Intelligent Transport System for Smart Mobility in Public Transport

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Abstract

The population boom along with the changing economic trends has led to the exponential rise of the vehicles all over the world where automobiles serve as a necessity as compared to a convenience. The automobile industry has focused on the private user ship than a shared commodity. It is non-compatible with the infrastructure on the roads in an overloaded region by the ever-increasing demands. It leads to the need for a comprehensive system to integrate the traffic measures with the road infrastructure and the technology to define measures to reduce the traffic. Thus, Smart Mobility comes into account which if simply put, devises a system to increase the efficiency and the movement of the vehicles and its users. Intelligent Transportation System is a by-product of the same which focuses solely to mitigate traffic congestion and collision problems by data acquisition, analysis, and information dissemination. Various countries have devised their own systems based on their cultural, social, geographic and environmental background by correlating the various components for an effective transport system. paper will demonstrate how ITS can be built to enhance the experience of transport consumers of urban area. Along with that this paper will discuss the emerging financial, policy and governance issues of ITS system in India. Eventually, the paper highlights the concerns required for a national transport issues, and the ITS models from developed countries which can be applied in India cities.

1. Introduction

The rapid growth of urbanization in the recent trends has led to the increased consumption of automobiles. According to the data published by the World Bank Group, the rate of urbanization in India has exceeded from 17.92% in 1960 to 34.08% in 2018 [1]. The accelerated growth of GDP combined with the trends of urbanization has spurred mobility's explosive concern nearly eight times since 1980–more than any other Asian economy. From many points of view, this tremendous growth has been assured, including the emergence of a prosperous automobile industry and cohesive financial progress. Be that as it may, there are a lot of difficulties to be tended to. In the world's top fifteen most contaminated cities, an ongoing study of the WHO has fourteen Indian cities. This check triggers extraordinary well-being and health misfortunes, now measured at 7.7 percent of India's GDP (balanced PPP) by the World Bank. In contrast, major metropolitan Indian populations are now also consistently located among the most overcrowded cities in the world. According to the BCG report, congestion is at present assessed to cost the four Indian cities only over USD 22 billion every year.
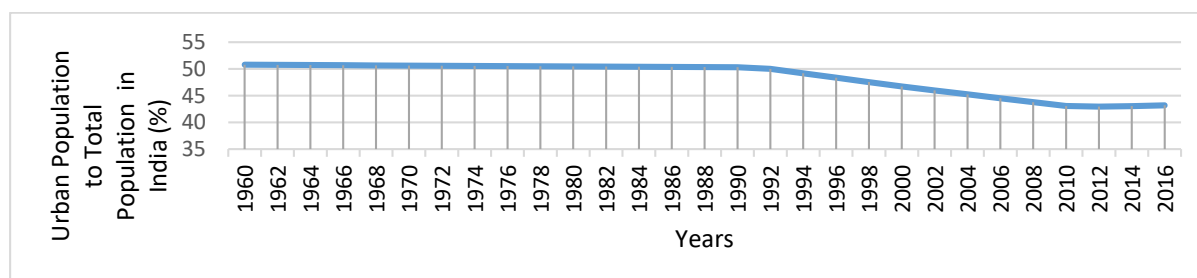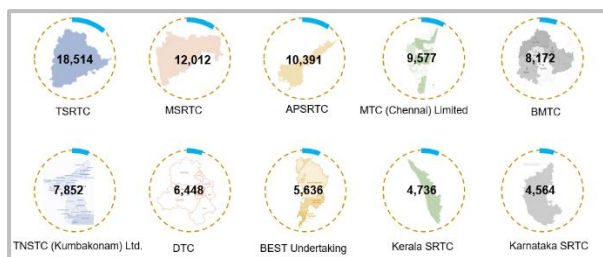

Figure 1 Urban population trend for India's total population

2. Indian Scenario

The degree of congestion is fundamentally higher in Indian urban communities than practically identical urban communities around Asia, averaging 149%, with vehicle possession being one conspicuous explanation. This implies, by and large, suburbanites take 1.5 times longer to travel a given distance. In India, buses take up majority of the public transport inter and intra city which is run by the individual transit agencies run by the state.

According to the data given by SRTU in 2016, the bus ridership in the state is 416.12 lakh/day out of which 69% of the total ridership in a day is served by the top ten agencies as shown in Figure 2 where the numbers in the circle represent the average fleet size of each transit agency. In Figure 3, the bar shows the loss incurred per day of the top ten agencies. [2]

Figure 2   Average fleet size of the top ten road transport agencies
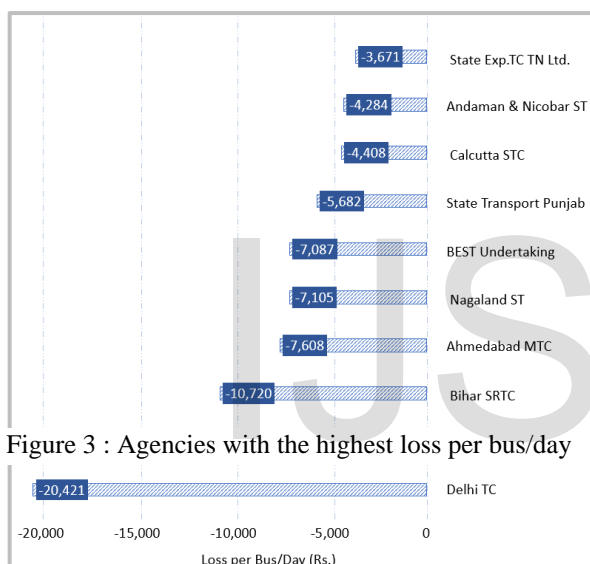
Figure 3 : Agencies with the highest loss per bus/day

The size and intricacy of our portability challenges requires a thorough structure that tends to the issue comprehensively. The high populace thickness, development, combined with our monetary development yearnings warrants a custom-made methodology, exceptional to our unique situation. It can be met by inculcating smart solutions and the promotion of the public transport which will be dealt in this chapter.

3. Smart Mobility

Keen agility is another liberal take on how we're going about it — one that's healthier, smarter, and more professional. In other words, this new vision was named by Neckermann: "Zero Emissions, Zero Accidents, Zero Ownership." Smart portability incorporates all methods of transportation and framework: autos, including rideshares, bicycle shares; traffic signals; structures; parking spots; crisis vehicles and individuals; and it uses sensors, programming and information stages to streamline these components into one intelligible framework. The concept of mobility encompasses a wide range of transportation methods: kick bicycles, bikes (standard, mechanical, foldable), transit, light rail, subway, streetcars, and taxis. Therefore, consumers have the option of buying or renting.

3.1 Key Principles of Smart Mobility

The concept of smart mobility is evolved keeping some aims in mind which needs the laying down of few principles:

- **Flexibility:** The travelers get options to choose from according to the different transportation modes which are available for a particular route.
- **Efficiency:** It minimizes the time of the disruption form a point to another point which also increases the ease of the travel.

- **Integration:** The transportation is perceived as a comprehensive system of multi modal transport from door-to-door.
- **Clean Technology:** The shift is made from the vehicles causing pollution reducing to the zero-emission ones.
- **Safety:** The accident rate is decreased drastically by taking safe measures.

3.2 Smart transportation components

Integrated systems are the cornerstone for intelligent transport. In a single view, data collected on traffic situations, availability of parking and options to different modes of transport should be presented. This makes it easier for citizens to make decisions on travel plans through real time. There are several components that add value to a smart transportation system, allowing the smart traffic management system to provide the real-time data needed. Smart transport can be introduced, as shown in Figure 4, through improvements in four major areas.
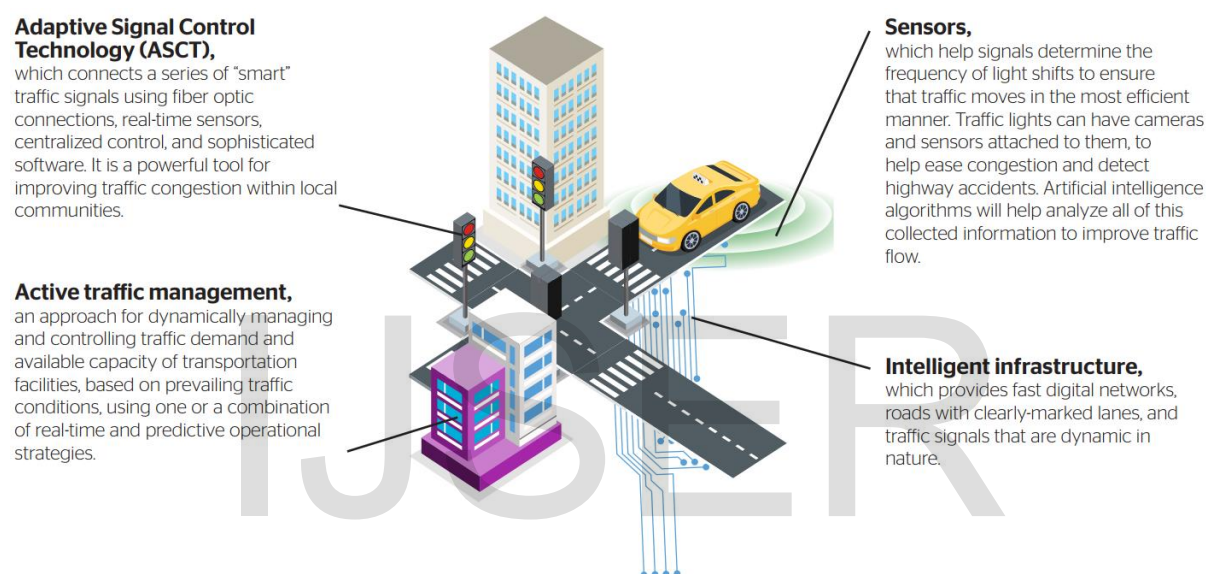

Adaptive Signal Control Technology (ASCT), which connects a series of "smart" traffic signals using fiber optic connections, real-time sensors, centralized control, and sophisticated software. It is a powerful tool for improving traffic congestion within local communities.

Active traffic management, an approach for dynamically managing and controlling traffic demand and available capacity of transportation facilities, based on prevailing traffic conditions, using one or a combination of real-time and predictive operational strategies.

Sensors, which help signals determine the frequency of light shifts to ensure that traffic moves in the most efficient manner. Traffic lights can have cameras and sensors attached to them, to help ease congestion and detect highway accidents. Artificial intelligence algorithms will help analyze all of this collected information to improve traffic flow.

Intelligent infrastructure, which provides fast digital networks, roads with clearly-marked lanes, and traffic signals that are dynamic in nature.

Figure 4 Components of Smart Mobility

3.3 Challenges

While the work to improve the country's, transportation needs to be increased, there are some inherent challenges and threats. Public infrastructure is insufficient and unreliable, leading to poor public transport and traffic on the path. In addition, BS IV standards in India compared to BS VI in European countries are being followed. All of these challenges make it difficult, though not impossible, to work towards the goal of smart mobility.

Smart cities must provide effective solutions to smart mobility while fostering creativity, enabling a shared economy, and achieving sustainability targets. Such problems are part of the rapidly changing social mobility environment as seen through an urban city planner's eye. Strategies to face the demands of urban migration and solve the problems of urban mobility are unique to each region:

- Development of effective, accessible, safe and secure public transport systems, combined with mobility-as - a-service (MaaS) and other technologies
- Adaptation to vehicle technology and implementation (autonomous, wired, electronic, sharing, dockless)

- Design of policies and approaches to encourage compliance with air quality requirements and other steps for quality of life
- Developing public-private partnerships (PPPs) and partnering with information organizations to tackle air quality, pollution and conservation problems
- Developing viable physical and digital networks to enable emerging public-private mobility approaches

4. Intelligent Transport System

Intelligent Transport System (ITS) is the utilization of detecting, investigation, manage and communicate technologies to running transport modes with the aim to make it more efficient, safe and reliable. ITS incorporates a wide scope of utilizations that procedure and offer data to decrease the on-road traffic, improve traffic management, limit ecological effect and increment the advantages to all the users on the road. ITS incorporates vehicle-to-vehicle[1] (V2V) and vehicle-to-infrastructure[1] (V2I) innovation and consolidates both remote and wire line communications-based data and gadgets advances. The wireless technology is used to transmit all the data through the cloud which is mapped to different vehicles and their infrastructure in terms of the destinations. Community development change remains one of the world's biggest challenges facing policymakers. According to the United Nations, "1.3 million people are estimated to be killed on the streets of the planet every year. This number could reach 1.9 million deaths worldwide by 2020 if left unchecked. There is a tremendous human cost involved with these traffic crashes – unimaginable suffering and sorrow. Road traffic still tends to account for around 80 percent of CO2 emissions from transport and is expected to reach 9,000 Megaton per year by 2030 if current trends in commuting are not curbed"[19].

4.1 How ITS works

The Intelligent Transport System works in a methodology of three different steps of handling the data which is explained below.

A. Data Collection – The foremost and the primary task is to collect the data which is available on the field. It includes all the real-time data which is analysed from the travel patterns. The patterns may show the origin and destination points, the speed and the delays between the points which is personalized with the data of the vehicle in response to its physical attributes. It is identified through cameras, sensors, GPS in vehicles and the Vehicles Identifiers.

B. Data Transmission – The collected data needs to be transmitted to the Traffic Management Centre which then analyses the data. The collected data in its raw form is sent to the Centre where it is processed before sending it back to the field. The modes of transmission can be short-range and long-range through radio and the cellular connectivity.

C. Data Analysis- At the end, the data is analysed and processed with respect to the need of the hour and the travel patterns. Any rough edges are smoothened and the data is purged of any irregularities. This is done according to the conditions of any particular site.

4.2 Technology Interventions in Bus Operations

Certain different technologies are used in the public transport to make the travel more efficient. Some of the technologies used around the world are mentioned below.

A. GIS (Geographical Information System)

A GIS is a digital map showing all bus routes in a particular city. The GIS when used with a GPS system, identifies the location of a bus on the particular digital map. The system provides

bus operators and users RTI (Real Time Information) on the location of the bus, traffic congestion, time to destination, and so on.

B. Vehicle Tracking System - GPS (Global Positioning System)

A Vehicle Tracking System is a device that uses GPS satellites to identify its exact position. On the basis of X & Y axis, a GPS system can ascertain its exact latitude and longitude. When `integrated with a digital map, a Vehicle Tracking System can provide users real time positioning of a vehicle in a city. Vehicle location data also serves to produce warnings from standard criteria in the case of any divergence.

C. Operation Control Centre

The control centre is the main monitoring & command centre of a transport provide which is essential for a vehicle tracking system to work efficiently. The control centre has interfaces to recognize any irregularities at the field from the pre-scheduled patterns and produce any solution measures for the same to support the drivers of the vehicles.

D. On Board Computer

Various automated features in modern buses such as traffic data, passenger information systems, CCTV feeds, automated announcements, etc. are controlled by an On-Board Computer installed within the buses. The computer also log data relating to the driver efficiency, fuel consumption, over-speeding, engine idling time etc.

E. Driver Console

In order to ensure that the driver maintains his schedule at all stops, a special interactive Digital Display Screen called a Driver Console is recommended. This screen gets necessary data from the Operation Control Centre on traffic, as well as warnings to the driver in case of deviation from route, over speeding, not stopping at a bus stop, and so on.

F. Driver Behaviour Monitoring

Sensors installed within the bus and connected with the On-Board Computer can provide the control centre vital data on the behaviour of the bus driver. The data can indicate sudden braking, over speeding, unscheduled stops, dangerous turns etc. This data can help in appraisal monitoring of drivers. Dangerous driving is not just a threat to passenger safety but also affects the engine life and fuel efficiency.

G. Two-way Communication

A two-way radio communication unit is mounted in situations where there is no Driver Controller. This facilitates contact between inspection centre, dispatchers and driver. In the event of an emergency, road block or deviation, the system helps the control center exchange messages with the driver and vice versa.

H. Panic Button

The Panic button is integrated with the GPS system that provides the control room with a location of the distress message in the event of an emergency. In buses and taxis, it is usually installed. It is also possible to transmit emergency CCTV footage to the control center.

I. ETM (Electronic Ticketing Machines)

ETMs are used for passenger ticket printing. Two forms of ETM machines are available-offline and online. The data is stored in the computer in an offline ETM and retrieved at depot at night. In Online ETM, the data is sent in real time to the control center and can help the bus operator analyze user requirement patterns.

J. Ticket Vending Machines

These are vending machines that dispense bus tickets. These machines are placed at bus stops or at other transit places to reduce boarding time. Usually both cash and credit cards are accepted by these machines and they can be made to operate 24 hours. Fare Gate Validators are another form of off-board ticketing to increase boarding time, comparable to metros.

K. Card Validators

With increasing use of smart cards, an automated way of validating the cards and deducting the necessary fare is required. Card validators allow users to pay using a smart card (in lieu of cash) on the bus. This helps save time and also can eventually eliminate the need for a conductor.

L. Mobility Card

A mobility card is smart card that has payment information stored on it. The user can use these smart cards in lieu of cash. In most countries, a Mobility Card can be used on multiple modes of transport such as Trams, Buses, Metro Rail etc. This ensures the convenience of seamless transport across the city.

M. CCTV and Surveillance System

CCTV and monitoring systems monitor in-bus passengers. The data is either stored locally in a DVR or transmitted to the live monitoring control room in real time. Especially during rush hours, the control center can see the insides of buses. The video data can help in analysing cases of theft, lost property, accidents etc.

N. Passenger Information System

Passenger Information System are installed at key locations where it is located at the key sites of maximum transit of people like the bus stops and terminals and all the public transport junctions. It helps in real-time information of the modes of transport available at the particular point in the field through GPS and radio signals. They are small screens and boards where the user can see the real time expected time of arrival and the timings of the next modes.

O. Journey Planner and Mobile App

Journey Planner Apps are mobile apps that provide commuters with all the bus-related information. For real-time information on bus position, ETA, seat availability, etc., commuters can find out the different travel choices and connected with vehicle tracking system.

P. Planning & Scheduling System

Programming modules are available to arrange schedules that help improve arrangements and vehicle and driver executives – from making lists to moving financial bookkeeping information. Also, the vehicle organization process guarantees high accessibility of the vehicles and preventive and remedial support plans.

Q. Bus Fleet Management System (BFMS)

BFMS is an ERP framework used to improve depot services, bus service performance and other resources productivity of operation and administration by combining all core activities – planning, preparation, personnel, fuel needs, etc.

R. Automatic Passenger Counting Systems (APC)

An APC system uses sensors to automatically count the number of passengers on a bus. This information helps the bus operator plan the routes and bus frequency better, especially during peak hours. Also, when integrated with journey planning apps, the commuters can know how crowded the next bus is.

S. Data Analysis and Optimisation

It is possible to use data analytics to acquire structures and agree on options to enhance conveyance management. For instance, ticketing information can give data identified with request and utilized for administration streamlining. Essentially, transport appearance, time spent at stops, unforeseen delays, passenger usage and so on, are a significant resource that help recognize wasteful aspects in vehicle and staff organization.

T. Wi-Fi and Infotainment System

Wi-fi and infotainment systems on buses improve commuter's satisfaction and allow passengers to utilise their journey time at bus stations or terminals. Infotainment systems not only provide free entertainment but also real-time, accurate bus location, schedule updates and key announcements to improve passenger's personal safety and awareness on their journey.

U. On-Bus Diagnostics

Initially designed to reduce emissions by monitoring the performance of major engine components, On-Bus Diagnostics is a computer-based system. OBD systems help to collect vehicle health information related to electrical system, protection, engine, transmission and track ITS unit functionality as well.

5. Best Practices and its Relevance in Indian Cities

A smart traffic management system that provides artificial intelligence-enabled decision support. This smart city mobility solution provides smart traffic management services such as changing traffic light phases, information about road users, and dynamic traffic capacity changes. The accessibility approach was designed to help transit agencies meet strategic goals by lowering vehicle emissions and increasing urban traffic congestion. Various major cities such as Amsterdam, the Netherlands Manchester, the United Kingdom etc. have successfully implemented ITS systems to their running public transport. Although Indian cities have started investing in the solution for ITS. [19]
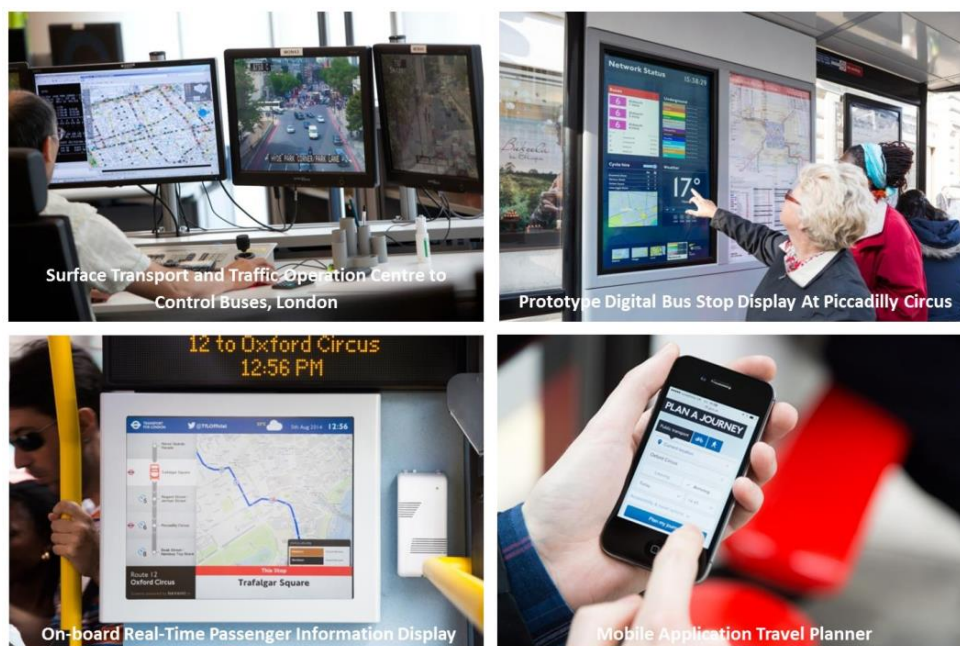
5.1 ITS Solution for Bus System – TFL London

Figure 5 Technology Interventions in London in Bus Transport

The capital city of the United Kingdom and one of the oldest cities in the world, London has a population of 8.78 million and a land area of 1,583 square kilometers. Its road network covers motorways, A roads and B roads that totals to 14,833 kilometers. [7]

London's vehicle population at the end of 2016 stood at 3.1 million, of which close to 2.7 million were cars. Congestion costs the economy an estimated £2 billion a year. Public transportation is playing a key role in ef6ficiently moving Londoners today. Compared to the start of the decade where private and public trips accounted for 47 and 36 percent, respectively, there is a marked change, although there was an increase in population as private and public trips accounted for 36 and 37 percent, respectively. [3]

Transport for London (TfL) manages London's public transport system. This includes buses, subway, Docklands Light Railway, London River Services, Tramlink, and Overground London. London faces similar challenges to other mega cities such as an increasing population and congestion. However, it is also focusing on reducing emissions and creating a sustainable and affordable transportation network as mentioned in figure 5.

A. Intelligent Transportation Solutions

London employs a variety of ITS solutions to tackle its challenges. It includes intelligent traffic signals, traveler information systems, advanced transport pricing systems, and variable speed systems.

B. Advanced Public Transportation Systems: Smart Ticketing

As the adoption of public transportation increased, the congestion caused due to purchase and checking of tickets increased. The TfL introduced a smart payment card called Oyster in 2003 that allowed public transport users to tap in and out when using transportation services. Over 85% of all tube and bus travel is paid with an Oyster card.

C. Advanced Transport Pricing Systems: Congestion Zone and Peak Pricing

Congestion charge is fee imposed on most vehicles for entering a prescribed zone during certain hours of the day. A certain fee is charged for entering the congestion charge zone between 07:00 – 18:00 Hrs. on Monday to Friday excluding public holidays. However, a few vehicles are exempt from paying this charge. This includes two wheelers, emergency service vehicles, health service vehicles exempt from vehicle tax, vehicles used by the physically challenged, taxi, and private hire vehicles.

D. Advanced Traffic Management Systems

Variable speed limits are introduced on roads and motor ways to control congestion, and increase safety of road users during adverse weather conditions.

E. Advanced Traveler Information System: Traveler Information Systems

TfL uses multiple media to disseminate traveler information. It has recently launched a social media TravelBot service that customers can ask questions to. The application is powered by artificial intelligence and runs on Facebook Messenger.

5.2 New York City

New York City, projected to have a population of 8.54 million in 2016, is one of the most populous cities in the United States. It has 788 square kilometers of land and consists of five boroughs, and approximately 10,000 kilometers of road network. [5]

New York City has a vehicle population of 2.2 million registered vehicles in force. Congestion costed the economy $16.9 billion in 2016 and is the second most congested city in the United

States. The average American commuter spent 42 hours in peak-hour traffic, whereas a New Yorker lost 89 hours.[3]

The majority of public transport systems are managed by the Metropolitan Transport Authority (MTA), the largest regional transportation system in the western hemisphere. It manages buses, rail, rapid transit routes, seven toll bridges and two tunnels. It transported an average weekday 5.7 million riders by subway in 2016. New York City's challenges mainly revolve around congestion, traffic accidents and emissions. Average bus speeds on arterial roads are at 16 kph.

A. Intelligent Transportation Solutions
New York City employs a variety of ITS solutions to tackle its challenges. Some key examples of ITS includes intelligent traffic signals, traveler information systems, smart ticketing and variable speed systems.

B. Advanced Traffic Management Systems: Intelligent Traffic Signals
New York City has upgraded to a more advanced system its existing smart traffic signal infrastructure. The new system uses RFID readers and cameras that allow real-time traffic control to be transmitted to the traffic management center. New York City has implemented the largest traffic signal control system in the world with more than 12,000 advanced solid-state traffic controllers, over 60 RFID reader sites, 210 remote vehicle microwave sensor detectors, and 400 traffic video cameras capable of managing 16,000 intersections.

C. Advanced Public Transportation Systems: Transit Signal Priority
The NYDOT implemented TSP in Staten Island, Victory Boulevard/ Bay Avenue Corridor from Saint George Terminal to Forest Avenue. A corridor extending 2.4 kilometers that includes 14 signalized intersections. Around 300 MTA buses and 14 intersections were equipped with emitters and detectors respectively. It was found that time saved during morning and evening peak hours were 17 and 11 percent, respectively. [4]

5.3 ITS in Istanbul

To overcoming Istanbul city traffic challenges the application of ITS was introduced in the late '90s and has been improved since. ITS applications in Istanbul nearly all the ITS areas that are globally available.

A. Advanced Traffic Management Systems (ATMS)
Signalization is one of the key elements of advanced traffic management systems. With the stable growth in total number of intersections over the last 15 years, the number reached to 2,142 by 2016 which are working via signalization in multi plan, demand-base reactive, dynamic, flash and adaptive modes. [3]

All signalized intersection points located in the city of Istanbul are kept on the geographic information system and can be monitored and managed online through the intersection control system and the Traffic Control Center (TKM).

The functional features of control systems in Istanbul are as below.
- Monitoring city traffic in real time,
- Immediately receiving traffic density information,
- Real-time monitoring and management of signalized intersections,
- Providing visual and audio information of traffic intensity
- Informing the drivers in the traffic of instantaneous changes,
- Providing traffic and road status information to users via web and telephone,
- Monitoring of regional traffic conditions

- Conformity to e-transportation concept
- Route to alternative routes with information on the right time

B. Advanced Traveler Information Systems (ATIS)

The instant traffic density data obtained from Traffic Control Center, the meteorological data obtained from automated road and meteorology surveillance sensors and the infrastructure works information obtained from road networks are processed and presented on Digital Traffic Density Map.

C. Advanced Public Transportation Systems (APTS)

APTS in Istanbul covers multimodal coordination, tracking of transit vehicles, tracking of real-time locations, informing passengers at stations about vehicle locations, collecting tickets via an electronic system.

D. Advanced Transportation Pricing Systems (ATPS)

Electronic Toll System (ETC) in Istanbul is being used on highways and bridges connecting Bosphorous. The automated toll collection system is active since 1999. It has been improved since and changed couple of times to serve better without disrupting the traffic. As of 2017, multilane free flow ETC systems are introduced on several points.

E. Commercial Vehicle Operations (CVO)

Fleet Operations are mainly buses serving Istanbul residents with 5,100 bus and over 40,000 round trips. This bus fleet is controlled over electronic system from central location in Ikitelli Fleet Management Center. Buses are tracked via GSM/GPRS to the computer that is collected by GPS satellites. Sensor also helps to distinguish different regions and create alarms and routes according to specific needs.
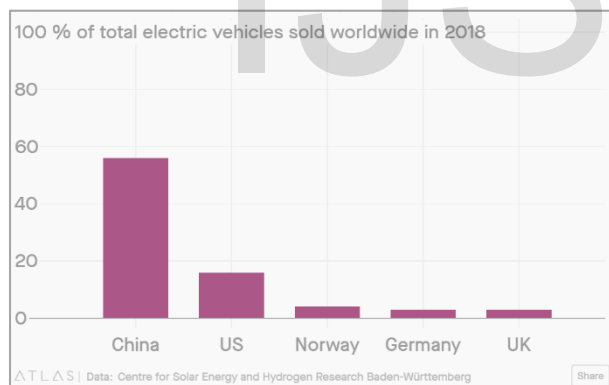
5.4 Electrification of Bus Fleet

Figure 6: Top five country by electric car sales globally

There is increasing trend to shift towards electric buses worldwide

- Shenzhen (China) will operate only electric buses by 2017
- Paris (France) will completely shift towards electric buses by 2025
- London (UK) will electrify all buses by 2037

According to the industry estimates, the worldwide e-bus fleet is approximately 173,000 in 2015. The cities around the world are adopting alternative fuel options including bio-gas, ethanol. The Indian government has set ambitious goals to speed up electric vehicle (EV) adoption. In 2023, it wants to run on batteries for all three-wheelers. By 2025, most two-wheelers will be covered by the rule. It also offers incentives for carmakers to develop new EV models and manufacture components such as lithium-ion batteries and electric motors as shown in figure 6.

Challenges: Perhaps the most critical is the need for effective policies. "India has a policy problem where somebody can come up with a great idea and get lost in transition before reaching the right person," a think tank, Arunabha Ghosh, CEO of the Energy, Environment and Water Council.

5.5 ITS solutions in India

IT implementation has the potential to have a transformative impact on the public transport sector. It can help public transportation authorities and operators improve operational efficiency, enhance customer relationships, integrate with emerging mobility players and services, and manage issues related to cyber security, governance and organization, etc.

Many cities in India are still in the process of transformation. Intelligent Transport Management System (ITMS) has already been implemented by some cities and attempts to optimize the service. On the other hand, the system is still being tried by some cities. While many cities still lack the necessary technology to improve the bus service.

A. Indian Automotive Industry

The Indian automotive industry is the 4th largest industry in the world with production increasing to 5.17 million units in 2018, inclusive of passenger cars and commercial vehicles. The nation is also a leading exporter of vehicles and has hopes of development for the future. The automobile exports grew 15.54% during FY2018.
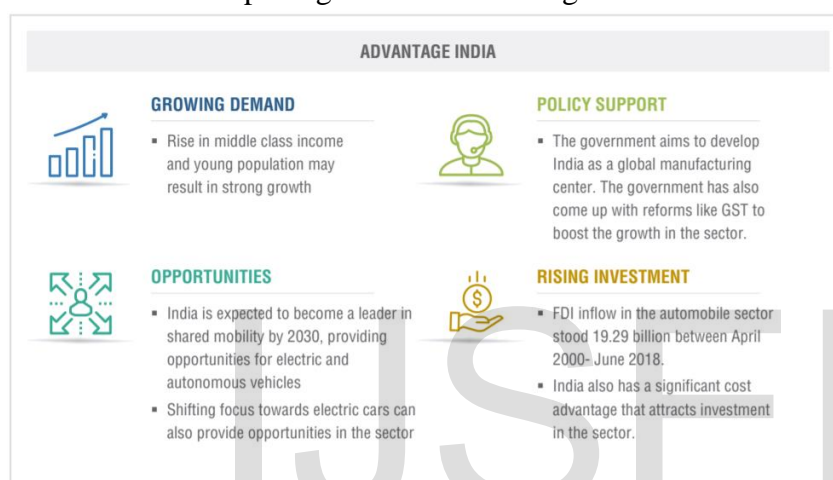
In FY2018–2019, "overall automobile exports grew by 14.50% with passenger car exports registering a decline of (-) 9.64% while commercial vehicles, three- and two-wheelers registering a growth of 3.17%, 49.00%, and 16.55% respectively".

Source: IBEF Organizations, Secondary Research, Expert Interviews, and Markets and Markets Analysis.

Figure 7 Supporting Factors

B. Indian Public Transport

Public transport needs to foster digital innovation and be bold in the search for innovative solutions. For the future, digitalization is not a concern. It is already changing and it needs to be accepted by the public transport industry, to take advantage of the many possibilities it provides and to plan for its position in the emerging mobility market. For example, in terms of ticketing, travel planning and inter-modality, personal mobile devices such as the smart phone are and will remain key.

Government of India is pushing for implementation of Vehicle Location Tracking and Panic Button in all Passenger Transport vehicles. Further, there is greater push by the government to adopt cashless and mobile payment methods. The bus operators in India should also adopt

Some of the ITMS contracts are:

(1) BEST (Brihanmumbai Electric Supply and Transport) Undertakings has awarded a contract to implement ITMS solution for the city buses, consisting of depots and workshops management system, scheduling and planning of routes and frequency of buses, and vehicle tracking and passenger information system (PIS) for real-time information on bus movements. The contact of INR 1.12 billion has been awarded to Quess Corp Limited (other consortium members are DIMTS Limited and Trapeze Group).

(2) The first private bus operator in Thane, Maharashtra, is City Life Line Travels. The corporation also completed the implementation of an advanced enterprise resource

management system offered by Trapeze Group to increase the efficiency of its activities and business processes.

(3) Pune Mahanagar Parivahan Mahamandal Ltd (PMPML) appointed NEC Japan to implement ITMS solutions in the city buses, including vehicle location system, passenger information system, LED boards and public announcement system. In March 2018, PMPML awarded NEC Japan a contract for (a) Vehicle Planning Scheduling and Dispatch System (VPSD) supporting bus route design and change, as well as ass, optimizing bus service and crew and bus allocation, and (b) Depot Management System (DMS) automating bus depot operations, vehicle management and inventory management for a variety of components.

(4) Prasanna Purple Mobility Solutions Pvt. Ltd. is one of the largest inter- and intra-city bus operators in the county. The company has implemented ITMS solution in different cities, provided by Trapeze Group. The solution includes complete ITMS, including planning & scheduling system, as well as, data analytics.

(5) Ahmedabad Municipal Corporation (AMC) appointed NEC Japan to implement ITMS and Automatic Fare Collection System (AFCS) solution in October 2016. Vehicle Planning and Schedule Dispatch system provided by Lumiplan India to optimize the operations of public transport

Some other public bus operators are in the process to finalize the contract of ITMS solutions including MSRTC (Maharashtra State Road Transport Corporation), CTU (Chandigarh Transport Undertakings) and BCLL (Bhopal City Link Limited) as shown in the figure 8. Further, some of the public bus operators like Uttar Pradesh State Road Transport Corporation (UPSRTC) are looking for the solutions to manage their planning and scheduling. There is need to create more awareness among bus operators (both public and private) as investment in complete ITMS will help to improve the operation.
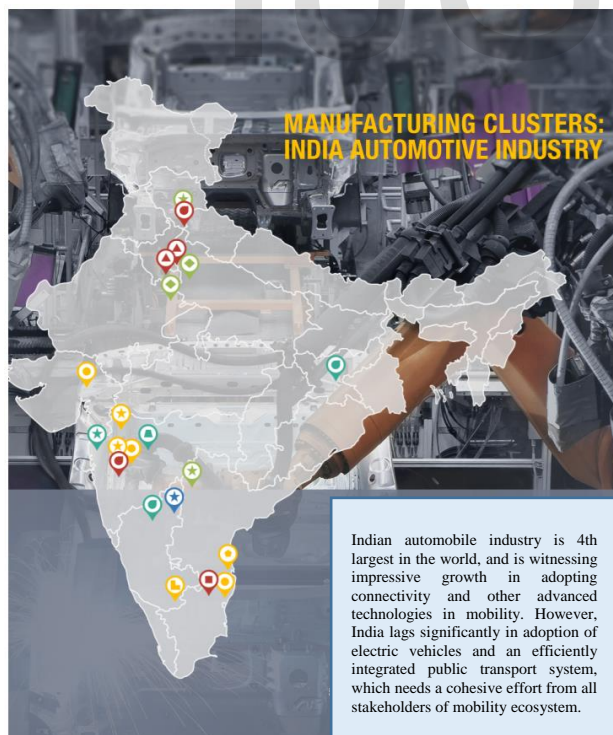

MANUFACTURING CLUSTERS:
INDIA AUTOMOTIVE INDUSTRY

Indian automobile industry is 4th largest in the world, and is witnessing impressive growth in adopting connectivity and other advanced technologies in mobility. However, India lags significantly in adoption of electric vehicles and an efficiently integrated public transport system, which needs a cohesive effort from all stakeholders of mobility ecosystem.

Figure 8 Indian Automotive Industry

Challenges: In the Indian market, various ITS components are in use; in essence, adaptations of systems deployed in the freight and logistics industries. A lack of experience and knowledge among transport authorities culminated in the sub-optimal use of the deployed system, thereby failing to realize its full potential. This is due to several factors (Navi Mumbai Municipal Transport 2014) (Brihan Mumbai Electricity Supply and Transport Undertaking 2014) (Fin 2014):

• limited market share of applications for public transport
• complexity involved in urban bus operations
• Budgetary constraints in this category of operational agencies
• Specific operational and technical requirements to direct the implementation of ITS in this area; and
• the need for interagency knowledge and experience.

6. Policy Interventions Related to Smart Mobility

a) **National Urban Transport Policy, 2014**: The Ministry of Urban Development has prepared this policy document. It has paved the way for reforms in the transport sector and is likely to give a big boost to the business.

b) **Atal Mission for Rejuvenation and Urban Transformation (AMRUT,2015):** This mission focuses on capacity building, implementation of legislation, water supply, sewerage and waste management, storm water runoff, urban transport, and green space and park development. An investment of INR 50,000 crore will be done by the central government over a period of five years, FY 2015-16 to FY 2019-20. One of its important components is improving urban transport. [17]

c) **Automotive Mission Plan 2016-26:** A plan prepared in consultation with ACMA and SIAM by the Ministry of Heavy Industries and Public Enterprise. Upon its proper implementation, automotive industry will emerge as a vehicle for growth of Indian economy. It is expected to boost domestic turnover from INR 2.3 lakh crore to INR 9.67 lakh crore, exports from INR 33,333 crore to INR 2.3 lakh crore and provide employment to 25 mn people. This will contribute up to 10% of the national GDP by 2026.

d) **Smart Cities Mission:** Under this project, INR 48000 crore will be invested over the next five years. Names of the smart cities will be finalised through a competition named Smart City Challenge. The first phase of challenge concluded in February 2016 and names of top 20 cities were declared for the funding.

e) **Make in India:** India is a regional center for producing vehicles and ranks among the world's top 10 countries. Domestic vehicle sales of Indian Automobile industry have been growing at CAGR of approximately 9.6% over the period of FY05-FY15 while exports have grown at a CAGR of approximately 18.9%. However, in FY13-FY159, domestic sales grew at a CAGR of just about 4.4% mainly due to sluggish economy. On the contrary, over the past few years, the export market has shown growth. The government, however, is investing heavily in urban mass mobility schemes such as mass rapid transportation systems (MRTs)/metro rail systems and state-of - the-art buses due to increasing pressure on infrastructure. [10] As a result, mass mobility industry manufacturing is set to grow at a high rate in the coming years. This would also boost automotive-related manufacturing. In addition to automobiles, the construction of infrastructure such as roads, highways, ports, airports and waterways would also require heavy industries to manufacture at competitive prices in India.

f) **National Manufacturing Policy (NMP):** With the goal of increasing the share of GDP manufacturing to 25 percent and creating 100 million jobs over a decade, the project aims to achieve the intended goal within the set timeframe. In the transport and automotive industries, a large percentage of jobs are expected to be generated in the coming years.

g) **Skill Development:** The automotive sector currently provides direct and indirect jobs for more than 25 million people. When manufacturing is about to develop in the transportation and automotive industry, there is an immense demand for skilled labour. According to the NSDC's Automotive Sector Skill Council, by 2022 there will be a supply vs. demand gap of incremental 35 million people. Through designing specific training programs for the sector, the Automotive Industry Skill Council is already collaborating with industry and academia to fill this gap. India has 550 million employable youth, a big benefit to the manufacturing industry. During the period from April 2000 to December 2012, this attracted high INR 18.67 lakh crores FDI.

h) **FAME India Scheme on April 8th, 2015:** "FAME India (Faster Adoption and Manufacture of Electric / Hybrid) Vehicles in India has been announced by the Government of India – a scheme under the Ministry of Heavy Industries and Public Enterprises". This

program is part of the "National Electric Mobility Mission Plan (NEMMP)", which targets 6-7 million hybrid and electric vehicle sales by 2020, an estimated 9,500 million liters of combined fuel savings, 2 million tonnes, 65,000 direct jobs and 3,00,000 indirect jobs. [13]

i) **Voluntary Vehicle Modernisation/ End of Life Policy:** The Union Road Transport Minister has finalized the draft end-of-life policy requirements in a bid to encourage emission control measures that will provide atleast with a 50 percent discount on excise duty on new vehicles for buyers who surrender their polluting old vehicles. It will result in an increase in vehicle output of about 40% and will reduce pollution significantly.

7. Conclusion

India is well positioned for strong economic growth, rising from declining Western economies to 7.4 percent. India has emerged as the most preferred investment destination in the world. A 550 mn pool of young human resources and a strong political climate support this. Greener technologies and India as a manufacturing center offer opportunities to partner with car manufacturers and affiliate sectors to cut costs and improve performance. The central government has already funded contracts "worth INR 1.8 Lakh crore over the past two years and is expected to award INR 3 Lakh crore roadbuilding projects by 2017". The requirements for a giant leap in India's transport industry have matured these technologies. [19]

In the next decade, "India needs to reduce carbon emissions from vehicle sources, create huge job opportunities in the transport and automotive industries, and build a green and smart transport system to meet rising demands for economic and public mobility. Investment in surface transport projects will create a world-class transportation infrastructure; put in India's best automotive technology, green options, and intelligent transportation system". Combined with greener fuels, sustainable public transport options will greatly enhance the quality of life of citizens and boost long-term economic growth.

The public transportation and urban mobility scenario needs improvement and additional spending with the goal of 100 smart cities and the growing urban population. The National Transport Policy Committee formed under the aegis of the Government of India delivering its report, India Transport Report – "Moving India to 2032, on behalf of the Planning Commission, Government of India, reported that total passenger traffic is expected to grow by around 15 percent per year to cross 168,875 bpkpm in 2031-32 from 10,375 bpkpm observed in 2011-12". [15,19]

It is also estimated that growth in rail passenger traffic is estimated at around 9% per year and 15.4% in road traffic. This form of expansion includes government and private investment as well as adequate support for infrastructure. In absolute terms, about INR 30 trillion will be expected by 2031-32. A large portion of this budget will and can be used to enhance mobility through the implementation of smart technology. And they are increasingly embracing various means and modes of transportation, including the use of electric cars, the use of fast, simple mass transit systems, fast metro trains, and the use of advanced technology that regulates vehicle movement and mobility through cities. These means not only save fuel, but they are powerful and futuristic. [13]

India is no further from using and implementing smart travel. It's just the beginning of our capital cities ' current and future metro network. Around 2030, India has already formulated a proposal for all electric busses. FAME (Faster Hybrid and Electric Vehicle Adoption and Production) included in the Union Budget 2015-16. This provided for INR 795 crore support for hybrid vehicles. The same was held this year as well. To boost the appeal and adoption of hybrid vehicles, this allowance is expected to need to be expanded by the government. A

mixture of effective policy, regulations, public and private sector funding and public awareness will bring about the desired change in promoting and executing the smart transport dream of the country. [15,19]

Our cities are facing a range of problems with congestion, air pollution and road safety. Technology and innovation have challenged and generated incentives in the transportation sector to change people's travel and lives. We should tap into this movement to make our public bus network more attractive and inclusive. The benefits of investing in smart mobility systems are compelling, particularly given the improvements that could be made to deliver innovative solutions to increase our economic efficiency and productivity. While the role of smart technology in "sweating capital" is increasingly understood by decision-makers and leaders operating cities around the world, global adoption is still intermittent and not universal. We need to move beyond a project-by-project view and upgrade smart infrastructure planning, operating and delivery systems to stimulate change programs and capture potential savings. Such development would provide our cities with an opportunity to upgrade their infrastructure and help drive economic growth and create jobs for the 21st century. [13]

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