MODULE 5

Fig. 1. Working of the E-Toll collection System

TRANSPORTATION DEMAND MANAGEMENT

- Transportation Demand Management (TDM), also called Travel Demand Management, aims to maximize the efficiency of the urban transport system by discouraging unnecessary private vehicle use and promoting more effective, healthy and environment-friendly modes of transport, in general being public transport and non-motorised transport.
- The focus is on managing the demand side of transportation equation rather than increasing supply by widening or building new roads.
- TDM can provide many benefits, as summarized in the table below:

Benefits	Definition
Congestion reduction	Reduced traffic congestion to motorists, bus users, pedestrians and cyclists
Road cost savings	Reduced costs to build, maintain and operate roadway systems
Parking savings	Reduced parking problems and parking facility costs
Consumer savings	Transportation cost savings to consumers
Improved mobility options	Improved mobility options, particularly for non-drivers
Road safety	Reduced per capita traffic crash risk
Energy conservation	Reduced per capita energy consumption
Emission reductions	Reduced per capita pollution emissions
Efficient land use	More accessible community design, reduced per capita land consumption
Public fitness and health	Increased physical activity and associated health benefits

TRANSPORTATION DEMAND MANAGEMENT

Peak Transport demand can be managed through:

- Modal shift
- Spatial Changes
- Time of day changes
- Time substitution.

TRANSPORTATION DEMAND MANAGEMENT

APPLICATION OF ITS IN TDM:

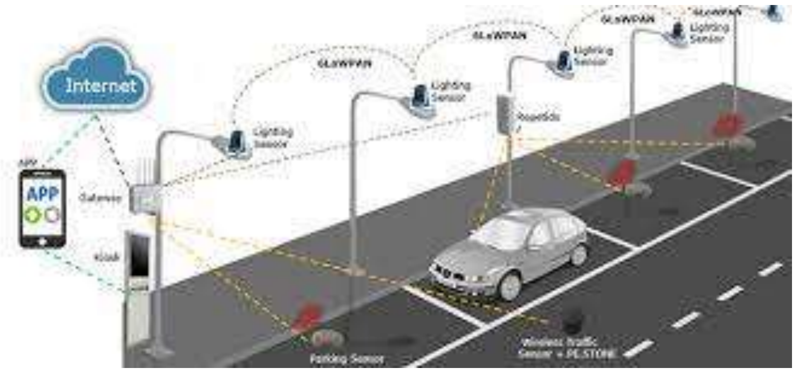
- ITS can be applied to meet the objectives of TDM in number of ways as below:

1. **Promotion of Public Transport:** The objective is to make public transport system attractive to the users to facilitate shifting of people from private to public transport. ITS applications such as real-time passenger information systems, mobile application with real-time information of public transport, integrated automatic fare collection systems etc may be quite useful for the people and may attract them towards public transport.
2. **Road User Charging:** The road user charges are collected from the users who use a particular stretch of road. These are direct charges levied for the use of roads, including road tolls, distance or time-based fees, congestion charges and charges designed to discourage the use of certain classes of vehicle, fuel sources or more polluting vehicles. These charges may be used primarily for revenue generation, usually for road infrastructure financing, or as a transportation demand management tool to reduce peak hour travel and the associated traffic congestion or other social and environmental negative externalities associated with road travel such as air pollution, greenhouse gas emissions, visual intrusion, noise pollution and road traffic collisions

APPLICATION OF ITS IN TDM:

- ITS can be applied to meet the objectives of TDM in number of ways as below:

3. **Parking Management System**: Affordable and easy availability of parking encourages use of private transport. On the other hand limited availability or costly parking encourages use of public transport and helps in reducing the traffic demand on the roads. Parking management refers strategies that encourage more efficient use of existing parking facilities, reduce parking demand and shift travel to non-single occupant vehicle modes. Manging parking helps to reduce the undesirable impacts of parking demand on local and regional traffic levels and help in manging the transport demand in a city. The following tools may be used to effectively manage parking in a city:
   - Demand based Parking Charges
   - Electronic parking guidance systems
   - Electronic parking management system



TRANSPORTATION DEMAND MANAGEMENT

APPLICATION OF ITS IN TDM:

- ITS can be applied to meet the objectives of TDM in number of ways as below:

4. **High occupancy lanes:** High-occupancy vehicle (HOV) lanes are one or more lanes of a roadway that have restrictions on use to encourage ridesharing and can reduce vehicle miles traveled (VMT). Typically, HOV lanes are open to motor vehicles carrying two or more people, and sometimes access is open to motorcycles or vehicles that use alternative fuels (hybrid or electric vehicles). Access restrictions on HOV lanes can apply 24-hours a day or only during peak congestion periods. The goal of HOV lanes is to provide an incentive to use ridesharing and public transportation, remove congestion from normal lanes of travel, and improve overall traffic operations.
5. **Bicycle Rental schemes:** The bicycles can be promoted as first and last mile connectivity with public transport to encourage people to shift to public transport. Bicycle sharing schemes are short-term schemes that enable bicycles to be picked up at any self-serve bicycle station and returned to a similar point, either at the point or origin or elsewhere in a network. PBS offers a low cost, flexible transport option particularly adapted to cities given the short distances usually travelled.

TRANSPORTATION DEMAND MANAGEMENT

APPLICATION OF ITS IN TDM:

- ITS can be applied to meet the objectives of TDM in number of ways as below:

6. **Traffic Rule Enforcement:** The ITS tools can be used for effective implementation of the traffic rules to ensure transport demand management in the city. Foe example of Odd/Even scheme which was implemented in Delhi as TDM measure can be enforced through Automatic Number Plate Recognition (ANPR) system.
7. **Incentive Scheme to Travel in Non-Peak**: ITS tools can be used to launch incentive schemes to encourage people to travel in non-peak hours. The scheme awards credits to users every day depending on their arrival time. The credits accrued by a commuter qualifies them for a monetary reward made at the end of each week. However, evidence continues to illustrate that focused non-cash travel programs stimulate additional effort and tremendous results.
8. **Active Traffic Management**: It is one of the means of increasing peak capacity and smoothening traffic flow on busy major highways. ATM strategies include: Variable Speed Limits. Temporary Shoulder Use. Queue Warning. Dynamic Merge Control. Adaptive Ramp Flow Control. Dynamic Truck Restrictions. Dynamic Rerouting & Traveler Information

TRANSPORTATION DEMAND MANAGEMENT

APPLICATION OF ITS IN TDM:

- ITS can be applied to meet the objectives of TDM in number of ways as below:

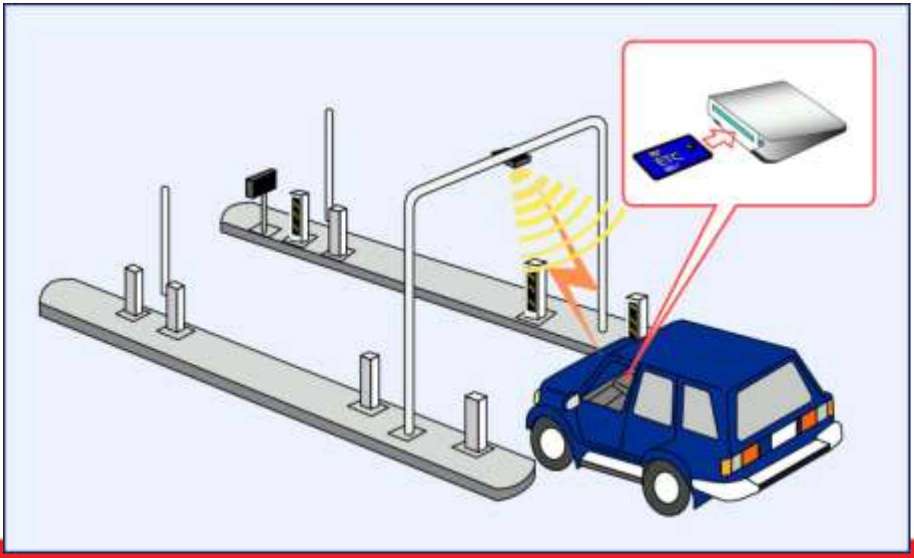
4. **Carpooling:** Carpooling allows travelers to share a ride to a common destination and can include several forms of sharing a ride, such as casual carpooling and realtime carpooling. Because carpooling reduces the number of automobiles needed by travelers, it is often associated with numerous societal benefits including:
   - reductions in energy consumption and emissions,
   - congestion mitigation
   - reduced parking infrastructure demand.

   By connecting public transit with ride-sharing platforms, users have an alternative to using their private automobiles. If urban areas continue to adopt multimodal transportation, we might see a decrease in the number of households purchasing vehicles. This could be achieved by combining transit options into a seamless system to make travelling around a city easy, equitable and enjoyable.

5. **Integrated Fare System:** Integrated ticketing can be defined as the purchase of a single ticket that allows passengers to travel on one or more modes of transport provided by one or more operators. It is an important component of the broader concept of integrated transport, which aims to make interchanges between modes and operators as effortless as possible. This would not only provide travelers with a wide range of travel options but also make transport systems more efficient and interconnected as a whole.

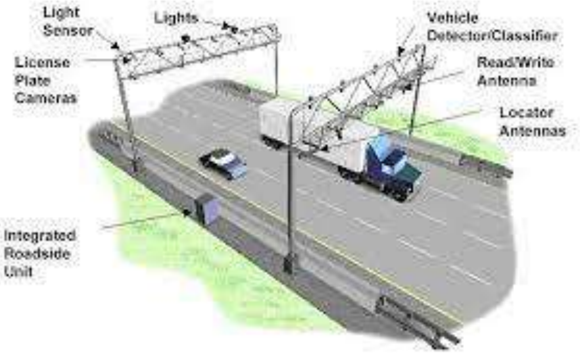
ELECTRONIC TOLL COLLECTION (ETC)

- Electronic toll collection is defined as "a system for automated collection of tolls from moving or stopped vehicles through wireless technologies such as radio-frequency communication or optical scanning.
- The most common method of ETC involves the use of dedicated short-range communications technologies (microwave wireless) to support nonstop transaction processing between a suitably equipped vehicle and roadside equipment.
- Electronic toll collection (ETC) systems charge a toll to users without requiring any action or stopping by the driver. The system debits the accounts of registered car owners or identifies the license plate for later billing, without requiring vehicles to stop. ETC lanes improve the speed and efficiency of traffic flow and save drivers time.



ELECTRONIC TOLL COLLECTION (ETC)

- As the vehicles pass through a toll zone, a transponder or tag fitted onto or inside the vehicle is read by roadside equipment.
- This identifies the vehicle and enables a toll amount to be deducted from a prepaid account.
- The transponder or tag sends a unique identification number to the roadside reader which, in turn, sends the information to a roadside computer.
- The roadside computer has data that links each identification number to a unique account number.
- The identification of the vehicle can also be achieved through optical scanning and character recognition of the vehicle license plate.
- The identification data is transferred to a back office system, which deducts the appropriate toll from the account and adjusts account records accordingly.
- Because it supports nonstop operation, ETC also paves the way for the use of pricing techniques such as value pricing and congestion pricing. These techniques are described later in this module.



Electronic Toll Collection (ETC)

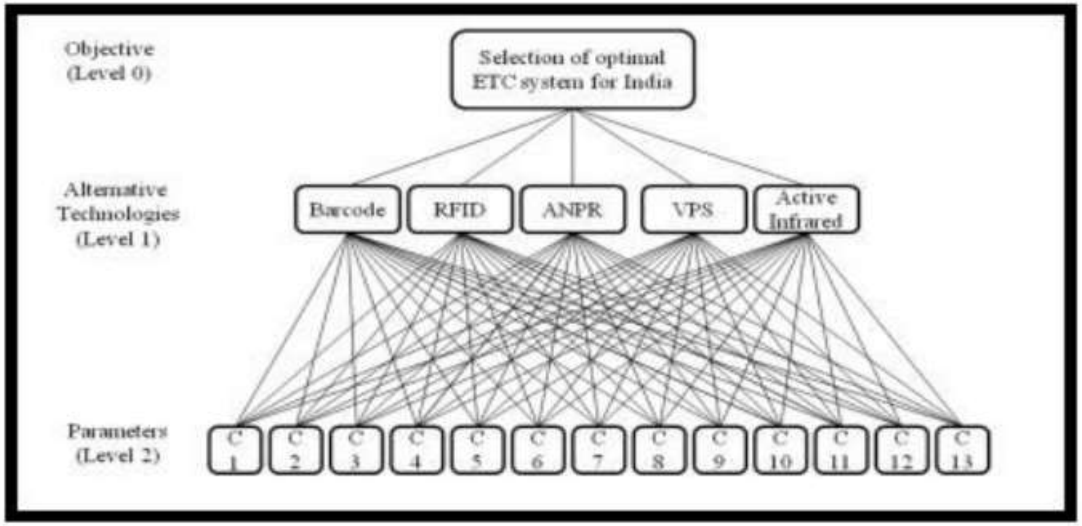
Benefits of ETC

Beneficiary	Advantages
ETC Customers	Speeds transaction time and reduces journey delay.
	Improved convenience and comfort (no need to search for change, wind down the window etc.).
	Extends payment options (cash, credit card, debit card, cheque etc.).
	Commercial users no longer require cash or ticket from employer (open to abuse). Can also be extended to allow vehicle tracking.
	Receive monthly statement (no need for individual receipts).
	Improved safety (conventional toll collection can lead to accidents – typically rear-end collisions - by drivers distracted by the need to find change, choose lane etc.).
	Often linked to a discounted toll structure.
The Toll Authority	Increased toll processing throughput without new infrastructure.
	Reduced cost of toll collection (lower staffing costs).
	The authority receives payment in advance.
	Enhanced auditing capabilities.
	Enhanced toll enforcement.
	Improves public attitude to tolling[19].
	Minimises right-of-way requirements for new plazas.
	Allows for elaborate discount programmes.
	Can be employed for congestion management purposes (through variable – eg. peak period – pricing) and other applications (see Section 6.6).
The Environment	**Air quality**: Improved air quality (particularly at toll plazas and in high-emission departure zones).
	Noise: Reduced noise from vehicle acceleration in departure zones.
	Light: Reduced lighting spillover to adjacent communities.
	Water quality: Improved water quality (reduced contaminated runoff from plaza pavement).

ELECTRONIC TOLL COLLECTION (ETC)

Methods of Toll collection System

1. **Manual Toll Collection**: The toll is collected manually where a toll collector stands and accepts the cash from the driver and the information is fed on the spot in the computer and then the toll receipt is generated.
2. **Electronic Toll Collection**: This system also is human-less however it involves electronic machines that accept tokens provided by the toll agency booth.
3. **Automated Toll Collection**: The whole system is automated and human-less. It uses a tag to identify the vehicle and the toll is debited automatically from the bank account as the vehicle passes through the toll gate.



ELECTRONIC TOLL COLLECTION (ETC)

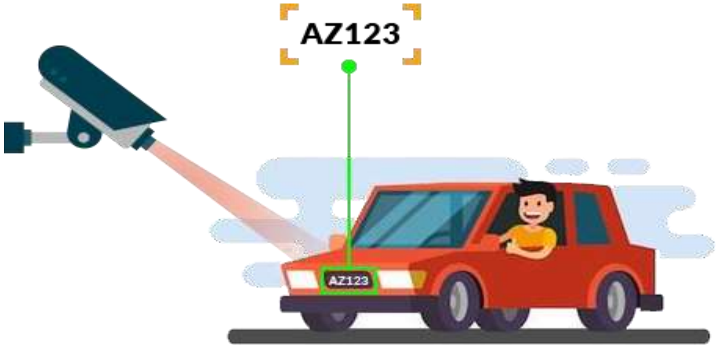
- Typically, the technologies for ETC include vehicle detection, classification and some form of account identification such as:
  - a Radio Frequency (RF) tag
  - a Dedicated Short Range Communication (DSRC) tag
  - video tolling using an ANPR camera to read a vehicle number plate with back-office support to identify the vehicle and its owner)
  - some ETC systems depend on smart cards that use an On Board Unit (OBU) – which is a transponder, possibly with a card reader and display – to communicate with the roadside.

1. **Radio Frequency Identification (RFID)** is a technology that uses radio waves to passively identify a tagged object. It is used in several commercial and industrial applications, from tracking items along a supply chain to keeping track of items checked out of a library.

ELECTRONIC TOLL COLLECTION (ETC)

2. **Dedicated short-range communications (DSRC)** are one-way or two-way short-range to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards.

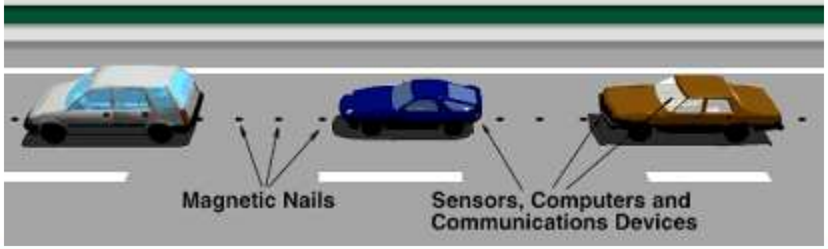
3. **Video tolling using an ANPR camera** :Captures the number plate, video tolling and effective charging with almost zero-human intrusion.



4. **Smart cards that use an On Board Unit (OBU) for toll.**

Automated Highway Systems

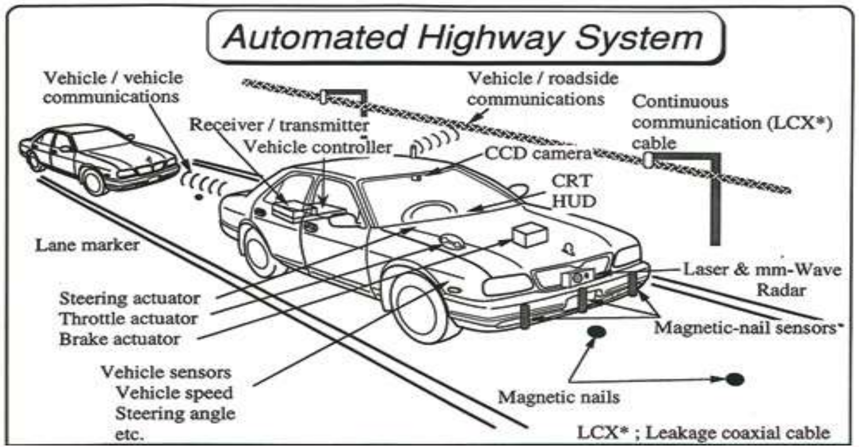
- The Automated Highway System (AHS) concept defines a new relationship between vehicles and the highway infrastructure. AHS refers to a set of designated lanes on a limited access roadway where specially equipped vehicles are operated under completely automatic control.
- AHS uses vehicle and highway control technologies that shift driving functions from the driver/operator to the vehicle.
- Throttle, steering, and braking are automatically controlled to provide safer and more convenient travel.
- AHS also uses communication, sensor and obstacle-detection technologies to recognize and react to external infrastructure conditions.
- The vehicles and highway cooperate to coordinate vehicle movement, avoid obstacles and improve traffic flow, improving safety and reducing congestion. In sum, the AHS concept combines on-board vehicle intelligence with a range of intelligent technologies installed onto existing highway infrastructure and communication technologies that connect vehicles to highway infrastructure.



AUTOMATED HIGHWAY SYSTEMS

Concept of AHS

- A driver electing to use such an automated highway might first pass through a validation lane, similar to today's high occupancy vehicle (HOV) or carpooling lanes.
- The system would then determine if the car will function correctly in an automated mode, establish its destination, and deduct any tolls from the driver's credit account. Improperly operating vehicles would be diverted to manual lanes.
- The driver would then steer into a merging area, and the car would be guided through a gate onto an automated lane.
- An automatic control system would coordinate the movement of newly entering and existing traffic.
- Once travelling in automated mode, the driver could relax until the turnoff. The reverse process would take the vehicle off the highway. At this point, the system would need to check whether the driver could retake control, then take appropriate action if the driver were asleep, sick, or even dead



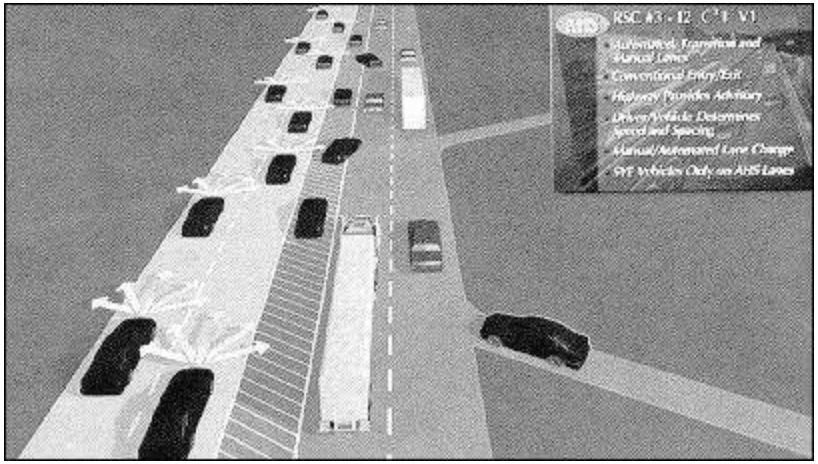
AUTOMATED HIGHWAY SYSTEMS

Concept of AHS-types

- **Independent Vehicle Concept**: This concept puts a smart vehicle in the existing infrastructure. In-vehicle technology lets the vehicle operate automatically with on-board sensors and computers. The vehicle can use data from roadside systems but does not depend on infrastructure support.
- **Cooperative Concept**: This concept lets smart vehicles communicate with each other, although not with the infrastructure. With on-board radar, vision, and other sensors, these AHS-equipped vehicles will be able to communicate with each other and coordinate their driving operations, thereby achieving best throughput and safety.
- **Infrastructure-Supported Concept**: A smart infrastructure can greatly improve the quality of AHS services and better integrate AHS with local transportation networks. This concept envisions automated vehicles in dedicated lanes using global information and two-way communication with the smart infrastructure to support vehicle decision-making and operation.
- **Infrastructure-Assisted Concept**: In this concept, the automated roadside system provides inter-vehicle coordination during entry, exit, merging, and emergencies. This concept may provide the greatest throughput benefit; it also may require the greatest civil infrastructure investment.
- **Adaptable Concept**: This concept acknowledges the fact that AHS implementation will vary by locality. It envisions the development of a wide range of compatible standards that leave as many of the specific architecture decisions, solutions, and deployment progressions as possible to area stakeholders.

AUTOMATED HIGHWAY SYSTEMS

Major AHS Goals: The AHS program is designed to influence how and when vehicle-highway automation will be introduced. AHS deployments will be tailored to meet the needs of public, commercial, transit, and individual travellers in rural and urban communities. The major goals are to:



1. **Improve safety by significantly reducing**:
   1. Fatalities.
   2. Personal injury.
   3. Pain and suffering.
   4. Anxiety and stress of driving.
2. **Save money and optimize investment by**:
   1. Maximizing efficiency of the existing infrastructure investment.
   2. Integrating other ITS services and architecture to achieve smooth traffic flow.
   3. Using available and near-term applied technology to avoid costs of conventional highway build-out.
   4. Developing affordable equipment, vehicles, infrastructure, operations, maintenance, and user fees.
   5. Closing the gap on predicted infrastructure needs.
   6. Using public/private partnerships for shared risk; using the National AHS Consortium as a global focal point to influence foreign deployment efforts.
   7. Reducing fuel consumption and costs, maintenance, wear-and-tear, labor costs, insurance costs, and property damage.

AUTOMATED HIGHWAY SYSTEMS

Major AHS Goals:

3. Improve accessibility and mobility by:

i. Improving employee on-time performance, resulting in amore effective work force.

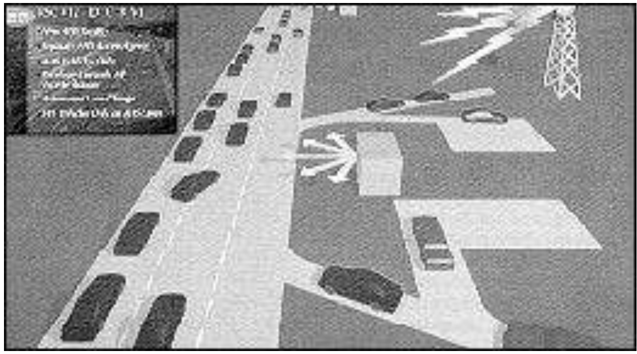
ii. Facilitating "just-in-time" deliveries.

iii. Improving public transportation service, increasing customer access, and expanding service levels, resulting in increased revenue, reduced costs, and reduced accidents.

iv. Achieving a smooth traffic flow, reducing delays, travel times, travel time variability, and driver stress.

v. Making driving more accessible to less able drivers.

4. Improve environmental efficiencies by:



i. Reducing emissions per vehicle-mile travelled.

ii. Providing a solid base for reliable, lower cost transit.

iii. Providing an efficient base for electric-powered vehicles and alternative fuel vehicles.

5. Create jobs by:

i. Providing a stronger national economy and increasing global competitiveness

ii. Increasing jobs in research and development and in early ITS deployment.

iii. Facilitating technology transfer (e.g., from military to civilian use).

iv. Creating new automotive products and new technology based industry to compete in the international marketplace

AUTOMATED HIGHWAY SYSTEMS

AHS BENEFITS: Research has proven that the benefits of AHS on the performance of the existing transportation system will, over time, be enormous and far reaching.

- **More vehicles can be accommodated on the highway**. The number of vehicles per hour per lane can be significantly increased as traffic speeds are standardized and increased and headway distances are decreased.
- **Driving safety will be significantly greater than at present**. The human error factor will be removed.
- **High-performance driving can be conducted without regard to weather and environmental conditions**.
- **All drivers using AHS can be safe, efficient drivers**. AHS offers enhanced mobility for people with disabilities, the elderly, and less experienced drivers.
- **Fuel consumption and emissions can be reduced**: These reductions will be accomplished because start-and-stop driving will be minimized and because on-board sensors will be monitored to ensure that the vehicle is operating at top performance.
- **Land can be used more efficiently**. Roads will not need to take up as much room, since AHS facilities should allow for more effective use of the right of way.
- **More efficient commercial operations.** Commercial trucking can realize better trip reliability to support "just-in-time" delivery.
- **More efficient transit operations**. Transit operations can be automated, extending the flexibility and convenience of the transit option to increase ridership and service.

PLATOONING

- In transportation, platooning or flocking is a method for driving a group of vehicles together. It is meant to increase the capacity of roads via an automated highway system
- Platoons decrease the distances between cars or trucks using electronic, and possibly mechanical, coupling. This capability would allow many cars or trucks to accelerate or brake simultaneously.
- This system also allows for a closer headway between vehicles by eliminating reacting distance needed for human reaction.
- Platoon capability might require buying new vehicles, or it may be something that can be retrofitted.

PLATOONING

Platooning classification according different criteria.

Criteria	Platooning types	Features
Vehicle type	Homogeneous	Vehicles of similar characteristics in terms of size and degree of automation
	Heterogeneous	Vehicles of different sizes and/or degrees of automation
Vehicle number	Finite	Finite number of vehicles
	Infinite	Infinite number of vehicles
Information flow topology	Nearest vehicles	Each vehicle receives/exchanges information from/with r vehicles ahead
	Nearest vehicles and leader	Each vehicle receives/exchanges information from/with r vehicles ahead, plus the leader
Formation policies*	Opportunistic (on-the-fly)	Only CAVs that happen to drive consecutively in a lane form a platoon
	Cooperative	All CAVs within a certain range try to join in a platoon
	Online, dynamic or in real time	Vehicles announce their destination and/or routes just before or during the journey
	Offline, static or scheduled	Trips are announced in advance to facilitate coordination
	Merging policies	Catch-up, slow-down or hybrid strategies
Car-following policies	Constant space gap	Followers maintain a fixed distance with the preceding vehicle
	Constant time gap	Followers maintain a fixed time with the preceding vehicle
	Variable gap	Followers maintain a variable space or time gap depending i.a. on road features

PLATOONING

Table below gives an overview of the four reviewed platooning systems:

	Vehicle type	Control	Infrastructure requirements	Traffic integration	Sensors	Goals
SARTRE	Mixed	Lat + Long	None	Highway, Mixed	Production	Comfort, safety, congestion, energy
PATH	Cars or Heavy	Lat + Long	Reference markers in road surface	Dedicated lane	Mixed	Increased throughput per lane, energy saving
GCDC	Mixed	Long	Augmented GPS	Mixed	SoA and production	Accelerate deployment of cooperative driving systems
Energy-ITS	Heavy	Lat + Long	Lane markings	Dedicated lane	SoA	Mitigate lack of skilled drivers
SCANIA	Heavy	Long	None	Highway, Mixed	No V2V comm. in first stage.	Commercial fleet, energy

PLATOONING

POTENTIAL BENEFITS

- Greater fuel economy due to reduced air resistance and by reducing the need for acceleration, deceleration, and stopping to maintain traffic flow.
- Reduced congestion.
- Substantially shorter commutes during peak periods.
- On longer highway trips, vehicles could be mostly unattended whilst in following mode.
- Fewer traffic collisions.

POTENTIAL DISADVANTAGES

- Some systems have failed in traffic, as they have been hacked by remote computers, creating a hazardous situation.
- Drivers would feel less in control of their own driving, being at the hands of computer software or the lead driver.
- Drivers may be less attentive than usual, and they may not be able to react as quickly to adverse situations if the software or hardware were to fail.

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

- A number of ITS applications have been developed by various organizations/institutions around the globe and tailored to offer transportation solution to meet their specific needs.
- In developed countries, road operators have become dependent on ITS for not only traffic congestion and travel demand management, but also for road safety and improved transport infrastructure.
- ITS employs modern communication, computer and sensor technology directly, and are also enabled indirectly by developments in terms of materials, technology and operations research, including network analysis and risk assessment.
- The vastness of the playing field makes the ITS a cooperative effort between the public sector, private sector, and academia.
- Substantial changes have been made in the core competencies and perspective of these organizations and relationships for developing programmes towards a successful ITS.
- Some implementations of ITS around the world are briefly described here:

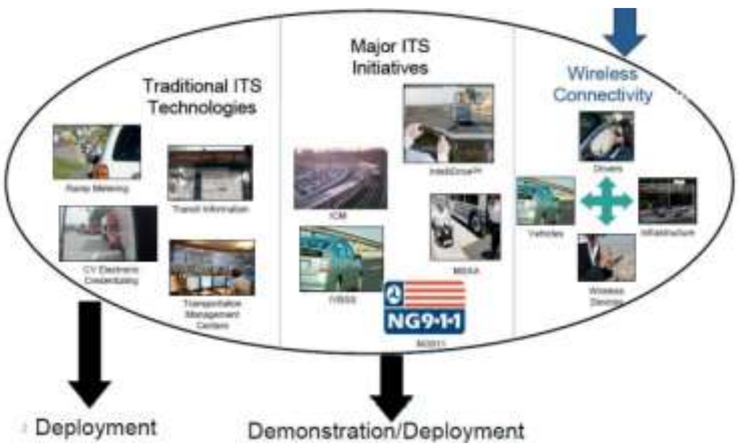
OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

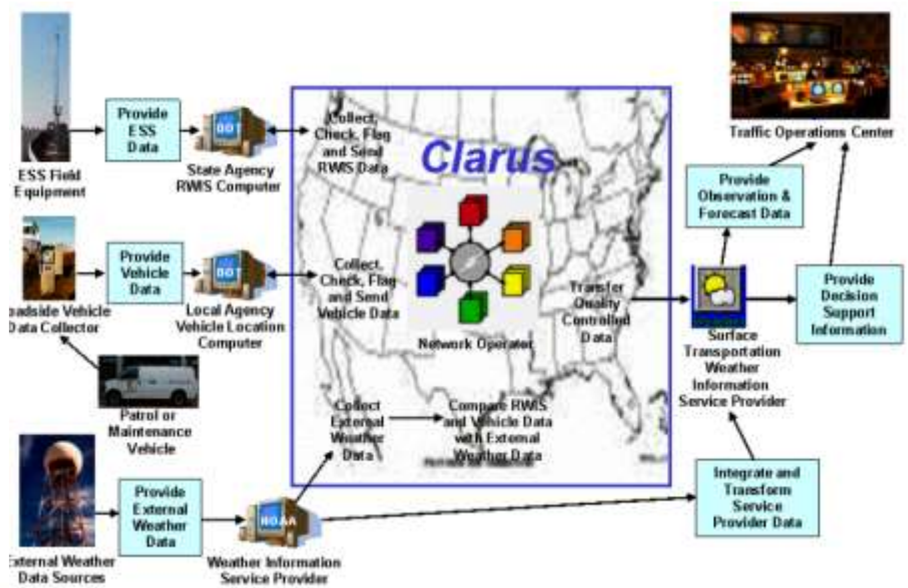
United States of America

- The U.S. Department of Transportation (USDOT) with the help of Intelligent Transportation Systems Joint Program Office (ITS JPO) conducts research on all major modes to advance transportation safety, mobility, and environmental sustainability through electronic and information technology applications.
- USDOT developed ITS strategic Plan for 2015-2019. This presents the strategic themes and programme categories under which ITS categories reflect modal and external stakeholder input about the areas where attention, focus and resources should be devoted.
- Los Angeles smart traveller project has deployed a small number of information kiosks in location such as office lobbies and shopping plazas.

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

United States of America





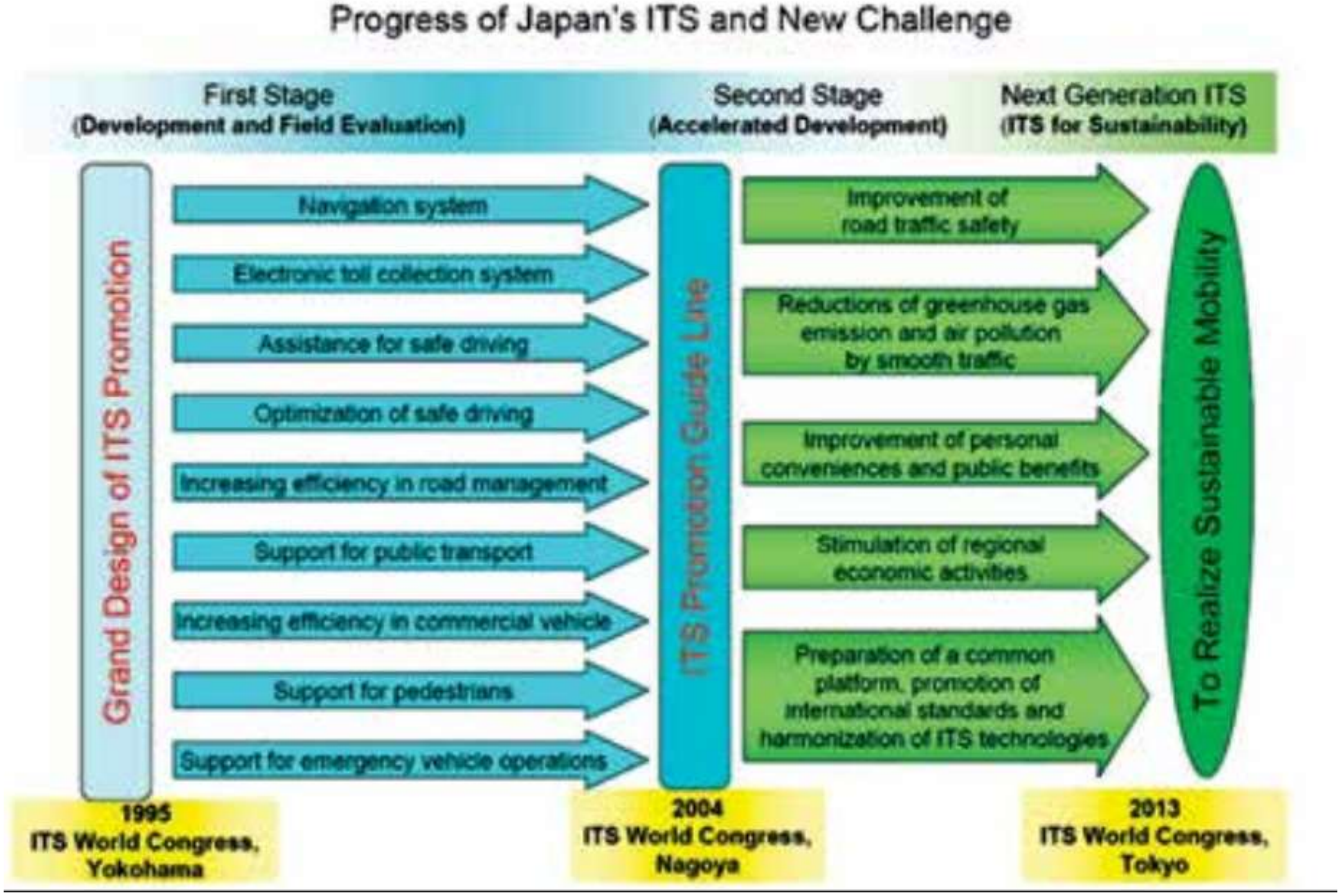
OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Japan

- Japan's ITS not only promotes the optimization of road traffic control, but also achieves reduction in traffic accidents and congestion, and aims to co-exist with energy saving society.
- Under cooperative project between Japanese government and private companies, "Grand Design of ITS Promotion" clarified nine development fields and twenty one utility services in July 1997, and led them into national projects.
- Research and Development of Japan's ITS, such as car navigation, VICS (Vehicle Information Communication System) and ETC (Electronic Toll Collection System) have progressed, and market of these systems has grown rapidly in Japan.
- In the second stage of ITS, "ITS Promotion Guide Line" as government/ private collaborating project promoted the practical applications of ITS, and assisted safe driving to realize "the world's safest road traffic environment".
- And hereafter, Japan's ITS activities are also expected as a better approach to "a sustainable mobile society", and solve the environmental issues and traffic issues. ITS tools in Japan used to resolve the problems such as traffic congestion, traffic accidents and environment degradation (**Figure**).
- Due to implementation, 20% of CO_2 reduction in transport sector, saved 5 billion hours annually and reduced fatality accidents to 4400 (Year 2010). Practical application of VICS (**Figure**) reduced annual CO_2 emission by 2.4 million tonnes in the year 2009.
- ETC eliminates almost all toll gate congestion on expressways. Japan Launched nationwide 1600 ITS spots on expressways to provide basic services such as dynamic route guidance, safety driving support and ETC. ITS spot transmit optimum speed and Headway Distance

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Japan

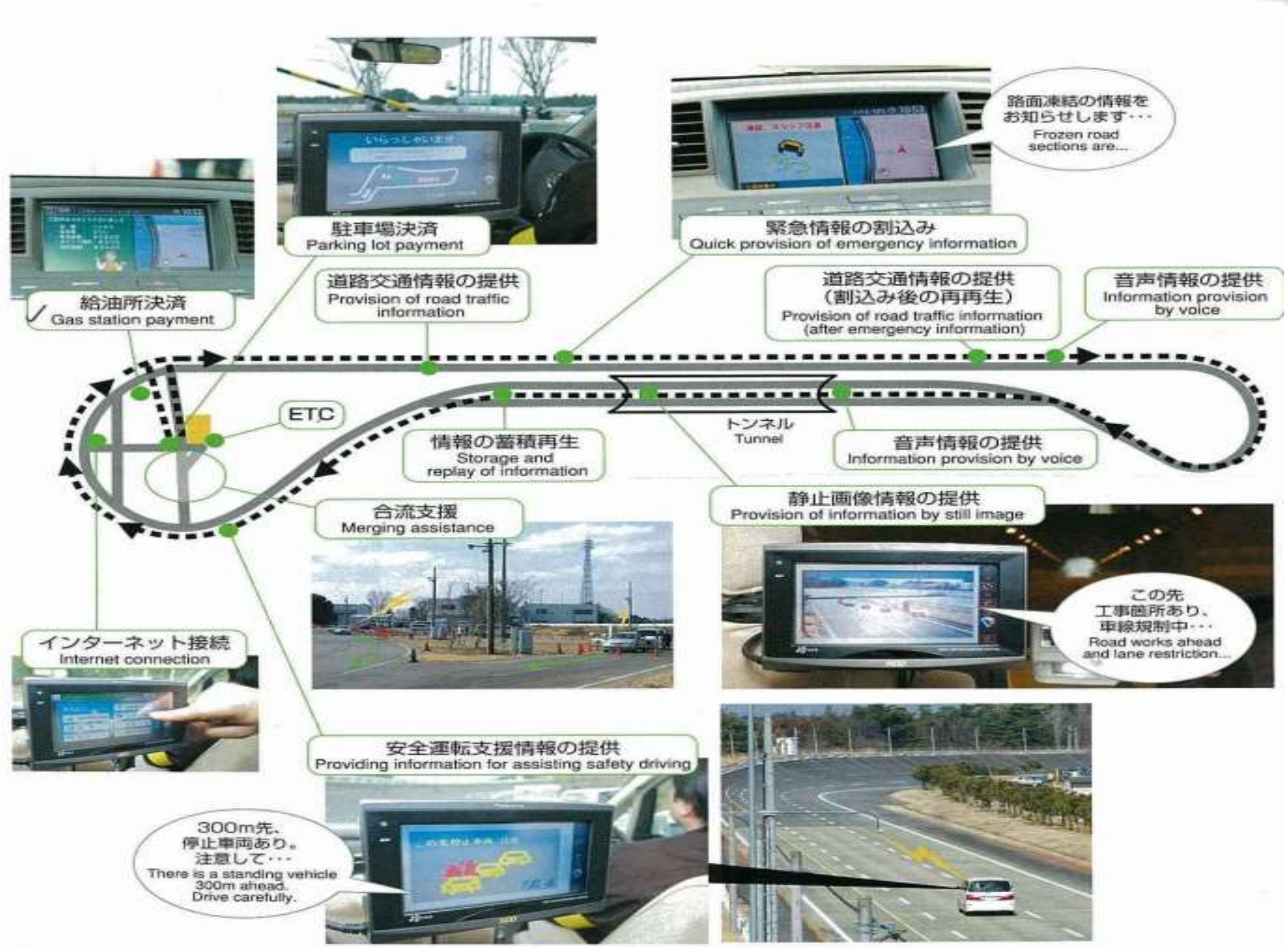


OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Japan

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Japan



OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Europe

- Mainland Europe's Intelligent Transport Systems falls under the umbrella of Road Transport Informatics (RTI).
- RTI focuses on two interacting programs – Road Infrastructures for Vehicle safety in Europe (DRIVE) and Program for European Traffic with Highest Efficiency and Unprecedented Safety (PROMETHEUS).
- DRIVE falls under the control of the Commission of European Communities (CEC), and PROMETHEUS is part of the European Research Coordination Agency (EUREKA) platform, an industrial research initiative involving 19 countries and European vehicle manufacturers.
- Other European Union (EU) public-private partnership focusing on specific safety applications of ITS technologies initiatives are eSafety, INVENT, and PReVENT.
- The INVENT program works towards improving traffic flow and traffic safety by development of novel driver assistance systems, knowledge and information technologies, and solutions for more efficient traffic management, to prevent or minimise the severity of accidents.
- Traffic Impact, Legal issues and Acceptance evaluate the economic and business implications of the new technologies, as well as potential legal conflicts.
- The PReVENT programme integrates a number of safety functions in order to create a safety belt around the vehicle.

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Europe

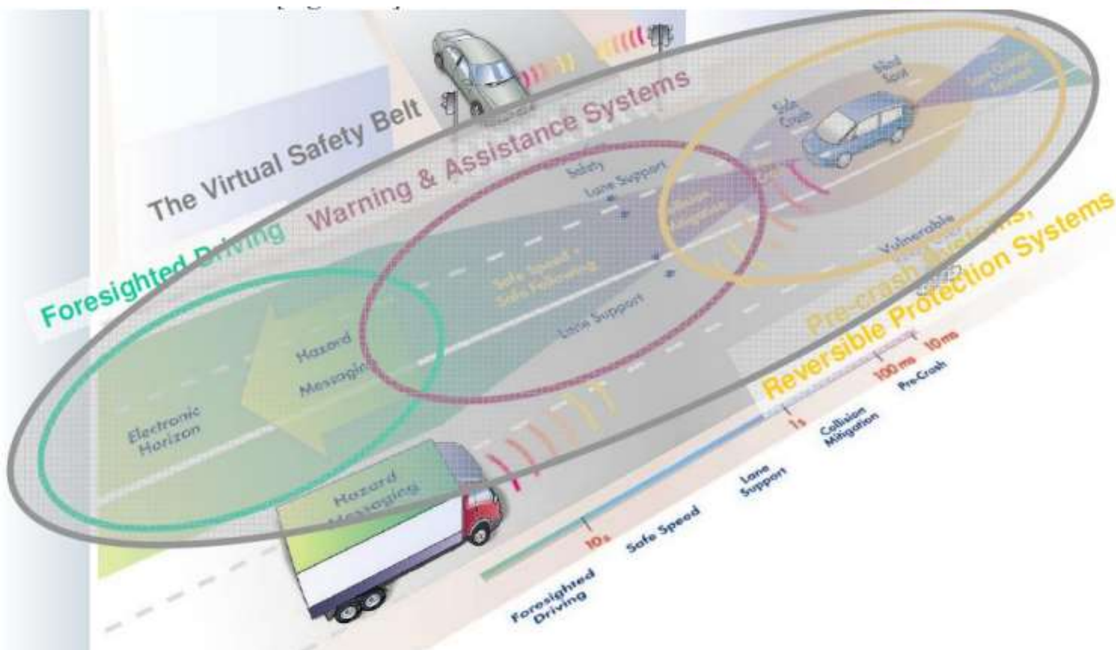


Figure 28: Features of PReVENT [44]

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

United Kingdom

- In London, Internet based maps is aimed at facilitating the operation of freight transport. In London, “Transport for London” (TfL) have produced a digital map of all London’s speed limits which is available free of charge to anyone who wishes to use the map for personal use, or to create commercial applications. Various facilities developed to ensure smooth and safe flow of traffic are described as under:
  - Information services to support travel planning - for towns, workplaces, other activity centres, and individuals.
  - Toll collection and management. Electronic toll collection has been implemented in several regions of the country.
  - Point to point speed enforcement has been ensured by use of multilane cameras.
  - Automated information display for smoother and safer traffic flows.
  - Two kinds of Intelligent Speed Adaptation (ISA) applications are being implemented.
- **London Congestion Pricing:** London congestion pricing is one of the most talked about ITS applications. Transport for London has used thousands of ANPR cameras to identify vehicles entering into London CBD (Central Business District) to reduce congestion. Authorities implemented a unique solution of levying a hefty charge on Vehicles entering CBD areas during peak hours. ANPR cameras provide an efficient and accurate inventory of vehicles, which are visiting CBD areas during peak hours and automatically charging them through an account linked to License plate.

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

United Kingdom

Figure 29: PIPS Spike camera as part of the "Ring of Steel" Programme

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- **Figure 30:** Concept of ISA [47]

Figure 31: One of the 100 Speed Cameras installed in London as part of London Safety Camera Partnership (LSCP) [Image adapted from Ref. 48]

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Middle EAST

- Dubai Municipality started the implementation phase I for project ITS Dubai, which is considered to be the first comprehensive ITS project in the Middle East, and one of the most sophisticated ITS projects currently being implemented in the world.
- This ITS is expected to serve a rapidly growing population. Several integrated approaches are being implemented to achieve ITS in Dubai, such as constructing new roads and interchanges, promoting public transportation, and enhancing road network.

Figure 34: State-of-Art Traffic Control Centre [52]

Figure 36: Lane Control Signals [52]

Figure 39: Traveler Information Kiosk [53]

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Canada

- Canada has been in the forefront of intelligent transport for more than half a century [54]. The world's first computer-controlled traffic signal system operated in Toronto in 1959.
- The world's first all-electronic, open-access toll highway, the 407 ETR (electronic toll route) opened in Greater Toronto in 1999.
- Other ITS innovations in Canada have included ramp metering on the Queen Elizabeth Way (QEW) and the COMPASS freeway traffic management system on the QEW and Highway 401, the main route through Toronto and one of North America's busiest highways.
- The very successful Combo smartcard has been used on the Burlington, Ontario transit system since 1995**.**
- Transport Canada has been responsible for the development of a “Border Information Flow Architecture (BIFA).

Figure 40: (a) COMBO Card (b) COMPASS Advisory [55]

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

China

- In China, the National ITS strategy has been generated. This is mainly focused for development of ITS standard and Framework.
- Many ITS technologies have been applied in China and created new industries. National and local ITS application system promote safety, flexible, and environmentally safe movement of people and goods. The current status of ITS in China is as follows:
  - Traffic Information Services: Become popular Smart Phone, Car-navigator, Website, VMS, Broadcast
  - Car Navigator: Cumulative sales of on-board units: 65 million
  - ETC: ETC cover the total national expressway network. More than 12,000 ETC lanes have been built.
  - Network Reservation Taxi/Car Service; Taxi hailing, Express, Private car service,
  - City Traffic Control Centre: Established in 256 Cities
  - Smart Public Transport and Service: Smart Card: issued more than 430 million
  - The Use of GNSS Big Data
  - Commercial Vehicle Monitoring System
  - Online Ticket booking System.

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Singapore

- Singapore is a world leader in intelligent transportation systems based on its:

  1) use of probes vehicles to collect traffic information,

  2) use of electronic road pricing (that is, congestion charging),

  3) nationwide deployment of adaptive computerized traffic signals,

  4) and of traffic management ITS applications.

- Singapore collects real-time traffic information through a fleet of 5,000 taxis which act as vehicle probes, feeding their speed and location information back to Singapore’s Traffic Operations Management Center
- Singapore disseminates traffic information via its Expressway Monitoring and Advisory System (EMAS)
- Singapore is a world leader in electronic road pricing, and has actually had some form of congestion pricing scheme in place in its city center since 1975 .
- In April 2008, Singapore launched a Parking Guidance System, consisting of roadside variable messaging signs

OVERVIEW OF ITS IMPLEMENTATIONS-WORLD

Singapore

OVERVIEW OF ITS IMPLEMENTATIONS-

South Korea

- In December 2000, South Korea unveiled its National ITS Master Plan for the 21st century, a 20-year blueprint for ITS development which addresses traffic operations and management, electronic payments, information integration and dissemination, public transport quality enhancement, enhanced safety and automated driving, efficient commercial vehicles, and pollution control.
- South Korea built its ITS infrastructure on a city-bycity basis, establishing “ITS Model Cities” starting in 1998.
- South Korea’s Hi-Pass electronic toll collection system (Figure 8), which uses 5.8GHz DSRC technology to enable non-stop cashless toll payment, covers 260 toll plazas and over 3,200 km of highway in South Korea.

ITS IMPLEMENTATIONS-INDIA

- The ITS program in India is aimed at ensuring safe, affordable, quick, comfortable, reliable and sustainable access for the growing urban and rural population to jobs, education, recreation and such other needs. Some of the ITS initiatives in India are as follows:

Table. 3 List of some Projects on ITS in India [14]

Sr. No	Name of Project	Main Function of ITS used in Project
1	Traffic Regulatory Management System Chennai (TRMS)	A traffic monitoring system using surveillance cameras, mainly at road junctions.
2	Area Traffic Control Project Mumbai	Traffic Flow management
	Project on Chandigarh-Parwanoo on NH-5 and Ahmedabad-Mumbai Highway (RFID-based)	Automatic and Electronic Toll Collection
5	ITS on BRT Corridors	Signal priority, Vehicle Tracking, and Automatic Fare Collection in Indore BRT
6	Advance Parking Management System In New Delhi	The parking lot at Palika Bazar – Capacity to park 1050 cars and 500 two-wheelers - Electronic Parking Guidance and VMS Smart Cards Automated multi-level parking in Sarojini Nagar Market

ITS IMPLEMENTATIONS-INDIA

7	The Traffic People Project in New Delhi (2009)	Real-time traffic conditions and updates of in-and-around New Delhi.
8	Rapid Transit Systems projects in various cities	Rapid transition of Buses
9	ITS Master Plan for Hyderabad	Automatic Traffic Counter-cum-Classifiers (ATCC), CCTVs, Variable Messaging System, Traffic Signals, Pedestrian Signals, Flood Sensors, Weather Stations, Pollution Sensors
10	B-TRAC, Bangalore of traffic police Bangalore	adaptive and controlled/monitored by the Traffic Management Center
11	6-Lane Eastern Peripheral Expressway (NH NO.NE-II), Kundli-Ghaziabad-Palwal expressway	Electronic Toll Collection and Emergency Management
12	2-Laning of Shillong Nongstoin Section of NH-44(E), Meghalaya	Electronic Toll Collection and Emergency Management, Law Enforcement

ITS IMPLEMENTATIONS-INDIA

Table. 4 Additional services of ITS in India [15]

E-Challan	very helpful in law enforcement. The offense of the vehicle is automatically detected, and the vehicle is automatically identified using the Automatic License Plate Recognition System thereafter, using a database of vehicles, a challan according to the offense is sent to the offender
M-Parivahan	Database management of various vehicles is maintained by M- Parivahan, which is being provided for various services like E- Challan, payment of Road tax, applying for various services and appointment with RTO, and upload of document
Electronic Monitoring and Enforcement of Road Safety	electronic monitoring and enforcement of road safety on National Highways and State Highways or in any Urban as per standard prescribed like route diversion, display boards, warning boards, etc.
Emergency	Integration of various Emergency services and helplines for quick response.

ITS IMPLEMENTATIONS-INDIA

Figure 46: Toll Collection in India [69]

Figure 47: Ongoing Advanced Parking Management Setup at Palika Bazar, Delhi

Figure 44: Electronic display at the Metropolitan Bus Stand in Chennai [64]

Figure 41: TRMS in Chennai [59]

Figure 42: ATC in Pune [60]


Thank You