Demand & Supply Strategies to Ease Peak Hour Congestion in Metro Rail Transport System

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Abstract— The demand for Urban transportation is characterised by a large scale temporal and spatial variations. Till recently our approach has been to increase the supply by way of introduction of more trains, increasing the length of the trains, optimising the time table to increase the capacity of the system. However, there is a limitation of supply side determined by the design capacity of the systems beyond which any addition in the capacity requires huge capital investments and a need for demand side interventions to actually spread the demand across the time and space. In this study, an attempt has been made to identify the potential Transport Demand Management tools applicable to Urban Rail Transportation systems with a special focus to differential pricing. The supply management strategies have also been identified on the basis of literature survey. A combination of demand and supply management strategies has been proposed to ease peak hour in Metro rail transport system.

Key words: Urban transportation, Transport Demand Management, elasticity, differential pricing, Congestion

I. INTRODUCTION

The demand of urban transport has been ever growing due to rapid urbanisation and the increase in the socio-economic activities in the cities. Urban transportation is characterised by a large scale temporal and spatial variations in demand patterns. The demand during the morning and the evening hours are high due to office timings, similarly, the traffic demand near Central Business District (CBD) of the city is considerably higher than that in the outskirts. Till recently the approach has been to increase the supply by way of introduction of more trains, increasing the length of the trains, optimising the time table to increase the capacity of the system. In the short term, this approach has helped in addressing the problem to a limited extent. However, there is a limitation of supply side determined by the design capacity of the systems beyond which any addition in the capacity requires huge capital investments. A part of the solution may lie in demand side interventions to actually spread the demand across time and space. This study is an attempt to develop an Elasticity Model for Examination of Differential Pricing system for Metro trains

II. DEMAND OF URBAN TRANSPORT

The demand of urban transport has been ever growing thanks to rapid urbanisation and the increase in the socio-economic activities in the cities. Urban transportation is characterised by large scale temporal and spatial variations in demand patterns. The demand during morning and evening hours is high due to office timings, similarly, the traffic demand near CBD of the city is considerably higher than that in the outskirts. The hourly variation in demand is measured in terms of Passengers per Hour per direction (PPHPD). The PPHPD varies across the day (temporal variation) and across the network of the system (spatial variation).

A. *Spatial Dimension of Transport Demand:*

Basically, the need of the transportation arises due to differential placement of the demand and supply centres. The demand in the context of commuters is the 'work place' and supply is residence. The commuters need to travel as the work place is at a distance from their residences. This characteristic of the travel demand is termed as 'spatial dimension'.

The travel demand widely varies across the length of the line with higher demand near the CBD area and lower demand towards the ends. This spatial demand variation is quite visible in crowded trains while near the central area and partially empty trains towards the terminals.

B. *Temporal Dimension of Transport Demand:*

Another characteristic of travel demand is temporal i.e. time of the demand. The travel demand varies hourly, daily, weekly, monthly, seasonally and annually. On a weekday, the travel demand is high in the morning and evening hours owing to the office timings. The demands remain comparatively lower in non office/school/college hours. The demand curves for a typical line of Delhi Metro throughout the day would is as shown in Fig 1 below:

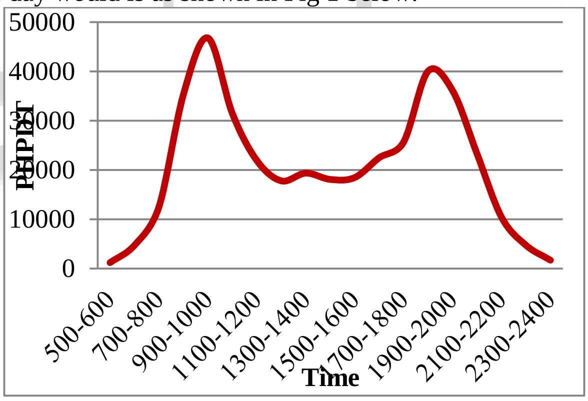

Fig. 1: Hourly variation in demand for Line 2 of DMRC (Souce: DMRC)

III. WHY DEMAND SIDE MANAGEMENT IN URT?

The main reason of overcrowding in urban trains is very high peak hour demand. There is a wide variation in peak hours and nonpeak hours demand of urban transportation. A very high peak hour demand results in overcrowding during peak hours and partially empty trains during non peak hours. The traditional approach to address the problem of overcrowding in the trains is to increase the number of trains or cars per train in peak hours, i.e., to increase the supply (availability of occupancy). However, this supply side solution has the limitation of capacity of the system. Beyond a certain capacity, there would be need of additional track, significant improvement in the train control (signalling) system which involves huge capital investment. Further, the supply side solutions may address the problem of overcrowding in peak hours by substantial investment but this additional capacity shall remain underutilised during the non-peak hours. A system designed for peak hour demand will always result in suboptimal utilisation of infrastructure during non-peak hours.

Demand side management1 of variable demand is more relevant and logical in URT systems due to their cost characteristics. The URT systems are characterised by very high fixed cost and low variable cost. The fixed costs of URT systems are disproportionately high as compared to road based transport systems largely due to heavy investment involved in laying of track, installation of signalling system & traction system and procurement of rolling stock. The variable cost of operation of the URT system is relatively low due to low friction between wheel of train and the steel tracks and automation in train operations. The relationship of various types of the costs associated in the in the demand and supply analysis is shown as below:

TC = FC + VC;

TC- Total Cost, FC- Fixed Cost, VC- Variable cost

The average per unit total cost for Q unit of supply (occupancy in trains):

TC/Q = FC/Q + VC/Q

ATC = AFC + AVC;

ATC- Average Total Cost, AFC- Average Fixed Cost, AVC- Average Variable cost

Since VC is significantly less as compared to FC, the ATC predominantly depends upon AFC i.e lower the AFC, lower the ATC.

The AFC is inversely proportional to Q (FC being constant over short term), more is the Q, lesser is the AFC.

Since, variable cost is minimal, the key to minimising the unit cost (average total cost) is to reduce the average fixed cost (AFC). The AFC is determined largely by the design capacity of the system. The AFC for a system designed to cater to the peak demand is likely to be high in case of large variation in demand. The FC for the system designed for average demand will be relatively less, but it would result in low level of service (overcrowding) during the peak hours. The optimal design of the system is only possible if demand is constant and system is designed for this constant demand. The flatter is the demand curve; the optimal is the design of the system. Unfortunately the real life demand curves for URT systems show wide variation in maxima and minima. The key to optimisation of design is to reduce the gap between maxima and minima by adopting demand side management tools. Further, AFC can also be reduced by increasing supply (Q). However, any increase in Q (number of trains) in non peak hours will not serve any purpose to the commuters and will only lead to wastage of resources and consequent rise in cost of operation.

IV. TRANSPORT DEMAND MANAGEMENT1 TOOLS

The demand management in URT systems is not only required for mitigation of overcrowding but also for optimal utilisation of fixed assets. The following Transport Demand Management Tools may be employed to level out the demand and for optimal utilisation of the assets:

1) Differential pricing2,3,4

It entails higher fares during peak hours and lower fares during non peak hours. The differential pricing system discourages commuters to travel in the peak hours and encourages non peak hour travelling and thereby may help in levelling the peak hour demand.

The focus of this paper is on adopting Differential Pricing for demand levelling in peak hours by offering higher Fares in peak hours and lower fares in non peak hours.

2) Parking Policies

The higher parking rates during peak hours may deter the passengers from using Metro rail in the peak hours and lower parking rates in non-peak hours will encourage passengers to use Metro rail in non-peak hours. The differential parking rates for peak and non peak hours may be helpful in demand levelling to some extent.

3) Land use planning- Mix land use

Mix land use ensures multiple economic and social activities in a region thereby reducing the need of long distance transport for going to work, market, schools etc. Mix land use planning may greatly help in minimising the overall transport demand.

4) Integrated Fares

The integrated fares with other modes of transport encourage hassle free and economical use of multiple transport options. The transport demand is optimally distributed among different modes of transport in the regime of integrated fares. The MORE Card launched by MOUD recently, if adopted by all modes of transport across the country, can bring a revolution in the field of integrated fares.

5) Polycentric city

The city with multiple CBDs helps in evenly spreading of transport demand across the city. Unlike a city with one CBD where a predominant transport demand is concentrated to/from CBD, the polycentric city helps in spatial levelling of the demand.

6) Staggered office/school timings

Most of the offices in the capital work from 9-9:30 to 1730-1800. The same office hours results into very high concentrated demand in morning peak and evening peak hours. If we may stagger the timings of the offices in two slots of 9:00-17:30 and 10:00 to 18:30, the transport demand during peak hours can be levelled out considerably.

7) Work from Home

These days the concept of ‘work from home’ is gaining momentum with the help of reliable, advanced IT systems available and the convenience to the employee as well as employers. In many cities (Hong Kong, Singapore) the office space is so costly that the employer encourages the employees to work from home. These policies may help in further reduction of transport demand.

8) Network design- radial to circular

In the early stages, the Metro rail networks in a city are designed radially to connect the high demand corridors with the CBD. The radial network forces everybody to move to the centre of the city even if one has to travel from one radial line to other radial line resulting in heavy concentration of the demand towards the CBD. The conversion of radial network to circular helps in re-distributing the demand over circular lines and reducing the peak hour demand towards CBD.

9) Encouraging non peak hour travel by offering special facilities

The customers may be encouraged to travel in the non peak hours by offering some promotional schemes like Incentives for Singapore commuters (INSINC) scheme, special facilities for Senior Citizens, differentially abled etc.

V. Supply Side Management Tools for URT

Similar to the Road transport sector, the supply management tools in URT focus on increasing the capacity of the system to cater to the increasing demand. The supply management tools are applied incrementally to match the increasing demand over the time. The supply management tools deployed in URT are listed below:

1) Increase in trains:

The carrying capacity of a URT system is determined by passenger capacity of the trains passing through a point in an hour. The carrying capacity can be simply increased by introducing more trains in an hour if system permits.

2) Increase in Cars per train:

The carrying capacity can also be increased by adding more cars per train even without increasing the number of trains provided system permits addition of more cars. DMRC has progressively increased the number of cars per train from 4 cars to 8 Cars now at Line 2 and Line ¾.

3) Increase in frequency of trains:

The number of trains per hour (frequency) can also be improved by removing the bottlenecks in the system like reducing the terminal reversal time, increase in speed of the trains, minimisation of dwell time at stations, optimisation in time tabling.

4) Increase in Parking space, AFC gates, DFMD:

The capacity of the station to manage the increasing demand may be increased by adding facilities like Automatic Fare Collection Gates, DFMDs, Lifts, Escalators, reorganisation of the passenger flows and also by increasing the available parking space.

5) Signalling System up gradation:

The Signalling System may be upgraded to allow the trains at closure headways. The Paris Metro, London Underground have adopted the most modern Communication Based Train Control Systems (CBTC) with driverless Train Operations to improve the frequency of the trains and to increase the capacity of the system.

6) Station Capacity enhancement:

The stations especially those near CBD may not be able to cater to the ever growing traffic demand. The capacity of the station can be increased by adding more area to the station building, relocating some of the activities outside the station like ticketing activities etc

7) Limitations of Supply Management tools:

The supply side solutions can be adopted only to the extent of capacity of the infrastructure. For example, the length of the platforms of the BG lines of DMRC can accommodate 8cars only as the maximum length of the train. Further, any addition beyond capacity needs improvement in track, signaling, rolling stock, manpower which involves huge capital investment. The supply side solutions always results into suboptimal utilisation of the assets as demand during non-peak hours remain below the capacity of the system.

VI. Differential Pricing as Demand Management Tool for URT

Differential pricing as a demand side management tool has seldom been tried in URT systems barring some examples in UK, Australia, US and most recently in Singapore. One major purpose in congestion pricing for road sector is to deter the commuters from using already congested roads and push them to public transport. The congestion pricing model cannot be straight forwardly adopted for URT systems as promotion of public transport is also equally important for sustainable development of a city. For URT systems, the differential pricing scheme is to be used as a pull measure to attract passengers during non peak hour rather than pushing them out of URT system. There is a need of offering reasonable concessions in fare in non peak hours/ non working days so as to shift some peak hour demand to non peak hours. In this study an attempt has been made to develop an elasticity model for determining the differential fares for peak hours and non peak hours in a metro system.

VII. Easing Peak hour congestion in Metro trains

For optimum utilisation of the Metro infrastructure, the peak hour demand needs to be controlled by adopting suitable demand management tools including higher fares in peak hours. The customers want better services in peak hours i.e more capacity without increasing fares. There is a trade-off between operator’s proroties and customer’s expectations. The solution lies in an optimal mix of demand and supply management strategies to ease peak hour congestion. The increase in fares in peak hours should be supported by increase in services not only in peak hours but also in off peak hours (early morning & late evening) and nonpeak hours (between morning and evening peak) as with higher peak fares, the passengers are likely to be shifted to off peak and non-peak hours. Adoption of other traffic management strategies like staggered timing for schools, government offices along with differential fares and increase in supply would be more effective in easing congestion in metro trains.

VIII. Conclusion

The high level of congestion in peak hours is one of the reasons for metro services not being attractive to the car users. The peak hour congestions needs to tackle to attract the car users to Metro services. Further, the optimal utilisation of the assets can also be achieved if demand is near constant throughout the day. The differential pricing can be effectively adopted as a Transport Demand Management Tool to ease out the peak hour traffic congestions in Metro trains. The current smart card based fare collection system offers adequate flexibility to the metro operators to charge time and distance based fares. However, higher fares in peak hours would not be liked by the customers. Moreover, increasing fares in peak hours without adequate augmentation in services both in peak and non-peak hours would only irk the passengers. The solution to peak hour congestion lies in adoption of a suitable mix of transport demand management and supply management tools. The metro operators have to work with the state government to work out a feasible strategy to curb the peak hour congestion in Metro trains.

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