

Model for Modern Traffic System Using Remote Sensing and GIS Tools

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(Received May 03, 2018)

Abstract: Traffic congestion continues to be one of the major problems in various transportation systems. The ever increasing demand for mobility in urban centers has resulted in increased traffic congestion and a multitude of problems associated with it. This paper proposes a model for modern traffic system. The main objective of the proposed model is to meet the demand of faster mobility by different modes; building capacity and extending network facilities to accommodate growing traffic needs. Global Information System (GIS) and Remote Sensing tools are used for this purpose.

Keywords: Traffic congestion, GPS, GIS, Remote Sensing, Model.

1. Introduction

It is estimated that delays from congestions on highways, streets, and transit systems throughout the world result in huge productivity losses amounting to hundreds of billions of rupees annually. Other negative effects of congestions are also very significant, which include property damage, personal injuries, increased air pollution, and inefficient fuel consumption. Remote sensing is a science, rather a technology commending the art of obtaining reliable information about an object, without being in physical contact. These sensing devices exhibit a remarkable capacity in obtaining various useful data. For example, we can capture the data of traffic intensity, its frequency and the resultant effect on it caused by congestions. Not only this, it also gives us a feel of the various traffic snarls being caused on the entire surface of the earth, their cause and effect. These devices also help us

understand the entire spectrum of various Electro Magnetic Radiations (EMR), hitting our planet from other celestial bodies and outer spaces.

One of the devices that would help us is GIS; a geographic information system that stores, analyzes, and displays geographically referenced information provided by GPS. GIS is used to monitor vehicle location, which enables us in formulating effective strategies that can keep vehicles in transit, on schedule, apart from informing the passengers of their precise arrival time. Mass transit systems use this capability to track rail, bus, and other vehicular traffic, to plan and execute their efficient movement and ensure their on-time performance.

The immense possibilities and capabilities of GPS also excites and enthuses us. A world without GPS cannot be imagined. All navigational apps make use of it and a driver runs the risk of being way laid without it. Ola and Uber will cease to exist without it. Instant car pools are being made feasible with its help, as people desiring a ride get matched with a vehicle in the nearby area.

The use of GPS in tracking and forecasting the movement of freight has ushered in a logistical revolution, by implementing the Definite Time Delivery application. It is being widely used by the truckers and the transporters for picking up and delivering the consignments, on time, country wide. The process has been simplified to a great extent. When an order comes in, a dispatcher punches a computer function, and a list of trucks appear on the screen, displaying a full array of detailed information on the status of each of them. The nearest one or the one for whom it is most convenient is then directed to pick up the consignment. After being tracked on the entire route it is then delivered on time at the destination. Not only that, if a truck gets delayed because of other extraneous circumstances, or strays off route, an alert is sent to the consignee and the consigner both. Many nations use GPS for surveying their road and highway networks, by identifying and locating the features near, or adjacent to the road networks. These include service stations, maintenance and emergency services, supplies, entry and exit ramps, damage to the road system, etc. The information serves as an input to the GIS data gathering process. This database of knowledge helps transportation agencies to reduce maintenance and service costs and enhances the safety of drivers using the roads.

Research is underway to provide warnings to drivers of potentially critical situations, such as traffic violations or crashes. Additional research is being conducted to examine the potential for minimal vehicle control when

there is a clear need for action, such as the pre-deployment of air bags. The information provided by GPS is an integral part of this research.

2. Literature Review

Modelling, the process of traffic flow was previously studied from different points of views. Consequently, different methods were used to describe the same process. It also encountered difficulties in choosing a universally applicable method for identifying vehicle, and for object specific recognition, primarily based on their physical appearances that we encounter on our streets and roads. Different authors have different views for the same phenomena and are focusing on different aspects of the same problem (C. J. Dong and H. X. Li¹, C. J. Dong, C. F. Shao and Z. C. Xiang², C. J. Dong, M. Z. L. Shao, Z. C. Xiang and Y. Y. Li³⁻⁴, C. F. Shao, C. J. Dong and Z. H. Xiong⁵, X. Y. Wang and J. L. Zhang⁶⁻⁷, X. M. Li, G. M. Wang and H. P. Zou⁸⁻⁹ etc.

But, all the authors and researchers seem to agree on the basic traffic flow parameters like, traffic flow density, traffic flow rate or the average speed. Apart from that there seems to be no uniformity in the selection of the methodology for investigations being applied; in the study of traffic flow models, which would ultimately help to identify and subsequently lead to their engineering solutions. (Y. Li, and M. McDonald¹⁰).

3. Functional Area of Modern Traffic System (MTS)

Following are the major MTS components:

- (i) Advanced Traffic Management System (ATMS).
- (ii) Electronic Toll Collection (ETC).
- (iii) GPS Route Guidance (GPS-RG).
- (iv) Traveler Information (TI).

3.1. Advanced Traffic Management System (ATMS): The Advanced Traffic Management System (ATMS) field is a primary subfield within the Intelligent Transportation System (ITS) domain. The ATMS view is a top-down management perspective that integrates technology primarily to improve the flow of vehicular traffic and improve safety. Real-time traffic data from cameras, speed sensors, etc. flow into a Transportation Management Center (TMC), where it is integrated and processed (e.g. for mishaps and detection of traffic disruptions), helping in arriving at remedial actions (e.g. traffic routing, DMS messages) aimed at improving the traffic flow⁶.

The principal users of ATMS are passengers, car drivers, pedestrians, public transport passengers, truck drivers, bus drivers and management agencies. The following are the main tools of ATMS.

3.2. Emergency Call Box (ECB): Emergency call box is a pedestal mounted box, installed at every 2 Kms. Installed in a well-protected safe place, is primarily used by the highway users, for security and emergency communication needs as an aid, facilitating urgent help and assistance¹¹. It is capable of working in extreme weather conditions and can be deployed globally. No matter what the road direction is, no matter how the device is oriented on deployment - the design takes care of capturing maximum sunlight to fully charge the internal power reservoir. Its internal power management capability assures a low power consumption resulting in uninterrupted service even in cloudy weather conditions. The ECB is capable of communicating with Control Room through optical fiber or GSM media.

All ECB's are clearly marked with white reflective lettering that reads as "Emergency Call Booth". A flashing Red light located at the top of the box ensures visibility which helps to identify the ECB location during night hours. It is capable of hands free operation.



Figure 1. Emergency call box

3.3. Salient Features of ECB: Following are the salient features of ECB

- (1) 99.99% uptime.
- (2) Easily Visible to the distant road user, Illuminated front call panel.

- (3) Clear voice communication between road user and control room operator (Clearly audible in noisy highway environment).
- (4) Hands free - single push operated.
- (5) Easily operable - even by a child.
- (6) Locally powered by Solar Energy.
- (7) Powerful battery backup; Talk Time- 17hrs, Standby Time- 148hrs (in zero sunlight conditions).
- (8) Wireless or wire line options available.
- (9) Uses Digital Telephony: All standard call features are supported like handling multiple calls, call holding- retrieve, transfer etc.
- (10) Easy Installation and Maintenance.
- (11) Components are designed for long service life.
- (12) Self-Diagnostic / Alarm Feature, device health reports available, Remote programming capability.
- (13) All ECB's are monitored live on GIS based software.

3.4. Variable Message Signs (VMS): Variable Message Signs are mounted on sleek gantries. The modern day traffic can best be explained by one word- chaotic; with every moving thing in the street, jostling with the other, moving frantically to reach its destination as early as possible. The Variable Message Sign is a very effective tool when it comes to managing the chaotic traffic efficiently. The VMS signs display messages and instructions for the drivers behind the wheels, depending on the conditions. The signs help them regulate and organize and thus improve their driving conditions by making adjustments according to the situation, which in turn, saves a lot of time for the people commuting on the streets.

The VMS board consists of LEDs which are available in three different variants, mono colored, two-colored and multi-colored. It is an interactive device that delivers the messages in a new format. These signboards are bright enough to be seen even in the scorching sun, and pleasantly cool enough to the eyes even at night. It can even automatically adjust to the ambient brightness prevailing at the given spot⁹. Apart from warding off the massive traffic jams at times, it also helps to display messages containing directions instantly thus contributing in a large way in efficient traffic movement.

The Variable Message Sign is the safest means for alerting the drivers about the changes necessitated because of sudden disruptions in the traffic and road situations. These devices can easily inform the motorists about the work zones, diversions, lane merging and closures, parking bays and similar blockades. VMS boards use latest technology to provide accurate and

instant information to the people driving on roads. It makes maximum use of the available resources and helps in providing the information without any time lag. Thus the operator sitting in the control rooms can manage the traffic in a better way and thus ease the roads of the heavy traffic by distributing them uniformly throughout the city.



Figure 2. Variable Message Signs

3.5. Salient Features of VMS: Following are the salient features of VMS

- (1) It uses latest technology to ease the traffic.
- (2) Available in mono, two and multi-colored LEDs with different pixel pitches and matrix.
- (3) Very bright displays to enable the drivers to see it easily in broad daylight.
- (4) Automatic brightness control to adjust to the ambient light without any jarring effect on the eyes of the drivers in low light.
- (5) Glare-free display by using specialized lens over the LEDs.
- (6) Standalone fixed as well as portable units.
- (7) Power supplied via mains, battery or even solar power, enabling it to be installed virtually anywhere and everywhere.
- (8) Wired as well as wireless connectivity to make every unit easily programmable while enabling it to display the latest message with no time lag.
- (9) Perfectly sealed, weather proof and resistant to vibrations.
- (10) Highly energy efficient.
- (11) Robust design, durable and tough.
- (12) Minimum maintenance requirements.
- (13) Customizable Dimensions making it extremely flexible.
- (14) User-friendly software interface makes it easy for the operators to display the information and modify it without much problem.

- (15) Having optional features like traffic detection, video surveillance and monitoring etc.

3.6. Traffic Classification System (TCS): Traffic Classification System provides statistical information related to traffic flow. It uses inductive loops. It is used for automatic classification of vehicles, measures speed and occupancy level.



Figure 3. Traffic Classification System

3.7. Salient Features of TCS: Following are the salient features of TCS

- (1) Information regarding the number of vehicles passing at any desired spot per day.
- (2) Classification of Vehicle by size, rating and speed range.
- (3) Classification of the number and category of vehicles commuting every day.
- (4) Based on these information, construction of new access roads and bridges can be taken.
- (5) It uses latest technology to ease the traffic.
- (6) Minimum maintenance requirements.
- (7) Customizable Dimensions making it extremely flexible.

3.8. Meteorological Information System (MEIS): Meteorological Information System is a Road Weather Information System (RWIS) comprising of automatic weather stations (technically referred to as Environmental Sensor Stations). It is a communication system for data transfer, and it also has a central systems to collect field data from numerous environmental sensor stations. These stations measure real-time atmospheric parameters, pavement conditions, water level conditions, and visibility.

Central RWIS hardware and software are used to process observations from environmental sensor stations to develop new casts or forecasts, and display or disseminate road weather information in a format that can be easily interpreted by a manager¹¹. RWIS data are used by road operators and maintainers to support decision making. Real-time RWIS data is also used by Automated Warning Systems (AWS).



Figure 4. Meteorological Information System

3.9. Salient Features of MEIS: Following are the salient features of MEIS

- (i) Wind Speed.
- (ii) Air Temperature.
- (iii) Humidity.
- (iv) Visibility.
- (v) Road Temperature and road conditions.

3.10. Electronic Toll Collection (ETC): Electronic toll collection (ETC) is a wireless system to automatically collect the usage fee or toll charged from the vehicles using toll roads, HOV lanes, toll bridges, and toll tunnels. It is a faster alternative which is replacing toll booths. Earlier vehicles used to stop and the driver manually paid the toll in cash by a card. In most systems, vehicles using the system are equipped with an automated radio transponder device called Fast Tag. This has automated the toll collection system. When the vehicle passes a roadside toll reader device installed at the toll booths, a radio signal from the reader triggers the transponder, which transmits back an identifying number registering the vehicle's use of the road, and charging the user through an electronic payment system. A major advantage of this system is that the driver pays the toll without stopping, which saves valuable time. Electronic tolling is cheaper than a staffed toll booth, reducing transaction costs for government or private road owners. The ease of collecting the varying amount of toll for different class of vehicle, makes it

easy to manage efficient vehicular movement, at the same time bringing a reduction in costs¹¹. The payment system usually requires users to sign up in advance and load money into PAYTM, which is a payment application.



Figure 5. Electronic Toll Collection (ETC)

3.11. GPS Route Guidance (RG): GPS Route Guide- Live Earth Map provide worldwide map information with live street view and satellite map view of the user driver's current location. It provides Maps, Navigation & Directions which allows to plan trips, find routes to travel and it also provides information about restaurants, filling stations en-route to the destination. The widely used Google Driving Directions available through Google Maps is a perfect example.

GPS Route Guide-Earth Map app has all required features of navigation, on which we can find the location of our desired destination. This application easily runs on our smart phones. Voice navigation route finder application issues audio directions and just requires internet connection. We can turn on our location and take the tour of beautiful and historical places around the world through this Route Guide application¹².

GPS Route Finder City Guide provides a lot of useful features. We can search all the places in the city we live. It has the facility of finding shortest route. GPS navigation app with real-time traffic for Android is available free. Navigation maps with GPS gives us complete guidance for going from place A to place B. It constantly gives us directions about the traffic conditions and route guidance. It is so elaborate that it not only selects the shortest route, it even tells about average speed, distance covered, and the

probable time of reaching the destination. This application uses satellite and street view for GPS Route Tracking.

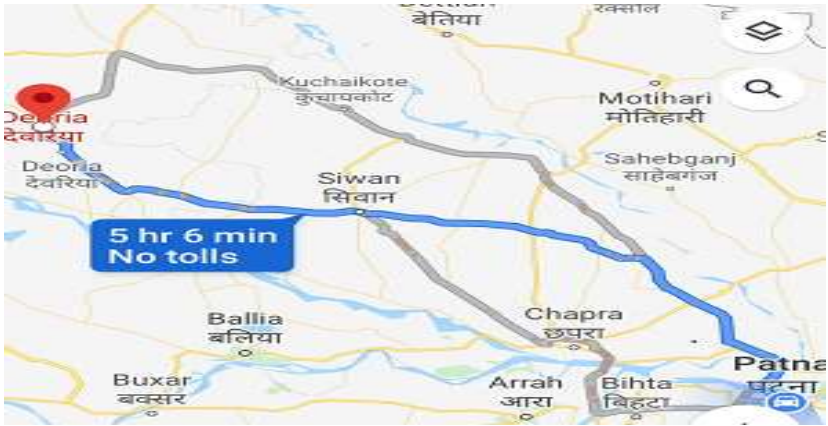


Figure 6. GPS Route Guide

3.12. Travelling Information (TI): Different danger warning such as vision obscured due to fog, disabled car ahead, instructions to slow down and remain vigilant because of falling object ahead etc., are displayed, which is very useful while driving. Not only this, if the road ahead is closed because of any reason, the application also suggests an alternative route and instructs accordingly.



Figure 7. Travelling Information

4. Proposed Model for Modern Traffic System

In proposed Model four components of Modern System (MTS) have been integrated. They are Advanced Traffic Management System (ATMS), Electronic Toll Collection (ETC), GPS Route Guidance (GPS-RG) &

Traveler Information (TI). All four components work in cohesion and share the data.

Advanced Traffic Management System (ATMS) has also been divided into four different parts namely Emergency Call Box (ECB), Variable Message Signs (VMS), Traffic Classification System (TCS) & Meteorological Information System (MEIS). Each of these component needs to be connected to a Data Base (DB).

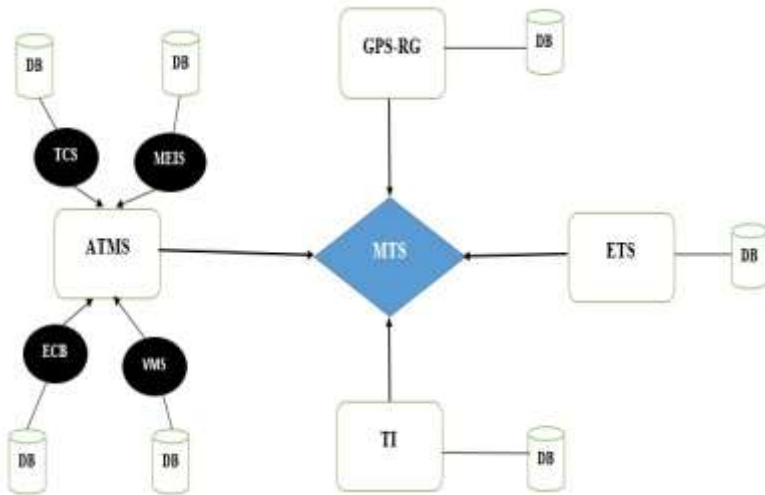


Figure 8. Proposed Model for MTS

5. Conclusion

As per statistics, more than 1.6 million buses are registered in India, and the State Road Transport Undertakings (SRTUs) altogether operate 1,50,000 buses carrying roughly 70 million people per day. The proposed system has proved to be the only optimal solution to solve the enigma of building and operating transportation systems capable of catering expeditiously the growing urban traffic demands of the developed and developing countries.

The use of proposed model will give us the following advantages

- (1) Improved vehicle highway system operations and management techniques.
- (2) Optimal use of existing infrastructure.
- (3) Removed Congestion.
- (4) Coordination of traffic movements.
- (5) Ease driver's frustration and the ensuing driving rage.
- (6) Constant monitoring of environmental condition.

(7) Monitoring and management of stress related accidents.

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