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Urban Corridor Management Strategy Based on Intelligent Transportation System

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Abstract**—**Intelligent Transportation System (ITS) is the application of technology for developing a user–friendly transportation system for urban areas in developing countries. The goal of urban corridor management using ITS in road transport is to achieve improvements in mobility, safety, and the productivity of the transportation system within the available facilities through the integrated application of advanced monitoring, communications, computer, display, and control process technologies, both in the vehicle and on the road. This paper attempts to present the past studies regarding several ITS available that have been successfully deployed in urban corridors of India and abroad, and to know about the current scenario and the methodology considered for planning, design, and operation of Traffic Management Systems. This paper also presents the endeavor that was made to interpret and figure out the performance of the 27.4 Km long study corridor having eight intersections and four flyovers. The corridor consisting of 6 lanes as well as 8 lanes divided road network. Two categories of data were collected on February 2016 such as traffic data (traffic volume, spot speed, delay) and road characteristics data (no. of lanes, lane width, bus stops, mid-block sections, intersections, flyovers). The instruments used for collecting the data were video camera, radar gun, mobile GPS and stopwatch. From analysis, the performance interpretations incorporated were identification of peak hours and off peak hours, congestion and level of service (LOS) at mid blocks, delay followed by the plotting speed contours and recommending urban corridor management strategies. From the analysis, it is found that ITS based urban corridor management strategies will be useful to reduce congestion, fuel consumption and pollution so as to provide comfort and efficiency to the users. The paper presented urban corridor management strategies based on sensors incorporated in both vehicles and on the roads.

Keywords**—**Congestion, ITS Strategies, Mobility, Safety

I. Introduction

TRANSPORT governing authorities, in developing countries, like India, as part of their traffic management role, have been observing and aggregating traffic data (traffic stream volume, density, speed etc.) for many years, but typically they did not share this information with the public. Transportation plays a significant role in the extension of economy of a country. In fact, the development of a country and the progress of its transportation system are complementary to each other. Due to spatial and temporal deviations in traffic, roadway and weather conditions, travelers travelling within cities are not generally conversant with these ongoing conditions. Hence desideratum of ITS is to bridging this information gap in order to provide the pre-trip and/or en-route information to the travelers. Motorised vehicles are the backbone of transport in urban areas. The escalation in vehicle population lays a clog on traffic especially in the urban cities of India, where roads are not wide enough. Economy induced automobiles usage is thus making prodigious demands on the transportation infrastructure in an overloaded region. In urban areas, improving in transportation system cannot be done by means of building new roads or mending waning infrastructures, but the future of transportation lies only in using ITS.

Deployment of ITS technologies usually requires combination of sensors, communication technologies, computing infrastructure and algorithms. Sensors provide ability to acquire data from vehicles and transportation infrastructure. Michigan Department of Transportation installed adaptive traffic control and video imaging sensors at over 300 road junctions for developing driver information system in Southeast Michigan [17]. Communicating technologies enable transmission and reception of information across various entities such as vehicles, infrastructure and any centralised units. Computing technologies include hardware and software components that aid in processing of large volume of data acquired by various systems. The algorithms process the information gathered by ITS infrastructure and develop operating strategies for transportation facilities. ITS therefore provides the ability to collect, store, organize, analyze, retrieve and share information about transportation systems to support informed decision-making.

In recent years, Geographic Information System (GIS) and Global Positioning System (GPS) technologies play an important role in several ITS applications. GIS was not only useful for network and geo-statistical analysis but also used for creating spatial database and for spatial queries. Similarly, in India, GPS technology is being commonly adopted for Automatic Vehicle Location (AVL) systems for fleet operation and management.

II. Advantages of ITS

Some of the major advantages of deploying an ITS are:

- ITS were specifically designed to overcome the limitations of traditional traffic control systems.
- Traditional traffic control systems cannot adequately respond to sudden fluctuations in traffic demands. ITS functionality allows for real-time manual or automated

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implementation of improved optimum traffic control strategies such as responsive/adaptive control.

- ITS allows agencies to efficiently and cost-effectively manage both recurring traffic congestion (routine traffic conditions) and perhaps most importantly non-recurring traffic congestion (due to incidents and special events).
- Historically, traditional traffic control systems are operated and maintained independently by various jurisdictions. ITS can unite various agencies/jurisdictions (local/regional/State DOTs, police, emergency management, etc.) to coordinate efforts to reduce regional traffic congestion issues.
- The advancements in equipment and software, coupled with the standardization efforts, allow for interoperability, interchangeability and exchange among various ITS traffic control devices. With ATMS, traffic control systems are no longer just reactive; rather, ATMS allows for proactive control and management of regional traffic congestion.
- ITS Traffic Management Centers provide operators with the advanced capabilities unlike those lacking with traditional legacy control systems. System operators now have tools that allow them too quickly and efficiently response and manage incidents and other emergencies. The real-time data feeds and high speed communications links, combined with decision support software, all within an integrated network, allows the TMC to operate efficiently and "intelligently."
- ITS has the ability to integrate live video images for distribution to the media and to report traveler information to various web sites.

III. Literature Review

In this section, discussion on the research efforts in the area of ITS developed by different researchers around the world are carried out.

A. Studies Conducted Abroad

A GIS based Multi-Modal Advanced Traveller Information System (MATIS) has been proposed for New Jersey that advanced under the UNIX based GIS environment [14]. An Internet GIS based transit information system has been designed for Interactive Trip Planning for Waukesha Metro Transit, Wisconsin, U.S.A. [16]. An integrated genetic algorithm and GIS to evaluate route for HAZMAT has been developed by considering exposure, socio-economic impact, and risks of hijack, traffic conditions and emergency response [8]. Sawant in their study proposed the concept of wireless adhoc sensor networks to enhance the safety of road travel [19]. An Urban Transportation Information System (UTIS) for the Guangzhou city of China that integrating traffic information with GPS has been proposed in 2006 to monitor traffic congestions, traffic flows and accidents on roads [3]. The real-time data collection for journey time estimation has been evaluated using AVI, GPS, and Video image processing techniques on a 6.23 km stretch of Kowloon Central road network in Hong Kong [13]. To determine the spatial distribution and concentration features of congestion in Shanghai city, a spatial autocorrelation analysis has been done [5]. An AVL system has been developed for the city of London U.K. based on GPS and supporting technologies like optimization filter and map matching software [7]. Ultrasonic and passive infrared sensors at the King Abdullah University of Science and Technology (KAUST) have been used to classify cars and detect flooding on streets [21]. To model the distribution of travel time using traffic volume measured by ultrasonic vehicle detectors deployed as part of ITS technology on the Hanshin Expressway has been attempted in 2014 [2].

B. Studies Conducted in India

The evolution of ITS for urban corridors of developing countries like India is at a primal stage with very few accumulations. In India, regular studies have been carried out on congestion for different cities. An ITS using a sensor network that counts vehicles, average speed of vehicles on the roads segment has been developed in 2000 [12]. GIS based advanced traveler information system has been proposed for Hyderabad city in India using ESRI's ArcView 3.2 GIS software [18]. With the help of audio and visual means an in-vehicle Advanced Traveler Information System has been proposed for Chennai city that provides drivers with the information about congestion, alternate routes and status of the vehicles and roadway conditions [15]. A Web GIS based ATIS named as Computerized Traveler Information and Decision Support System (CTIDSS) has been developed for disseminating the information to the travelers under prevailing road and traffic conditions [20]. A GPS application for the traffic data has been proposed which includes traffic speed and volume, travel time and they verified the GPS data through standard methods and evaluated the results [10]. An architecture has been developed with the help of Wireless Sensor Network (WSN) and Bluetooth technology developed architecture to enhance the road travel safety [11]. A Real Time Passenger Information System has been proposed for the city of Mumbai in India that used RF Transceiver to poll a signal and GPS to display positioning of the buses in real time in the city [4]. To reduce the traffic congestion for Coimbatore city of Tamil Nadu by using GIS, SPSS16 based model has been used [1]. Micro-simulation using VISSIM software has been applied to evaluate the performance of BRTS in Ahmedabad and New Delhi. The study used probe-vehicles mounted with GPS to conduct speed and delay studies on urban roads in the study cities [6]. GIS and GPS has been used in their study to develop a web-based Passenger Information System (PIS) for Ahmadabad city [9].

IV. Study Area

Delhi being the capital city of India expanse over an area of 1483 sq. km of which 700 sq. km is cognominated as urban. The corridor selected for the study is 27.4 Km long arterial road that covers significant areas of the city. It starts from the Kashmiri Gate Interstate Bus Terminal (ISBT) and touches Raj Ghat Flyover, Maharani Bagh, Andrew Ganj, AIIMS,

Yusuf Sarai, IIT Delhi, Qutub Minar, and ending at Mehrauli Terminal. Study area road network is shown in Fig. 1. This road is dissociated into 6 road segments for data collection and analysis purposes.

Traffic Data Collection

The traffic data needed to figure out the traffic behavior for the objective of corridor management are as follows:

A. Traffic Volume Data

Video recording was done at selected six mid blocks in the month of January 2016. The total traffic volume data collected spanning for 16 hours i.e. from 6:00 AM to 10:00 PM at every fifteen minutes' interval is shown in Table I. The traffic composition observed at one mid-block section is shown in Fig. 2.

B. Spot Speed Studies

The average spot speed data collected for different types of vehicles at six midblock sections on the corridor using radar gun are also presented in Table I. From this table, it can be observed that the average speed of vehicles is ranging between 15 to 30 kmph.

V. Data Analysis

To anticipate the speed and capacity of the urban roads under study the speed–flow functions shown in Fig. 3 has been developed between the average speed of all the vehicles and the total traffic volume on the given six mid blocks of the study corridor. The coefficient of determination ($R^{2)}$ obtained shows that the data is closely fitted to the regression line or the model thus obtained best fits the data.

The capacity of urban road for six lane divided two-way road is 10800 PCU/h in both the direction [7]. For the purposes of congestion determination in the study corridor, v/c ratio is calculated for each mid-block section. This is evident from Table II that heavy congestion is recognized at Sarai kale Khan mid-block of the corridor as v/c ratio is 0.84 which is in the range of 0.75 to 1.0.

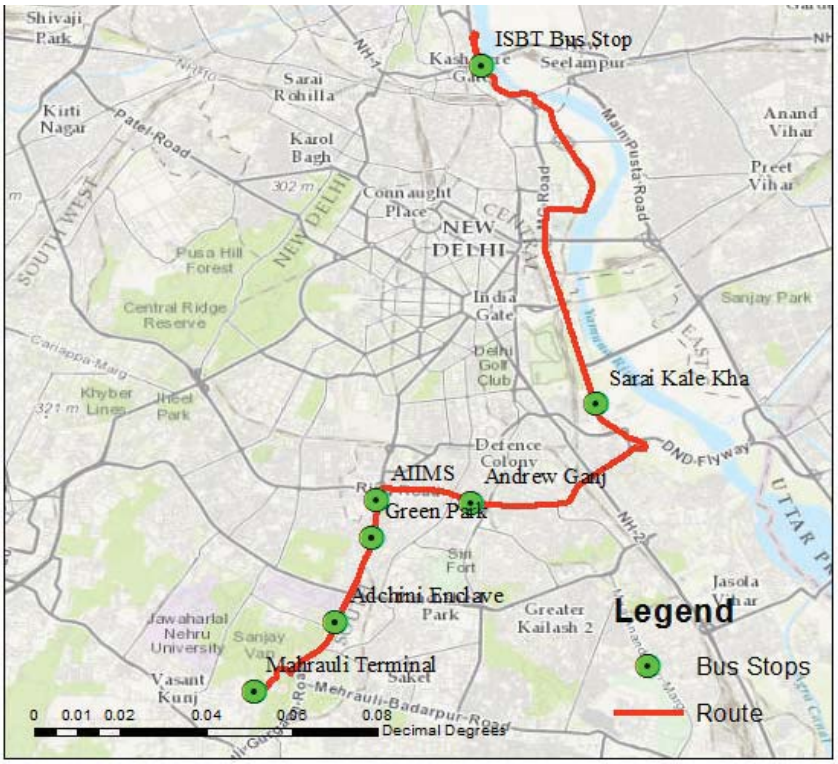

Fig. 1 Corridors selected for study

TABLE I
Total Traffic Volume and Average Speed on Midblock Sections

S. No.	Name of Mid-Block	Total Traffic Volume	Avg. Speed (Kmph)	Date of Survey	Time Span (Hours)
1	Before Rajghat Flyover	107752	21.8	18. 01.2016	16
2	Sarai Kale khan	145392	16.5	19. 01.2016	16
3	Andrew Ganj	98421	23.4	20. 01.2016	16
4	AIIMS	93206	25.7	21. 01.2016	16
5	Green Park	71936	23.6	21.01.2016	16
6	Adchini Enclave	82631	24.0	22. 01.2016	16

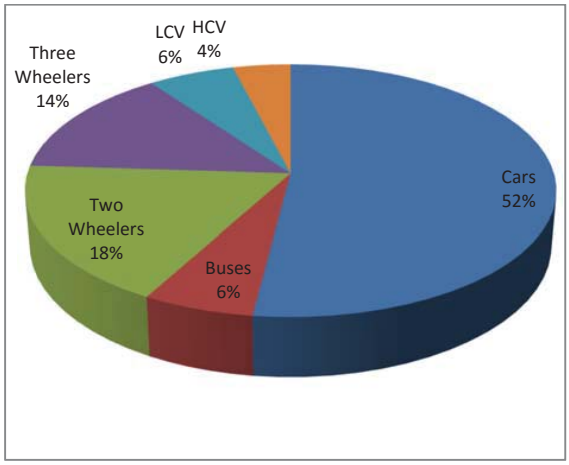

Fig. 2 Traffic Composition at Andrew Ganj

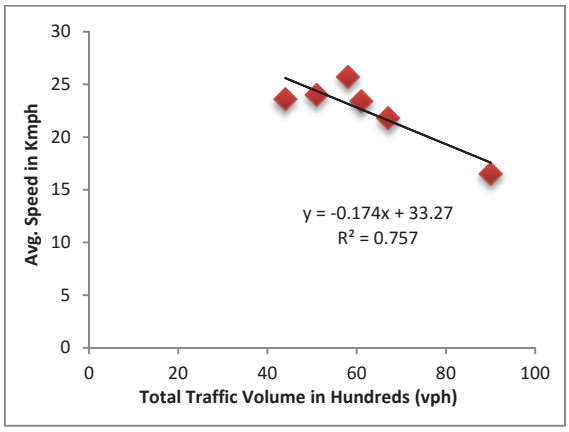

Fig. 3 Speed - Flow Relationship

TABLE II
VOLUME TO CAPACITY RATIO

S. No.	Name of Mid-Block	Volume/ Capacity Ratio	Congestion Level
1	Before Rajghat Flyover	0.62	Moderate Congestion
2	Sarai Kale khan	0.84	Heavy Congestion
3	Andrew Ganj	0.56	Moderate Congestion
4	AIIMS on Inner Ring Road	0.54	Moderate Congestion
5	Green Park on Sri Aurobindo Marg	0.42	Low or No Congestion
6	Adchini Enclave	0.48	Low or No Congestion

VI. CONCLUSIONS

After evaluating all the traffic parameters of the study corridor, it is concluded that urban corridor does not produce required LOS and caters heavy congestion due to mixed traffic. Hence, there is an urgent need to develop ITS with the help of sensors, cameras, detectors as well as traffic Management Centre that supports controlling, monitoring and management of traffic to disseminate both multi-modal transit information as well as static and real time traffic information to a wide range of travelers who use various modes of travel and have different travel attributes.

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