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Advanced Public Transportation System for an Urban Metro

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Abstract:

Transport is very important for any city whether it is a small city or big city especially public transport. If Public Transport in the city is good then there will be no traffic problems like traffic congestion, accidents, delays which will side by side also reduce the pollution mainly air pollution as well as noise pollution in the cities. For public transport, passengers and commuters go to bus stands/bus stops and catch the bus to their desired destination. If Public Transport will not provide good and effective management then people will use their private vehicles for various trips which will increase pollution, congestion and other traffic problems. To make the Bus Stands smarter, better and hi-tech we have various technologies of Intelligent Transportation Systems (ITS) which can be used to make the Public Transport advanced. Congestion reduces transport infrastructure efficiency, increases journey times, air pollution, and fuel consumption. Developing novel transportation organisations was costly, may be harmful to the atmosphere and cannot practically catch up with the increasing transportation demand. The main opportunity is to turn awareness about transport networks into genuinely ITS aimed at sustainable development. ITS provides a large and increasing suite of technologies and technical applications to enhance transportation system safety and efficiency. ITS aim is to improve the transport system to make it more, efficient and secure. This article comprises the key components and technologies of ITS, evaluates case studies of Advanced Public Transport System (APTS) which is one of the key categories of ITS as well as brings out an APTS proposal for a key urban metro in India.

Keywords: *Advanced Public Transport System, Congestion, Modes of transport, Transportation Demand Management Systems, Traffic Growth*

INTRODUCTION

Transportation is now our basic need in the day to day life. In the past, few years because of the technological advancements in the automobile industry, there is an enormous increase in vehicles which now causing traffic congestion, safety concerns

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etc. But these advancement is highly appreciated because it is responsible for the safe, reliable and smooth operation of the transportation system which is commonly called an Intelligent transport system (ITS). It is a comprehensive system for a secure, safe and provides a pleasant environment for traffic.

While many countries' resources are depleting, the trend has been toward data and communication innovation that enables the most efficient deployment of techniques and applications. The notion of regional sustainability is evolving, as it is characterised as achieving a high degree of engagement. All three pillars of sustainability – social, economic, and environmental – coexist harmoniously. At the municipal level, sustainability is critical and determined by cities' ability to react to changing needs and the capability of their infrastructure elements and actions that enable society to adapt to its numerous changes over time [6]. For a pro-long time, countries throughout the world have strived for continued economic prosperity. Sustainability exhibits a dedication to resource conservation and material stewardship to ensure future survival generations. Transportation is critical for economic development in urban regions from a long-term perspective. As a result, advanced countries' urban smart transportation systems are improving by rapid electrification, automation, and connectivity are all possible shortly. Simultaneously, the demand for customised services is expanding. The expansion of diverse, high-quality travel services, as well as the process of innovation in urban public transit, continues. Transportation service models are likewise evolving at a rapid pace [3]. Appointments, sharing, and customisation are all possible online. On the horizon are new modes of bus transportation with specific characteristics. Additionally, new technology, such as big data analysis includes GIS (Geographic Information System) and BIM (Building Information Modeling) utilised in the planning and construction of big cities.

Traffic congestion and its associated problems are a global phenomenon. The congestion decreases transport infrastructure efficiency, enhances travel period, air pollution, as well as fuel ingesting. Many think that enhancing the transportation scheme of a country simply means constructing innovative roads or revamping the ageing substructure [4]. But transportation's future stays not only in concrete as well as in steel, but also in technology operation, specifically a network of sensors, micro-chips, and communication devices that gather and distribute information regarding the transportation system's working. ITS also called or named as Transport telematics is a

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transport system that uses the latest and modern technologies available for the improvement of traffic and transport network operations. The system gathered and collect all the traffic relevant data like speed, traffic volume, load carried, headway then after analysis it gives results to reduce traffic congestion by providing real-time information, guiding traffic, reducing accidents and transport costs. For all the operations, applications of ITS need TMC (Traffic management Centre) where collection, analysis and combination of data with other relevant data are carried out to solve the complex transportation problems.

The ITS tools are focused on three core features- Information, Communication, and Integration- which help operators and travellers make better and more organized decisions [8,14]. ITS interface with other roles such as police, collectors of tolls, public transport operators, operators of traffic signals, i.e. local authorities. ITS serves a wider range of uses ranging from automated traffic controlling schemes to electronic ticket payment schemes, ramp meters and collision warned schemes. At the heart of ITS is the ITS Centre. It operates 24 hours a day, ensuring the smooth flow of traffic as well as responding in a timely fashion to emergencies. In the world's leading nations, ITS significantly improves the efficiency of the transport system, including decreased congestion and improved safety and convenience for travellers [1].

This article introduces the technologies and applications of ITS as well as elaborates on one of its major ITS categories -Advanced Public Transportation System (APTS). Understanding their benefits and challenges will help us to evaluate and implement mega-scale public transportation infrastructure projects and to propose meaningful and suitable APTS solutions to our traffic problems [2,21]. The broad objectives of this article are to study the various ITS applications like vehicle notification systems, warning systems, GPS and explore APTS with the help of case studies to come up with an APTS proposal for an urban metro.

OVERVIEW OF ITS AND APTS

Key Categories of ITS

ITS was used in the United States in the year 1960 when the use of Electronic route guidance system (ERGS) was started to deliver real-time information based on traffic analysis to road users and drivers. Special hardware was used by the system to analyse

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current traffic conditions. This hardware was further installed in various intersections as well as an on-board 2-way devices were installed inside vehicles which create a 2-way communication between the vehicle and the ERGS system from which road users get the route guidance information [3]. During the early seventies, the country started using the Automatic Route Control System (ARCS) which is the advanced version of ERGS. The Japanese ARCS was developed further in the same era. In the year 1986, the Intelligent Vehicle Highway System (IVHS) was developed which bring a spate of developments in ITS to comprise abroad and a rising group of technologies and uses as shown in Table 1. The key benefits include an increase in safety, improvement in operating performance, particularly through decreasing congestion, offering conservational assistance, strengthening efficiency, increasing economic and employment growth [22, 23]. An instance of real-time traffic information systems technologies is shown in Figure 1.

Table1.ITS Categories/Uses

ITS Category	**Specific ITS applications**
Advanced Traveller Information Systems (ATIS)	Real-time Traffic Information Provision Route Guidance/Navigation Systems Parking information Roadside Weather Information Systems
Advanced Transportation Management Systems (ATMS)	Traffic Operations Centres (TOCs) Adaptive Traffic Signal Control Dynamic Message Signs(or "Variable" Message Signs) Ramp Metering
ITS-Enabled Transportation Pricing Systems	Electronic Toll Collection(ETC) Congestion Pricing/Electronic Road Pricing (ERP) Fee-Based Express (HOT)Lanes Vehicle-Miles Travelled Usage Fees Variable Parking Fees

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Advanced Public Transportation Systems (APTS)	Real time Public Transit System Status Data (e.g. Bus, Subway, Rail) Automatic positioning of the vehicles(AVL) Electronic Fare Payments (Smart Cards)
Vehicle-to- Infrastructure Integration (VII) and Vehicle- to-Vehicle Integration (V2V) [4]	Cooperative framework for preventing collisions (CICAS) Smart Adaptation to Velocity(ISA)

Figure 1. An example of real-time traffic information systems technologies

ITS Technologies and Applications

(1) Traffic Signal Control Systems

ITS allow for more complex traffic control systems than typical timed traffic lights. Intelligent traffic lights, for example, produce a dynamic time schedule based on traffic data acquired at the local intersection and future traffic information provided by RSUs to maximise traffic flow across an intersection. Variable speed restrictions are another control mechanism. These systems work by dynamically adjusting the speed restriction of highways based on weather conditions, road conditions, or the existence of congestion regions to reduce traffic density in crowded areas [24]. Finally, because

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traffic in many urban areas is not symmetrical, dynamic lanes can be employed to give additional inbound or outgoing lanes depending on the flow of traffic.

(2) Transit Management

An intelligent transportation system (ITS) is a sophisticated USE that strives to continue providing novel services related to various modes of transport and traffic management, allowing users to be properly focused and knowledgeable about safer, more synchronized, and 'smarter' usage of transport systems. Buses are kept on schedule thanks to automatic vehicle location (AVL) technology and computer-aided dispatch schemes [5].

(3) Traveller Information Services

An Advanced Traveller Information System (ATIS) is any device that gathers, processes, and displays data to help surface transport passengers go from their starting point (origin) to their ultimate stop. Services allow travellers to access pre-trip and route information [25]. Multi-channel delivery of travel information occurs to contact networks, such as Twitter, TV, kiosks, and mobile phones.

(4) Video Vehicle Detection

Because of its non-intrusiveness and requirement to acquire control involving behaviour data, video-based vehicle detection technology has become an important aspect of the Intelligent Transportation System (ITS). Measuring the traffic flow and automated identification of accidents using video cameras.

(5) Electronic Fare Payment Technologies

E-checks, e-drafts, e-wallets, and credit cards all provide excellent ease for payment services during e-commerce, but none of them can replace cash because they all possess audit trailing capabilities. These payment tools will show you where your money is going. A common electronic means of payment for the various modes of transport.

(6) Emergency Management Services

Continuously monitor roadway conditions. Incident drivers alerted by complex message signs

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India is a developing country. There are many good expressways and highways in India. The Kuthiran Expressway is a good example. A centralised traffic control system equipped with CCTV is used there.

Advanced Public Transportation System – APTS

Advanced Public Transportation Systems (APTS) are techniques that enable public transportation services, car maintenance, including administration to run more efficiently and effectively. These techniques included a variety of computer databases, software, and hardware, and also vehicle equipment like mobile data terminals (MDTs), GPS sensors, and automatic vehicle locating (AVL) systems. The use of APTS was the emphasis of our research. The research concentrates on APTS implementations, which include both sophisticated and basic technology, that are used in smaller urban and rural transit operations. Complex techniques like MDTs, AVL, and smart cards were examples of innovative materials (i.e., electronic fare media). These techniques are most commonly used in medium and larger transportation systems, as well as those with a higher degree of service intricacy. The basic technology, on either hand, can assist in resolving issues even in the simplest or least sophisticated transport systems and could be thought of as the foundation on which the more sophisticated technology was built. Custom database and spreadsheet use, as well as preparing financial statements and automobile service software, were samples [6]. This was one of the most important components of the public transport system that aided to made public transport an attractive choice for travellers by improving their visibility of arrival and departure. It provides passengers with public transport services that are safer, more comfortable and more convenient, and that will encourage more public transportation to relieve traffic jams with greater social and economic benefits[7]. APTS is needed to improve mobility and attain assistance for both the transportation operator as well as the users, to improve transit and ride-sharing services, to utilize ideas for aligning halts, planning ways, and assess the precision of the scheme and progress longer-term plans concerning capacity as well as system improvement. Applications include priority techniques in advanced control systems for buses, including targeted identification, bus advance zones, relocation of queues, congestion organization, automatic vehicle location (AVL) systems for passenger idea, priority

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bus, fleet organisation, automatic camera enforcement schemes for incidents for bus processes and instinctive ticket-based system, shown in Table 2.

Table 2. APTS Applications/Technologies

Transit Application	**APTS Technologies**
Fleet Management System	➢ Automatic Vehicle Location Systems (AVL) ➢ Transit Operations Software ➢ Communications Systems ➢ Geographic Information Systems ➢ Automatic Passenger Counters ➢ Traffic Signal Priority Systems
Traveller Information Systems	➢ Pre-Trip Transit and Multimodal Traveller Information Systems ➢ In-Terminal/Wayside Transit Information Systems ➢ In-Vehicle Transit Information Systems
Electronic Payment Systems	➢ Smart Cards ➢ Fare Distribution Systems ➢ Clearinghouse
Transportation Demand Management	➢ Dynamic Ridesharing ➢ Automated Service Coordination ➢ Transportation Management Centres
The Transit Intelligent Vehicle Initiative	➢ Lane Change and Merge Collision Avoidance ➢ Forward Collision Avoidance

The key advantages include:

Transit Management System

- Enhanced security and safekeeping of transfer for drivers and users of transit.
- Improved operating efficiency, reduced fleet requirements and non-revenue vehicle miles.
- More standard and efficient transit service, promoting increased riding [15,16].

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- Enhanced route planning details and vehicle/driver scheduling systems.
- Better response to interruptions in transit service [17].
- Enhanced oversight of vehicle and driver operations, and functions of fleet dispatch.
- Reduced cost of procurement of a transport fleet.
- Reduced transit fleet operating costs.

Automated Traveller Information System (ATIS) [18]

- Increases transport ridership and sales.
- Better bus quality and Public visibility.
- Greater comfort for customers.

Transportation Demand Management System (TDMS)

- Improved transit operating efficiency.
- Better transit quality and better customer satisfaction [19,20].
- Increased adherence to ADA Transit requirements.
- Reduced transit fleet operating costs.

LITERATURE CASE STUDY – APTS IN SINGAPORE

Public transportation in Singapore covers a variety of modes of transport including buses, trains and taxis. According to the "Population 2000 Singapore Census", about 52.4 per cent of Singaporeans (excluding foreigners) use public transport. 41.5 per cent of school-going residents use Transit Link services. Singapore Government has put a great emphasis on promoting the use of public transport. Transit Link, a subsidiary of the Land Transport Authority,[9] oversees the integrated multi-modal system across public transit operators (SMS Transit, SMRT trains and buses) as well as card managers (EZ-Link and NETS), by bringing in a single ticketing interface, an information channel and a consistent network of services. The key features of this integrated system include – payments using contactless EZ-Link smart cards, taxis being fitted with meters and radio, and call bookings made through GPS or digital voice dispatch [10].

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Public Transport Infrastructure and Challenges

In 1967, the urban planners projected the need for an urban rail transport system. Following lengthy debates, the Parliament agreed that a bus-only network would not be adequate, as it was to fight for road spacing in a land-scarce nation. MRT construction began in 1983 (it was the largest public works project in Singapore at the time) at $5 billion estimated cost. The network was built in stages, with priority being given to high demand areas [11]. The MRT network was launched in 1988 and further extensions have taken place later with the introduction of 21 more stations, and are still in progress. The idea of rail transporting people to their homes led to the creation of LRT lines connecting with the MRT network. LRT went into operation in1999.

Current Transport Scenario in Singapore

- Transit Link aids to make a combined multi-modal scheme by a fare payment operation, information portal as well as a physical network without repetition of services, as shown in Figure 2.
- Bus and MRT fares are charged using a contactless smart card known as the EZ-link card.
- The station has General Ticketing Machines (GTMs), a customer Service Centre, LED screens and plasma monitors showing train schedule information and updates.
- Singapore uses an e-payment system for public transit, called Symphony for e-Payment (SeP). The ticketing scheme utilizes contactless EZ-Link, as well as NETS Flash, Pay smart carding which are compliant with the CEPAS (Contactless e-Purse Application Standard) technology standard [12]
- Additional Credit can be purchased from GTMs.

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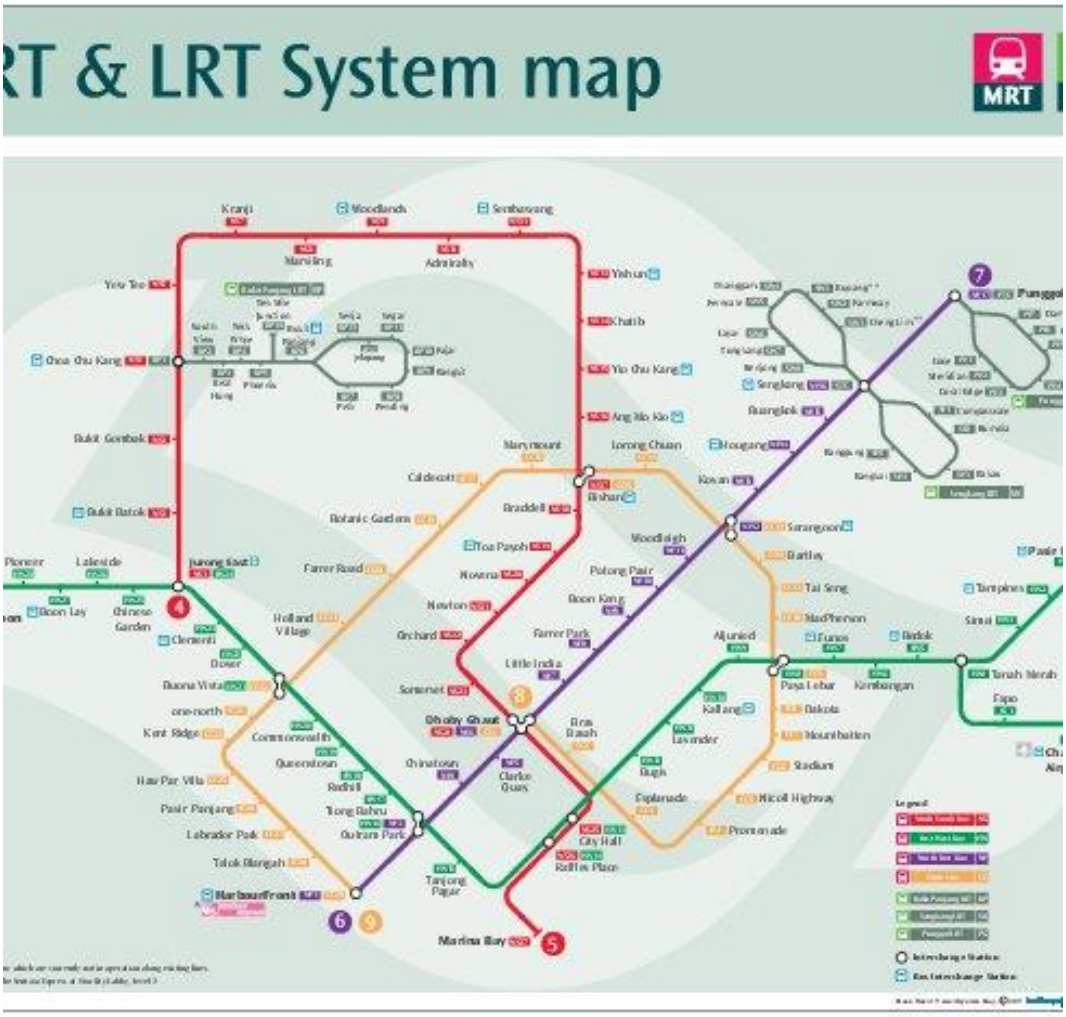

Figure 2. MRT and LRT in Singapore

Charges and Ticketing

- Stations were separated into 2 paid and unpaid areas that permit rail operators to accumulate tariffs by limiting entry only by ticket gates, also called gates for accessing control.
- These gates, which are linked to a computer channel, may read and update data, save electronic tickets and store information like initial stations and destinations as well as the duration of every journey.
- Standard ticket machines sell single-trip tickets or permit the customer to acquire extra value for the stowed tickets.

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- As transit link has integrated the ticket system, commuters must pay 1 price only and permit via 2 ticket gates (once they enter, once they exit) for the whole journey, even when moving among lines functioned through diverse companies, as shown in Figure 3 [13].

- Passengers may select to prolong a middle-term trip and recompense the change when they leave its terminus.

Figure 3.GTMs at Expo Station, wherever travellers may buy the ordinary ticket, or increase the value of their EZ-Linking card.

APTS FOR TRIVANDRUM (INDIA) – A PROPOSAL

Trivandrum district stretches 78kms along the shores of the Arabian Sea and mainly comprises three regions, Highlands, midlands and lowlands. Nedumangad taluk in mid/highland, Chirayinkeezhu and Trivandrum taluk in mid/lowland, Neyyattinkara taluk stretches across all 3 regions, as shown in Figure 4.

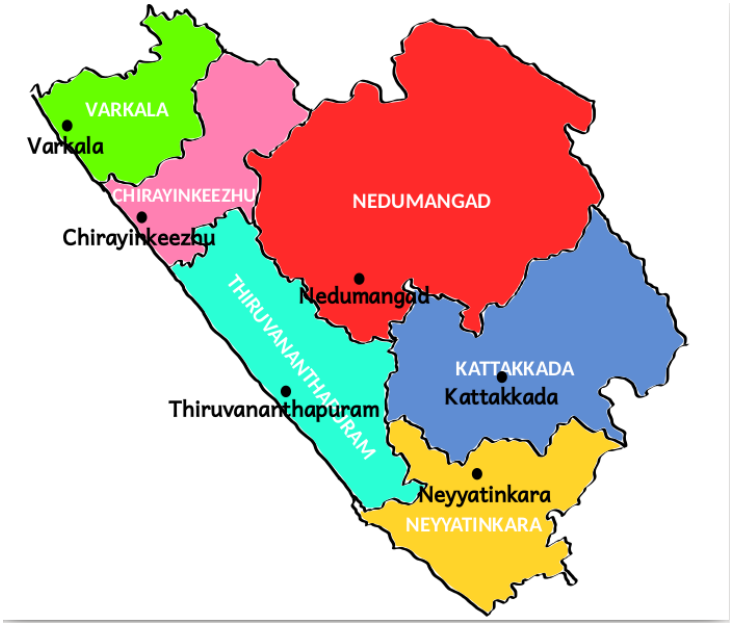

Figure 4. Mapping of regions under the proposal

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The city has a high mix of land use. The central zone has a high intensity of different uses and recreational centres occupied the central city zone. The peripheral zones were predominantly residential. Linkages through a series of parallel roads and this got converted into a system of radial and circumferential roads towards the peripheral zone. Land use changed over time from residential to public/semi-public and commercial land use.

The various factors that emphasize the growth prospects in Trivandrum city are

(1)DemographicAspects
(2) LandUse
(3) Economy
(4) PilgrimTown
(5) Medical Tourism
(6) Academic Hub
(7) Growth of Automobiles

Road Transportation Network

The city has a partial ring and radial type of road network. They include

(1) Major radial roads
(2) Major arterial roads
(3) Sub Arterial roads
(4) Local through roads
(5) Access roads.

Transport Development Plan for Trivandrum Urban Agglomeration (TUA)

The report was published in the year 2011 by NATPAC and this forms the basis for future development plans, as shown in Figure 5. The plan was prepared considering the existing traffic scenario as well as evaluating future traffic. All the available modes of travel were covered. Focuses on the area comprising Trivandrum Corporation and five neighbouring panchayats, Sreekaryam, Kazhakuttom, Vattiyoorkavu, Kudappanakunnu, Vizhinjam

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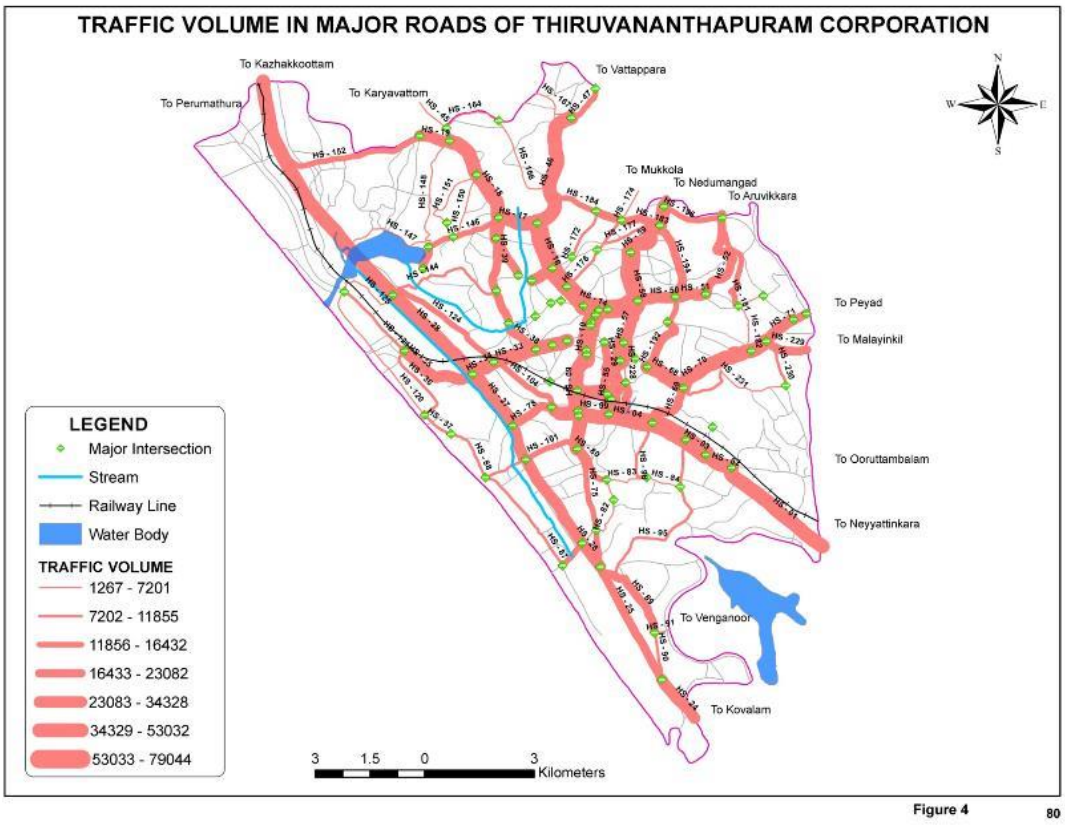

Figure 5. Traffic volume in major roads of Trivandrum (Source-Comprehensive traffic studies, NATPAC-2011)

Prime Issues and Problems of Study Area (TUA)

A detailed study of the current traffic scenario of the city through Traffic Volume Count and vehicular growth data was conducted, Population details and data collected from an observational survey are analysed and various calculations are done to understand the problem briefly and to find the appropriate solution. A huge percentage of people are not satisfied with the current facilities provided in the bus stand and percentage of willingness to shift towards public transport is also high if we provide better service which is only possible by the use ITS technologies. The prime issue was inadequate road width and the road geometry leading to traffic bottlenecks and congestion. The design of intersections was not proper. The absence of adequate parking facilities leads to on-street parking which again adds to the problem. Another issue is the absence of adequate by-pass or ring roads and pedestrian facilities. Even the transport terminals are located at vulnerable points on the major roads. The hawker zones are not delineated. By making the bus stand smart and Hi-Tech, it will

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increase the performance of the city making the city environment better and more friendly.

Recommended Development Strategy

Considering the above issues of the area, development strategies were put forth as shown in Table 4 and Figure 6. The influence of the study region over the entire state is taken into account. Adequate connectivity with satellite towns was ensured. As a result, a regional transport system plan linking the major settlements needs to be evolved.

Table 4. Projected trip share of different modes – with project scenario

YEAR	**2021**		**2031**		**2041**	
Mode Share	**Trips**	**% Share**	**Trips**	**% Share**	**Trips**	**% Share**
Two Wheeler	32195	28%	35954	27%	36976	24%
Cars	16933	15%	23469	17%	29567	19%
Auto	11006	9%	15307	11%	23527	15%
PTS	55939	48%	60772	45%	66947	43%
TOTAL	116073	100%	135502	100%	157017	100%

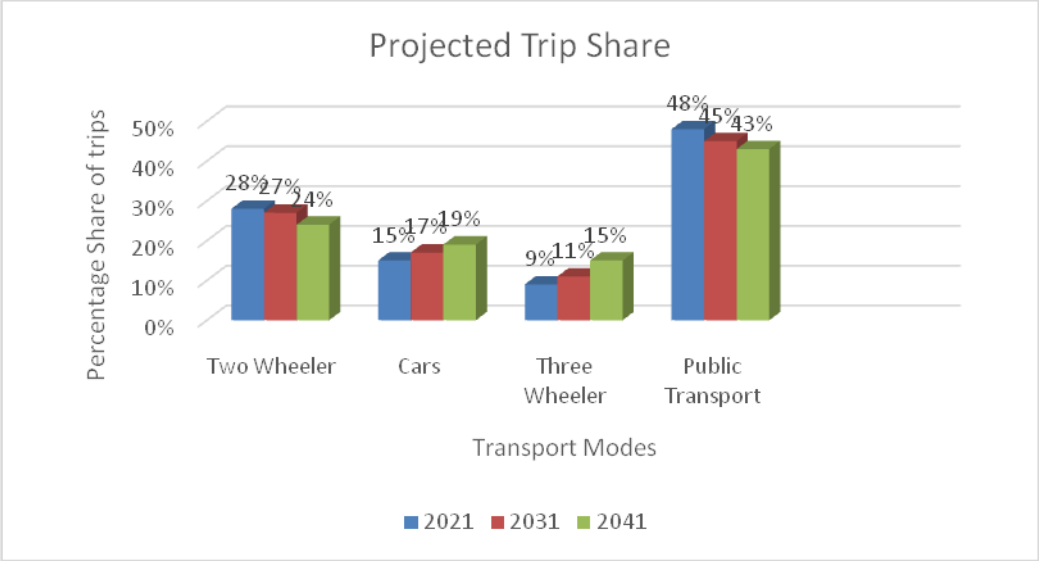

Figure 6. Projected trip

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With APTS project implementation share of the public transport system could be maintained somewhat at a constant rate.

Proposal for Transport Terminals in TUA

Bus transport satisfies 60% of inter-city motorized passenger demand. Owing to acute problems of space and amenities it is suggested to decentralize the city services by locating eight bus depots all around the city. The proposal includes shifting of inter-city bus stand to Eanchakkal on NH Bypass.

The location for the proposed terminals is at Technopark, Sreekaryam, Mannanthala, Peroorkada, Vattiyoorkavu, Nemom, VizhinjamandEanchakkal. The key strategies include developing alternative links to divert the traffic through CBD

(1) Relocating traffic generating facilities like bus terminals
(2) Provide efficient PTS for the city incorporating ITS
(3) Improve pedestrian facilities and off-street parking lots
(4) Adequate rail and air connectivity

CONCLUSION

The transportation challenges faced by developing countries, especially the emerging economies are manifold. Rapid population explosion, lack of infrastructure and significant growth in the number of vehicles implies that radical approaches are needed in transportation planning. APTS and associated technologies provide some solutions to tackle these challenges. Benefits include improved safety, convenience, accessibility and reliability for public transit services enabling effective fleet management. This article looked at the overall value proposition that APTS brings. The study focused on a key urban metro in India (Trivandrum) and assessed the feasibility of implementing an APTS system. It called out the key development strategies to put in place, as well as identified the benefits that will result from an APTS deployment. More due carefulness is needed from a cost and practical implementation perspective before adopting these strategies for the selected urban metro region.

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