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# USE OF VTCS DATA FOR STUDY OF SCHEDULE ADHERENCE AND ITS IMPACT ON BUS TRANSIT PERFORMANCE

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**ABSTRACT:** Bus Transport is the most preferred Public Transport System in many cities. A healthy and efficient public transit system is indispensable to reduce congestion, emissions, energy consumption, and car dependency in urban areas. Recently the passenger patronage for bus transport is on the decline. Reasons reported are increased travel time, low reliability and low frequency of services in urban fringe areas. Higher dependency on private modes for travel increases the congestion level. Regular monitoring of bus operation by the operators on daily and hourly basis in terms of duration, schedule adherence is essential, as these aspects have a greater influence on passenger ridership level. Large fleet operators especially the State Transport Undertakings (STUs) in India face difficulty in monitoring the operations and are in the situation of losing passenger ridership due to declining reliability. Vehicle Tracking and Control System (VTCS) is a cost effective way of monitoring fleet of vehicles and to manage their operations. Metropolitan Transport Corporation (STU bus operator in Chennai) operates buses fitted with GPS on a busy corridor (Tambaram to Broadway) in Chennai and the bus operation along this corridor has been taken for the study. Knowledge of vehicle position time wise precisely, loading/unloading details from automatic ticketing machine has enabled to evaluate the operations of buses along the study corridor with respect to passenger loading and adherence of schedule. Variation of headway deterioration along the study corridor was analysed stretch wise using data collected from vehicle tracking system for various service types. The reasons for deterioration and its impact on passenger patronage were studied.

## 1. INTRODUCTION

The increase in population and exponential growth of vehicles in cities has increased the congestion level and queuing of vehicles has become a daily affair. The inadequacy of the public transport system to meet the rising travel demand has also forced commuters to switch to private modes. The people in cities have migrated to outskirts of the city and the daily commuting distance is on the rise. Bus route operations are extended to serve the commuters from extended suburbs. Due to the enroute delay and increase in number of stops, the non-adherence to schedule has become the order of the day and in total the reliability of bus services has on the decline.

It is indispensable to study the efficiency of bus operation to sustain the existing ridership and to identify the management options to attract the people from private modes. The efficiency of public transportation can be measured by obtaining information of bus transport namely the number of services operated on the route, the travel time stretch wise, the dwell time at the bus stops and passenger loading. The analysis results that is required to modify operations depends on the availability of above data, it has been noticed that the bus operator face difficulty in providing the data for planner to schedule buses for optimal passenger capacity and optimal revenue performances.

In-vehicle, travel time by bus depends upon running time, delay at Intersections, and dwell time at bus stops. Dwell time is operated to be proportional to volume of passengers boarding and alighting and the amount of time required to serve each passenger (TCRB Report 3). It was also emphasized that the amount of time required to serve each passenger depends upon the vehicle type and available in vehicle circulation space. The amount of time required to serve each passenger depends upon the volume of passengers inside the bus. The dwell time was high during peak hours when passenger occupancy is 1.5 to 1.7 times than that of capacity (Muthukannan, 2004).

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Vehicle Tracking System is slowly gaining popularity among the bus operators. It is mainly used to act as an information system to passengers. The facility is very good source for providing information about bus movements precisely and can be utilized for studying the schedule adherence of buses. The derived travel information and loading information can be used to study bus transit performance and for planning optimal fleet operations (Furth , P G et al 2004 )

## 2. BUS OPERATIONS ALONG STUDY ROUTE

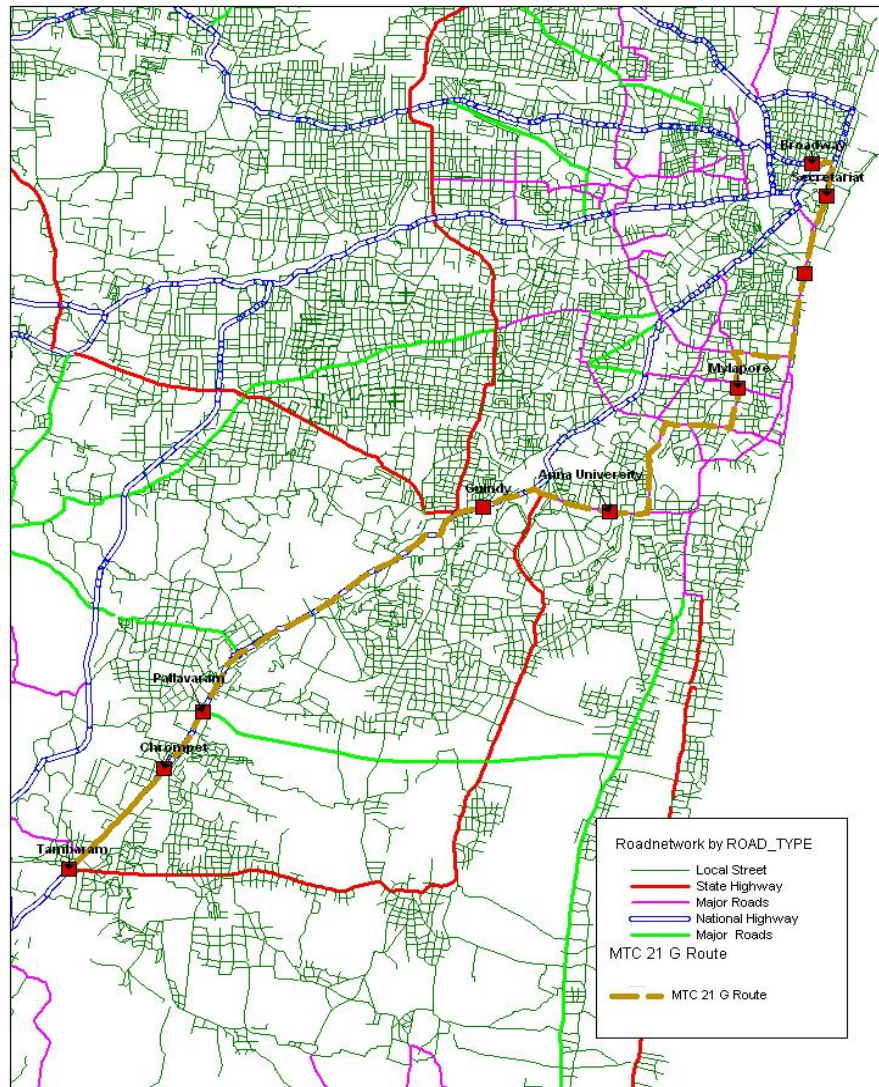
Chennai Metropolitan Area (CMA) extends over 1177 sq.km and had a population of over 7 millions in 2001. Chennai city, which is at the core, covers 172 sq. km and had a population of over 4 million in 2001. The road network in CMA is of radial and circular/ orbital pattern. The development of the city is mainly oriented along these radial and circular roads. 3300 buses are operated by Metropolitan Transport Corporation (MTC) over 640 routes in Chennai. It caters to over 4.8 millions trips per day. One of the busy bus routes operated is from Tambaram to Broad way. The route length is 32.6 Kilometers and the buses are operated between Tambaram, a suburban area in South Chennai, to Broadway located in the City Centre. The route is designated as 21G by MTC and is shown in Fig.1 Part of the study route (from Broadway to Guindy) is within the city and whereas from Guindy to Tambaram the area is classified as suburban areas. All the three services stop at the five bus stops in the suburban areas viz. St. Thomas Mount, Airport, Pallavaram, Chrompet and Tambaram. Buses have more stops in the city areas and their scheduled trip duration has been fixed based on the number of designated stops in the city area. The average bus stop spacing is one Kilometer within the city and whereas in the suburban area it is nearly 3.75 Kilometers.

31 MTC Buses are operated along the route out of which 6 buses are operated as Limited Stop Service (LSS), 10 buses as Express and 15 buses as deluxe services. LSS bus services stops almost at all bus stops along the route and lowest fare is collected from the commuters. A minimum fare of 2 rupees is collected from the passengers for a distance upto 4 kilometers travel and for every additional 2 kilometers of travel 0.5 rupees is collected. The fare for travel in deluxe service is 1.5 times that of LSS and for express service it is twice that of LSS. Bus services viz. Express, Deluxe, and Limited Stop Service (LSS) are operated with frequency of 15 minutes, 17 minutes and 20 minutes respectively. The schedule trip time of each bus service is kept fixed throughout the day, without variation in peak and non peak hours (Table 1).

Bus routes analysis is carried out by collecting commuters' travel pattern and passenger loading details from trip sheets. Obtaining the data from the field and trip sheet is time consuming. The travel pattern of past when compared to that of current situation is found to differ drastically. So it is essential the data should be availed on day to day basis and should be used for planning the operations along route for the immediate future.

**Table 1 Bus Services operated along Tambaram and Broadway route**

S. No	Type of Services	Number of Buses	Number of Trips Operated Per Bus / Day	Schedule trip Duration in minutes	Frequency of services in minutes	Number of designated stops
1	LSS	6	10	90-95	20	22
2	Deluxe	15	11	80-85	18	20
3	Express	10	12	70-75	17	17



**Fig1 Study Route**

All the 31 buses operated in the route have Vehicle Tracking facility. The information about location of the buses are collected with GPS equipment fitted in the bus, stored in Global System for Mobile Communication (GSM) and transferred to central server via General Packet Radio Service (GPRS) for every 4 seconds. The raw data received by the server is processed and utilized for passenger information display. Processed data has been used in this study.

### 3. METHODOLOGY

The study has been carried out as two components i.e., evaluation of existing operations and use of real time bus travel and passenger loading information for fleet management. Evaluation of the bus operation  $\pm 5\%$  is performed with respect to scheduling, and schedule deviation. Performance evaluation with respect to scheduling was carried out by comparing actual trip duration and the prescribed schedule for a typical working day. The variation has to be within tolerable limits ( $\pm 5\%$ ) and when it exceeds the limits the prescribed schedule has to be altered. The variation may be due to congestion related delay or intersection delay or dwell time at bus stops either in single or in combination. The stretch wise speed was analysed and the probable causes were identified. The prescribed schedule has to account the influence of these factors hour wise and direction wise. Though all the buses operated in a particular period are subjected to uniform traffic delay the variation in dwell time at bus stops and crew misbehavior leads to bunching of buses. The Time-space plot of all the buses operated in peak period, peak direction was prepared to analyse the locations where bunching is noticed.

The average loading profile of passenger service wise was analysed for both directions of travel in the morning peak period and compared with the bus carrying capacity. The sections where the buses were overloaded or where the passenger occupancy was lower were identified. The above information along with the actual trip duration was used for suggesting operational modifications.

#### 4. BUS SCHEDULE EVALUATION

Schedule of Bus services has been given by the operator considering trip duration as fixed throughout the day. The trip duration is 70 – 75 minutes for Express Bus Services, 80 – 85 minutes for Deluxe Bus Services and 90 – 95 minutes for LSS Bus Services. The mid value of operator specified duration was taken for analysis. But the actual trip duration is found to vary direction wise, service type wise and hour wise (Fig 2 to Fig 4). In the morning peak period (7 AM to 10 AM) the actual trip duration of the buses towards CBD (Tambaram to Broadway) exceeded by 16 to 24% whereas in the reverse direction the difference was -7% to +17% the prescribed trip duration.

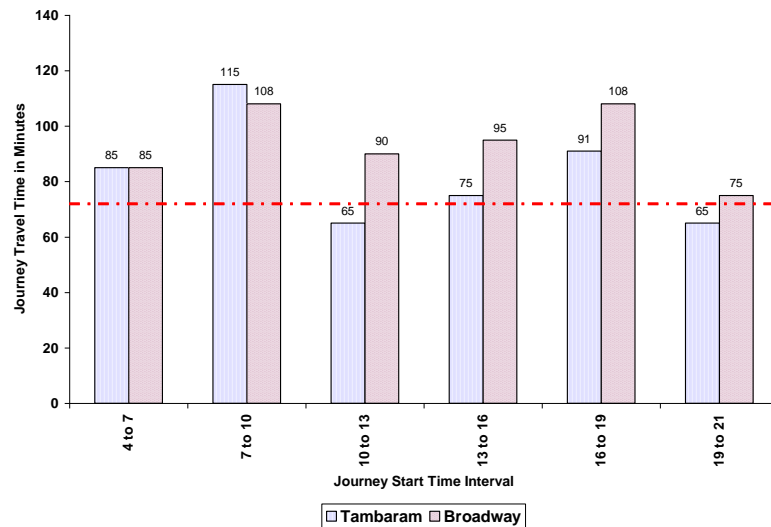
After the morning peak period the observed trip duration matches with the operator specified duration, whereas in the evening peak period (4 PM to 7 PM) the trend reverses. Before the morning peak period (4 AM to 7 AM), after evening peak period (7 PM to 9 PM) and in a non peak hours the travel time required was less than prescribed time. As LSS service has more stops than the Deluxe and Express Bus Services the trip duration throughout the day was more. The stretch wise speeds of buses indicate the existence of speed variation in the stretches. Fig. 5 shows the average stretch wise speed for the services during the morning peak period. The average speed between major bus stops accounts the traffic delay in the stretch and at the intersections.

Services designation and the fare fixation for a service has been done based time taken to complete the trip. The express services are supposed to travel faster and complete the trips in shortest time possible. LSS is expected to complete the trips with longer duration and least speed among the services. The Deluxe service is expected to perform in between with the lowest range defined for LSS and highest range defined for Express buses. Due to higher trip duration during morning peak hour in the Tambaram to Broadway direction and in the reverse direction during evening peak hour the trip scheduled departure time from Broadway and Tambaram respectively were delayed. Whereas the actual trip duration during morning peak hour in the Broadway to Tambaram direction and that in evening peak hour in the Tambaram – Broadway direction were less than prescribed trip duration. The buses in the above directions reached the destination earlier and were idle. The waiting time of passengers was high and over crowding was noticed due to behind schedule arrival of the buses waiting for prescribed departure time to begin their trip.

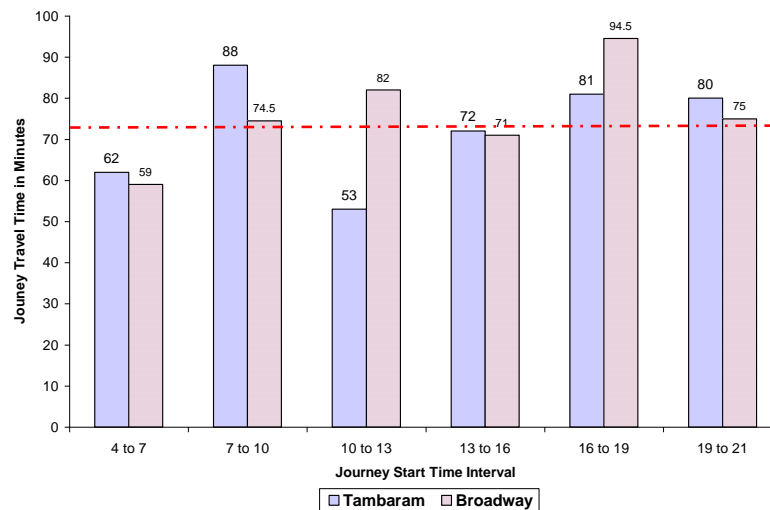
During peak hour, along peak direction, the trip duration is found to be 20% more than the prescribed trip duration, whereas the trip duration in non peak direction was found to be sufficient in peak hour. During non peak hour the trip duration was less than prescribed trip duration and almost equal in equal in both direction of travel. The trip duration recorded hour wise has to be taken as the base for scheduling of trips. But with the current practice of scheduling with uniform fixed time buses are operated behind schedule and the reliability of services is low .

Passenger boarding of buses depends on arrival of buses as per the scheduled time. The variations from the scheduled time influences the passengers travel decisions. To adhere the scheduled timing the traffic characteristics along the route, the traffic management measures in practice and their impact on travel speed has to be clearly understood for planning the bus schedule throughout the route. The vehicle tracking enables to study the influence of traffic parameters on bus speed and model their influence. Scheduling with maximum precision can be done realistically on availability of stretch wise speed for various hours of the day.

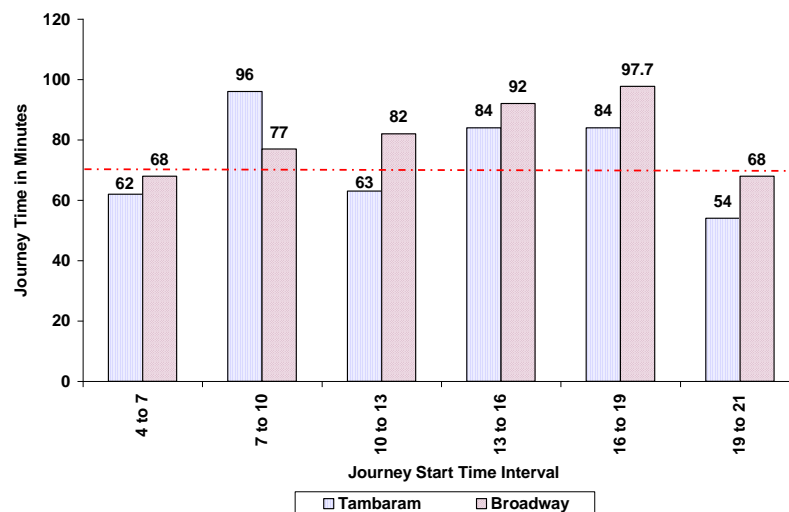
The stretches between Guindy to Anna University and Kannagi Statue to Secretariat had the lowest average speed. Delay at junctions located in the stretches and due to the high passenger loading/unloading the average speed was lowest in the route during morning peak hour in Tambaram to Broadway direction.



**Fig 2 Average Trip duration of LSS Service along Study Route**



**Fig 3 Average Trip duration of Deluxe Bus Service along Study Route**

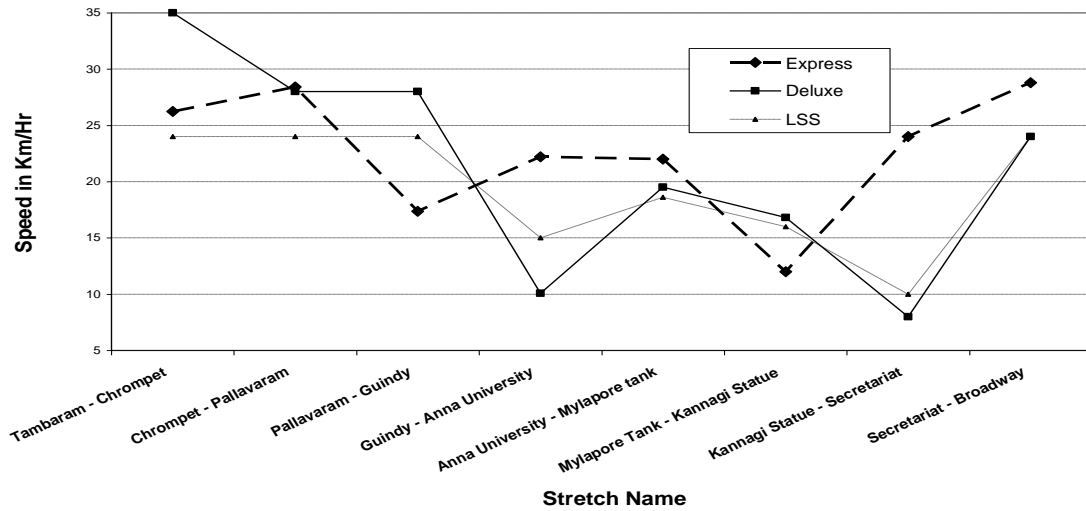


**Fig 4 Average Trip duration of Express Service along Study Route**

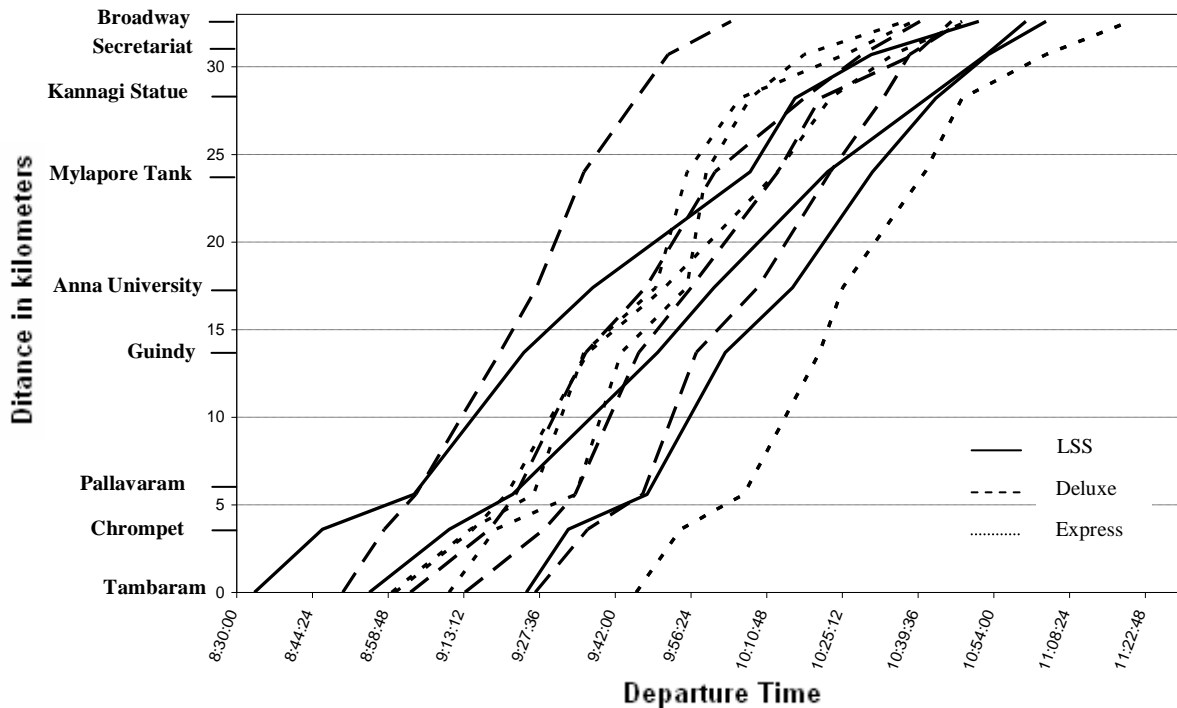
## 5. EVALUATION OF HEADWAY

If the time headway between buses is maintained throughout the route the waiting time of passengers at bus stops would be the minimum and all the buses operated in the period will have uniform load profile. Uniform headway was observed during non – peak hours but headway deterioration was a common phenomenon during peak hours. The bus trajectory plot (Fig. 6) on a typical morning peak hours explains the existing scenario.

The headway deterioration was mostly due to variation in dwell time/passenger. The dwell time was influenced by the number of passengers boarding/alighting the bus and occupancy level inside the bus. On avoiding the headway deterioration or the bunching effect reliability of bus transport would improve and attract more commuters. The buses do not have any preference and they move along with the regular traffic. Buses of all service types are exposed to the same traffic situation and more or less they travel at the same speed. The major influencing aspect for trip duration was dwell time.



**Fig 5 Average Stretch wise Speed of the Bus services (Tambaram to Broadway Direction)**



**Fig 6 Bus Trajectory during Morning Peak Hour (Tambaram – Broadway Direction)**



## 6. FLEET MANAGEMENT

Bus routes and schedules are planned and operated to meet the travel demand of maximum commuters. The optimal carrying efficiency can be achieved by continuous revision of existing operations. The average occupancy in buses is 73 persons with chair for 48 persons to sit and 25 to travel in standing position. The desirable occupancy range for passenger comfort and economic bus operations is 70% to 125%.

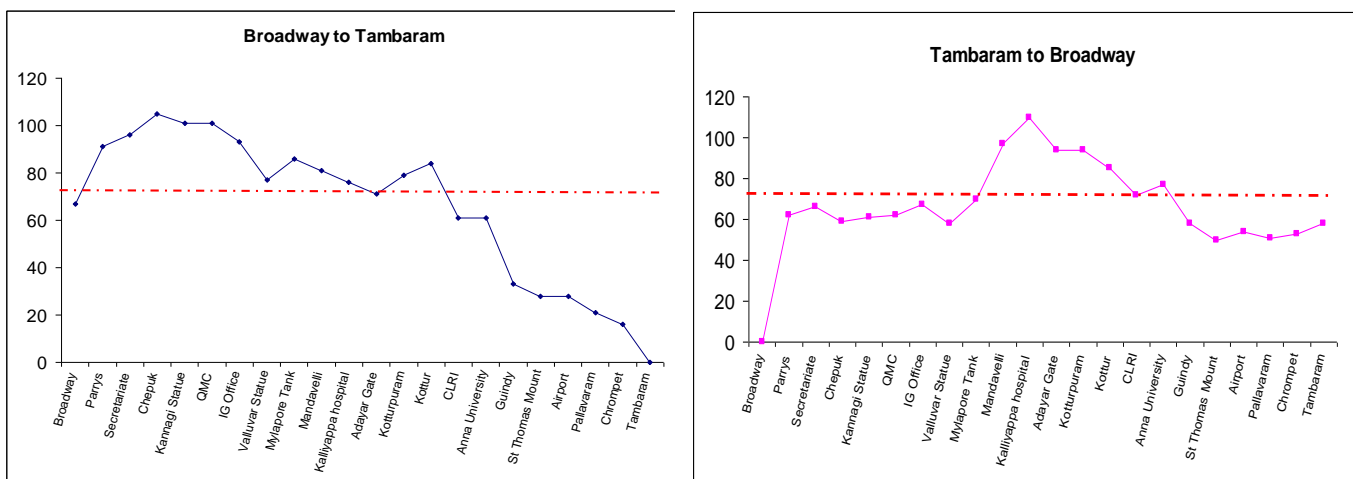
The average passenger load profile of the bus services in the morning peak period in both directions was analysed (Fig 7). More commuting towards the City Centre was observed in the morning peak period. The occupancy was more than 100% from Tambaram to Mylapore Tank for LSS services, Tambaram to Adyar Gate for deluxe services and Tambaram to Anna University for Express services. The maximum occupancy level was 171% for LSS buses, 167% for deluxe buses and 126% for express buses. Occupancy in deluxe buses and express buses was low (less than 60%) from Mylapore Tank to Broadway.

Commuting in the reverse direction (Broadway to Tambaram) was high within the city indicating that trips from one part of city to the other were high. But travel from city to suburb was low. The occupancy was more than 100% from Broadway to Anna University for LSS and Deluxe buses. The occupancy for all the services was less than 60% from Guindy to Tambaram section.

Analysis of travel pattern indicated that residents in the suburbs traveled to various destinations in the Guindy to Broadway section of city for work or education. The travel of the people in suburb was unidirectional i.e. towards the City Centre. The residents in the city commuted from one part to the other for work or education and it was in both directions. The residents in the city preferred to travel by bus from City Centre towards suburb as there was a possibility of getting a seat. Whereas for travel towards City Centre, the preference people in city for bus was low as the buses were operated from suburb and they were overloaded with commuters from suburb.

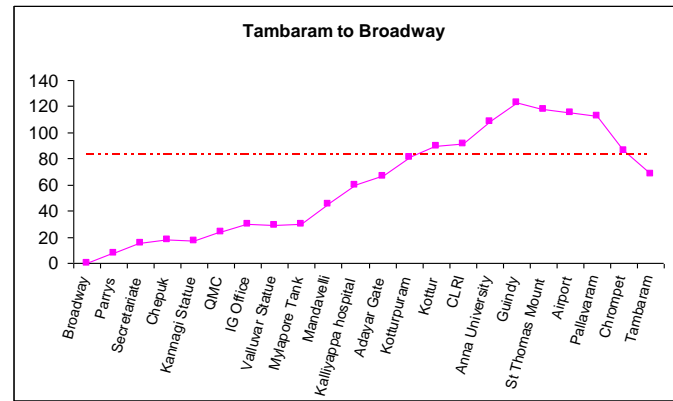
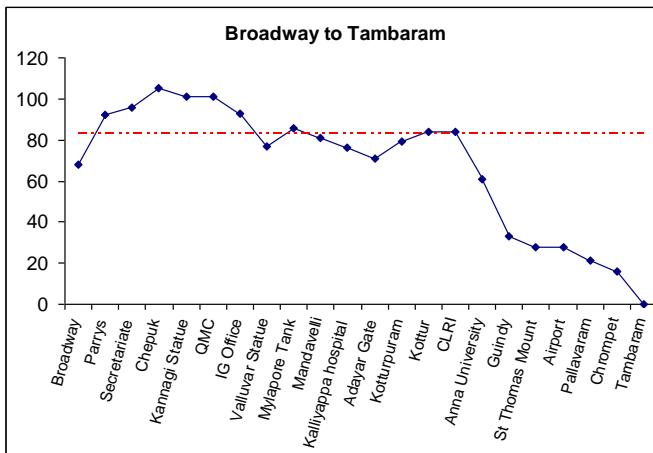
Though it was peak period in some sections in both directions the occupancy was less than 60% i.e. even the seats were not occupied. It is essential to increase the bus operations in overloaded sections and reduce it in minimum preferred sections. The Express buses were not loaded so 2 buses one in each direction can be pulled out to enhance the strength of LSS service.

As the loading in both directions for all services have peak within half of the trip length it is desirable to reduce trunk route operation i.e. Tambaram to Broadway to 50% and to operate balance 50% of all services between Tambaram and Mylapore Tank and Broadway and Guindy equally. The suggested measure would enable the commuters within the city to travel by bus comfortably in both directions and reduce operations in low patronage sections.

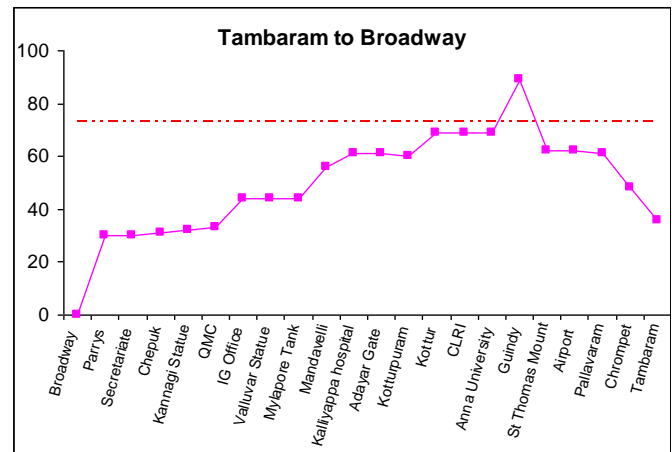
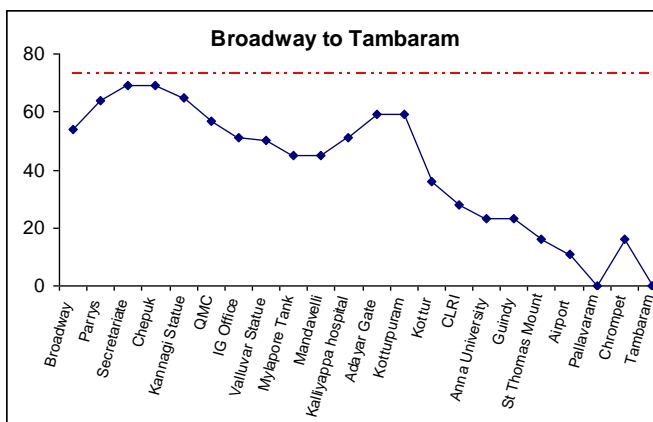


a) Average Load profile of LSS Bus Service





**b) Average Load profile of Deluxe Bus Service**



**c) Average Load profile of Express Bus Service**  
**Fig 7 Load Profile of Bus Services in Morning Peak Period**

## 7. CONCLUSION

Metropolitan Transport Corporation is operating 3300 buses in 640 routes. The Bus operations were planned for Chennai as ring and radial pattern. The length of radial routes was extended in tandem with the growth of the city. The schedule trip duration was kept fixed throughout the day and it was not sufficient for peak period peak direction travel i.e., Tambaram to Broadway in the morning peak period and Broadway to Tambaram in the evening peak period. Whereas during non peak periods and in peak hour non peak direction the trips were completed before the scheduled trip duration and the buses were kept idle/waiting to start the next trip in opposite direction. The loading profile of the buses was studied and suggestions for modification in operation are made.

The travel time in the sections were influenced by the traffic flow, number of bus stops and the passenger boarding and alighting. It is difficult to collect travel time of buses for every section with reasoning and monitor the bus operations. The travel pattern of commuters varies with the time of the day. Extraction of passenger loading and unloading data from trip log sheet is difficult. Vehicle tracking facility provides seamless data of vehicle position and in combination with data obtained from automatic ticketing machine evaluation of bus operations and passenger patronage can be analyzed and optimal planning of operations can be carried out.

## ACKNOWLEDGEMENT

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## LIST OF NOTATIONS:

STU	: State Transport Undertakings
MTC	: Metropolitan Transport Corporation
VTCS	: Vehicle Tracking and Control System
CMA	: Chennai Metropolitan Area
LSS	: Limited Stop Service

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