Smart Mobility 2030

ITS Strategic Plan for Singapore

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Foreword

Intelligent Transport Systems (ITS) play an important role in influencing our everyday commuting habits. Since its inception in 1995, the Land Transport Authority (LTA) has constantly leveraged on ITS to optimise and better manage its transportation networks to provide a pleasant travel experience for different groups of commuters in Singapore.

The first ITS Master Plan developed in 2006 has guided the successful completion and implementation of several ITS initiatives and solutions. However, the changing social and economic landscape over recent years has brought about new transportation challenges. The evolution of smart mobile devices in recent years has also provided new opportunities. In the past, ITS were often infrastructure reliant. Today, greater emphasis is placed on data collection, analytics and the availability of relevant information on-the-move. On top of this, advancement in transport technologies has also enabled us to better optimise the transportation network and enhance users' experience. It is therefore necessary and timely, for Singapore to review its ITS Master Plan so that we can effectively tap on these technological advancements and map out the overall direction for future ITS developments.

Hence LTA, together with the Intelligent Transportation Society Singapore (ITSS), embarked on a review of the first ITS Master Plan, culminating in this new ITS strategic plan called "Smart Mobility 2030". This plan consolidates perspectives from both the Authority and the industry, paving the way for a more comprehensive and sustainable ITS ecosystem in Singapore in the coming years till 2030. Through close collaboration between LTA and ITSS, we hope to facilitate the co-creation of a holistic plan in tackling the challenges ahead.

This strategic plan will help provide guidance for advancing the applications, developments and inter-operability of ITS in Singapore as we strive for a more connected land transport community.

Chew Hock Yong

Chief Executive, Land Transport Authority

“In the past, ITS were often infrastructure reliant. Today, greater emphasis is placed on data collection, analytics and the availability of relevant, useful information on the move.”

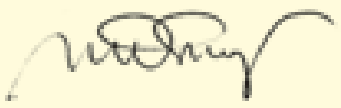
Foreword

Achieving urban mobility is a big challenge in major cities, including high growth, land-scarce Singapore. Over the years, the Land Transport Authority (LTA) has leveraged on technology and successfully deployed innovative Intelligent Transport Systems (ITS) solutions to manage traffic more efficiently to overcome these challenges. This includes the setting up of an integrated traffic control centre assisted by a myriad of traffic sensors deployed along expressways and major arterials to monitor traffic conditions and to provide quick response to traffic incidents.

Besides LTA, stakeholders such as fleet operators, service providers, government agencies, motorists and commuters can play a more significant role in helping to keep our road network flowing. With this in mind, LTA and Intelligent Transportion Society Singapore (ITSS) have embarked on the new ITS vision and strategies to enable stakeholders to collaborate and to share their views, information, technological know-hows and bring urban mobility to a new level.

The "Smart Mobility 2030" is conceived collaboratively by members of ITSS and LTA. It takes into consideration the need for inter-operability and open standards for more collaborative operations as well as content and service delivery. It takes a bold step in harvesting the latest technologies and injecting creativity to develop innovative services, one of which would be the supply of personalised and real-time information using intelligent devices in vehicles and commuters' smart devices.

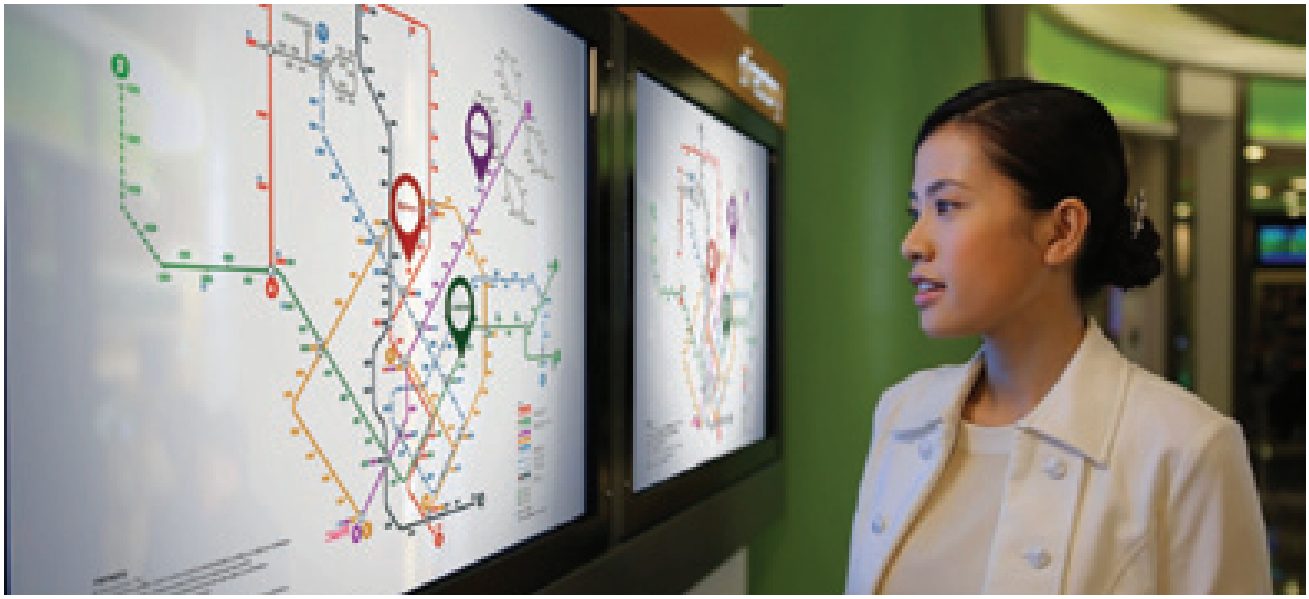
I believe that this new strategic plan will provide yet another exciting phase of ITS implementation and augmentation of values for all transport operators and road users. Every stakeholder of this plan is capable of investing time to develop and provide ITS solutions to best meet Singapore's needs. "Smart Mobility 2030" will serve as a useful platform for sharing and shaping exciting and innovative ITS solutions for Singapore for years to come.



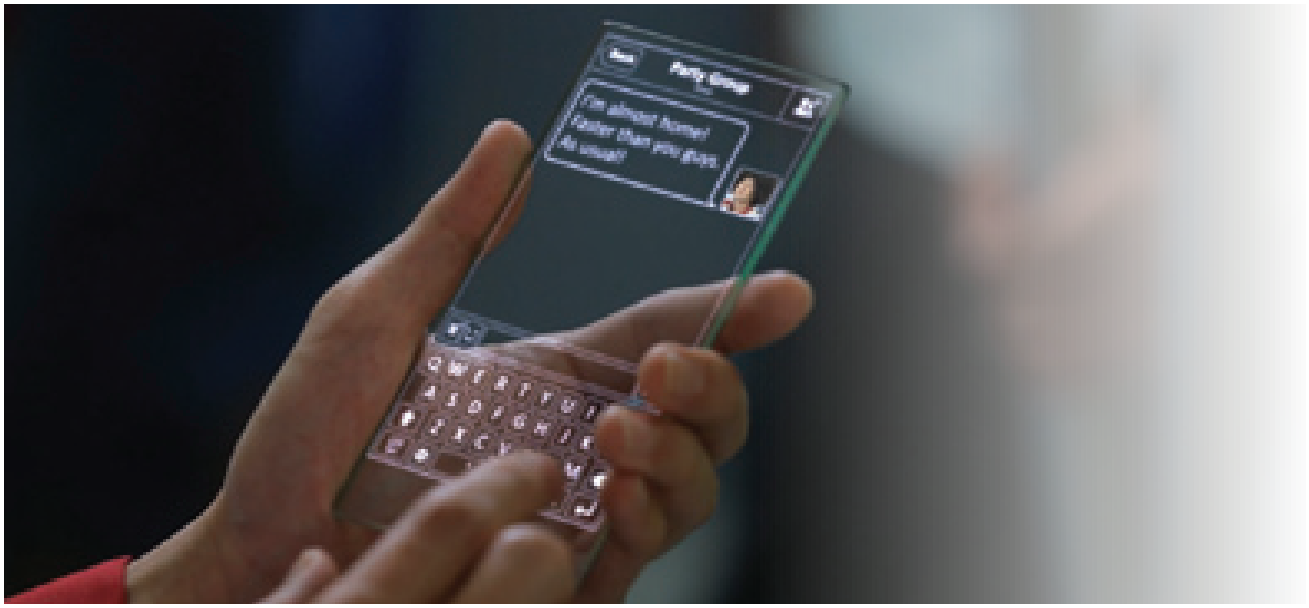
Sing Mong Kee

President, Intelligent Transportation Society Singapore

“... a bold step in harvesting the latest technologies and injecting creativity to develop innovative services.”



Introduction



Bernice Tan, who is born and bred in Singapore, has never owned a car. She has never found the need to do so ever since she graduated and joined the workforce several years ago. She, together with her peers at her workplace, never understood the fuss made by senior colleagues over car ownerships. She recalled the time when her parents and her uncles were lamenting the reduction in vehicle quota to 0.5% in 2013, when she was still a student.

Bernice has always found it pleasant using the comprehensive Mass Rapid Transit (MRT) network and public buses to get around. The fully automated MRT runs on schedule almost all the time. So do the public buses that are equipped with intelligent systems, notwithstanding the many cars, vans and lorries that share the limited road space. Even when it rains, she remains assuredly dry as she makes her way along well sheltered walkways or in underground passageways from the transport hub. Through her smart device, she is able to time her arrival at MRT stations and bus stops to minimise waiting time. Moreover, she will know whether the next arriving bus will have available seats.

On the few occasions when Bernice wants to drive, she will use a car from the car sharing scheme which she has subscribed to. The technology in the car has always been a marvel for her. Enroute to her destination, information is streamed continuously to the car to provide advice on the best route to her destination. Roadside furniture like traffic signals and road signs are also "talking" to her car, giving advice for safe and efficient travel. This has come some way since the satellite-based road pricing system was introduced, with its compact on-board unit doubling up as a parking assistant and a versatile traffic information device, among other useful features.

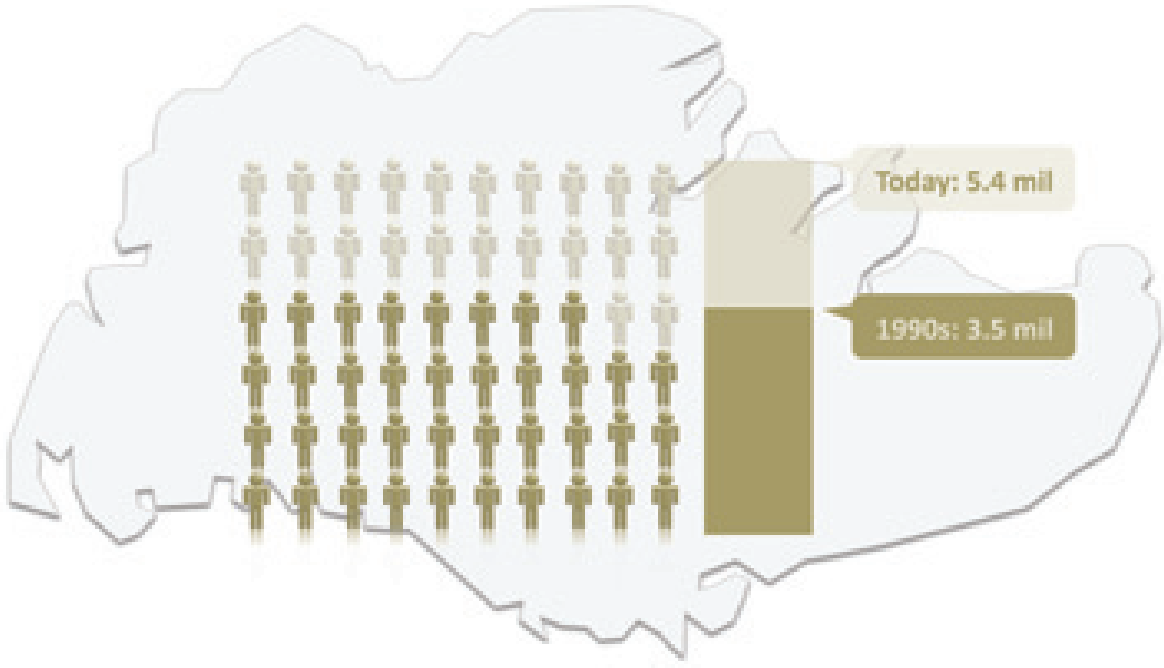
But what fascinates her most are the occasions when the car would seamlessly take over control from the driver. Autonomous driving has become fashionable with higher-end vehicles, which she occasionally manages to get access. It would be at times like these, with the car making all the driving decisions, that she would sit back and appreciate all the Intelligent Transport Systems (ITS) that are used to make her daily travel so much more pleasant, safe and efficient.

This narrative of Bernice Tan in 2030 is a vision that the ITS community, comprising the industry, the academia and the government, has on the role of ITS in the years ahead. There is a lot of hard work and plenty of collaborations needed among all parties, and this document sets out the strategies and focal areas to make this possible.

Taking Stock

As part of Singapore's drive to leverage on ITS for road networks optimisation and better public transport systems, the first ITS Master Plan was developed in 2006 to guide the adoption and systematic implementation of ITS in Singapore. The key thrusts under the first ITS Master Plan include implementing advanced incident management and parking guidance systems, enhancing transport information delivery to users, as well as improving road safety through ITS.

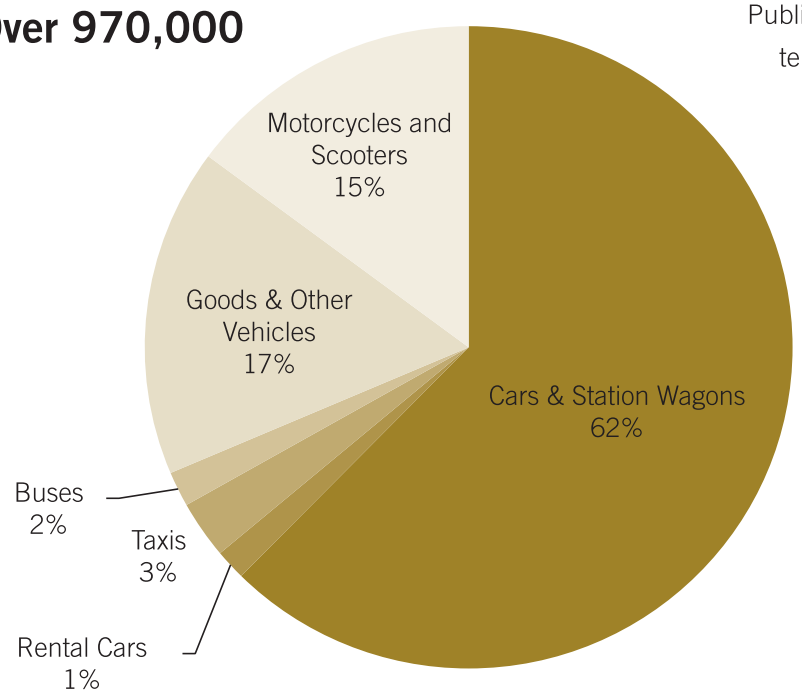
Population Growth



Singapore's demographic and socio-economic landscape has changed considerably over the last decade. Covering a land area of just 715km^2, Singapore's resident population has increased significantly from 3.5 million in the late 1990s to more than 5.4 million, translating to a population density of more than 7,500 persons/ km^2 today.

Total vehicle population has also grown from 700,000 in 2002 to more than 970,000 today, with roads occupying 12% of Singapore's total land area compared to 14% for housing. This issue of land constraints places private and public transport under strain and the trade-off between land use for roads and other competing essential needs will be more acutely felt in the coming years.

All Motor Vehicles: Over 970,000



Public Transport is the key to meeting our long-term land transport needs sustainably. Road networks will continue to expand albeit at a more sustainable pace, mostly to serve newly developed areas and to improve bus routes penetration. The rail network has been expanded with the opening of Boon Lay Extension, Circle Line and part of Downtown Line. More upcoming rail lines are in the pipeline and more buses are deployed on the roads with the aim to make public transport a more attractive option, reducing the reliance on private vehicles.

To boost the robustness, reliability and safety of Singapore's rail services, the world's first ***fully automated underground driverless Mass Rapid Transit (MRT) line*** spanning 20km with 16 stations was introduced. Encouraged by its success, all subsequent rail lines will be driverless. Display panels showing train arrival times in train stations and bus panels showing arrival times at major bus stops have been implemented, providing commuters with real-time information to better plan their journey.

Singapore has come a long way since the early beginnings of manual cash payments for public transport ticketing. In 1990, an integrated ticketing system using a common magnetic card for bus and rail fare payments was introduced. The convenience of not having to carry cash for payments premeditated a progressive conversion towards farecards, following which several other farecard payment systems were introduced.

Today, Singapore has established its own ***Contactless e-Purse Application Standard (CEPAS)***, a national standard that enables different card issuers to offer cards and services that are compatible with the ERP system without additional modifications. This standard allows users to use the same CEPAS card for both transport and non-transport related transactions. In 2010, ***distance-based fare*** was introduced to bring about a more integrated and equitable fare structure using complex computation algorithms that allow public transport commuters to make transfers without incurring additional boarding charge. Passengers travelling trends captured through CEPAS cards when entering and exiting the ticketing systems provide a rich source of anonymised data for analysis, allowing better transport planning and improved public transport services.

The ***PublicTransport@SG*** website was launched in 2008 to help commuters plan their journeys using public transportation. The site's interactive map covers all bus and rail trips and also features a simple calculator to compute fares. In 2011, ***MyTransport.SG***, a dedicated and integrated web portal offering a suite of transport information ranging from public transport, traffic information, taxi-stand locations, vehicle and cycling related information, was made available to the public. Recognising the pervasiveness of smart mobile devices, Singapore has also launched the award winning ***MyTransport.SG mobile version***. This enables the public transport commuters and motorists to make smart choices on-the-move with real-time information.

In addition, a web portal called ***DataMall@MyTransport*** was launched in 2011 to facilitate the sharing of real-time public transport and traffic information to industry players, which can then be disseminated as part of their product offerings to extend information outreach to the public. This has garnered strong interest from businesses, research institutions and 3rd party apps developers and has helped to catalyse numerous innovative transport and location-based applications.

On the ***social media*** front, LTA has also leveraged on social media such as Facebook and Twitter to gather public feedback as well as to provide regular timely updates on public transport matters and road conditions.

In view of constraints in the land and vehicle growth rates, there is a need to optimise the road networks through the application of technologies. The ***expansion of the Expressway Monitoring and Advisory System (EMAS) to 10 major arterial road corridors*** provides motorists advance traffic advisories through strategically placed Variable Message Signs (VMS) along these corridors to complement the VMS on expressways. Motorists are able to make informed decisions for their travel, hence avoiding incident or congested locations. Close to 600 video detection cameras and high definition surveillance cameras were also deployed for traffic data collection and traffic monitoring at the traffic control centre. In addition, ***radar-based traffic data collection systems*** were also deployed in more than 60 locations to gather accurate traffic data to complement the existing sensors on the ground that are essential for traffic operations, data analysis and planning purposes.

Opened in 2008, the 12km Kallang-Paya Lebar Expressway (KPE) has 75% of its roads underground, making it one of the longest underground road tunnels in Asia. Another expressway – the 3.6km Marina Coastal Expressway (MCE), an underground tunnel with a 420m section that crosses the Marina Bay Channel seabed also went into operation in end 2013. A dedicated 24x7

KPE and MCE Operations Control Centre was put in place to monitor the traffic in both tunnels. It leverages on state-of-the-art technologies such as automated incident-detection cameras, fibre-optic heat detectors and various other monitoring sensors to ensure tunnel operations are safe and effective at all times.

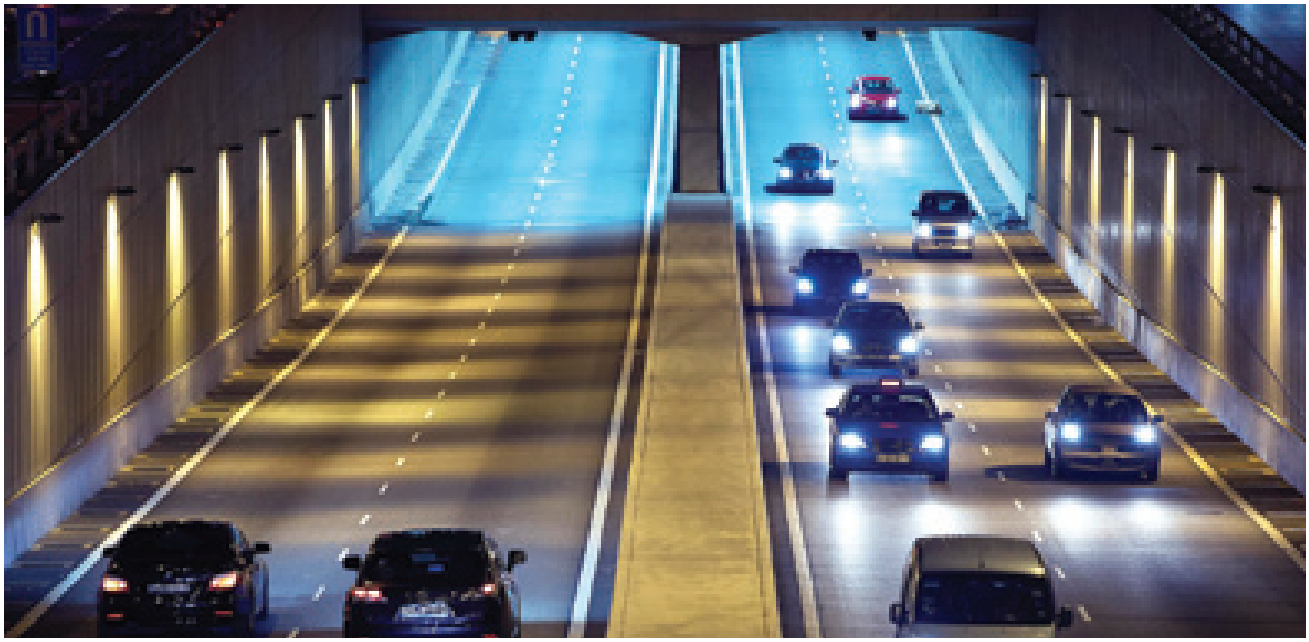
Leveraging on the same Dedicated Short Range Communications (DSRC) technology and In-vehicle Unit (IU) of the Electronic Road Pricing (ERP) system, the ***Electronic Parking System (EPS)*** was introduced to provide motorists with an integrated and consistent driving experience. The EPS has been widely adopted nationwide and it automates parking fees payment, which was previously possible only through paper coupons, or manual payments at ticketing machines. The tedious search for car parks, often a headache for motorists in densely populated areas, and especially within key shopping zones, was made easier with the introduction of the ***Parking Guidance System (PGS)***. The PGS signage, placed strategically to provide information on real-time parking lots availability of car parks in 3 key shopping zones – Marina, Orchard and Harbour Front areas, have reduced unnecessary circulation of vehicles in search of parking.

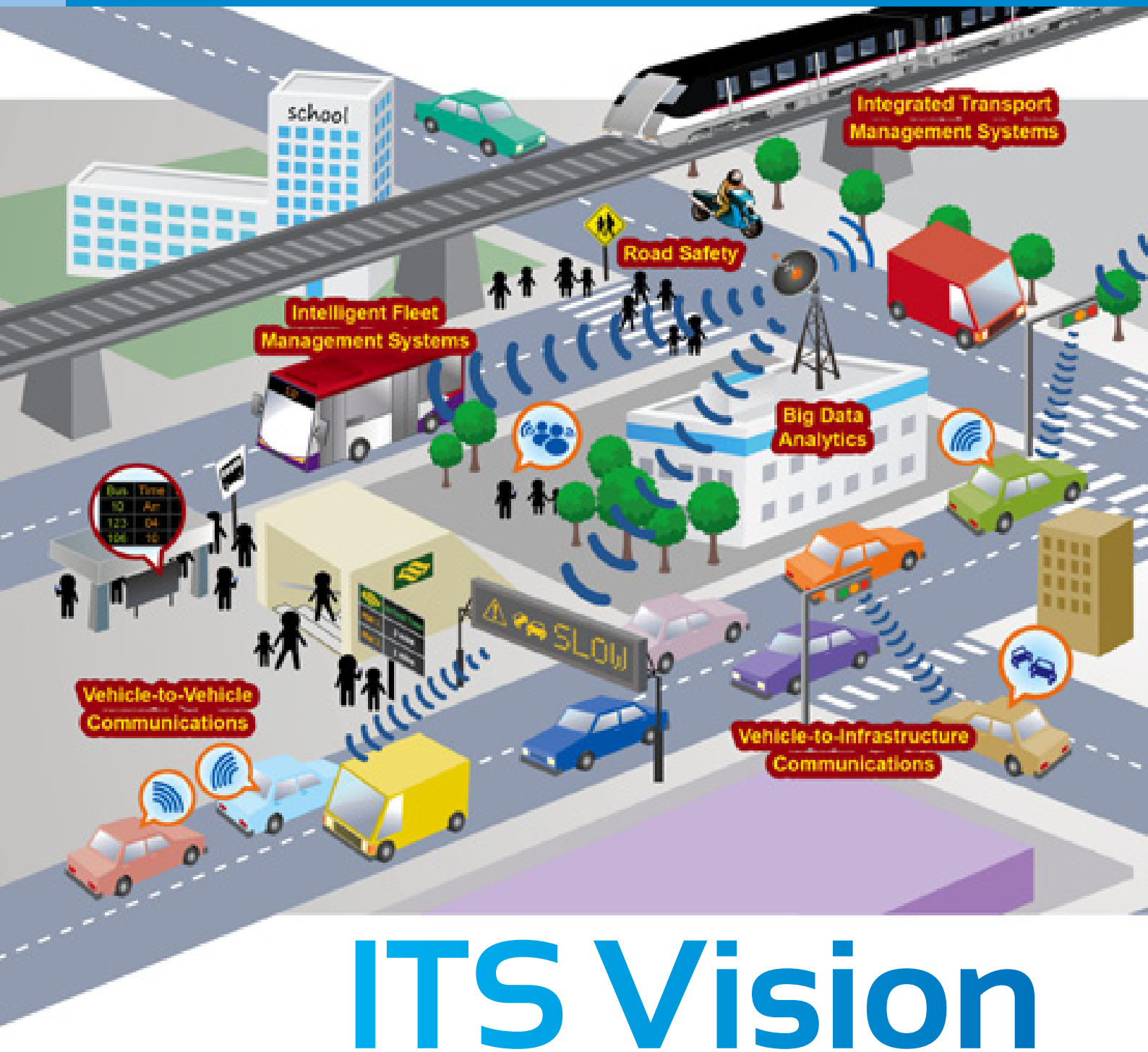
Besides motorists, ITS in Singapore also seeks to benefit other groups of transport users. Close to 250 pedestrian crossing locations island-wide have been installed with ***Green Man Plus (GM+)***, a system to assist the elderly and mobility-challenged in crossing the road by extending the green man time. Another 250 more pedestrian crossings with GM+ will be added by 2015. To improve the public transport system, specialised ***B-signal junctions*** were introduced to give buses priority movement. Buses at these junctions enjoy a shorter waiting time, thereby reducing the overall travelling time of the passengers to their destinations.

Singapore developed and achieved certification for its ***Traffic Message Channel Location Table (TMC-LT)*** from the Traveller Information Services Association (TISA) in July 2010 based on the international TMC data standards. This certified TMC-LT allows motorists access to real-time traffic information through their TMC-enabled navigation devices which have the capability to provide alternative dynamic routes based on the traffic information received.

The ITS has been pivotal in enhancing our public transport systems, as well as managing and optimising the limited road space over the years. ITS will continue to be the mainstay for delivering a convenient, safe and comfortable travelling experience. In addition to the public and private transport, it is also important

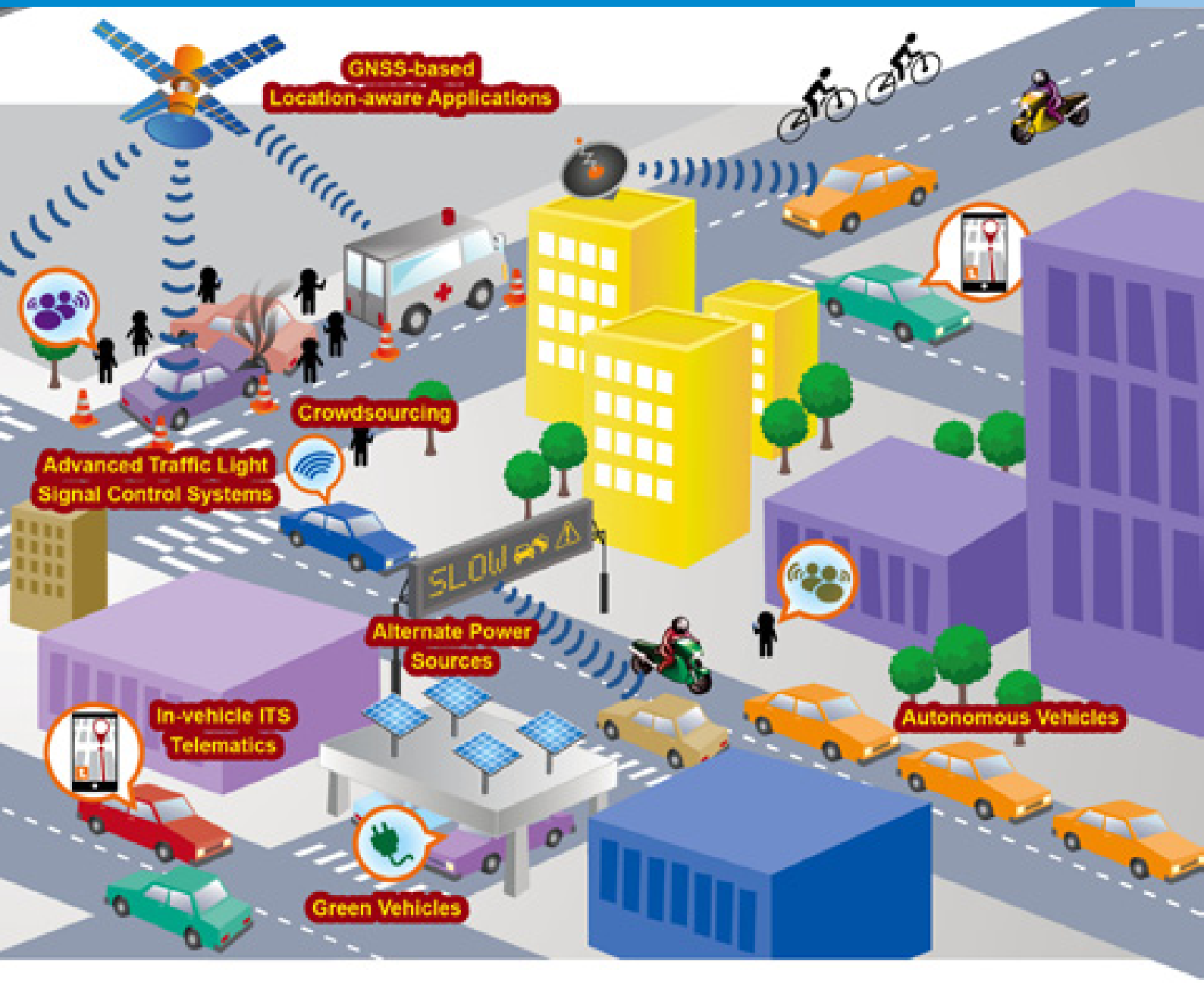
that ITS addresses the changing needs of the diverse user groups especially the growing elderly population and others such as the mobility-challenged, cyclists and children. In view of these challenges, more can be done to address these changing needs. It is hence timely to review the ITS plan and map out the overall direction for future ITS developments.





ITS Vision

Singapore's ITS vision is ***"Moving towards a more connected and interactive land transport community"***, a well integrated and sustainable transportation system. A smart urban mobility of the future where people and the transportation system are seamlessly connected, interacting through innovative, state-of-the-art ITS technologies.



In essence, transport users will enjoy a pleasant and convenient travel experience with smarter connectivity and easy access to a wide variety of real-time information on-the-move. There will be greater interactivity and sharing of information within the community. This will benefit diverse groups of users including the elderly, the mobility-challenged and the cyclists by allowing them to travel more efficiently and safely.

This ITS vision, in short, will shape Singapore into a highly-integrated, lively and more inclusive community where people enjoy higher quality of life.

Key Strategies

The "Smart Mobility 2030" aims to provide the necessary strategic leadership, guidance and support to facilitate a highly connected transport community through innovative and interactive smart mobility solutions. Three key broad strategies and four focal areas have been identified to help Singapore realise the ITS vision in a systematic and coordinated manner to achieve smarter future urban mobility.

1st Strategy – Implement innovative and sustainable smart mobility solutions

Innovation in the ITS ecosystem needs to be sustained to address Singapore's current and future transportation challenges. This can be achieved through implementing cost-effective smart mobility solutions for diverse transport users and the broader use of intelligent big data analytics that can give quick insights to transport trends to facilitate better travel planning and transport management.

2nd Strategy – Develop and adopt ITS standards

Sharing of accurate transport data and the provision of reliable, timely and relevant information services are vital to the ITS ecosystem. Homogenised data standards and protocols are necessary for ensuring overall system efficacy and inter-operability. Efforts will be placed on the development and adoption of ITS standards which allows for the productisation of ITS solutions.

3rd Strategy – Establish close partnerships and co-creation

Establishing partnerships and collaborations between both public and private sectors are keys to innovative co-creation as they leverage on each other's expertise and strengths. These collaborative efforts are important to align the thoughts and needs of all parties and serve as an effective channel to promote ITS awareness among the industry and the public.

Focal Areas

"Smart Mobility 2030" is anchored on four key focal areas, namely ***Informative, Interactive, Assistive*** and ***Green Mobility.***

Having highly reliable and accurate data ***(Informative)*** is becoming increasingly important to meet the rising expectations and diverse needs of the wide spectrum of users. Through active engagement ***(Interactive)*** with users, greater transport-related services and convenience can be provided. At the same time, future ITS will possess advanced features to assist travellers ***(Assistive)*** with their daily commute, simplifying decision making whilst enhancing transport safety. Furthermore, the adoption of suitable ITS will help to streamline operational processes, reduce redundancies and create a friendlier and more sustainable environment ***(Green Mobility)***.

FOCAL AREAS

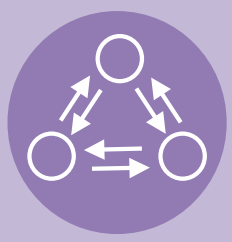
WHY DO WE NEED THEM?

To outline key focal areas that will lay the foundation for initiatives and programmes to support and steer Singapore towards achieving its ITS vision

Informative

High Quality Transport Information to Meet Diverse Needs

Interactive



Enhanced Traveller Experience with Smarter Interactivity

Assistive

Towards a Safe and Secure Roadway Environment

Green Mobility

Towards a Sustainable and Environmentally Friendly ITS

High Quality Transport Information to Meet Diverse Needs

- Adopt new transport data collection technologies
- Dynamic processing of big data and use of intelligent data analytics
- Enhance delivery of relevant and high quality transport information
- Adopt common standards
- Enhance data security and privacy

Informative

Information is key in helping transport users make smart travel decisions for a delightful journey. This information has to be simple and relevant and built on consistent, accurate and reliable data.

Overview

Tremendous progress and breakthroughs have been observed in sensor technologies. Data that was previously difficult to gather can now be easily collected and processed in real-time. These technologies also allow for a much wider geographical coverage along with greater granularity and improved accuracy in the data collected. As a result, users' appetite for transport-related information has increased - information that was once deemed "unimportant" became "good-to-have" over time, and now it is a "must have".

IMPORTANCE OF INFORMATION

Transport data from various sources will facilitate greater integration between various transportation systems, connecting people to places through well integrated transport services. With a more mobile population that possesses smarter mobile devices, there will be greater demand for information while on-the-move. The years ahead will need more innovative and cost-effective ways of collecting, processing and transforming these transport data for timely dissemination to the diverse user groups.

Transport Data Collection Technologies

Emphasis and efforts on data collection in the coming years will be placed on several fronts, the first being the continual pursuit for high quality data through state-of-the-art data collection systems and methods. This involves leveraging on data from location-aware mobile devices, application of Global Navigation Satellite Systems (GNSS) technology, deployment of next-generation high-definition video detection and surveillance systems, as well as other means of sensor data collection.

Secondly, strategic sensor deployment is crucial in keeping infrastructure to the minimum whilst maximising geographical coverage of data collection. This can be realised through strategic expansion of infrastructure and its deployment.

Thirdly, quality enhancements through smart processing of the rich data collected are important to meet the needs of diverse user groups. These enhancements include improving accuracies of collected data through smart algorithms and reducing data transfer latency to end users as these will affect data analysis downstream. Examples of these travel data include travel time, crowdedness in buses/ trains, bus-stops, train stations and taxi-stands as well as queue lengths at traffic junctions.

Dynamic Processing of Big Data and Analytics

The exponential growth in the amount of travel data collected signals a need for appropriate technologies and techniques to manage big data. The ability to store, process and analyse massive amounts of data needs to improve in tandem with the advancement in data collection technologies. These will lead to deeper insights into transport trends and travelling behaviour that in turn will allow for better decision making and planning, as well as quicker response to disruptions in the transport network.

Other techniques such as transport data analytics using visualisation tools will become important too as it allows for enhanced visualisation of island-wide travel patterns and travel behaviours.

A strong data-driven analytical capability enhances the service quality and responsiveness under normal and event-based conditions. Furthermore, predictive analytics can provide insights on possible impact to transport users as situations unfold in real-time.

Transport Information Delivery

Delivering reliable, timely and relevant information is an important element in the overall information management strategy. To achieve this, there are several considerations.

The first involves the expansion of the information delivery channels to quickly and effectively reach out to the public. On-site digital signage, web portals and over-the-air radio broadcast will continue to be the main advisory dissemination channels. However, targeted and localised information propagation to users through other new media such as applications on smart mobile devices, personal navigation devices and integrated in-vehicle systems will become more common. Besides serving as an important source of information for motorists when making daily travel decisions, they also perform other vital functions, reaching out to the masses during times of emergency such as train breakdowns or road/tunnel closures.

The second aspect delves into the quality of information being shared and delivered. The pervasiveness of smart devices and the availability of information on demand have resulted in increasing expectations from the public on the reliability and timeliness of information received. Thus, focus will be placed on achieving this for both public transport commuters and motorists so that there is trust in the information and hence a greater willingness of the users to act based on the information.

Thirdly, emphasis should also be placed on the presentation and visualisation of transport information to end users. Information should be kept simple and easy to understand for commuters and motorists to make quick informed decisions

on-the-move. Information contextualisation and location-aware technologies can alleviate information overload to the users through filtering, where only relevant information pertaining to their travel needs and locations is presented.

Data Standardisation and Security

As transport data and information become increasingly shared, there is a need to establish more open data/information formats, interfaces and communication protocols. Harmonisation and standardisation of collected and processed data, as well as the information delivered, forms part of this overall ITS standardisation strategy. This can be achieved through examining and identifying internationally-adopted standards or best-practices and adapting them to the local context.

Another area of importance lies in communication security, especially when sensitive or confidential information is being transmitted. In this era of heightened security, steps need to be taken to ensure that the overall ITS ecosystem remains robust and secured. Likewise, the importance of privacy and anonymity should not be overlooked and proper measures need to be in place to maintain data anonymity. All these will enhance users' confidence and acceptance of ITS.

Enhanced Traveller Experience with Smarter Interactivity

- Intelligent fleet management system
- Apply advanced road usage demand management
- Smart junction management
- Enhance integration between public transport and road operations
- Enhance spatial contextual awareness for smart mobility
- Crowdsourcing

Interactive

Rapid advancement in info-comm technologies and the developments of many innovative solutions and platforms have greatly transformed the way people work, live, learn and interact. More than 80% of our households are connected digitally to the world and Singapore has been consistently placed highly on global and regional info-comm development rankings. It is clear that Singapore is moving towards greater interactivity amongst people and systems in a seamless and more intelligent way.

Awareness

Overview

The majority of the transport data collected today relies predominantly on infrastructure-based sensors. However, the use of advanced wireless communications has seen the rollout of many innovative ITS services that collect information, allowing agencies and operators to perform more with less effort.

The growing myriad of intelligent mobile devices, applications and sensors are capable of collecting useful data such as locations and speeds. This signifies a more interactive future with greater intelligence and pervasive computing occurring in the background. Surrounding transport infrastructures, vehicles and smart mobile devices will be able to react and respond in accordance to users' travel preference or behaviour without human intervention.

Intelligent Fleet Management System

As more public buses are put on the roads to encourage greater public transport utilisation, having a real-time monitoring and management system is important for a more holistic management of the different bus fleets. A real-time integrated bus management system will provide for a more cost-effective planning and management of island-wide bus service operations and better use of resources and provision of bus information from a single integrated data source. This will provide more reliable bus arrival times and bus load information for the commuters through information panels, kiosks, smart devices and web portals.

For private transport users, intelligent car-sharing system can allow users to locate the vehicle on their smart mobile devices and drive to their destination without having to return the car to its original location. The car can subsequently be picked up by another user from the previous location. Such smart on-demand vehicle sharing mobility solution can potentially reduce vehicle ownership and promote sharing of vehicles within the community.

Smart logistics fleet management system incorporating real-time traffic conditions and advanced fleet monitoring capabilities can also improve service quality through faster goods delivery and better resource management.

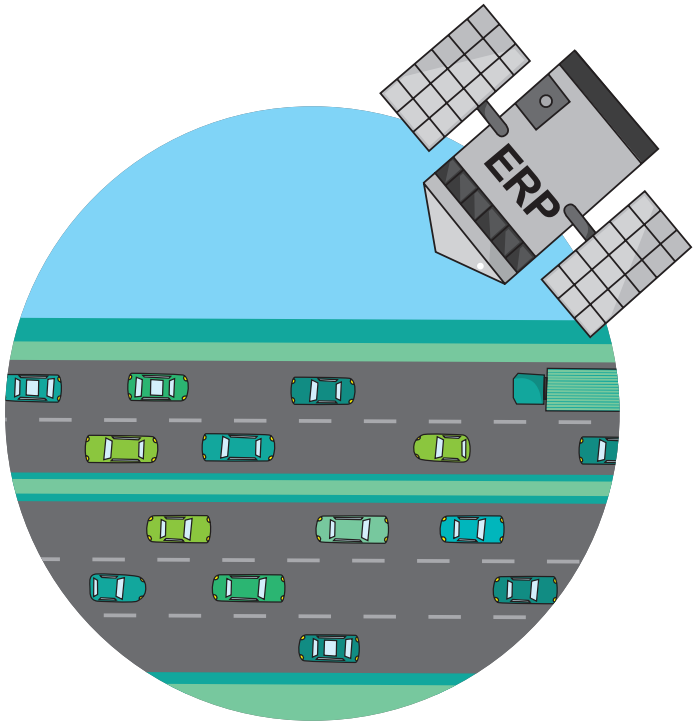
Enhancing Integration between Public Transport & Road Operations

Given Singapore's land constraint and growing population, the increase in travel demand must be largely met by the public transportation system. The public transport experience is dependent not only on the reliability of the transport service but also on the performance of the road network. An integrated transport management and control system is necessary to holistically manage the land transport system, including both public transport and road operations.

Through an integrated transport operations management system, data from various land transport systems can be consolidated, processed and analysed. This will present a more holistic situational picture and aid in the effective deployment of recovery measures during crisis and incidences. Sharing of such information among relevant government agencies and key stakeholders such as the public transport operators and emergency services will lead to more effective and coordinated response plans from a centralised integrated management platform. This will speed up the incident recovery response time and reduce traffic pile up on the roads.

Advanced Road Usage Demand Management

Effective traffic congestion management is crucial as it affects both public and private vehicles and also adversely affect the environment. The advancement and maturity in GNSS technology provides an option for the next generation electronic road pricing system to overcome the constraints of physical gantries, allowing for more flexible distance-based congestion charging. The use of GNSS and various communication channels by the road pricing system also open doors for a wide range of innovative ITS applications and services that can be offered to motorists. Anonymised user data collection can facilitate more localised traffic information dissemination to targeted groups of users, thereby providing smarter mobility to enhance their travel experience.



Spatial Contextual Awareness

The advancement and rapid adoption of smart mobile technologies has opened up new channels for traffic information to be delivered easily through consumer mobile devices. Information from these spatially and contextually aware devices can be harvested to deliver richer and more personalised content based on end users' locations.

Such ITS applications have the ability to process dynamic event information in real-time using artificial intelligence before re-packaging it for targeted dissemination based on motorists' current locations, traffic conditions and users' preferences. The adaptive learning ability of motorists' frequently travelled routes and providing only relevant traffic advisory based on their travel patterns are one of many possible applications where contextual and situational awareness can enhance motorists' travel experience. When appropriately applied, these applications can prevent information overload, which otherwise would affect motorists' cognitive ability and judgement on the roads.

Crowdsourcing

Crowdsourcing through smart mobile devices can allow for a cost-effective and easy way to gain further insights into public transport crowdedness and commuting patterns through the data which can now be collected more easily and anonymously. The end result is a community-driven data collection model requiring fewer infrastructures to operate and maintain.

Social media platforms accessible through smart mobile devices can also be leveraged to provide regular updates, such as the train service recovery status to affected commuters, or advisory to motorists caught in traffic jams near affected train stations. The crowdsourced data from the community can also provide ground sensing on commuters' sentiments, serving as an indicator of transport service quality.

Mobile applications can be extended for broader use such as supporting field equipment maintenance

through more responsive notifications and faults reporting as well as closer monitoring of maintenance works to enhance organisation efficiency and productivity. It provides greater visibility and traceability on maintenance trends over time, thus enabling more appropriate pre-emptive measures to be taken in a timely and cost-effective manner.

Smart Junction Management

Besides real-time adaptive capabilities of traffic signalling at junctions, having predictive and pre-emptive capabilities with integrated pedestrian detection are important elements for a smarter traffic light control system. More balanced traffic distribution is possible by minimising delays and eliminating unnecessary stoppages for vehicles. Motorists will spend less waiting time at traffic junctions. They will have the ability to know traffic signals downstream and can travel at a more steady speed, avoiding start-stop situations and improve fuel efficiency. Facilitating the movement of buses at traffic junctions and reducing the variability of travel time can allow on-time pick up of passengers at bus-stops and reduce bus bunching. Potentially, these vehicle priority capabilities can be extended to support the emergency response vehicles responding to life-threatening cases.

Prioritised Bus Movement

Towards a Safe and Secure Roadway Environment

- Enhance safety at traffic junctions
- Promote connected vehicles and infrastructure
- Facilitate creation of in-vehicle ITS telematics
- Test-bed autonomous vehicles

Assistive

Over the years, efforts have been vested to reduce traffic congestion and mitigate the impact of accidents and fatalities on the roads. Instead of having silo systems addressing these issues independently, systems and vehicles are now becoming more integrated and connected to deliver a more pleasant and safer journey.

hicle ITS Telematics

Overview

We envisage that the co-operative and assistive transport system environment will signal a paradigm shift towards tackling traffic congestion and safety issues in the future. Vehicles of tomorrow will possess greater intelligence than that of today's. They will have the capability to communicate with nearby vehicles wirelessly, sharing useful information on their surroundings, which contributes to the overall driveability and ultimately providing commuters and motorists with an enhanced travel experience. More extensive research and test-bedding can be carried out on smart road infrastructure and vehicles applications to bring about greater connectivity and assistive solutions for a more harmonised and safer transport ecosystem.

Safety at Traffic Junctions

The use of advanced detection sensors and wireless communication technologies integrated with the traffic light controls can enhance safety at traffic junctions. Impending accidents can be detected and avoided through advanced warning alerts provided to motorists via their in-vehicle on-board devices. Such advanced intelligent applications integrated with the traffic light systems can potentially be an integrative part of the next generation smart traffic light control systems. Furthermore, enhancing traffic calming measures through the use of technology, such as digital warning signage and alerts, to enhance road safety at school zones are important to reduce the number of accidents for the more vulnerable groups of users.

Connected Vehicles and Infrastructures

In future, vehicles will become more actively connected with the ability for Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications. The primary driver behind the development of such connected vehicles and inter-vehicle cooperative applications is the enhancement of safety for both motorists and pedestrians. Vehicles in the future are expected to be inter-connected through different wireless communications channels such as Wireless Wide Area Network (WWAN), DSRC, Wi-Fi or Bluetooth. Real-time information can be transmitted and shared within the network of nearby vehicles almost instantaneously. This creates a platform for innovative ITS solutions where, for example, pre-emptive safety warning alerts can be provided to the drivers via On-Board Units (OBUs) of impending vehicle or pedestrian ahead to avoid collisions.

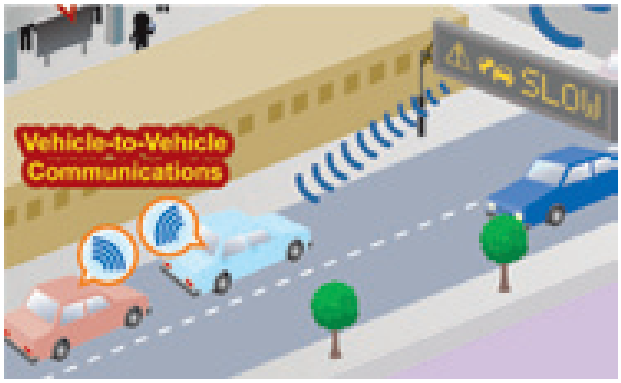
Similarly, such applications when deployed in buses, can allow bus drivers to have greater awareness of surrounding situations, thus providing a safer journey.

Furthermore, with the availability and pervasive adoption of the GNSS-enabled devices in vehicles, vehicles can effectively serve as moving sensors on the ground, returning useful ground information to the ITS ecosystem. This rich source of traffic data serves as an enabler for smart mobility applications in achieving a more distributed and optimal traffic network.

Connected vehicles integrated with backend operations can also improve incident response management where holistic measures can be quickly rolled out to mitigate the impacts. An example would be the quick response to a train breakdown by deploying alternate modes of transport to ferry commuters to nearby train stations or bus stops. Information on the incident can be quickly propagated via V2V and V2I technologies to motorists in the vicinity to avoid travelling to these locations.

In-vehicle ITS Telematics

The evolution of smart mobile devices and their wide array of applications have transformed and



revolutionised the way people communicate, work and travel. Functionalities of in-vehicle applications or vehicle telematics ecosystem are being expanded to integrate with smart devices to enhance motorists' driving experience. Automotive-related applications on users' smart devices amalgamated with telematics applications have formed a core telematics thrust. The development of telematics technologies and its ability to integrate with V2V and V2I intelligent communications will further augment in-vehicle telematics. These developments lay the foundation for telematics applications such as advance driver-assistance applications to alert motorists on road safety (e.g. pedestrian collision, lane deviation, speed limit indication, etc.), dynamic routing, intelligent parking guidance and real-time traffic news delivery amongst others. These telematics applications, while useful to the motorist, also benefit the industry by

returning data pertaining to vehicle usage, drivers' behaviours and habits as this allows better vehicle/driver management and will be particularly useful for enhanced fleet management system.

Since vehicles from automotive manufacturers come in various forms, makes and models, making these vehicles communicate with one another has

its challenges. The adoption of open in-vehicle standards and architecture is an important factor for telematics applications to be sustainable in the long run. Standardised interfaces and connection protocols between the smart mobile devices and the in-vehicle command panels or Machine-to-Machine (M2M) interfaces will become key requirements.

Autonomous Vehicles

Today, there are already commercially available driver assistance systems such as adaptive cruise control and parking assistance that can help drivers on certain parts of the driving process. Looking further down the horizon, a vehicle that is capable of self-driving is not something beyond our imagination. In recent years, many car manufacturers and research institutions, both locally and worldwide, have begun researching into driverless vehicles or fully autonomous driving and several cities have also started to allow testing of autonomous vehicles on their roads.

Autonomous or fully-automated driving signifies a paradigm shift for everyone – from motorists to pedestrians, and has created new possibilities for both public and private transport systems. In the area of public transport, driverless buses can potentially help to provide greater connectivity for first and last mile travel, mitigate driver shortages and improve productivity. Operators will have more control over the bus operational deployment as fleet management can be more dynamically and directly controlled.

In future, driverless cars can maintain a safe distance from other vehicles and comply with speed limits automatically, hence eliminating human errors in driving due to fatigue or distraction. Driverless vehicles (cars, buses and goods/trucks) that can move in platoon formation in a more compact and systematic manner on smart expressway lanes have the potential to optimise road capacity, increase productivity and lower carbon emissions as these vehicles can be self-driven more efficiently.

Apart from technological issues, there are also legislative and regulatory barriers to be overcome. Regulators around the world are still grappling with issues such as ascertaining the responsible party in accidents involving driverless vehicles. As autonomous vehicle technology continues to advance, it is important that we create an open platform where the industry, research institutions and the authorities can jointly conduct research, develop the technologies and test-bed the solutions in Singapore. This will enable and prepare the regulatory framework, operation requirements and infrastructure support in anticipation for the arrival of these 'smart' autonomous vehicles.

Towards a Sustainable and Environmentally Friendly ITS

- Promote use of public transport
- Promote green vehicles
- Promote use of green infrastructure and alternative energy sources

Green Mobility

In Singapore, land transport contributes about 20% of the total carbon emission and 75% of air pollution is attributable to motorised traffic. More importance should be placed on green and sustainable transport systems to reduce impact on the environment.

Air pollution due to motorised traffic

Carbon emissions due to land transport

Overview

While Singapore enjoys a relatively good quality of air, it is important to be mindful that transportation is one of the major contributors to harmful emissions. These harmful pollutants such as sulphur dioxide (SO_2), nitrogen oxide (NO_x), carbon monoxide (CO) and particulate matter (PM) affect the quality of air and pose as a significant risk factor for multiple health conditions, resulting in negative externalities and social cost. Thus, it is imperative to move towards a more sustainable, energy efficient and reliable transportation system.

Promoting higher usage of Public Transport

Using comparatively more energy efficient public transport instead of private vehicles is a way to help protect our environment. Trains and buses are much more efficient carriers of passengers than cars, preserving more land for other uses. Reducing the number of cars on the roads will reduce carbon emissions too. More effort shall be placed in encouraging and promoting greater usage of public transport. Hence, it is important to continue making public transport an attractive choice mode of travel and reducing the reliance on private vehicles.

Other technologies such as regenerative brakes recover the kinetic energy when trains stop help improve operational efficiency. These technologies often has the added benefit of reducing rate of wear on trains' mechanical brakes, thus enhancing safety and operations efficiency as well as greater energy and cost savings.

In addition, development in innovative green ITS technologies and solutions can support the collective efforts to reduce the overall carbon emissions contributed by our transport systems, making them more environmentally sustainable.

Green Vehicles

Industry players such as automotive manufacturers, component suppliers, public transport operators, service providers as well as research institutions shall be key drivers for the research and development into environmental-friendly or "green" vehicles. Vehicles powered by electric and alternative vehicle technologies such as diesel-hybrid systems are generally more energy efficient and less harmful to the environment.

Green ITS Infrastructures and Alternative Energy Sources

Existing infrastructures tend to use extensive materials, consume significant energy and incur maintenance cost. The use of ITS equipment should be adequately balanced with the ability to offer sufficient coverage of road networks. On the same note, the need for cabling works to provide power for these ITS equipment should be minimised. These can be achieved through reducing the need for more equipment, use of energy-efficient equipment or devices with lower power consumption and use of alternative energy sources such as solar energy or other clean renewable energy.

The growing maturity of cloud computing has witnessed the application of such technologies expand into many areas of the transport industry. Servers and systems often need to be sufficiently designed to handle future and peak period data processing. An overtly designed system will not be cost effective or energy efficient to maintain idle resources. Hence, quick system scalability and resource sharing through cloud computing can be an attractive option. Reducing power consumption in the data centre, such as reducing air-cooling usage and power required for servers is integral towards achieving a green data centre standard.

Realising the ITS Vision

The "Smart Mobility 2030" outlines the vision, key strategies and focal areas of Singapore's ITS over the next 15 years. Through this plan, efforts among the different ITS stakeholders in Singapore can dovetail and culminate in innovative and cost-effective solutions that meet Singapore's current and future transport challenges. As Singapore moves towards a more public transport centric city, more can be achieved through the use of advanced ITS to facilitate smarter urban mobility and greater use of our public transport system.

Public Agencies

Public agencies will continue to play a crucial role in driving key ITS initiatives and programmes to support the goals in meeting the ITS vision through gathering and understanding the ground sentiments and end-user requirements. They will play an important part to make public transport more attractive through better usage and integration of ITS technologies for a more sustainable transportation system in the long run. They will be instrumental in coordinating with other stakeholders, such as industry players and research institutions, in rolling out smart mobility solutions and services. This will empower commuters and motorists with the ability to plan their trips more decisively and confidently for more delightful and safer journeys.

Industry Players

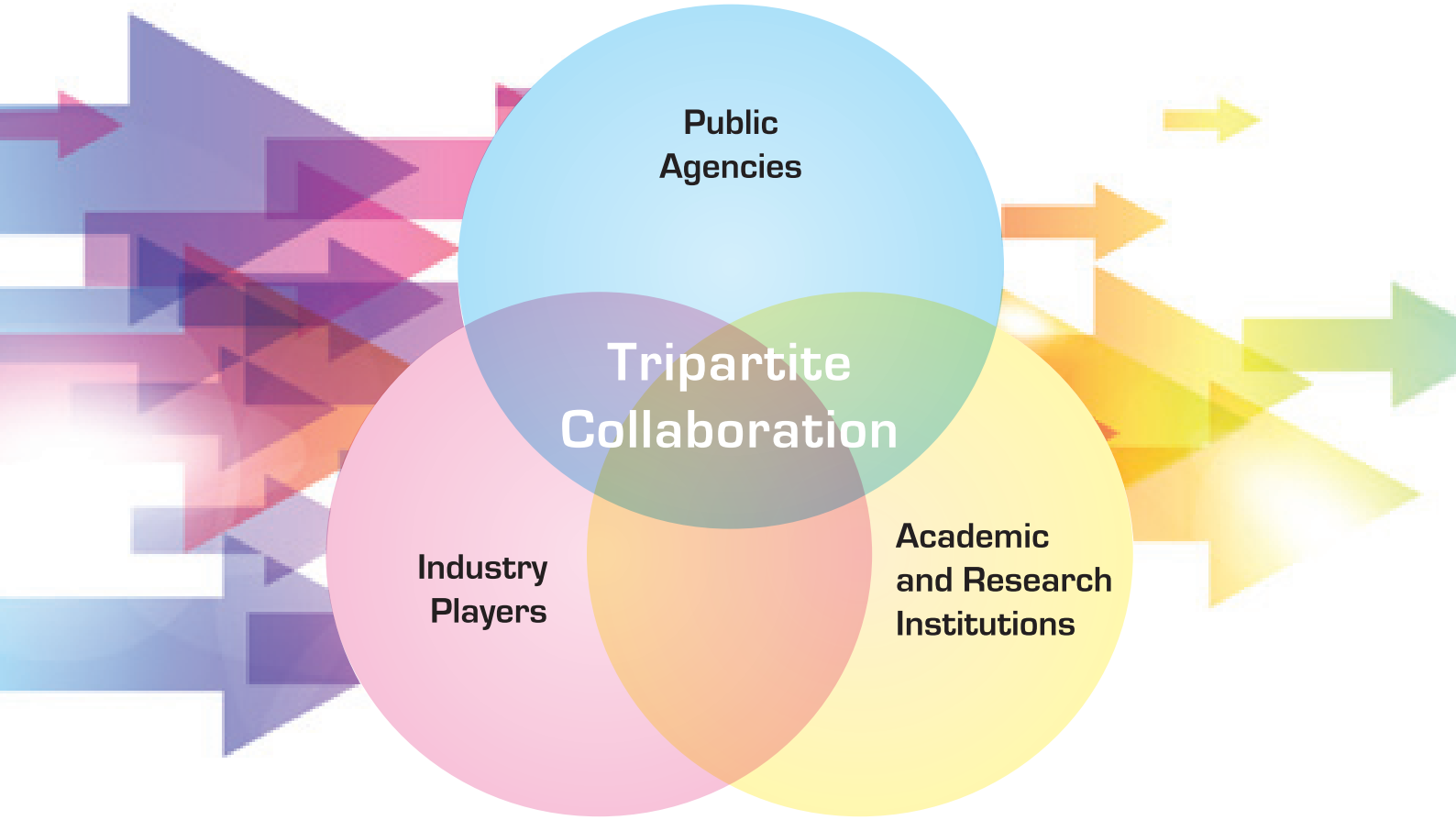
Industry players, ranging from multinational companies (MNCs), small-medium enterprises (SMEs) to start-ups as well as traffic service providers, public transport operators, system integrators, automotive manufacturers, navigation/map makers and mobile app developers, will be key technology drivers in the success of this strategic plan. Technologies relating to sensors, vehicles, in-vehicle telematics, navigations and location-based services are some key areas where the technical knowledge, expertise and skill-sets lie with the industry. It is essential to develop the industry's technological competencies and export the innovative solutions overseas to continue putting Singapore internationally at the forefront of ITS technology.

Academic and Research Institutions

The academic and research institutions will play an important and integral role in supporting and promoting technological innovations in transportation through in-depth research and experimentations. Hypothetical analysis together with sound theories and research methodologies are important factors for breakthroughs and new ideas or findings. Their participation and contribution will strengthen local ITS research capabilities and play a strategic role in steering research towards addressing transportation challenges, making Singapore a key transportation research and test-bedding hub.

Collaboration and Co-creation

To overcome the transportation challenges, active participation and collaboration by public agencies, industry players and academic/research institutions are important for co-creating innovative ITS technologies and smart mobility applications for a more sustainable transport ecosystem. It allows the convergence of the research and industry efforts to be in line with the goals of the public agencies. The partners can support, facilitate and accelerate the process from innovation to deployment, creating multi-fold benefits for the diverse user groups.



Singapore 2030

More intelligent devices, applications and mobility solutions will be in place and users like Bernice will enjoy smarter mobility and more pleasant travel experience. She can access a wide variety of personalised, interactive travel information services on-the-move and greater connectivity with the community. Public transport will be more comprehensively integrated and vehicles will be more intelligently connected.

"Smart Mobility 2030" unfolds yet another exciting chapter of ITS development towards achieving a liveable and inclusive community for Singapore where people enjoy a higher quality of life.

High Quality Transport Information to Meet Diverse Needs

- Adopt new transport data collection technologies
- Dynamic processing of big data and use of intelligent data analytics
- Enhance delivery of relevant and high quality transport information
- Adopt common standards
- Enhance data security and privacy

Enhanced Traveller Experience with Smarter Interactivity

- Intelligent fleet management system
- Apply advanced road usage demand management
- Smart junction management
- Enhance integration between public transport and road operations
- Enhance spatial contextual awareness for smart mobility
- Crowdsourcing

Towards a Sustainable and Environmentally Friendly ITS

- Promote use of public transport
- Promote green vehicles
- Promote use of green infrastructure and alternative energy sources

Towards a Safe and Secure Roadway Environment

- Enhance safety at traffic junctions
- Promote connected vehicles and infrastructure
- Facilitate creation of in-vehicle ITS telematics
- Test-bed autonomous vehicles

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