# Planning and Operation of Urban Bus Route- A Case Study in West Zone of Delhi

Amita Johar, S.S Jain, and P.K Garg

***Abstract***— Public transportation system is an essential feature of any country. However, the accidents, congestion and pollution are the major problems arising in the current scenario due to growth of population and vehicles. To overcome the problem and to reduce the number of private vehicles, proper planning and operation of urban bus route is required to be practiced in metropolitan cities like Delhi.

The primary objective of this paper is to present the methodology for planning and operation of urban bus route. For present study, the urban bus route of Delhi Transport Corporation (DTC) from Janakpuri D Block to Jai Mata Market has been considered. Based on the regression analysis, it was found that bus service time is dependent on alighting and boarding of passenger plus opening and closing of door. Sensitivity analysis was also carried out to check the performance of generalized service time model.

***Keywords***—Planning and operation, service time, urban bus route.

## I. Introduction

IT has been observed that in metropolitan cities, like Delhi, life of urban dwellers depends on the efficient transport system. Urban transportation consists of road traffic (including buses, taxis and other modes of public transportation) and private vehicles [7]. Therefore, bus service reliability is a key factor in influencing the choice of public transport [3]. The main factor to be considered for transportation planning process is transit travel time (like service time, arrival time and departure time) and passenger boarding and alighting. Proper transportation planning and day- to-day operation management require transit travel time and number of passengers boarding and alighting data, as it influence the system efficiency and service attractiveness.

The main objective of this paper is to better understand the factors affecting bus service time and improve decision making and performance assessment. This study uses detail stop level data, like service time, alighting and boarding of passengers that are collected through site visits for urban bus route. This paper discusses the methodology that could be used to develop generalized service time model through regression analysis. The model value are calculated when regression analysis are performed on the data collected from route studied. Sensitivity analysis was carried out to check the performance of generalized service time model.

## II. Previous Studies

Some studies have been briefly explained on planning and operation of urban bus route which are summarized as follows:

"Ceder (1984) [3] analyzed several appropriate data collection approaches for bus operator in order to set the bus frequencies/headways efficiently. Four different methods were exhibited to derive bus frequencies; two are based on point check (maximum load) data and the remaining two propose use of ride check (load profile) data.

Bertini and El-Geneidy (2004) [2] modeled dwell time for a single inbound radial route in the morning peak period in their analysis of trip level running time. They incorporated the results of the dwell time analysis directly into the trip time model by estimating the parameters for number of dwells and number of boarding and alighting passengers.

Dueker et al (2004) [4] presented an analysis of bus dwell time that use archived automatic vehicle location (AVL)/automatic passenger counter (APC) data reported at the level of individual bus stops. Various determinants of bus dwell time were identified, like passenger activity, lift operation and other effects such as low floor buses, time of day, and route type. Passenger activity was an important determinant. The archived data collected served the better understanding of determinants and analysis of rare events, such as lift operation.

Jaiswal et al (2009) [6] described the relationships of bus lost time with platform crowd and passenger – bus interface. This relation was useful in station capacity estimation. They also developed a dwell time model for buses at busway stations. Finally, they concluded that busway station where boarding is predominant increases the passenger – bus interface duration. Increased passenger – bus interface duration leads to lost time for buses, and hence increases the bus dwell time

El-Geneidy and Vijayakumar (2011) [5] analyzed the effect of articulated buses on dwell and running time. The dwell and running time of articulated and running low-floor buses are different. To measure this difference, they used bus operation and passenger information from three heavily-used bus routes. Operation of articulated buses resulted in saving dwell time, especially with high passenger activity."

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## III. Methodology Used

Planning and operation of an urban route involves the development of generalized service time model for that route. The urban route taken for study lies between latitudes $28^0$ 36' North and $28^0$ 40' North and longitudes $76^0$ 58' East and $76^0$ 10' East. The methodology is shown in Fig 1.

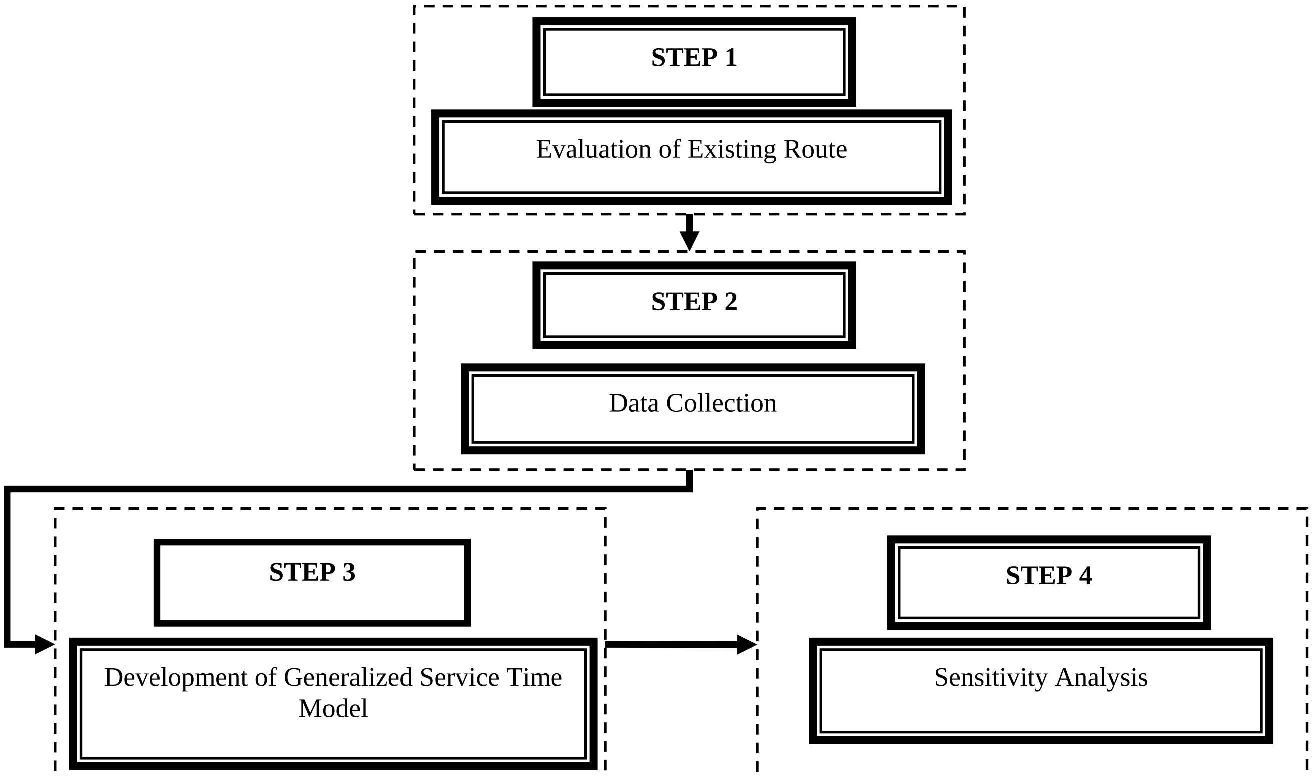



Fig.1 Methodology for Planning and Operation of Urban Bus Route

### A. *Evaluation of Existing Route*

The first step deals with the evaluation of existing DTC bus route number 832 in west zone of Delhi, India. The route chosen for the study is about 17.4 km in length having 43 numbers of bus stops. Fig 2 shows the graphical representation of this route. The average running speed of the bus is 18 km/hr. The inbound route runs from Janakpuri D Block to Jai Mata Mandir while outbound route runs from Jai Mata Mandir to Janakpuri D Block.

### B. *Data Collection*

Data collection for the route number 832 is done through site visits on June 16 and 17, 2013 for morning peak period 9 to 11 am and evening peak period 5 to 8 pm for working days and weekend to obtain bus data and passenger data. In all, there were 6 trips; 3 trips for inbound direction (that includes 2 trip for working day i.e., morning peak and evening peak and 1 trip for weekend day i.e., evening peak), and 3 trips for outbound direction (that includes 2 trip for working day i.e. morning peak and evening peak and 1 trip for weekend day i.e., evening peak). The bus data included service time, arrival time and departure time. The passenger data included alighting and boarding of passengers.

Location for collecting the data was inside the bus for all the stops that lie along the route. Arrival time is calculated as the bus reaches the stop and departure time is recorded as bus leaves the stop. The arrival time and the departure times were recorded for all the stops, still the bus does not stop to serve the passengers. Service time is recorded in seconds, it is the total time that the door open and closed plus alighting and boarding of passengers takes place. Each trip includes the layover time at the beginning and end. The layover time includes the time when the doors are open or closed while the bus is waiting to start a new trip. The development of the service time model began with the departure time from the first stop and ended with the arrival time at the last stop discarding the layover time at both the ends.

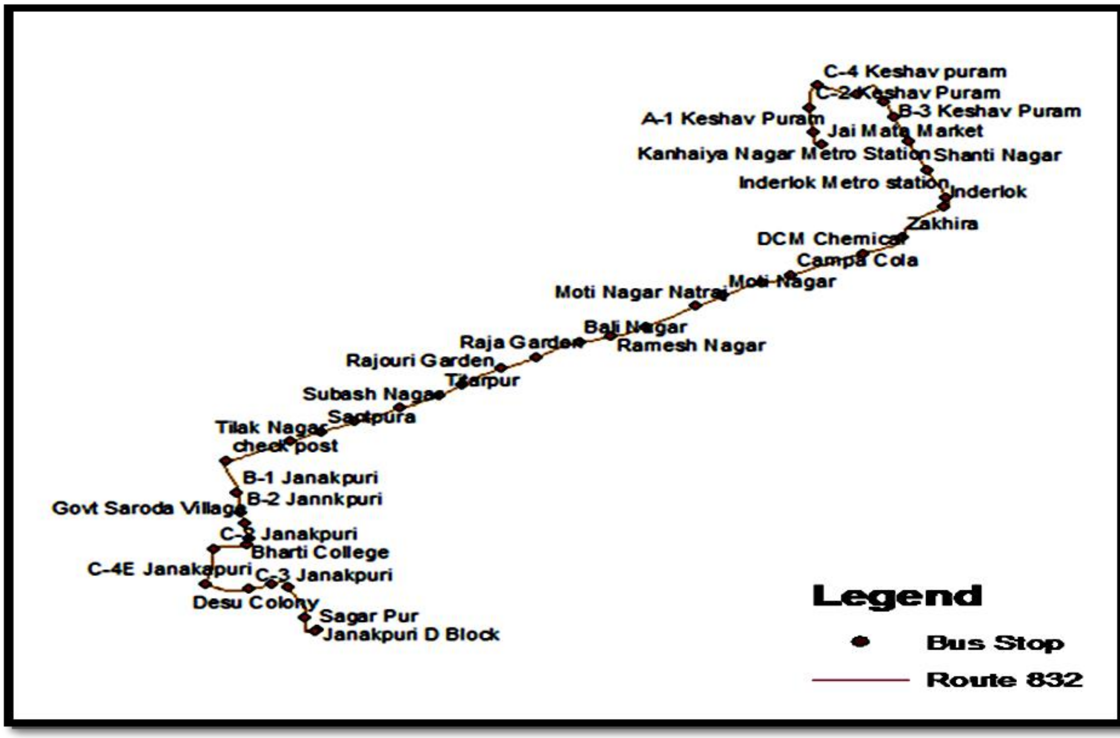



Fig. 2 Graphical Representation of Route No. 832 in Delhi

### C. Development of Generalized Service Time Model

The third step deals with the development of generalized service time model for inbound and out bound directions. Approach for developing the model has been described here. The modeling objective consists of estimating how alighting and boarding plus opening and closing of door affect the service time. Table 1 gives the statistical summary of the variables selected to build the generalized models for inbound and outbound directions. The parameters included for study were traffic characteristics, like service time (ST), passenger alighting (PA), and passenger boarding (PB).

TABLE I
STATISTICAL SUMMARY OF MODEL PARAMETER

| Parameters | Inbound Direction | | | Outbound Direction | | |
|---|---|---|---|---|---|---|
| | ST | PB | PA | ST | PB | PA |
| Sample Size | 123 | 123 | 123 | 123 | 123 | 123 |
| Mean | 10.50 | 3.46 | 3.76 | 11.35 | 4.06 | 4.11 |
| Median | 10.00 | 2.00 | 3.00 | 10.00 | 3.00 | 4.00 |
| Minimum | 5 | 1 | 1 | 5 | 1 | 1 |
| Maximum | 40 | 23 | 11 | 40 | 16 | 15 |
| Standard Deviation (SD) | 8.385 | 4.243 | 3.168 | 7.036 | 3.930 | 3.918 |
| Variance | 70.301 | 18.004 | 10.034 | 49.508 | 15.448 | 15.348 |

Using simple linear regression analyses, the generalized model (combining weekend and working day data during two distinct time period morning and evening peak) for inbound direction was developed as:

$$ST = 1.75 + 1.15\ PB + 1.23\ PA \qquad (1)$$

The regression output revealed that $R^2 = 0.81$, with parameters significant at the 95% level. This indicates that approximately 1.75 seconds time lost is attributable to each stop accompanied by a door opening and closing regardless of the number of passengers boarding and alighting and 1.15 seconds of time to serve boarding passenger (from both the door i.e. front and rear) and 1.23 seconds of time to serve alighting passengers (from both the door i.e. front and rear). Similarly, generalized model (combining weekend and working day data during two distinct time period morning and evening peak) for the outbound direction was also developed as:

$$ST = 4.3 + 0.88\ PB + 0.83\ PA \qquad (2)$$

The regression output revealed that $R^2 = 0.70$, with parameters significant at the 95% level. This indicates that that approximately 4.3 seconds time lost is attributable to each stop accompanied by a door opening and closing regardless of the number of passengers boarding and alighting and 0 .88 s of time to serve boarding passenger (from both the door i.e. front and rear) and 0.83 s of time to serve alighting passengers (from both the door i.e. front and rear). Regression equations, separately for weekend day, working day (morning and evening peak) for both the directions, are shown in Table 2. Since the $R^2$ value is larger than 0.5 for all the cases, this shows that models for inbound and outbound directions are best-fit model. Fig 3 shows relationships between the total service time and the period of the day for the all 6 trips studied for inbound and outbound directions. It shows an increase in total service time during working day (morning peak) for inbound direction and working day (evening peak) for outbound direction.

TABLE II
REGRESSION ANALYSIS FOR WEEKEND DAY AND WORKING DAY

| Period of the Day | Model | $R^2$ | Significant coefficient |
|---|---|---|---|
| Weekend for Inbound Direction | ST = 1.1 + 1.6 PB +.72 PA | .80 | 95% |
| Working Day (Evening Peak) for Inbound Direction | ST = 2.2 + 1.0 PB +1.1 PA | .82 | 95% |
| Working Day (Morning Peak) for Inbound Direction | ST = 2.8 + 1.1 PB +1.2 PA | .79 | 95% |
| Weekend for Outbound Direction | ST = 3.2 + .84 PB +.73 PA | .74 | 95% |
| Working Day (Evening Peak) for Outbound Direction | ST = 2.4 + .98 PB +1.0 PA | .77 | 95% |
| Working Day (Morning Peak) for Outbound Direction | ST = 2.3 + 1.8 PB +2.0 PA | .87 | 95% |

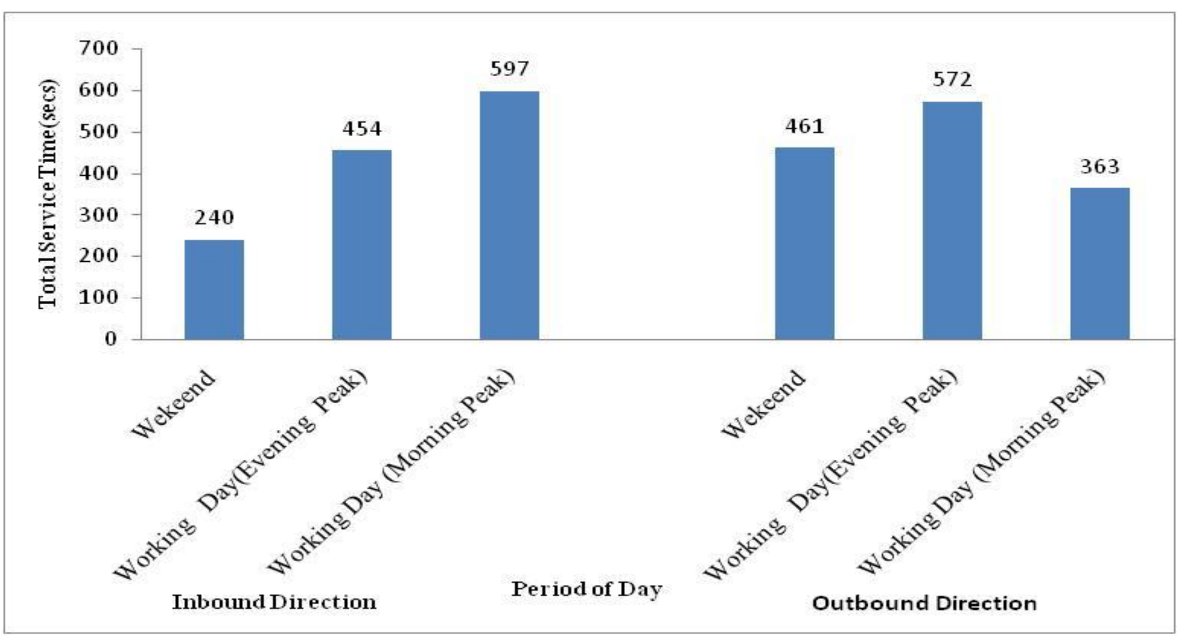
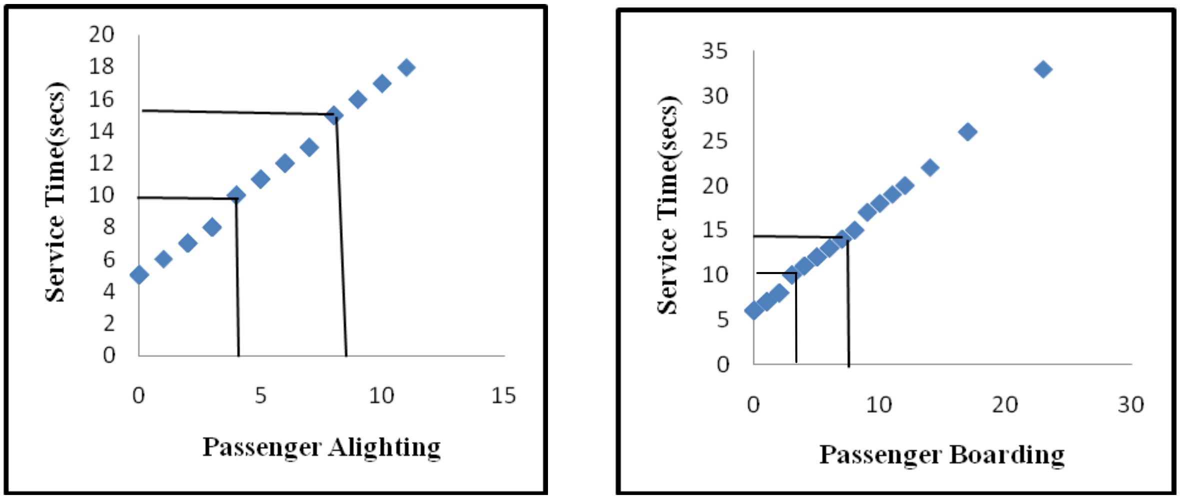



Fig.3 Total Service Time by Period of Day

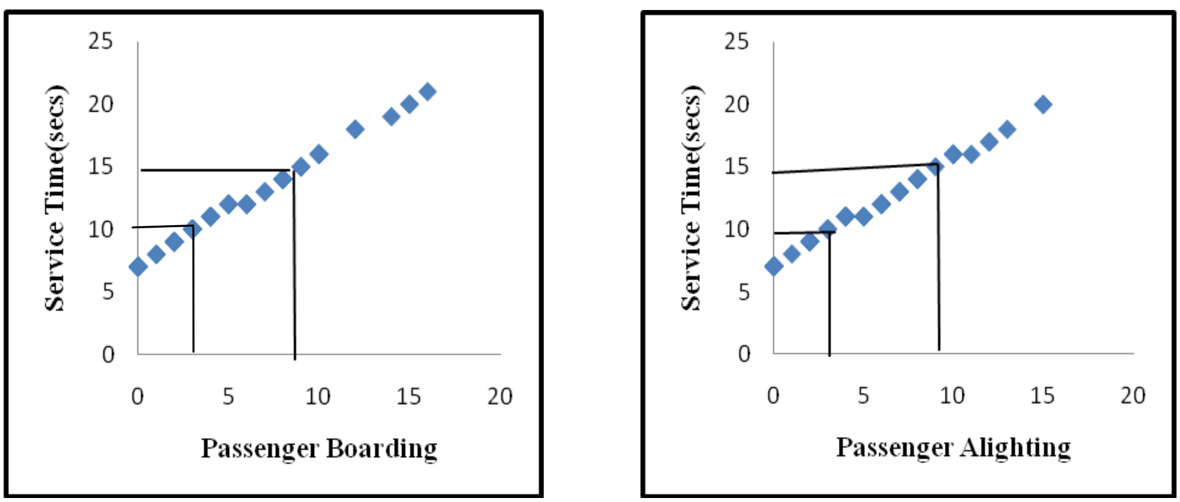
### *D. Sensitivity Analysis*

Finally, the sensitivity analysis is performed for the generalized model developed in equations 1 and 2. The analysis was carried out to understand the performance of generalized service time model. It is done by varying one of model parameters, keeping the value of other parameters constant. The marginal effect of passenger boarding and passenger alighting on service time for inbound and outbound direction are shown in Figs. 4 (a & b) and 5 (a & b). Based on the average boarding and alighting, the service time should lie between 10-15 seconds. Therefore, from Figs. 4 and 5 all the stops having service time more than 15 seconds should be paid more attention to improve the service time.




4(a) 4(b)

Fig. 4 Sensitivity Analysis for Generalized Model for Inbound Direction




5(a) 5(b)

Fig. 5 Sensitivity Analysis for Generalized Model for Outbound Direction

## IV. CONCLUSION

This paper presents an approach which can be used to analyze the parameters affecting service time. The data collected was used to develop a generalized service time model for inbound and outbound directions. Based on the regression analysis, it was concluded that service time is dependent on alighting and boarding of passengers plus opening and closing of door. The value of the generalized model in both the directions was also found, which for inbound direction indicates that 1.75 seconds time lost is attributable to each stop accompanied by a door opening and closing, and 1.15 seconds time to serve boarding the passengers and 1.23 seconds time to serve alighting the passengers with $R^2 = 0.81$. The generalized model for outbound direction indicates that 4.3 seconds time lost is attributable to each stop accompanied by a door opening and closing, and 0.88 seconds time to serve boarding the passengers and 0.83 seconds time to serve alighting the passengers and $R^2 = 0.86$. Since the $R^2$ value is larger than 0.5 for all cases, it shows that model for Inbound and outbound direction is best-fit model. Based on the sensitivity analysis between the service time and passenger boarding and alighting found that service time at the bus stop should lie between 10-15 seconds.

Model developed in this study is useful to transport planner for planning of day to day operation management, which make the public transport system attractive in terms of quicker travel time.

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