Optimization of Public Bus Mass Transit System: A Case Study of Anand City

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Abstract— The study is carried out in the city of Anand. The objective of the study is to find the optimal route length of Vallabhipur Transportation Cooperative Society Pvt. Ltd. (VTCOS) buses selected routes. Various data are being collected such as primary and secondary data for the existing network of the bus service. Here the study is done by using TransCAD software. Software provides useful tools such as road network links, shortest paths, etc. The data was inserted in the software to make road network maps and shortest paths. The data is collected including, passenger capacity, route length, time per trip, total trips made per day, Boarding and Alighting survey of passengers is carried out for each route. Research it is seen that the bus service does not run throughout the city of Anand. Some of the routes are having very low load factors, thus buses are running empty and some routes are so largely used that increase in number of buses is advised. A circular route and an alternate route for route 7 is suggested from the study.

Key words: Bus Mass Transit; Route optimization, TransCAD; VTCOS

I. INTRODUCTION

The development of cities in India has been substantial in the recent year. Thus it has led the country to the state of urbanization. Urban development has possessed very serious issue to the transportation planners in India. Urban transportation is the most important component in shaping urban development and urban living by Patel K., May 2013. The test of urban governance depends upon the quality of life the city or town offers. Since transport is one of the prime determinants of quality of life, it is for the government to articulate the need for mobility and facilitate it through an appropriate mechanism by Kadiyali L. R.. In fact, the efficiency of cities greatly depends on the development of transport systems, as urban transport is a catalyst for overall development. Boarding and alighting survey is carried out on each route of city bus service. VTCOS bus service runs on total 9 route throughout the city and surrounding rural areas. Load factors on various bus stops on each route as shown in fig.1.On each route the boarding and alighting of passengers is carried out by travelling in the bus in each route. Time taken to reach every stop is calculated. Different routes and their attributes is given in table 1.

For each route boarding and alighting data is given below, with load factors, travel time, total passengers in bus along route. For any transportation system to be effective, the transit network of the system must be optimum by Yosef Sheffi,1985. By studying the transit route optimization we can provide an effective transportation system which is optimum in length. We can improvise the existing transportation system. The study can also provide alternative routes for the existing transportation system.

Route ID	Actual Route no	Name of route	Length of route(km)	Travel time per trip(min)	No of trip	No of buses
1	1	Vadod	12	22	42	2
2	10	Vadtal	12	34	58	6
3	5	Bakrol	8	21	31	1
4	6	Mogri	10	25	26	1
5	6A	GIDC-ADIT	7	25	27	1
6	6C	Valasan	12	39	23	1
7	6D	Bandhani	12	34	61	6
8	8	Sandesar-Sinhol	14	33	25	1
9	9	Samarkha	5	15	20	1

Table 1: Typical non-spatial data for each route of city bus

Non-spatial data it is also called attribute data. Non spatial data includes the basic information about the city and data such as total population of Anand city, ward wise population, city bus routes starting from Anand railway station. The data was collected from nagarpalika of Anand.

Fig. 1: Load factors on various bus stops on each route

The boarding and alighting of passengers was considerably high on a very few stations of the city. Fig.1shows the load factors on different stops. Load factor can be obtained in software by data input in data view of the route system. It provides data entry where various characteristics of route can be entered. In fig.1, blue histograms are actual load factor and green histograms are allowable load factor. From the fig, it can be seen that some routes are having low load factors, i.e. the buses are running empty.

II. Objective and Methodology to Find Optimum Route-7

Objective of the study is to optimize route-7 as shown in fig. 2 of VTCOS bus service and to find optimum length of route of bus service in Anand city using TransCAD software.

This research has following objectives:

- To collect non-spatial data including number of trips, total length of route, number of buses used and travel time per minute.
- To conduct boarding and alighting survey on route-7 of VTCOS.
- To prepare O-D (Origin- Destination) matrix with the data collected from survey.
- To develop an intelligent maps showing attributes of various zones in study area.
- To create a GIS (Geographical Information System) database system for route-7 covering the study area.
- Transit Route Optimization: A case of Anand City
- To create coverage which is having both road network and bus network and bus stop location together?
- Optimization of study bus route-7 corridors.
- Propose new routes.

III. Optimization Model

In the study, an optimization function is adopted and applied to the presented studyarea. The function is adopted similar to Han et.al.[4]. The optimization function is formulated as,

$$\text{Minimize:} \quad Z = \sum_{k=1}^{SR} (T_k \times f_k)$$

$$\text{Passenger flow assignment: } q_{ij}^k = g_{ij}^k (V^{ab}, f_r, A_r) \qquad \forall\ k \in SR$$

$$\text{Load feasibility: } CAP \times f_k \geq (q_{ij}^k)_{max} \qquad \forall\ k \in SR$$

- T_k = Round trip time of route k
- f_k = frequency of buses operating on route k
- A_k= set of other attributes associated with bus route k
- q= Passenger flow on link i – j of bus route k
- SR= set of all feeder routes
  = Maximum flow of passenger on between i to j on route k
  = General function form which determines passenger flow assignment on link i-j Of bus route k.
- V= Origin destination flow between nodes a and b.

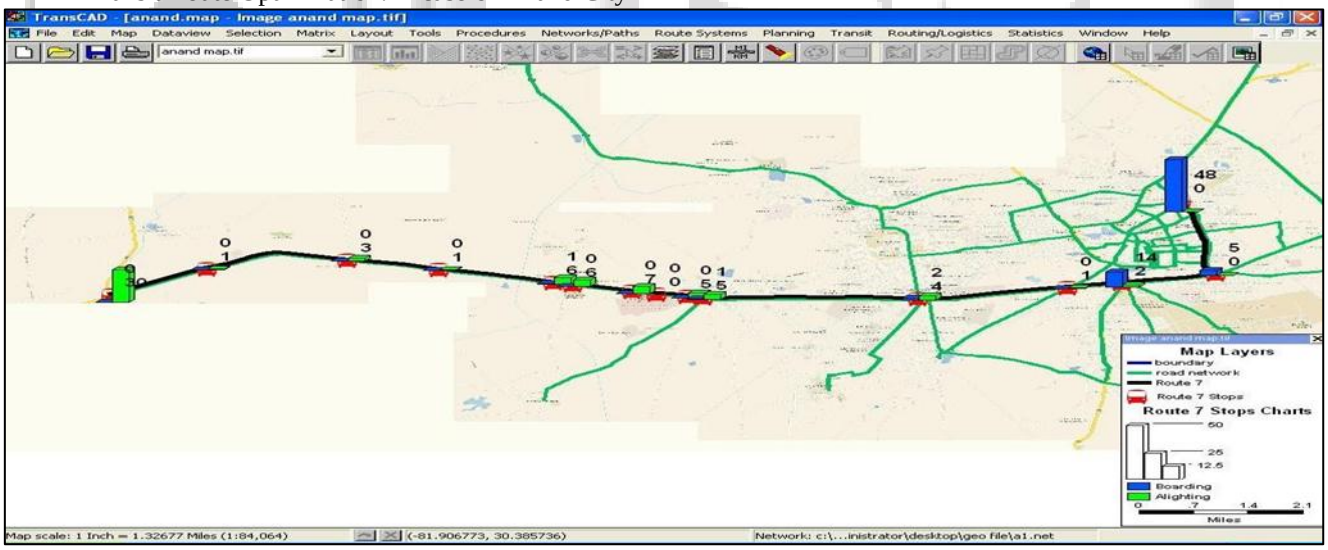

Fig. 2: Route-7

TransCAD software is a revolutionary system for transportation data management and analysis. TransCAD fully integrates GIS with planning, modeling and logistic operations (TransCAD 2000). It can be used for digital mapping, geographic database management and presentation graphics and operation research and statistical models in transportation. Advanced geo processing capabilities support spatial queries, polygon, overlay and multi-band buffering. It is ideal for highway network, transit routing and planning operations, inventory and facility management, accident reporting and analysis, pavement management, maintenance planning, demand modeling and forecasting, environmental impact assessment, regulatory and policy analysis, distribution planning and emergency management. TransCAD has been selected as the GIS-T software package in present study due to availability for developing and testing new analytical procedures with complete development of decision support systems.

TransCAD extends the traditional GIS model to include transportation data objectives such as by Advani M., 2005.

- Transportation networks
- Shortest paths
- Matrices

- Routes and Route systems
- Linear referenced data

These extensions make TransCAD the best data management and analysis tool for working with transportation data. The use of GIS functions to prepare, visualize, analyze and present helps to represent the work. Application modules can be used to solve routing, logistics and other transportation problems with greater ease and efficiency. Network and matrices can be of virtually unlimited size.

IV. Result and Analysis

From the analyses it was evident that the boarding and alighting of passengers were not sufficient on each and every stops. There were only few stops where the boarding and alighting of passengers were considerably high. These stops are Station, ganesh intersection, borsad intersection, grid, bhaikaka and janta intersection. Thus the demand of passengers was high at these stops. Table-2 shows the boarding and alighting of passengers on the route 7. Optimized routes indicate routes which are optimum in length and in revenue generation also. For optimization, route 7 is selected from the route system. Fig.3 shows optimized route7 with respect to operators' point of viewand shortest length.

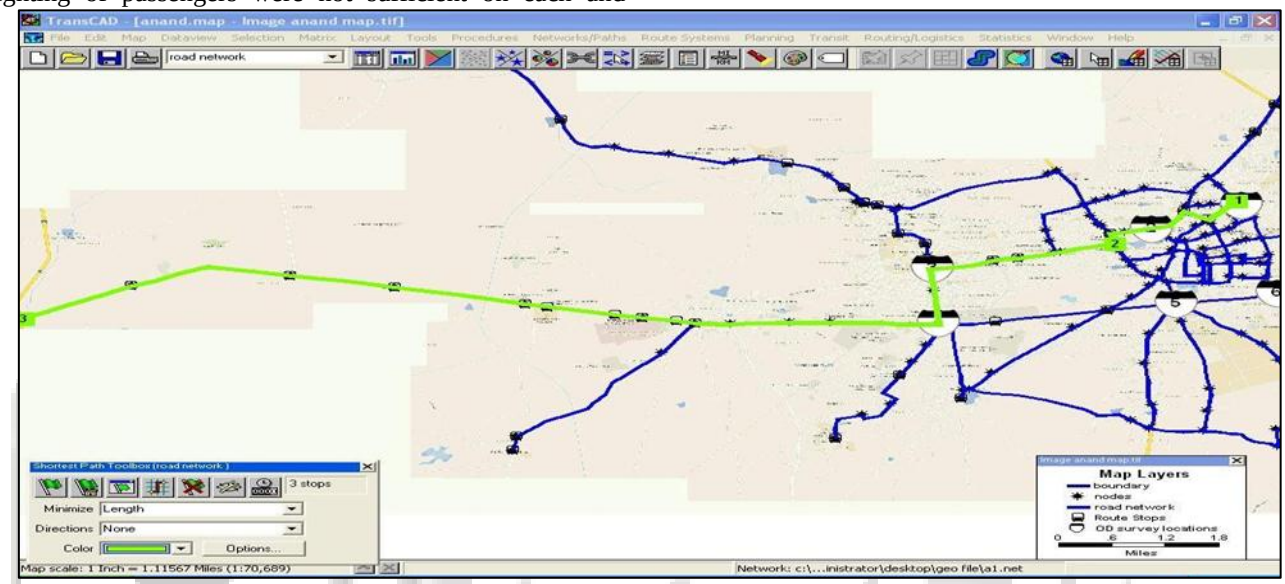

Fig. 3: Optimized route-7

Optimized routes indicate routes which are optimum in length and in revenue generation also. For optimization, route 7 is selected from the route system. Fig. 3 shows optimized route 7 with respect to operators' point of view and shortest length. Optimum route for route 7 remains as it is. The shortest path does not include major survey stops where passenger demand is high, thus route 7 remains the same.

Route stations	Time	B	A	TT(min)	Total passengers	Load factor	Total travel time (min)
Station	12:49	48	0	-	48	1.600	0
Ganesh cross	12:53	5	0	4	53	1.767	4
Borsad cross	12:57	14	2	4	65	2.167	8
Amin auto	1:01	0	1	4	64	2.133	12
Janta cross	1:05	2	4	4	62	2.067	16
Karamsad	1:08	1	5	3	58	1.933	19
Sandesh cross	1:13	0	5	5	53	1.767	24
Sardar smarak	1:14	0	0	1	53	1.767	25
Karamsad Medical	1:15	0	7	1	46	1.533	26
Vidyapith	1:16	0	6	1	40	1.333	27
Valasan	1:17	1	6	1	35	1.167	28
Dheba kuva	1:20	0	1	3	34	1.133	31
Ravipura	1:21	0	3	1	31	1.033	32
Boyada stand	1:24	0	1	3	30	1.000	35
Bandhani	1:25	0	30	1	0	0.000	36

Table 2: Boarding & Alighting survey form of route-7(Bandhani) (Total time of Trip: 34 min)

Here, B= Boarding, A= Alighting, TT= Travel time

Boarding and alighting survey is carried out on each route of city bus service. VTCOS bus service runs on total 9 route throughout the city and surrounding rural areas. On each route the boarding and alighting of passengers is carried out by travelling in the bus in each route. Time taken to reach every stop is calculated. Different routes and their attributes is given in table 2.

V. CONCLUSION

From the study conducted in this research, it was seen that the VTCOS bus service is not totally effective throughout the city of Anand. The network of the bus service in most of the routes is linear. i.e. the service does not cover the main city regions throughout the city. In some routes auto rickshaws dominates the city bus service. Also two alternate routes can be suggested as follows:

1) A circular route can be suggested from the obtained O-D data for the bus service which should run between stations 1-2- 5-6 as shown in fig.5.
2) The selected route 7 can be altered as a new route as shown in fig.6. This route is optimized based on the operator point of view, as the passenger demand throughout the route is maximum. Thus profit maximization of the operator is achieved.

Fig.4 shows the existingcitybus routes with bus stops locations and the stations where the demand survey was conducted. From load feasibility calculations, it was concluded that buses on route 6 and 8 to be reduced and the same can be added on route 7.

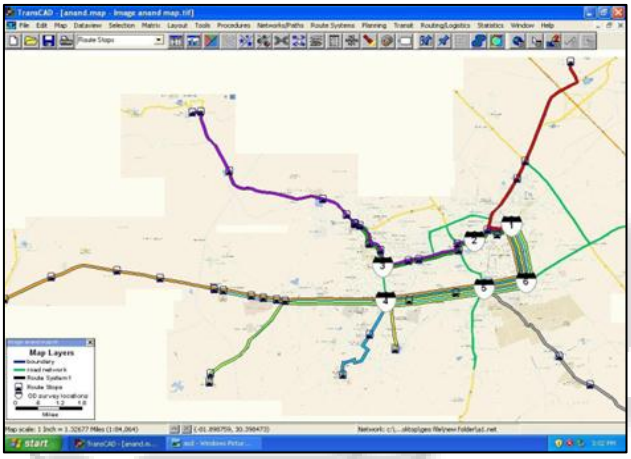

Fig. 4: Existing city bus routes and Survey locations

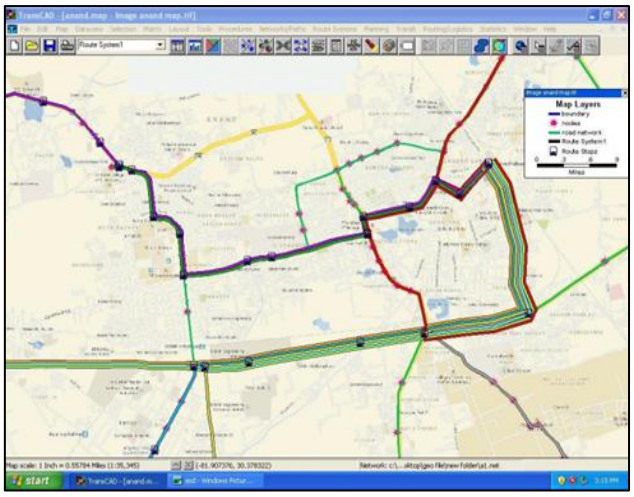

Fig. 5: Suggested Circular route

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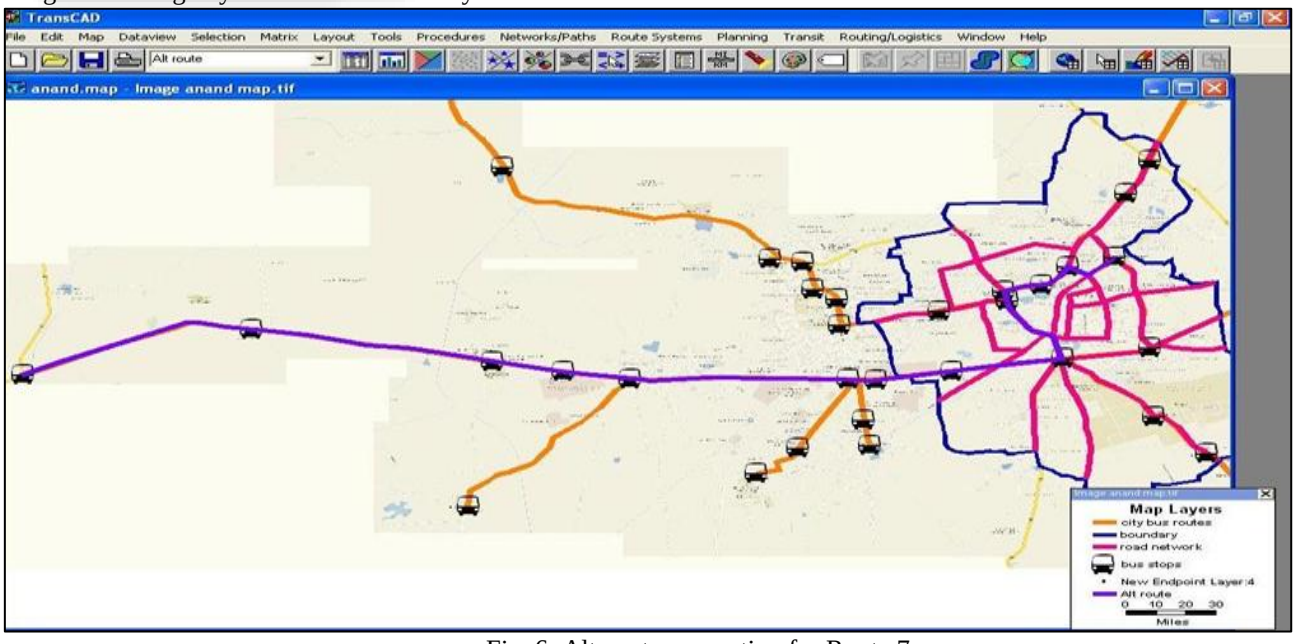

Fig. 6: Alternate suggestion for Route 7

The selected route 7 can be altered as a new route as shown in fig.6. This route is optimized based on the operator point of view, as the passenger demand throughout the route is maximum. Thus profit maximization of the operator is achieved.

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