Integration of Public Transport Fare: A Case Study of Ahmedabad

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Abstract*: *The Paper discusses the development of integrated fare structure for public transport in Ahmedabad. The main objective of the study is to bring the fare structure of the public transport services on same ground while taking into account the practical difficulties of collecting fare, electronic monitoring of passenger traffic, concessionary fares and fare integration modalities. Design of integrated fare systems is based on analysis of various parts of journey and fare collection methods. The basis of the study approach is developed by using the Toolkit on Fare Collection Systems for Urban Passenger Transport defined by World Bank. The study worked on all the transfers occurring in an area where an integrated fare system can exist, and make it possible the use of more means within certain limits and the choice of different itineraries with a single ticket. For integrated fare structure to work implementation of the general principles of the automated fare systems in transport is necessary. As a part of the study an integrated fare structure for the public transport services in Ahmedabad is formed with a model which will give out the fare of travelling in an integrated manner on putting in the values of the preferred mode and the distance to be travelled in each mode.

***Keywords*: Fare Integration, Unified Ticketing System, Integrated Fare Transport, Public Transport In Ahmedabad, NCMC (National Common Mobility Card), AFC (Auto Fare Collection System)**

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I. INTRODUCTION

The ministry of urban development has come out with a Smart National Common Mobility Card (NCMC) model to enable seamless travel by different metros and other transport systems across the country besides retail shopping and purchases. This Unified Ticketing is not the same as auto fare collection (AFC) system.

India is entering the Unified Ticketing system; it is right time to take advantage of the ticketing technology. Construction and Expansion of Metro Rail in most of the Metro Cities of India is prevailing. India has to follow stringent sustainability guidelines – Unified Ticketing Systems would be on the line of those guidelines

The National Urban Transport Policy and JnNURM proposed one single Urban Mass Transit Authority (UMTA). There is a growing realization that UT systems are not the same as AFC systems and that UT unifies all other AFC systems under one Central Clearing House.

This Smart Common Mobility Payment Card addresses the deficiencies associated with other cards being used in Singapore and other countries. This card meets travel needs based on stored value of money and can be used for travelling by any means of transport and also enables account-based retail applications. Accordingly, this card will do away with the need for carrying separate cards for banking and transit requirements.

Urbanization has been one of the dominant trends of economic and social change of the 20th century, especially in the developing world. Urbanization has been shaped by transport infrastructures, such as roads, transit systems or simply walkways. Urbanization is occurring in accordance to the development of urban transport systems, particularly in terms of their capacity and efficiency. Urbanization involves an increased number of trips in urban areas. Cities have traditionally responded to growth in mobility by expanding the transportation supply, by building new highways and transit lines. This has mainly meant building more roads to accommodate an ever-growing number of vehicles.

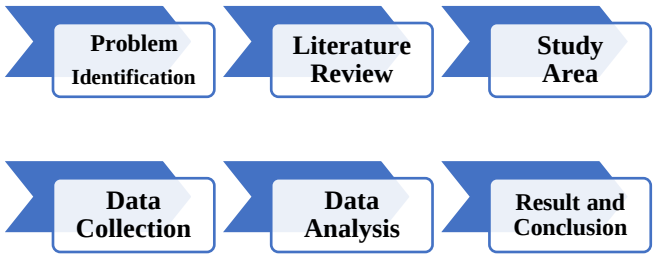
The city of Ahmedabad is the largest city in Gujarat and the seventh largest in India, with a population of 6.35 million in 2011 (Census of India 2011). Ahmedabad has two major public transport systems: the Ahmedabad Municipal

Transport Service (AMTS), a bus service running in mixed traffic, and the BRTS, operated by Ahmedabad Janmarg Ltd (AJL).
The modal share in Ahmedabad is 17% public transport (all buses) and 54% non-motorized transport (NMT) (walking and cycling) (LGBC 2001). Mapping public transport accessibility levels can be a useful tool in achieving the goal of improving the level and quality of service of public transport system.

A. Objectives

- To study existing fare structure
- To examine aspects and criteria of integration
- To identify strategies for Fare integration for public transport system in Ahmedabad
- To design a time saving system

II. METHODOLOGY



III. DATA COLLECTION

A. Data Collection Tool

- Case studies
- Observation: Descriptive and Inferential
- Interview: Citizens, workers, Public Transport authorities and academicians
- Survey/Questionnaire: Citizens

B. Primary Survey

Primary survey was conducted in three parts to know or collect the information about various aspects which will be further helpful in coming up with an integrated fare structure.

a) Survey Need: Cost of the journey, Willingness to pay, Modal shifts taking place, Time spent in: ticketing, boarding, alighting, onboard time, time in changing the modes

b) Pilot Survey: This survey was conducted to decide the study area. It was conducted on at three spots where AMTS, BRTS and IPT routes intersect. At each spot the 30 responses were taken. It was carried out to know the Modal shift and Number of modes used in a journey by the people of Ahmedabad.

User Survey*:* It was carried out with an objective to know the number of modes that the users use in their journey and their willingness to pay more for the facility of seamless travel of their journey. It was a purely questioner survey in which the users where asked about their full journey (starting from the origin to their destination with all the interchanges made in-between). This survey was conducted on 208 public transport users of Ahmedabad at various spots where the surveyor thought, are the maximum interchanges and modal shifts taking place.

Spots where survey was conducted: Iskon cross road, Akhbarnagar, Naroda Patiya, Rabari Colony.

Route Survey: This Survey was carried out to know the accurate time taken in the various parts of a multimodal journey. In this the surveyor travelled on various routes with various combination of the modal shift to know about the time and the cost of his journey in Ahmedabad. The distance travelled in the survey is kept equal to the average trip length of the users of public transport in Ahmedabad.

All the minute details of the time taken in the various parts of the journey given below where noted: Ticketing time, Boarding time, Alighting time, On-board time, Time in changing the modes.

C. Secondary Survey

a) Fare Structure: This survey was carried out to know the existing fare structure of the public transport services functional in the city of Ahmedabad. The method for this survey used was an Interview. This survey was carried out with Bus Rapid Transit (BRT) Ahmedabad and Ahmedabad Municipal Transport Services (AMTS) to know their existing fare structure that is used to calculate the fare. To go on with the process of integrating the fare structure of both the public transport services in Ahmedabad their present fare structure being followed is very necessary to know.

b) Fare Structure(BRTS): The existing fare structure of BRTS service in Ahmedabad was collected from the JanMarg office. Fare structure is attached in the annexure table:

Revised fare for AC buses = Base fare + 1.2 ((Base fare*0.5*change in fuel price) + (base fare *0.5*change in whole sale price Index))

Revised fare for AC buses = 1.25*Revised fare foe non-AC bus for same stage

Where:
Base fare: as mentioned in above slide
Base fuel price: 35.40 per lit for diesel bus (as existing in June 2008)
Base whole sale price index: 127.3 (as on June 2008)
Change in fuel price: (current fuel price-base fuel price) / Base fuel price
Change in Whole Sale Price Index: (current whole sale price index – Base whole sale price index) / Base whole sale price index

c) Fare Structure(BRTS): In AMTS the users are charged according to the stages that they travel. It was collected from the AMTS main branch. (AMTS, 2016)

IV. Data Analysis

A. User Survey Result

TABLE I. User Survey Result

Total Survey	**208**
Avg. Cost	₹ 14.1
Avg. Willingness to pay	₹ 18.1
Avg. Percentage (Willingness to Pay)	24.7
Avg. Time	32 min
Avg. Trip Length	13.1 km
Single mode users	36%
2 mode users	54%
3 or more mode user	10%

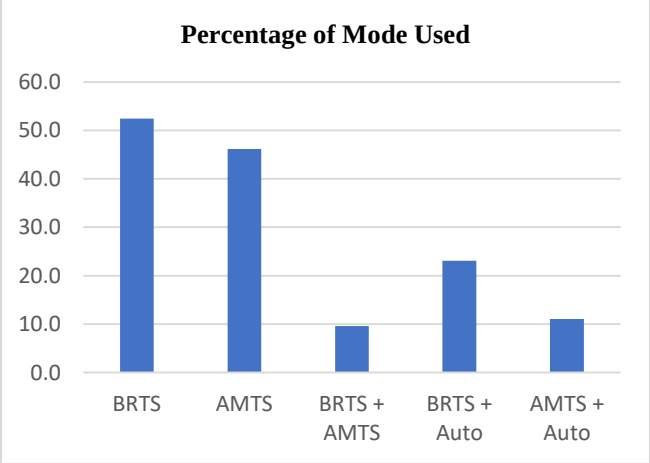


Fig. 1. Percentage of Mode Used

B. Route Survey

a) Survey Route 1

Ajay Tenament	Rabari Colony	Soni ni Chawl	Gomtipur Fire Bridge	Raipur Mill Compound

Fig. 2. Survey Route 1

Steps of the survey:
Step 1: The origin point of the journey was Ajay Tenement.
Step 2: Nearest BRTS stop was 6 minutes walk from the home.
Step 3: It took 3 minutes to buy the ticket, 6 minutes was the waiting time, 9 minutes to reach the destination Soni Ni Chawl.
Step 4: Modes were changed from BRTS to AMTS at Soni Ni Chawl which took 4 minutes.
Step 5: Waiting time was 4 minutes, 6 minutes to reach Gomtipur Fire Bridge.
Step 6: Reached final destination after a 6 minutes walk.
Total fare for the above journey was ₹10.

b) Survey Route 2

Ajay Tenament	Rabari Colony	Soni ni Chawl	Odhav Fire Station	Aadarsh Estate 2

Fig. 3. Survey Route 2

Step 1: The origin point of the journey was Ajay Tenement.
Step 2: Nearest BRTS stop was 6-minute walk from the home.
Step 3: It took 3 minutes to buy the ticket, 6 minutes was the waiting time, 9 minutes to reach the destination Soni Ni Chawl.
Step 4: Bus was changed from Soni Ni Chawl which took 5 minute and the waiting time was 2 minutes.
Step 5: Waiting time was 2-minute, 6 minutes to reach Odhav Fire Station.
Step 6: Mode was changed from BRTS to Auto at Odhav Fire Station which took 5 minutes.
Step 7: Waiting time was 3 minutes, 7 minutes to reach final destination Aadarsh Estate-2.
Total fare for the above journey was ₹14

V. Proposed Fare Structure

A. Generalized Cost Function

To find the cost of the journey there are many factors which need to be considered as the cost varies will all of them. To know the cost of the journey made by using more than one service and by choosing a particular mode out of the options available then the following method given by Domenico Gattuso, Giulia Carbone and Angela Chindemi can be used.

a) Generalized cost function for public transit:

$$\boldsymbol{C_k = P_k + VOT[\Sigma_i^N(\beta_\omega t_{\omega i} + \beta_s t_{si} + \beta_b t_{b_i} + \beta_d t_{di}) + \sum_i^{N1} \beta_t t_{tj}]}$$

Where,
C_k= total cost for path k, in monetary terms
P_k= fare paid for the whole path
VOT= monetary value of the time unit
t_ω= waiting time at the stop
t_s= boarding time
t_b= on-board time
t_d= alighting time
X_{tj}= time spent for the modal transfer in the node j
N= number of lines making up the path
N1= number of transfers (N1 = N-1)
$\beta_\omega, \beta_s, \beta_b, \beta_d, \beta_t$= scalar parameters useful to weigh the different time aliquots

b) Survey Route 1

P_k	10.00	₹
VOT	0.23	₹
t_ω	9.00	min
t_s	0.33	min
t_b	15.00	min
t_d	0.33	min
t_j	4.00	min
β_ω	0.4	
β_s	0.1	
β_b	0.15	
β_d	0.1	
β_t	0.25	
$\boldsymbol{C_k}$	**11.61**	

Total Time – 43 min
Total Cost – 10 ₹
Total Distance – 7 km
Total Time Spent in Ticketing – 3 min (7%)
So, the integrated fare or fare for the journey is 11.61 Rs. Which is 1.61 Rs. (16 %) more than the cost the user is paying at present. By the integration of the system the amount of time that can be saved is 7% for the above scenario.

c) Survey Route 2

P_k	14.00	₹
VOT	0.23	₹
t_ω	9.00	min
t_s	0.33	min
t_b	15.00	min
t_d	0.33	min
t_j	4.00	min
β_ω	0.4	
β_s	0.1	
β_b	0.15	
β_d	0.1	
β_t	0.25	
$\boldsymbol{C_k}$	**16.33**	

Total Time – 47 min
Total Cost – 14 ₹
Total Distance – 8.25 km
Total Time Spent in Ticketing – 2 min (4%)
So, the integrated fare or fare for the journey is 16.33 Rs. Which is 2.33 Rs. (16.6 %) more than the cost the user is paying at present. By the integration of the system the amount of time that can be saved is 4% for the above scenario.

B. Proposed Fare Integration

The modification of the fare structure of a transit system shows necessity of a supply model variation. So, it is useful to represent an appropriate model. On the other hand, supply variation can affect the demand if it is sensitive and some system performance indicators like effectiveness indicators.
The method is articulated in three steps concerning: Alternative strategies of fare integration, Generalized user cost function and the analysis of relative influence on user path choice, Revenue estimation
Revenue estimation by traffic flow on the link in demand assignment is not always feasible i.e. in case of non-linear fares. The model structure has three components: Fare structure model, User cost and path choice models, Aggregate model of revenue calculation.

a) Proposed Fare Structure Model

To come up with an integrated model of fare or integrated fare structure, it is important to bring the fare structure of all the services at a same ground. So, the fare structure of both AMTS and BRTS where first brought down to a common base.
The fare structure of a service can be of following types: Kilometric fare structure, Zonal fare structure, O/d pair fare structure.

b) The fares of both the services were converted into kilometric fare structure.

The Minimum and the maximum fare of both the services are not changed and kept the same and have been converted into kilometric by clubbing it with the zonal form. I this zone of 2km are made in which the fare will not change and remain the same. Accordingly, the fares have been finalized. Even the concession to be given to the various groups (Student, Senior citizen, Police/Defence, Disabled) are not under the service provider authority but decided by a political process. So, they have also not been reduced and just been modified in a manner that will attract more people to use the services and will still be in the favor of the users and not harm the service provider. Pass system is not prevalent in BRTS and only in AMTS, so that remains the same and the pass users have to pay the original fare for the BRTS system and will not get the benefit of the reduced fare of integrated system unless travelled without using the pass.

c) Proposed Integrated Fare Components

User End

1. Fare are same for the singe mode being used
2. 10% concession for the second mode being used in the journey
3. 15% concession for the third and the further changes in the mode for the journey

Conditions

1. Tap out time from the service is 2 hours
2. Delay in tapping or alighting penalty will be Half of the maximum fare of the Service
3. If did not Alight then maximum fare of the service will be charged
4. Interchange from AMTS to BRTS within 15 minutes to avail integration benefits

5. Interchange from BRTS to AMTS within 30 minutes to avail integration benefits

Service Provider End

1. Mechanism to track the interchange between the operators needs to be kept
2. If the interchange between the operators takes place evidence by the second operator to the first need to be provided
3. The second or the following operators bare the concession given to the user as he will be the first in the return journey
4. The provider gets the benefit of the increased ridership which will fill up the losses made in the reduced rates.

d) Comparing the Present and the Proposed Integrated Fares according to the model developed:

TABLE II. FARE CALCULATOR INPUT VALUE

Origin	Mode	Distance (km)	Mid Destination B	Mode
A	AMTS	4	**B**	BRTS

Distance (km)	Mid Destination C	Mode	Distance (km)	Final Destination
7	**C**	AMTS	3	**D**

TABLE III. FARE CALCULATOR RESULT

Present Fare		**Integrated Fare**	
Fare(A-B)	7	Fare(A-B)	7
Fare(B-C)	11	Fare(B-C)	9.9
Fare(C-D)	7	Fare(C-D)	5.95
Distance Travelled	14	Distance Travelled	14
Journey Fare	**25**	Journey Fare	**22.85**

As per above Table the present journey fare is Rs.25 and Proposed integrated fare is Rs. 22.85.

VI. MULTIPLE REGRESSION MODEL

a) Multiple Regression Model

Single Mode User

With Ticketing Time	**R^2 = 0.90**
$Y1 = 0.08X1 + 2.24X2 + C_1$	
Without Ticketing Time	R^2 = 0.89
$Y2 = 0.10X1 + 2.17X2 + C_2$	

Where,
Y = Time; X1 = Distance; X2 = Total Fare; C_1 = Constant (-0.04); C_2 = Constant (-1.10)

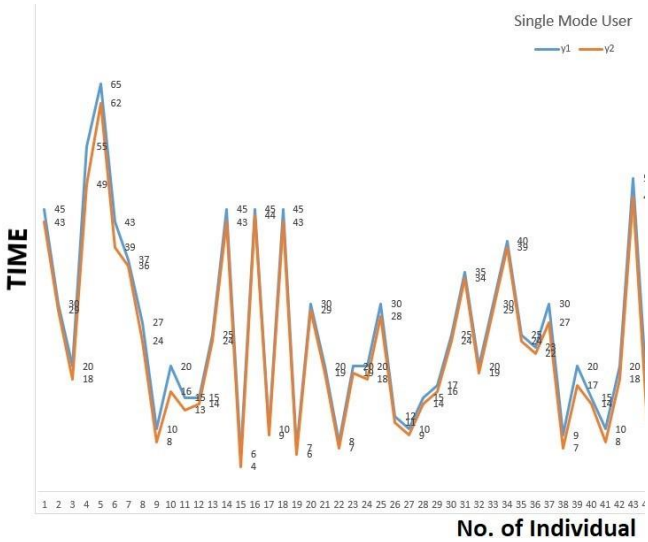


Fig. 4. Fig Comparison between Travel time

Double Mode User

With Ticketing Time	**R^2 = 0.87**
$Y1 = -0.16X1 + 1.84X2 + C_1$	
Without Ticketing Time	R^2 = 0.88
$Y2 = 0.12X1 + 1.53X2 + C_2$	

Where,
Y = Time; X1 = Distance; X2 = Total Fare; C_1 = Constant (8.22); C_2 = Constant (6.04)

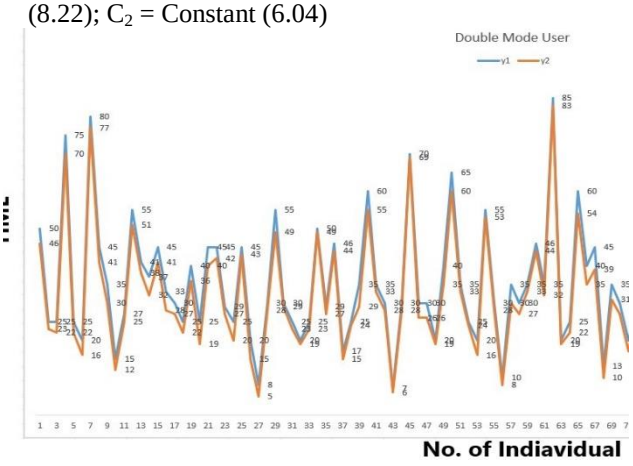


Fig. 5. Fig Comparison between Travel time

Triple Mode User

With Ticketing Time	R^2 = 0.89
Y1 = -0.72X1 + 1.24X2 + C_1	
Without Ticketing Time	R^2 = 0.89
Y2 = 1.05X1 + 0.85X2 + C_2	

Where,
Y = Time
X1 = Distance
X2 = Total Fare
C_1 = Constant (6.80)
C_2 = Constant (4.37)

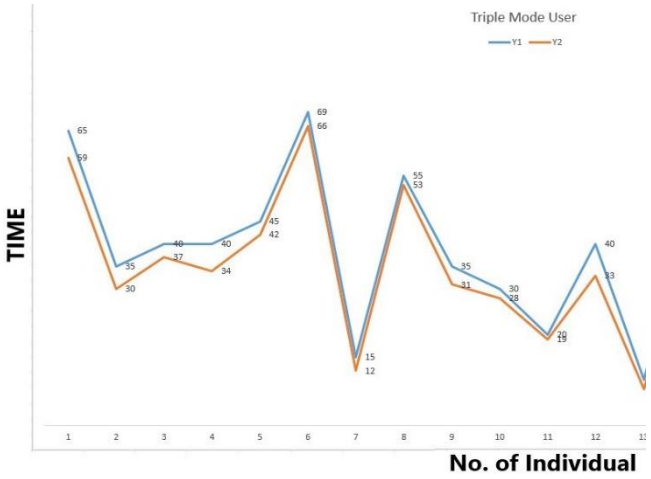


Fig. 6. Fig Comparison between Travel time

VII. Conclusion and Discussion

The research focuses on fare integration of the public transport services of Ahmedabad. Fare structure of the public transport services AMTS and BRTS were revised and brought down to the same scale without changing the minimum and the maximum fares. The fare structures were converted into the form of kilometric structure with stages (each stage of 2 km), where the fare in each stage remained the same.

Fares were calculated with a post processor module operating after the assignment, stressing the relation between users generalized cost and fare structure. These revenue calculations were carried out for the extensive data collected by the survey for different routes. This calculated value was compared with the present fares. The percentage of hike in the fare came out to be 16% which was within the average value of willingness to pay; earlier collected from the survey of the users.

The fare structures were made for AMTS and BRTS services. These structures were used to make a model that gave out the value of proposed integrated fare for few journeys and was compared with the present fare.

Then, Using Multiple Regression model were developed using three variables. Where time is independent variable and distance and total fare are dependent variable. Time, Total fare and Distance that gave out the value of time which is solving the problem of queuing of ticket, less time for boarding on buses.

References

[1] Armandi Mirco, Cocchi Daniela, "Integrated PT Fare System", CIVITAS, 2013

[2] Bibiána Poliaková, "Key Success Factors Of Integrated Transport Systems", The 13th International Conference "Reliability And Statistics in Transportation And Communication", 2013

[3] Domenico Gattuso, Giulia Carbone, Angela Chindemi, "A methodology for fare integration in transit system: Application to an Italian extra Urban area", Association for European Transport, 2002.

[4] Institute for Transport Studies, University of Natural Resources and Applied Life Sciences, Vienna, "Innovative Ticketing Systems For Public Transport", CIVITAS, 2010

[5] Leslie Woo, "GTHA (Greater Toronto Hamilton Area) Fare Integration", Metrolinx Board, 2016

[6] Mathieu Verougstraete, Ed MacDonagh, "Automatic Fare Collection System (AFCS): The Case of Manila", United Nations ESCAP, 2016

[7] Mohamad Kader, "Unified Ticketing- Indian and Global Perspective", UITP, 2010

[8] Mohamed Mezghani, "Study on electronic ticketing in public transport", European Metropolitan Transport Authorities, 2008

[9] Patel P. N., Dhamaniya A., "Developing Mixed Traffic Equivalency Factors to Estimate Saturation Flow at Urban Signalized Intersections", Transportation Research Record, 2021.

[10] Patel P., Dhamaniya A, " Stream equivalency factor for mixed traffic at urban signalized intersections", Transportation Research Procedia, 362-368, 2019.

[11] The World Bank, "Toolkit on Fare Collection Systems for Urban Passenger Transport"

[12] www.ahmedabadbrts.org

[13] www.amts.co.in

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