

Economic justification of electronic toll collection system

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Abstract — Transportation is the backbone of our economy. Advancement in transportation will lead to lifestyle characterized by extraordinary moments of people, immense trade in manufactured of good. Manual or automatic toll collection system as many drawbacks compared to electronic toll collection system like it needs collector to collect the amount at a toll booth, delay in time, traffic congestion, more fuel consumption, longer queue of traffic. All these points are eliminated in electronic toll collection system. Electronic toll collection is cost effective, it provides better audit control, less delay of time, shorter queue of traffic, less fuel consumption, use of sms service instead of receipts. The development of electronic toll collection holds the promise of providing revolutionary improvements in speed, efficiency, time, fuel consumption, operating cost, long queue lengths. This system determines whether passing vehicle is registered or not. ETC system can improve the traffic flow to the toll area. ETC system based on RFID technology is mainly used in India.

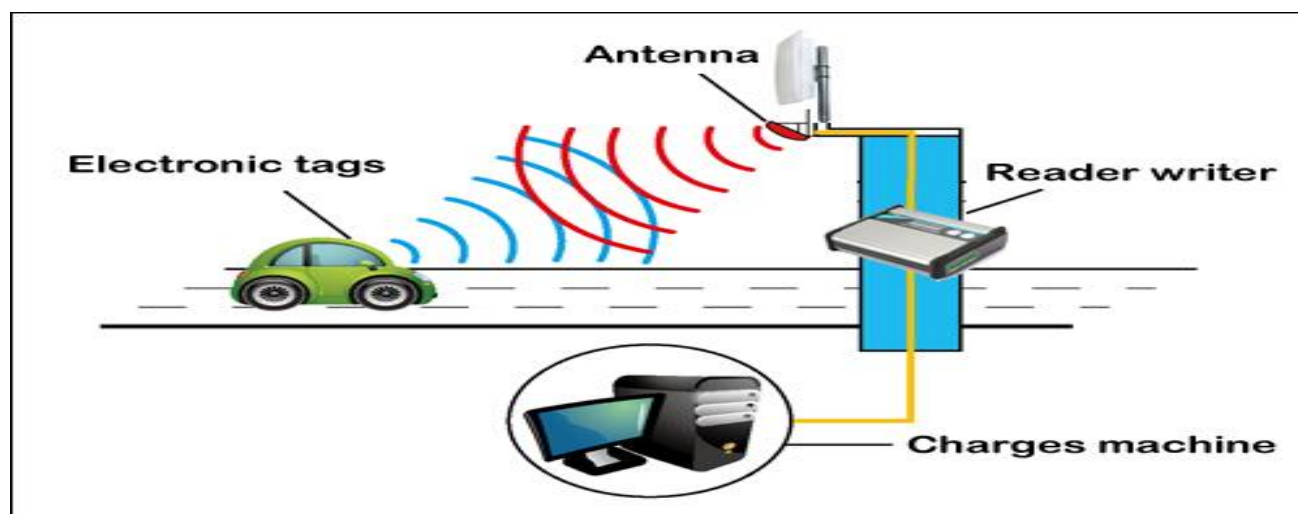
Keywords-Electronic toll collection, RFID, Fuel consumption, Traffic congestion

I. INTRODUCTION

India, the second most populous country in the world, and a fast-growing economy, is seeing terrible road congestion problems in its cities. The problem is often felt in almost all major cities. This is primarily because infrastructure growth is slow compared to growth in number of vehicles, due to space and cost constraints. Transportation is the moment of men and goods is as old as civilization. Roads or highway are one form of the means of transporting men and material from one place to another.

At present, revenue collection procedures at most toll facilities require a driver to stop his/her car, open the window or door, and find correct coins or a valid card before continuing his/her journey. As the use of tolls becomes more widely accepted, the drawbacks of this conventional toll collection method will be emphasized. Tollbooths suffer from being land intensive, labor-intensive (owing to the hiring of toll operators), and time-intensive. Electronic toll collection (ETC) systems are superior to manual methods from the perspective of both the toll agency and the user.

ETC toll collection is a technology enabling the electronic collection of toll payment. It has been studied by researchers and applied in various highways, bridges, and tunnel requiring such a process. This system can determine if the car is registered or not, and then informing the authorities of toll payment violation, debits and participating accounts. The most advantage of this technology is the opportunity to eliminate congestion in toll booths, especially during festive seasons when traffic trends to be heavier than normal. Other general advantages for the motorists include fuel savings and reduced mobile emissions by reducing or eliminating deceleration, waiting time, and acceleration.



Electronic toll collection system based on Radio Frequency Identification (RFID) technology is mainly used in India. As time and efficiency are a matter of priority nowadays, the traditional method as to be reformed. In order to overcome the major issues of traffic congestion and time consumption RFID technology is used. RFID reader fixed at tollgate frame reads the tag attached to windshield of vehicle. The object detection sensor in the reader detects the approach of the incoming vehicle's tag and toll deduction takes place through a prepaid card assigned to the concerned RFID tag that belongs to the owners' account. Electronic toll collection system (ETC) has various advantages compared to traditional method.

II. NEED OF STUDY

Nowadays in urban areas population is increasing drastically within few years, same time light and medium traffic is increasing day by day in the city. So, in urban development the major problem is space. So it is very difficult for us to provide extra space for the solution of traffic problem.

Due to increase in population, the no of cars has been increased which leads to more traffic congestion. More vehicles for low capacity roads. For newly constructed highway revenue is very important, for that toll need to be collected from users.

Generally, toll is collected manually which leads to long queue length, more fuel consumption, wastage of time, more operating cost on express highways. To solve this problem, it is necessary to develop electronic toll collection system. Electronic toll collection system will eliminate all the problems which manual system is facing. It will provide better efficiency than manual

III. LITERATURE REVIEW

Mrs. Deepashree K. Mehendale "To study the implications of Electronic Toll Collection System using RFID Technology(1st Dec 2015)

Mrs. Deepashree K. Mehendale, This paper focuses on use of Electronic toll collection based on RFID Technology. Manual toll booths require a number of operations like stopping the vehicle, lowering the window, finding the correct coinage or valid card, more fuel consumption, delay of vehicles. All these things are eliminated in electronic toll collection system based on RFID.

Apurva Hemant Kulkarni "Study of Different Electronic Toll Collection Systems and Proposed toll Snapping and Processing System(March 2014)

Apurva Hemant Kulkarni, This paper focuses on "Toll snapping and processing system" and study of different ETC system. The Toll collection systems are always in news for corruptions. The person who collects amount from vehicles charges less or more sometimes. They require vehicles to stop or slow down. Manual toll collection wastes time and raises vehicle operating costs. Thus to eliminate the corruption, and to keep data centralized and "Toll snapping and processing system" is used. The OCR cameras are used to photograph license plate numbers of vehicles that do not have transponders. The toll bill will then be sent directly to the registered address of the vehicle owners

Sanchit Agarwal, Shachi Gupta, Nidheesh Sharma "ELECTRONIC TOLL COLLECTION SYSTEM USING BARCODE LASER TECHNOLOGY (2014)"

Sanchit Agarwal, Shachi Gupta, Nidheesh Sharma, This paper focuses on an electronic toll collection (ETC) system using barcode laser technology. The proposed barcode laser system uses tags (barcode) that are mounted on the number plate of vehicles, through which information embedded on the barcode are read by barcode readers, the proposed system eliminates toll authorities to perform ticket payments and toll fee collections, respectively. Data information are also easily exchanged between the motorists and toll authorities, thereby enabling a more efficient toll collection by reducing traffic and eliminating possible human errors

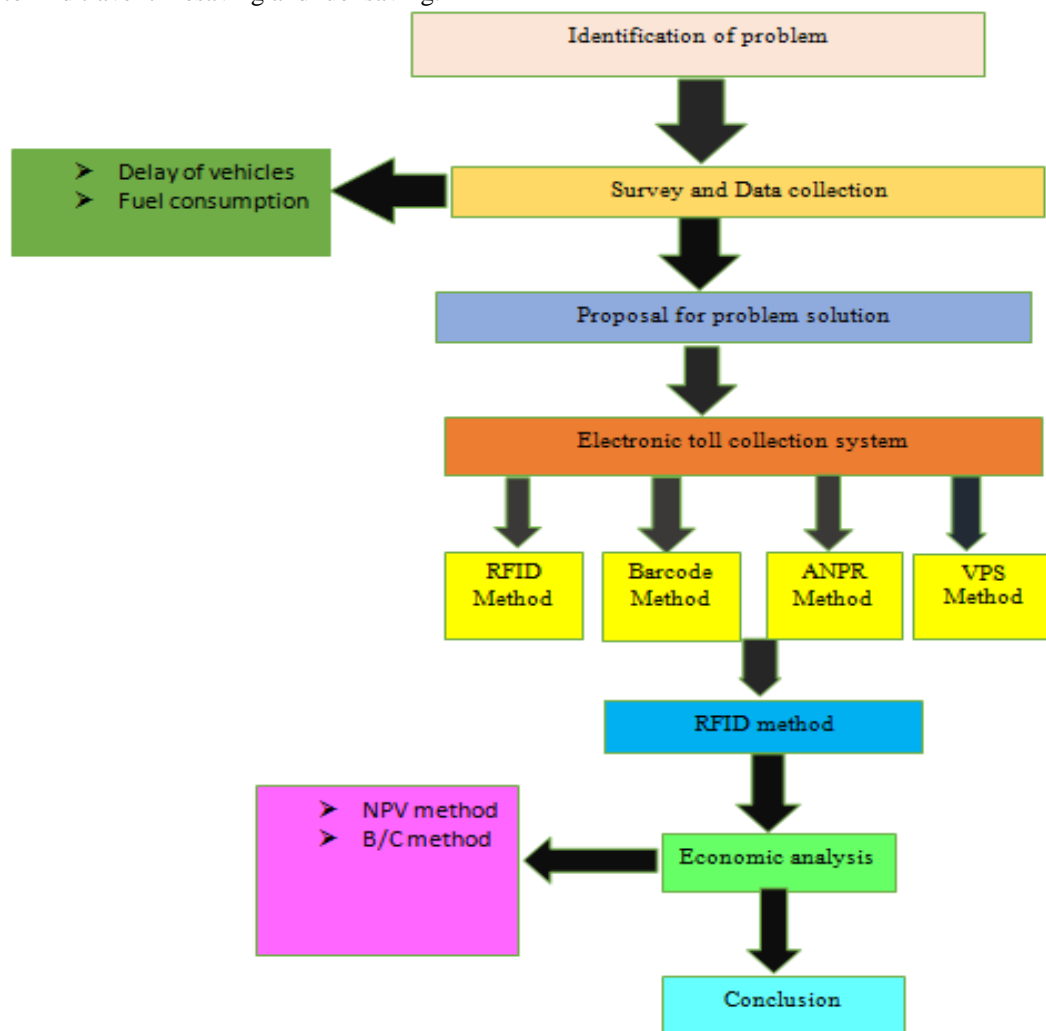
IV. STUDY AREA

The Ahmedabad Vadodara expressway is an expressway connecting the cities of Ahmedabad and Vadodara in the state of Gujarat, India. The 93.1 km long expressway reduces the travel time between the two cities from two and a half hours to an hour. There are lots of problem being faced at the toll system due to increase no of vehicles at the expressway. Larger number of queue line, delay in travel time, loss of fuel consumption, air pollution, noise pollution are the problems being faced at toll system. In order to solve all these problems we need to implement ETC system.



V. METHODOLOGY

To achieve the objectives a methodology is framed. Complete flowchart of each activity showing various stages involved as shown above. For this work study area is to identified for collecting data. Main stretches of the study area identify problems, such as delay in travel time, loss of fuel consumption, air pollution, noise pollution. Traffic data are collected from location and is used for analysis propose. Economic evaluation is carried out for the traffic data to find travel timesaving and fuel saving.



VI. DATA COLLECTION

In order to carry out detailed traffic analysis at toll booth, it is necessary to collect relevant data for carrying-out the study. The various traffic survey conducted are

- Traffic volume count survey
- Delay time at toll plaza

Table-1 Classified volume count survey at Ahmedabad-Vadodara toll plaza

Direction	Ahmedabad to Vadodara		Vadodara to Ahmedabad	
	In vehicles	In PCU	In vehicles	In PCU
Car	5330	5330	5602	5602
Bus	806	2418	862	2586
Trucks/LCV	936	2808	914	2742
Total	7072	10556	7382	10930

One day survey was carried out and it was observed that from Ahmedabad to Vadodara side 7072 vehicles are moving and from Vadodara to Ahmedabad 7382 vehicles were moving.

A. Delay of vehicles at toll plaza

Table-2 Delay time of vehicles at Toll plaza

Sr no	Vehicle	Delay time(Min)
1	Car	1.25
2	Bus	3.14
3	Truck/LCV	1.2

VII. ECONOMIC ANALYSIS

The data collected through field survey at Ahmedabad-Vadodara toll plaza were computerized and analysed primarily in view of the following

- The average delay of vehicles at toll plaza passing from Ahmedabad to Vadodara is 54 sec.
- The average delay of vehicles at toll plaza passing from Vadodara to Ahmedabad is 67 sec.

The vehicle hours are converted into passengers-hours based on vehicle occupancy. The following average occupancy values are adopted for different mode keeping in view the type of land use in study is

Table-3 Vehicle Occupancy

Type of Vehicle	Occupancy
Car	2.58
Bus	32.66
Truck/LCV	2.48

The computation of the passenger-hours lost in the form of delay for each type of vehicle is calculated and given in the following table. This computation is done for peak hour.

Table-4 Total Passengers hours at Ahmedabad-Vadodara toll plaza

Type of vehicle	No of Vehicles delayed	Delay in vehicle hours	Delay in passenger- hours per day	Delay in Passenger-hours per year
Car	10932	228	588	214620
Bus	1668	87	2871	1047915
Truck/LCV	1850	37	92	33580
				1296115

Fuel consumption

Fuel consumption for Cars:

It was observed that there were approx. 25% diesel cars and 75% petrol cars were travelling in 2 hours of duration. So as a result this data had been used for the further studies for calculating the yearly fuel consumption of vehicles.

Total number of vehicles = **10932**.

Idle fuel consumption for the vehicles was taken as **0.53 lit/hr.** (Idle fuel consumption for petrol and diesel engine)

Table-5 Fuel consumption for Cars

Type	No. of Cars	Delay	Fuel consumption (lit/day)	Fuel consumption (lit/year)	Yearly amount (Rs.)
Petrol	8199	1.25	90.189	32918.99	2403086.27
Diesel	2733	1.25	30.063	10972.99	721693.55
Total	10932		120.252	43891.99	3124779.82

Fuel consumption for Buses:

Total number of vehicles = **1668**.

Idle fuel consumption for the vehicles was taken as **0.86 lit/hr.** (Idle fuel consumption for petrol and diesel engine)

Table-6 Fuel consumption for Buses

Type	No. of Buses	Delay	Fuel consumption (lit/day)	Fuel consumption (lit/year)	Yearly amount (Rs.)
Diesel	1668	3.14	75.06	27396.9	1801894.11

Fuel consumption for Trucks:

It was observed that there were approx. 20% petrol vehicles and 80% diesel vehicles were travelling in 2 hours of duration. So as a result this data had been used for the further studies for calculating the yearly fuel consumption of vehicles.

Total number of vehicles = **1850**.

Idle fuel consumption for the vehicles was taken as **0.83 lit/hr.**

Table-7 Fuel consumption for Trucks

Type	No. of Cars	Delay	Fuel consumption (lit/day)	Fuel consumption (lit/year)	Yearly amount (Rs.)
Petrol	370	1.20	6.142	2241.83	163653.59
Diesel	1480	1.20	24.568	8967.32	654614.36
Total	1850		30.17	11209.15	818267.95

Total amount of fuel used yearly at toll booth = **5744942 Rs.**

The vehicle-hours computed are converted into passenger-hours based on vehicle occupancy. The following average occupancy value is adopted for different modes keeping in view the type of land is the study area

Table-8 Travel times Saving in Rupees (Source -DMRC Study 1996)

Type of Vehicle	Travel time saving in Rupees/passenger-hr
Car	Rs 10.31
Bus	Rs 10.31

A. Evaluation of travel time saving

Table -9 Travel Time Saving at Toll plaza

Type of vehicle	Delay in passenger-hours per year	Travel time saving/passenger-hr	Travel time Saving, Rs. Per year
Car	214620	10.31	221252
Bus	1047915	10.31	10804004
Truck/LCV	33580		33580
			11058836

Table-10 Benefit after construction of ETC

No	Saving	Amount in Rs
1	Travel time saving	11058836
2	Fuel saving	5744942
		16803778

B. Construction cost of ETC

After referring to many papers we can assume that total cost of Electronic toll collection system is 6 cr. It is assumed construction period for 2 yrs. The equal distribution of fund is assumed during the construction period.

- Year 1, 50% of initial capital cost
- Year 2, 50% of initial capital cost
- Maintenance cost of ETC is 200000 per year. With the help of above cost value we will go for economic evaluation. For economic evaluation, we go for following methods.

C. Calculation for Various Method of Economic Evaluation

Table-11 Results of Economic Evaluation of different methods

NPV Value	B/C Ratio
12.07Cr	3.01

VIII. CONCLUSION

The no of vehicles passing through Ahmedabad – Vadodara toll plaza are 14454 vehicles/day and 21486 PCU/day. In the Economic analysis

- NPV value is 12.07 cr, which is positive. Hence project is justified.
- B/C value is 3.01, which is greater than 1. Hence project is justified.

By implementation of the ETC project following benefits are proposed.

- Saving in travel time cost is Rs 11058836
- Saving in fuel is Rs 5744942

Various other benefits of ETC proposed by various authors are

- Emission control
- Accident hazards are eliminated
- Increase in convenience and comfort of passengers
- Congestion reduction.

IX. ACKNOWLEDGEMENT

The author would like to express their sincere thanks to Prof.Krupa Dave, family and friends for their unbelievable amount of help.

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