturday and Sunday).

GPS receivers are used for measuring travel time and speed .GPS collects more accurate and reliable data than traditional method. But it has some error for searching GPS if the weather is cloudy and heavily rain.

The bus travel time on a given segment is dependent variable in this research. Variables that represented for bus delays such as passenger boarding and alighting and number of bus stops, number of traffic signals and geometry of the roadways and route were collected. Many of bus stop along route located on the nearside of signalized intersections. Due to this combination of stop placement and the small amount of passenger activity at most stops (un-serviced stops), it is not possible to distinguish actual passenger stops from regular traffic stops. The road that the bus travel varied from arterials to collectors and from two to four lanes, with or without street parking. They travelled through commercial, educational and residential.

To establish the relationship between travel time for buses and private vehicles in the study area, each bus trips was matched with a probe vehicle trip that departed at approximately the same time. The data for bus and car trip was collected with three session such as a.m. peak (7:00 a.m. to 11 a.m.), off peak (11 a.m. to 3 p.m.) and p.m. peak (3 p.m. to 8 p.m.). Not only ground survey data but also GPS data were used to analyze the bus travel time. GPS devices were handling on the study buses to track the bus route and also these data could classify the different kinds of driver behaviors the final data set included one month data with each data representing for the whole day. Maximum travel time of bus take 31 minutes more than private car travel time. Table 2 shows the difference between the bus and private car travel times and speeds even though they travel at the same time. The range of operating conditions in the data set for the buses probably varied more than those for cars .The preliminary analysis was done with Excel and SPSS, and modelling was done with SPSS.

Table 2. Difference between Bus and Private Car Travel Times and Speeds

	Travel Time for one round (min)		speed (km/hr)	
	Bus	Private car	Bus	Private car
Maximum	247	216	40	50
Minimum	140	134	18	21
Average	206	185	21	40

Figure 2 and Figure 3 show the different travel time between bus and private car travel time for each day of week. According to the result, both travel time are longer on Monday and Tuesday than on the other weekdays. At the weekends, bus travel time are 0.86 times more than private car travel time. At the non-peak hour, bus travel time and private car travel time are nearly same because the bus speed are equal to the probe car speed.

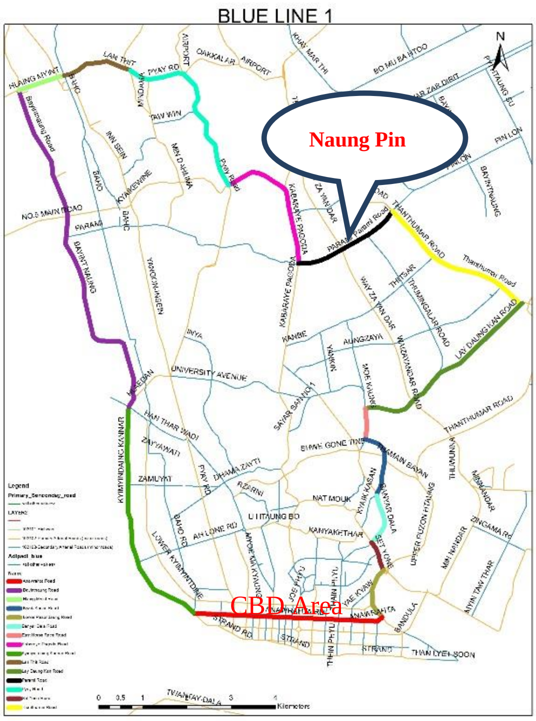

Figure 1.Studied Route (one round trip)

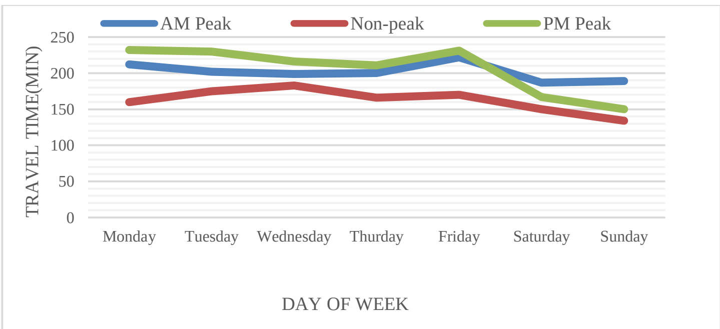

Figure 2. Actual Bus Travel Time

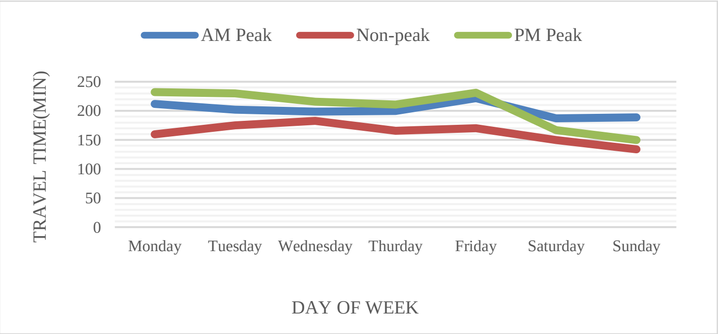

Figure 3. Actual Private Car Travel Time

Car speed were generally 1.11 to 1.77 times as fast as bus speed at weekdays. The peak hour bus travel time approximate 60 km/hr. in suburbs, 40 km/hr. in the city and 20 km/hr. in the central business district (CBD). In Figure 4.car speed in CBD area are less than bus speed in there because some places in CBD area have bus only lane priority systems. The result that the bus can travel faster than other vehicles at the mixed traffic. The passenger dwell times ranged from 30 to 60 seconds per stops in the CBD area.

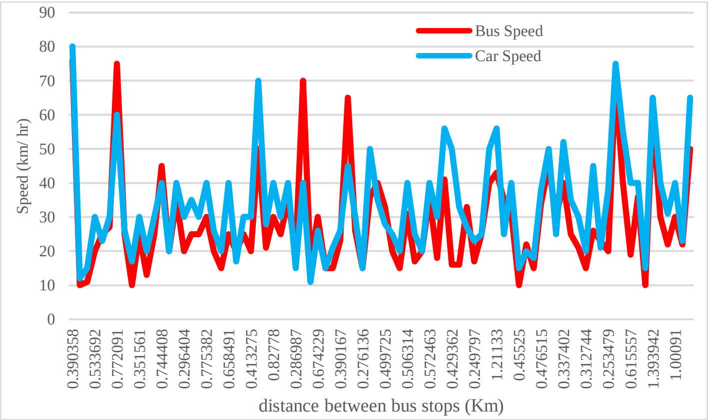

Figure 4.Comparison of Bus Speed and Car Speed (one round trip)

4. METHODOLOGY

To calculate the bus travel time pattern compared with probe car travel time along the studied route, the research team used the travel time data for route and analysis segments. Variables such as number of traffic signals and bus stops are included to control for operating environment. In Yangon city, the traffic signal time is strongly impacted on bus travel time and it make to cause more congested on the studied route. Run time is expected to less for private vehicle relatives to buses. Run time is also expected to be less for vehicles travelling on freeway segment relatives to vehicles travelling on arterials or residential streets. It is expected to increase with the number of possible stops in segment, number of traffic signals, and the length of the segment. Vehicles travelling during a.m. or p.m. peak hours are expected to have longer run times than vehicles travelling during off-peak hours. But the bus holding time for a.m. peak and p.m. peak are more than off-peak hours because bus drivers take long holding time at bus-stop to get more passengers.

Multi-linear regression analysis was used to relate bus travel time to traffic level. This analysis could measure the simultaneous influence of various factor affecting the dependent variables via correlation and significance tests. One bus travel time is dependent variable which run on studied route measured in minutes per km. The independent variables included the private car travel time on the studied route during the same period of the day which measuring traffic level ,passenger boarding time and alighting time, traffic signal time, bus holding time, number of bus stops accounted and so on. The name and description of dependent and independent variable are shown in Table 3.

Some input variables are strong correlation with bus travel time .However, all of the variables which are input in bus travel time also have strong correlation with the car travel time. The correlation between these input variables and the dependent variables, bus travel time in minute per km is known in table in Table 4.

Table 3. Name and Description of Dependent and Independent Variables

Variable	Description
Bus travel time (BTT)	Time (min) for bus trip on the studied route (total segment travel time)
Car travel time (CTT)	Time (min) for car trip on the studied route (total segment travel time)
Bus holding time (BHT)	Total time (min) for bus which delay at each bus stop
Boarding & Alighting time (BAT)	Total time (min) for boarding and alighting passengers at each bus stop
Traffic signal time (TST)	Total time (min) for bus which delay at each traffic intersection
Number of bus stops (BS)	Total number of bus stops in route segment divided by segment length

4.1. Modelling Process

Multi-linear regression are started with the simplest one of bus travel time as the function of car travel time were tried .Firstly, bus travel time model is built with car travel time to know the variation between bus travel time and probe car. The number of records for the model varies because some records were missing data for boarding and alighting time or traffic signal times, or both. All the coefficients in the table were at the 95% or higher level, and most were significant at the 99% level.

$$\mathrm{BTT} = -89.505 + 1.267\mathrm{CTT} \qquad (1)$$

$$\mathrm{R}^2 = 0.584$$

Where

BTT=bus travel time (minutes)
CTT=car travel time (minutes)

The coefficient of car travel time decrease as additional independent variables are added because of the inter correlation between car travel times and the other variables. In some cases, the reason for correlation with car travel time is obvious (e.g., left turns and traffic signals slow car just as they do buses).

Passenger activity and car travel time have also correlation. The correlation between car travel time and passenger –related variables is that passenger activity is high in the same areas where vehicular traffic is high, for example, downtown shopping area. In this research, both boarding and alighting are used as passenger activity because separate variables increase the explanatory power of the models by a slight mount, while weakening the significant of the model (i.e. lowering the F-value).

Table 4. Correlation between Input Variables and Dependent Variables

	BTT	CTT	BHT	BAT	TST	BS
N	31	31	31	31	31	31
BTT	1					
CTT	$.764^{**}$	1				
BHT	$-.538^{**}$	$-.633^{**}$	1			
BAT	$.732^{**}$	$.717^{**}$	$-.632^{**}$	1		
TST	$.824^{**}$	$.637^{**}$	$-.426^{*}$	$.651^{**}$	1	
BS	0.189	-.015	.108	.015	.041	1

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

5. MODEL OF BUS TRAVEL TIME

This bus travel time model can use to estimate the impact of traffic congestion in Yangon. And also this can also use for scheduling the new bus lines.

$$\mathrm{BTT} = -241.81 + 0.69\mathrm{CTT} + 2.31\mathrm{TST} + 0.48\mathrm{BS} \tag{2}$$

$R^2 = 0.805$

Where

BTT = bus travel time (minutes)
CTT = car travel time (minutes)
TST = traffic signal time (minutes)
BS = number of bus stop per km

The number of bus stops in this model include: they stop at bus stops and they stop at non-bus stops. The use of actual stop instead of total bus stop also appears more logical. But actual bus stop have to be estimated, whereas the total of bus stops is within the control of the agency and known. And also the coefficient of bus stops represent 20 seconds lost during acceleration and deceleration.
In this model, the traffic signal time is strongly effected to bus travel time. The coefficient of traffic signal time represent 2 minutes lost per signalized intersections. The number of signalized intersections along the studied route are 50 so that the impact of traffic congestion in Yangon city is depend on the traffic signal times.
However, there may be a logical appeal to model without a constant term. The model of bus travel time rate without a constant that is most similar to the preferred model is as follows:

$$\mathrm{BTT} = 0.42\ \mathrm{CTT} + 0.53\mathrm{TST} + 0.17\ \mathrm{BS} \tag{3}$$

The constant term are kept in this model because there may be a non-proportional reason for buses to be slower than traffic. Moreover, when bus speed were estimated as a function of car speed by using this model but the same explanatory variables will be used. This model has an R-square of 0.81, with all variables having a statistically significant effect on run time.

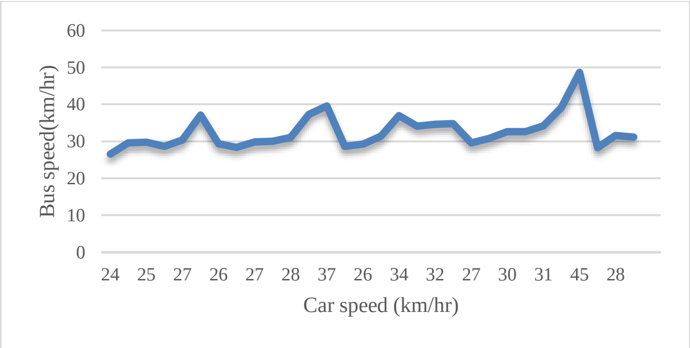

Figure 5. Increasing Bus Speed after Modelling

Figure 5.shows the observed bus speed changed 8% increase after modelling the predicted bus travel time. And also the bus speed were similar to the car speed under the free flow condition But passenger boarding and alighting and traffic signal time will be constant for both speeds. Figure 6.shows the observed bus travel time is decreased after modelling. The total predicted bus time for the complete trip under the free flow condition is about 30 minutes shorter than observed bus times. According to the result, the bus travel time can increase because of the traffic signal time and several number of bus stops for passenger activity. The small magnitude of this variable could be because of the large amount of possible stops and small number of actual stops being made on the studied routes. Alternatively, some impact of stops may be attributed to traffic signal in this model due to prevalence of stops located on the nearside of signalized intersection. The difference between the predicted and observed bus times represents the degradation of bus times due to traffic congestion.

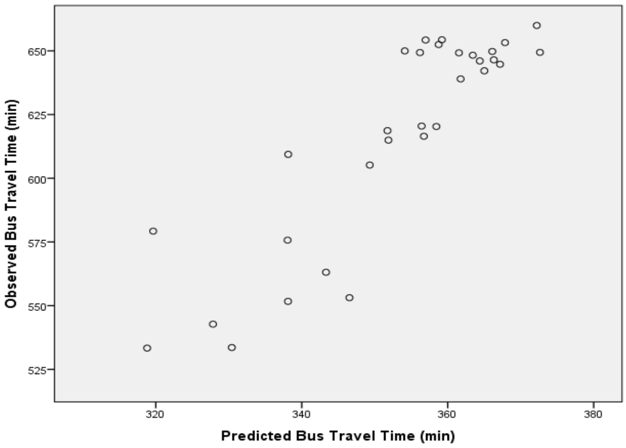

Figure 6. Predicted Bus Travel Time

6. CONCLUSIONS AND RECOMMENDATIONS

The model for bus travel time under the free flow condition can be used to estimate the traffic congestion in Yangon City. And also this model suggest that improvement in car traffic flow (e.g. from reduction in volume, improved signal timing, parking controls or other). If transit signal priority (TSP) is provided at these light for buses, this would lead to save 3 to 4 minutes run saving times. Reducing the number of bus stops will lead to save 2 minutes from current bus travel time. Bus only shoulder policies seem to have a great effect on the competiveness of transit vehicle over regular cars.

Future research will include the number of possible stops and actual stops to better the model. Other data such as advanced Intelligent Transportation System (ITS), and bus-only shoulder should be included in these model.

In conclusion, the model for bus travel time can reduce overall travel time and minimize the travel time disparity between buses and cars. Bus data to estimate travel time will be collected based on GPS data and ground survey data. This model can support to consider about bus –only shoulder polices, stops consolidation, serving major streets with fewer traffic signal time and removing bus stands which are near to the signalized intersections.

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