A Guide to
INTELLIGENT TRANSPORTATION
SYSTEMS & BEST PRACTISES
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EXECUTIVE SUMMARY

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INTELLIGENT TRANSPORTATION SYSTEMS & BEST PRACTISES
The population of the world is currently hovering around 7.5 billion and is increasing at a rate of 1.11% This equates to an addition of 80 million people per year. Frost & Sullivan estimates that by 2020, about 4.5 billion people would live in an urban environment.

The demand on the mobility infrastructure is immense, as people are commuting further every day to work. Although distance remains the same, commuting time has significantly increased due to congestion.

The mobility is transforming due to on-demand, platform-based systems driven by millennials straying away from traditional ownership models.

Future cities are focusing on tackling transportation related problems using an integrated platform that can centrally manage mobility, safety and the environment.

**CHALLENGES IN THE FUTURE CITIES**

Future cities are aiming to increase efficiency by reducing time spent in traffic, emissions by developing not only a sustainable but also affordable transport infrastructure. However, the key challenges that need to be addressed to create a sustainable future transportation network are listed below.

**Congestion:**
As population increases, urban cities are sprawling towards suburban areas fast due to limited areas inside the city. However the infrastructure towards suburban areas is not developed as fast as the expansion therefore in terms of work and school needs, people are still connected with city centers which causes daily travel time to increase and create congestion within the city. For example, 104 hours spent in congestion in Los Angeles as being the top city according to INRIX traffic statistics in 2016 which is followed by Moscow with 91.4 hours and New York with 89.4 hours.

**Energy and Emission:**
Emission is the environmental concern all over the world due to unlimited pollutants and increasing consumption.
Vehicle ownership is also increasing parallel with the population increase and emit considerable amount of pollutant gases that are hazardous to both humans and living bodies. In London, stalled traffic has been found to lead to 8% more CO2, 6% more PM10 and up to 9% more NOx emissions than free-flowing traffic.

**Safety:**
Road safety and vehicle safety has always been very crucial in saving lives, in 2015 according to latest WHO statistics still 1.25 million deaths occurred due to traffic accidents. Three quarters of the fatalities can be avoided by using vehicle-to-everything (V2X) communication technology.

**Cybersecurity:**
There are around 25 million cars are sold as connected cars on the road today; it is expected to increase to 70 million by 2022 according to Frost & Sullivan (North America, China, India, Europe, Brazil, South Korea and Japan). Cybersecurity is swiftly taking priority over comfort and convenience from both customer’s and manufacturers’ perspective. There are currently initiatives taken by OEMs as a startup, independent startup company founded solely to protect against cyber-attacks and also Tier 1 automotive suppliers are running V2X field trials to experience security.

**ITS Applications**

**Advanced Traffic Management Systems (ATMS)**
Advanced traffic management systems manage congestion dynamically. It increases the efficiency of utilization of existing infrastructure, by using intelligent systems. These systems monitor both recurrent (rush hour traffic) and non-recurrent (congestion due to accidents, stalled vehicles) traffic conditions and dynamically control the flow of traffic to reduce congestion.

**Advanced Public Transportation Systems (APTS)**
APTS is a collection of technologies aimed at improving safety, reliability, and efficiency while reducing commuting time of public transportation systems, thereby reducing congestion and emissions.
It offers key advantages to supervisors such as real-time location tracking, accident/event information, driver and vehicle monitoring.

**Advanced Traveler Information System (ATIS)**

ATIS is one of the most common ITS services, aiding the transportation of travelers from their origin to their destination. Information about traffic congestion, delays, accidents, and weather are disseminated through the media, Internet, visual messaging, and public announcement systems.

**Advanced Transport Pricing Systems (ATPS)**

ATPS are used as a method to control congestion by applying charges during certain hours. One of the types include electronic road pricing (ERP) uses a pay as you use system that charges motorists for entering certain zones during certain hours denoted as congestion times.

**Commercial Vehicle Operations (CVO)**

CVO is an ITS solution for commercial vehicles that aids in the efficient management of commercial vehicle operations. It leverages GPS locations along with digital radios and intelligent algorithms to manage commercial vehicles.

**Emergency Management (EM)**

Emergency management is an ITS application that deals with emergency medical services, large and small-scale emergency response, routing of emergency vehicles, and inform travelers of disasters.

**Maintenance and Construction Management (MCM)**

Maintenance and construction management is an ITS application that is used to maintain roadways and manage construction in a region. This includes clearing of snow or road repairs.

**BEST PRACTICES OF ITS IN SELECTED MEGA CITIES**

ITS applications are already applied since mid of 90’s in the world’s largest mega cities. ITS has been used to tackle the challenges that cities are facing and to ease the habitants’ daily lives.

**Singapore**

Singapore's motor vehicle population stands in at an approximate 1 million vehicles of which more than 50% constitutes of cars. Public transportation plays a key role in ensuring the safe and efficient movement of the nation’s population. Singapore has one of the world’s most cost-effective public transport networks in the world. Its transportation system includes bus, rail, road, and water taxi. The city employs a variety of ITS systems to tackle congestion and emissions to efficiently use existing roadways.

**Electronic Road Pricing (ERP)**

ERP uses short range communication system called DSRC to collect toll on certain road ways. This pricing system is levied during peak hours to control the traffic flow in congested areas. In the near future, ERP system is going to change from gantry system to GNSS Technology due to better practicality with an investment of $556 million.

**Electronic Parking System (EPS)**

EPS were introduced to provide a consistent user experience to motorists. It leverages the hardware that facilitates ERP.
It automates parking fees, collection and can accurately count the number of free spaces available in car parks.

**Intelligent Traffic Signals**
The traffic signals are network based and responsive to real-time traffic. It allocates green time based on traffic conditions. It also includes functions to extend the pedestrian crossing time for the mobility-challenged and elderly.

**Automated Vehicle Operations**
In terms of Smart Mobility Singapore has started world’s first autonomous taxi called Robo taxi. It is for a limited region currently within 2.5 square mile around area One North. It is expected to decrease the severity of congestion by lowering the number of vehicle ownership.

**London**

London’s vehicle population at the end of 2016 stood at 3.1 million, of which close to 2.7 million were cars. Congestion costs the economy an estimated £2 billion a year. Public transportation is playing a key role in efficiently moving Londoners today.

London is also a pioneer city in terms of transportation operation data sharing. TfL has committed to open data to serve public transparently and to support the development of startups and small to medium technology companies.

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

**Congestion Zone and Peak Pricing**
Congestion charge is fee imposed on most vehicles for entering a prescribed zone during certain hours of the day. A certain fee is charged for entering the congestion charge zone between 07.00– 18.00 Hrs. on Monday to Friday excluding public holidays.

A peak fare for travelling on certain public rail lines are applied on the peak hours during the work days. This aims to reduce the congestion of these services.

**Traveler Information Systems**
Transport Authority of London (TfL) uses multiple media to disseminate traveler information. For example, it has recently launched a social media TravelBot service in 2017.

**New York**

New York City has a vehicle population of 2.16 million registered vehicles in force. Congestion costed the economy $16.9 billion in 2016. The average American commuter spent 42 hours in peak-hour traffic, whereas a New Yorker lost 89 hours. New York City’s challenges mainly revolve around congestion, traffic accidents and emissions.
**Intelligent Traffic Signals**

New York City upgraded their existing intelligent traffic signal infrastructure to a more advanced system. The new system uses RFID readers and cameras that are used to transmit real-time information to the traffic management center, enabling real-time control of traffic. New York City has implemented the world’s largest traffic signal control system.

**Transit Signal Priority**

Transit Signal Priority (TSP) is a method used to improve bus travel times by prioritizing the traffic signals to reduce the travel time of buses along a corridor.

**Istanbul**

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

As of 2016, Istanbul’s vehicle population was 3.54 million vehicles, of which 2.64 million were cars. The number of people with a driver’s license reached to 5.9 million by the end of 2016.

**Traffic Control Center and Fully Adaptive Traffic Management.**

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

Another ATMS example is fully adaptive traffic management system (ATAK) has been introduced in Istanbul to prevent discontinuation in traffic by arranging periods of traffic signals dynamically with real time intervention, traffic signalization systems are managing highways, connections and tunnels.

**Digital Traffic Density Map and Mobile Traffic App**

The instant traffic density data obtained from Traffic Control Center, the meteorological data obtained from automated road and meteorology surveillance sensors and the infrastructure works information obtained from road networks are processed and presented on Digital Traffic Density Map. Istanbul also has a mobile traffic application that provides traffic information to motorist.

**Electronic Toll System and Smart Ticketing**

There are mainly two different advanced payment options in Istanbul; Electronic Toll System (ETC) in Istanbul is being used. Smart ticketing system that is called Istanbul Card has been introduced in 1995 and it can be used in all public transportation, parking, taxis and certain social services.
TRANSPORTATION IN FUTURE CITIES

INTELLIGENT TRANSPORTATION SYSTEMS & BEST PRACTISES
Transportation is one of the keystones of the modern world. Today with the growing technology and infrastructure, people can travel further and wider. However, the burgeoning of settlements into cities has seen transportation become a challenge than a boon. One of the most widely used forms of transportation; road transport has become heavily regulated to ensure smooth flow of traffic. Naturally cities cannot be extended indefinitely and are constricted by a limited road network while simultaneously urban population has grown exponentially over the last few decades.

The population of the world is currently hovering around 7.5 billion and is increasing at a rate of 1.11%. This equates to an addition of 80 million people per year. Frost & Sullivan estimates that by 2020, about 4.5 billion people would live in an urban environment.

The demand on the infrastructure is immense, as people are commuting further every day to work. Although distance remains the same, commuting time has significantly increased due to congestion. According to Texas A&M Mobility research, the annual delay due to congestion in urban parts of the United States has increased by 25% from 2010 to 2014.

Transportation has evolved from the humble wheel to a complex set of systems that are in place to ensure the efficient movement of people and goods. This transportation conundrum is expected to grow as safer, faster, greener and efficient modes of transportation are required.

Present transportation systems are primarily segregated into road, water, rail and air. Road systems include buses, taxis and private cars. While rail systems include trams, underground and overground services; waterway services include ferries. Air transport includes flights, heli-taxis and cable lifts. All these systems and vehicles are serving the function of most efficient private and public transportation.

Governments are reeling under urbanization and trying to mitigate its effect on transportation by increasing public transportation services as well as imposing congestion charges on private vehicles to counter congestion, reduce travel time, and reduce emissions. Some metropolitan transportation systems have embedded GPS tracking units in buses in order to track that real time and display arrival times at bus stations. However, these are stop-gap measures; a more robust solution needs to be implemented to ensure improved future transportation systems. Private car usage is one of the one of the most common forms of transport, yet it is under-utilized. It transports lesser occupants, and is used only a few hours a day. This phenomenon coupled with millennials preferring shared mobility; this has given rise to new mobility trends.
The mobility is transforming due to on-demand, platform-based systems driven by millennials straying away from traditional ownership models. They prefer a shared mobility model, driven by the proliferation of smartphones. This pushes automotive OEMs towards a transition in the behavior of “car as a service” since it is expected to decrease sales. Rising to this challenge many OEMs have invested in mobility solutions to ensure that they do not lose their presence in the automotive ecosystem.

Future cities are focusing on tackling transportation related problems using an integrated platform that can centrally manage mobility, safety and the environment. A three-tier approach to the right shows the strategic management that overlooks the operative and outstation levels.

New mobility trends involves car pooling, ride hailing, micro mobility and integrated mobility & reporting.
- Car pooling becoming trendy especially in Europe with 23 million registered members make it possible to share long distance trips.
- Ride hailing enables customers to book a taxi or private vehicle booking through smart phones such as Uber and Lyft.
- Micro mobility involves eBikes and bicycles incentives and creating a new business models bundled with other lease products or vehicles such as ALD 6 wheels.
- Integrated Mobility & Reporting on the other hand is a single platform that benefits its customers booking different transport modes via smartphone such as Moovel.
Intelligent vehicles also form a part of future mobility trend, where autonomous taxis will ferry people around. These vehicles leverage a bevy of systems that include artificial intelligence, V2X communication and advanced sensor systems to navigate autonomously.

V2X communication systems allow the vehicle to interact with other vehicles, pedestrians, infrastructure and the network. This enables safe, efficient and greener mobility system.

Forming a single platform that tracks and manages all the existing transportation systems is considered as the common aim by governments to serve better to their citizens. Combining all outstations under different management categories and operate them under an integrated traffic management platform.

One of the most striking examples of futuristic transportation system is a planned levitated pod that is enclosed in a low pressure tube and is accelerated and decelerated using electric motors. The pod travels at speeds of around 1125 KPH, covering the distance between Sydney and Melbourne in 55 minutes as opposed to 4.5 hours by air.

**Urbanization: It’s Impact on Mobility**

Future smart cities are aiming to increase efficiency by reducing time spent in traffic, emissions by developing not only a sustainable but also affordable transport infrastructure. However, the key challenges that need to be addressed to create a sustainable future transportation network are listed below.

**Congestion:**

As population increases, urban cities are sprawling towards suburban areas fast due to limited areas inside the city. However the infrastructure towards suburban areas is not developed as fast as the expansion therefore in terms of work and school needs, people are still connected with city centers which causes daily travel time to increase and create congestion within the city.

For example the top city that driver’s hours spent is congestion is Los Angeles with 104 hours during peak hours according to the INRIX statistics in 2016. The other top four cities dealing with long hours spent in congestion after Los Angeles are Moscow, New York, San Francisco and Bogota cities with 91.4, 89.4, 82.6, 79.8 hours respectively. Except for Moscow and Bogota the hours spent in congestion results even increased compared to 2015 results. One of the worst traffic jams in history occurred in China in 2010, a 62 mile long congestion on the Beijing-Tibet highway lasted for 12 days.

In US, an average cost of congestion to the average driver is $1,400 per year which proves the importance on challenges about congestion issues. The UK department of transportation estimates the average delay is 9 seconds per vehicle per mile (compared to free flowing traffic) in the year ending March 2017.
**Energy and Emission:**
Emission is the environmental concern all over the world due to unlimited pollutants and increasing consumption. Vehicle ownership is also increasing parallel with the population increase and emit considerable amount of pollutant gases that are hazardous to both humans and living bodies. The US Energy Information Administration (EIA) estimates around 80% of the US energy demand are met by fossil fuels. Consumption of fossil fuels has increased; however, this alternative fuel usage might be threatened by resource extinction because the EIA estimates that less than half the world’s fossil fuel reserves would be depleted by 2030.

**Safety:**
Road safety and vehicle safety has always been very crucial in saving lives, in 2015 according to latest WHO statistics still 1.25 million deaths occurred due to traffic accidents. Also according to the EU commission reports in 2016, even though the Europe considered as the safest region in the world with 50 road fatalities compared to 174 fatalities per one million people, a target of more than 50% decrease is aimed by 2020 since 2010.

**Cybersecurity:**
While connectivity increases that are combining smart phones, vehicles and infrastructure together, there stands a higher risk of security in terms of both vehicle safety and increase in vulnerability against outside attacks.

There are around 25 million cars sold as connected cars on the road today; it is expected to increase to 70 million by 2022 according to Frost & Sullivan. Cybersecurity plays a key role in ensuring connected cars are not compromised, leading to dire consequences. Cyber-attacks have become commonplace today and pose a great risk to commuters. Cybersecurity is expected to play a key role across the vehicle life cycle, from manufacturing to end of life.
INTRODUCTION TO INTELLIGENT TRANSPORTATION SYSTEMS

& BEST PRACTICES
WHAT ARE INTELLIGENT TRANSPORTATION SYSTEMS?

**Definition**
The European Commission defines Intelligent Transportation Systems (ITS) as a solution to increase safety and decrease congestion and emissions. It does this by applying information and communication technologies to passenger and freight transport.

Intelligent transportation initiatives are managed by ERTICO in Europe. It is a partnership of public and private companies. It consists of over a hundred partners spanning across eight sectors. It aims to provide a platform where industry participants can collaborate to develop, deploy, and promote intelligent transportation systems.

In the United States, the Department of Transportation (DOT) has formed the ITS joint program office. It aims to create an intelligent transportation network by integrating intelligent vehicles with intelligent infrastructure. ITS America is its leading authority to research, develop, and deploy an intelligent transportation network. It provides a platform where private, public; research and academia players can collaborate. It also educates the public on ITS technologies.

Japan is one of the most advanced ITS country. It’s ITS organization, ITS Japan was earlier known as the Vehicle, Road and Traffic Intelligence Society (VERTIS). According to Vertis, In the near future, ITS systems will arrive that offer fundamental breakthroughs in safety, congestion reduction, driving comfort, and environmental friendliness, bringing them to levels far higher than those provided by current road transportation systems.

**Benefits of ITS**
Intelligent transportation systems are expected to benefit multiple players; they include faster travel time for commuters, better city management for city councils, a safer commute to citizens and reduced fuel consumption. Although implementing these systems is extremely expensive, they are amortized over multiple avenues including reduced fuel imports, reduced accidents and fatalities, increased efficiency of public service departments such as garbage disposal, police departments and so on. It also increases driver comfort and reduces cost of road maintenance. These benefits are expected to increase the economic attractiveness of the cities because of increased work efficiency.

**What does each application do? What challenges does it help overcome?**
Application Areas of ITS can be investigated under 7 main categories as shown below.
- Advanced Traffic Management Systems (ATMS)
- Advanced Public Transportation Systems (APTS)
- Advanced Traveler Information System (ATIS)
- Advanced Transport Pricing Systems (ATPS)
- Commercial Vehicle Operations (CVO)
- Emergency Management (EM)
- Maintenance and Construction Management (MCM)

**Advanced Traffic Management Systems (ATMS)**
Advanced traffic management systems manage congestion dynamically. It increases the efficiency of utilization of existing infrastructure, by using intelligent systems.

*http://www.winion.us.edu.pl/sites/default/files/WSPOLPRACA/Art_2012_02.pdf*
These systems monitor both recurrent (rush hour traffic) and non-recurrent (congestion due to accidents, stalled vehicles) traffic conditions and dynamically control the flow of traffic to reduce congestion.

In order to work efficiently, ATMS require a control mechanism, sensors, communication, data collection, manipulation, and algorithms.

- Control mechanisms include traffic metering methods that include traffic lights, lane signals, traffic information and visual message systems.
- Sensors act as the input for the intelligent traffic systems they include cameras, vehicle probe data and radars.
- Communication systems include vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication systems. These systems enable seamless communication between vehicles and between vehicles and the infrastructure.
- Data collection and manipulation includes collecting data from different sources and fusing them. It also aids in understanding traffic congestion patterns to mitigate traffic congestion.
- Algorithms enable accurate predictions of traffic congestion from the data collected.

The most common applications under ATMS are traffic signal control, traffic incident management systems, traffic metering and variable speed limit panels.

**Traffic Metering:**
Traffic metering is one of the strategies to control congestion; this is applied in various points in the infrastructure including highway onramps. The highway onramp metering system uses congestion data collected from highways and uses dynamic traffic signals to meter the flow of traffic into the highway. If the system senses congestion due to a stalled vehicle on the highway, it will automatically activate onramp signals and meter the flow of traffic to reduce congestion.

**Variable Speed Limits:**
Variable speed limit signs are used as part of dynamic speed limit strategy to adjust speed limits in real-time according to prevailing conditions. These conditions include traffic flow, congestion, and weather. Variable speed limits can be enforced on a segment of roadway or individual lanes. This information is transmitted to motorists using visual messaging systems or with V2I systems the information can be sent directly to the car.
**Advanced Public Transportation Systems (APTS)**

APTS is a collection of technologies aimed at improving safety, reliability, and efficiency while reducing commuting time of public transportation systems, thereby reducing congestion and emissions. It offers key advantages to supervisors such as real-time location tracking, accident/event information, driver and vehicle monitoring.

**Transit Signal Priority:**
Transit signal priority systems modify traffic signal phasing/timing to prioritize the movement of in-service transit vehicles, such as buses, trams, and emergency vehicles. This reduces the time spent at traffic intersections increasing quality of transit services. These benefits are provided with a minimum impact to other road users.

**Advanced Traveler Information System (ATIS)**
ATIS is one of the most common ITS services, aiding the transportation of travelers from their origin to their destination. Information about weather, traffic congestion, delays, and accidents are disseminated through the media, Internet, visual messaging, and public announcement systems. This allows travelers to plan their journeys and make informed decisions that allow them to reach their destinations more efficiently. This leads to reduced congestion and emissions as travelers are using the most efficient route to reach their destinations.

Traditionally traveler information used to be sourced from physical maps, print brochures, and call centers. With the advent of ITS, traveler information is gathered from websites, online maps and mobile applications that offer real-time information on traffic, diversions, lane closures, and delays.

**Dynamic Ridesharing:**
Dynamic ridesharing offers more flexibility than conventional programs. Riders can request a one-time trip at short-notice by leveraging GPS, Internet, and social networks algorithms are able to match riders with drivers. The average car occupancy rate for trips in the United States is 1.6 persons; dynamic ridesharing reduces congestion and emissions.

**Advanced Transport Pricing Systems (ATPS)**
ATPS are used as a method to control congestion in general context and serve also in public transportation areas. Intelligent pricing systems can be a toll collection, congestion pricing, vehicle mile travel or electronic payment collection.
One of the types include electronic road pricing (ERP) uses a pay as you use system that charges motorists for entering certain zones during certain hours denoted as congestion times.

This similar approach is also applied to public transport, where using trains or buses during certain hours would attract a higher fare. This is used to reduce congestion in public transportation systems. The system enables tracking the frequency of the ERP road usage and charge accordingly higher.

The charges can be paid in advance or using short range communication systems that deduct charges in real-time when entering congestion zones. This reduces vehicle traffic mitigating congestion. Most common technologies used in ATPS are Video Tolling (ANPR), Dedicated Short-Range Communication (DSRC), Radio-Frequency (RFID) and Satellite Positioning (GNSS).

**Commercial Vehicle Operations (CVO)**

CVO is an ITS solution for commercial vehicles that aids in the efficient management of commercial vehicle operations. It leverages GPS locations along with digital radios and intelligent algorithms to manage commercial vehicles.

**CVO Fleet Maintenance:**

Fleet maintenance monitors the vehicle condition using telematics. The vehicle sensors feed information to the onboard telematics unit; once an error code is generated the driver and the fleet manager are informed.

It finds uses in oil and gas, healthcare, transportation, government, energy and manufacturing. The benefits include increased asset life, improved asset visibility and control and downtime management. It increases the safety and efficiency of operations.

**Emergency Management (EM)**

Emergency management is an ITS application that deals with emergency medical services, large and small-scale emergency response, routing of emergency vehicles, and inform travelers of disasters.

**Early Warning System:**

The sensors deployed in smart cities can be used to provide an early warning to detect large-scale emergencies such as natural disasters (earthquakes, tsunamis and so on) or also man-made disasters such as terrorist attacks and nuclear power plant accidents. ITS such as cameras and other sensors are used to detect disasters.
Maintenance and Construction Management (MCM)

Maintenance and construction management is an ITS application that is used to maintain roadways and manage construction in a region. This includes clearing of snow or road repairs. This also includes maintenance of the fleet of vehicles for maintenance. It also constantly monitors roadways, walkways and other infrastructure to ensure upkeep. It manages safety and other functions in construction zones.

Work Zone Management

One of the key functions of this subset includes work zone management. The frequency of accidents at a work zones are significantly higher. Thus safety of workers, pedestrians, cyclists and motorist is high priority. Thus sufficient information about construction/road closures is sent in advance. The speed reduction zones and sufficient warning boards are installed.

Working on highway construction projects is one of the more hazardous work environments. The risk of being struck by a vehicle traveling through a work zone increases with higher traffic volumes and speeds. Long delays can sometimes cause motorists to become impatient and act unpredictably. This subset should consider the risks faced by workers when developing a work zone management plan. This subset of ITS also covers the management of road weather and treatment of roadways during adverse weather conditions.
BEST PRACTICES OF ITS IN SELECTED MEGA CITIES

INTELLIGENT TRANSPORTATION SYSTEMS
& BEST PRACTISES
SINGAPORE

An island-city state has a population of 5.35 million as of 2015 (World Bank), and covers a land area of 718 square kilometers. Singapore’s total road network spans along 3,496 kilometers (as of 2014), that includes expressways, arterial roads, collector roads and local roads. This occupies up to 12% of land, in a small island nation*.

Singapore’s motor vehicle population stands in at an approximate 1 million vehicles of which more than 50% constitutes of cars. Public transportation plays a key role in ensuring the safe and efficient movement of the nation’s population.

Singapore has one of the world’s most cost-effective public transport networks in the world. Its transportation system includes bus, rail, road, and water taxi.

One of the main challenges faced by Singapore is transporting its growing urban population with its existing road network. Lack of physical space restricts the expansion of the road network.

Intelligent Transportation Solutions:

Singapore employs a variety of ITS systems to tackle congestion and emissions to efficiently use existing roadways.

Advanced Traffic Management Systems:

Electronic Road Pricing (ERP)

One of the systems used is electronic road pricing (ERP) system. It uses short range communication system called DSRC to collect toll on certain road ways. This pricing system is levied during peak hours to control the traffic flow in congested areas.

In the near future, ERP system is going to change from gantry system to GNSS Technology due to better practicality. With an investment of $556 million, ERP will allow motorists to be charged also according to the road they travelled not only to the specific road usage. Also the existing inboard units are improved to onboard units, these units can be used to pay parking fees and checkpoint tolls.

Advanced Traffic Management Systems:

Electronic Parking System (EPS)

EPS were introduced to provide a consistent user experience to motorists. It leverages the hardware that facilitates ERP. It automates parking fees collection and can accurately count the number of free spaces available in car parks. This is paired along with the parking guidance system (PGS), a visual messaging service that displays to road users the free parking spaces available in three key zones that include Marina, Orchard, and Harbor front areas.

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* https://www.lta.gov.sg/content/dam/ltaweb/corp/PublicationsResearch/files/FactsandFigures/Road Length-km.pdf
**Advanced Traffic Management Systems: Intelligent Traffic Signals**

The traffic signals are network based and responsive to real-time traffic. It allocates green time based on traffic conditions. It also includes functions to extend the pedestrian crossing time for the mobility-challenged and elderly.

The residents with mobility challenges and the elderly receive a card that allows them to extend the pedestrian crossing time, to ensure that they can cross safely.

Implementation of intelligent transportation systems has reduced congestion and increased average car speed to 27 km/h compared to London (16 km/h), Tokyo (11 km/h) and Jakarta (5 km/h)*.

Singapore’s ITS vision is “Moving towards a more connected and interactive land transport community”. In order to achieve this vision it plans to adopt three broad key strategies around four key focus areas. Those areas are informative, interactive, assistive and green mobility.

**What is Next?**

In terms of Smart Mobility Singapore has started world’s first autonomous taxi called as Robo taxi. It is for a limited region currently within 2.5 square mile around area One North. It is expected to decrease the severity of congestion by lowering the number of vehicle ownership. The taxis are developed by Renault and Mitsubishi EV and software by company called nuTonomy surrounded by 6 set of laser radars around the vehicle that gives flexibility to maneuver like a human.

**LONDON**

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

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

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* http://www.c40.org/profiles/2013-singapore
* https://www.lta.gov.sg/content/dam/ltaweb/corp/RoadsMotoring/files/SmartMobility2030.pdf
* Department of Transport, London
London’s public transportation system is managed by Transport for London (TfL). This includes buses, underground, Docklands Light Railway, London River Services, Tramlink and London Overground. London faces similar challenges to other mega cities such as an increasing population and congestion.

However, it is also focusing on reducing emissions and creating a sustainable and affordable transportation network.

**Intelligent Transportation Solutions**

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

**Advanced Public Transportation Systems: Smart Ticketing**

As the adoption of public transportation increased, the congestion caused due to purchase and checking of tickets increased. The TfL introduced a smart payment card called Oyster in 2003 that allowed public transport users to tap in and out when using transportation services. Over 85% of all tube and bus travel is paid with an Oyster card. Customers can top up their balance in stations, shops, or over the Internet. Through the use of Oyster cards the TfL has reduced the costs associated with producing tickets by 5 percent.

In December 2012, TfL announced the acceptance of contactless debit/credit cards and is accepted across all TfL networks and in 2014 NFC technology by mobile phones was introduced.

**Advanced Transport Pricing Systems: Congestion Zone and Peak Pricing**

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

TfL charges a peak fare for travelling on Tube, DLR, London Overground, TfL rail and National Rail services in London. This charge applies from 0630 – 0930 and 1600 – 1900 hours from Monday to Friday excluding public holidays. This is to reduce congestion on these services during peak hours.

**Advanced Traffic Management Systems:**

Variable speed limits are introduced on roads and motor ways to control congestion, and increase safety of road users during adverse weather conditions.
**Advanced Traveler Information System: Traveler Information Systems**

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

TfL also displays real-time bus information at bus stops and on mobile applications. It has also trialed a new bus occupancy technology that informs riders as to the number of free seats available in the upper deck.

London’s cycle hire scheme ‘Santander Cycles’ has launched a new mobile application that allows cyclists to find which of the 750 docking stations have a free space available.

**What’s Next?**

**London Infrastructure Plan 2050**

It is the first ever attempt to identify, prioritize and cost London’s future infrastructure plan to support future growth. The plan outlines issues, challenges and focuses on financial, environmental, social and economic sustainability. The plan covers transport, infrastructure, connectivity, energy, and housing.

London is also a pioneer city in terms of transportation operation data sharing. TfL has committed to open data to serve public transparently and to support the development of startups and small to medium technology companies. It is basically increasing investment in transportation for example parking space data to journey planners, google maps data for tube stations in that way people can leave cars and use tubes whenever necessary.

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**NEW YORK CITY**

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

New York City has a vehicle population of 2.2 million registered vehicles in force. Congestion costed the economy $16.9 billion in 2016 and is the second most congested city in the United States. The average American commuter spent 42 hours in peak-hour traffic, whereas a New Yorker lost 89 hours*.

The majority of public transport systems are managed by the Metropolitan Transport Authority (MTA), the largest regional transportation system in the western hemisphere. It manages buses, rail, rapid transit routes, seven toll bridges and two tunnels. It transported an average weekday 5.7 million riders by subway in 2016.

New York City’s challenges mainly revolve around congestion, traffic accidents and emissions. Average bus speeds on arterial roads are at 16 kph.

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

Advanced Traffic Management Systems: Intelligent Traffic Signals
New York City upgraded their existing intelligent traffic signal infrastructure to a more advanced system. The new system uses RFID readers and cameras that are used to transmit real-time information to the traffic management center, enabling real-time control of traffic. New York City has implemented the world’s largest traffic signal control system that boasts over 12,000 advanced solid state traffic controllers, more than 60 RFID reader sites, 210 remote traffic microwave sensor vehicle detectors, and 400 traffic video cameras and can manage 16,000 intersections.

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

In 2016, New York City Department of Transportation prepared 2016 ITS Strategic Plan for the city. Emerging Technology Readiness is one of six actionable areas identified as part of plan, that focuses on horizon searching; figuring out how to adopt new technologies, what should change operationally or organizationally, and what level of adaption or adoption is needed.

Focused new technologies as part of the Emerging Technology Readiness strategic area are below;
• Connected Vehicle Technologies
• Integrated Corridor Technologies
• Autonomous Vehicle Technologies

The USDOT is implementing ITS connected vehicle pilot across the United States; one of the locations for the trial is New York City. The deployment program is accelerating the adoption of connected vehicles and automation. New York City is also contemplating the implementation of a congestion pricing system, to control congestion.

The NYCDOT will deploy CV technology at approximately 250 intersections in Midtown Manhattan and central Brooklyn will be instrumented with Roadside Equipment (RSE) to communicate with up to 10,000 vehicles with aftermarket safety devices (ASD). The RSE will also be deployed along a highway, namely, the FDR drive. The instrumented vehicles include approximately:
• 6,000 Taxis - Yellow Cabs (Authorized for “hail” fares in lower Manhattan and airports.)
• 1,500 MTA Buses – which frequent lower Manhattan
• 500 Sanitation & DOT vehicles servicing Manhattan
• 500 UPS vehicles servicing Manhattan

Advanced infrastructure that will be useful in enabling the CV pilot in NYC include:
• 350 Signalized Intersections with CV technology – already “Advanced Traffic Controllers”
• Megabit Wireless communications backhaul covers all 5 Boroughs
• Extensive fiber network for backhaul at key locations
• Central system that integrates all traffic signal and ITS devices City-wide
The population of Istanbul had reached 14.8 million in 2016. The city has been depicted as Europe’s only megacity, has reached nearly 99% urbanization rate while Turkey’s overall urbanization rate is around 74% according to World Bank Statistics. Urbanization brought different modes of commuting alternatives to the Istanbul. Road transportation involves BRT, buses, minibuses, taxis and shared taxis, work & school services.

As of 2016, Istanbul’s vehicle population was 3.5 million vehicles, of which 2.6 million were cars. The number of people with a driver’s license reached to 5.9 million by the end of 2016. Topographically, Istanbul Straits divides Asian and European Continent as well as Istanbul City. The city lies on Europe and Asia which both have residential, work and school settlement, therefore a frequent travel with approximately 480,000 vehicles daily crossing from the 3 bridges connecting continents and 35,000 vehicles crossing via Eurasia Tunnel that is submerged under water, opened in 2016.

Existing transportation infrastructure also involves, 52 km bus rapid transit line built for metrobus that passes through one of the bridges crossing Bosphorous. Metrobuses are carrying around 900,000 people daily in Istanbul and made 21 people out of 100 people to give up personal cars. About 86% of the passengers in total are commuted via road transportation.

Another way of transportation between continents is seaway, in total 566,000 passengers are carried daily. Seaway involves ferries, intercity sea buses with very frequent schedules.

Railway infrastructure is also one of the most developing mode of transportation in Istanbul, roads and seaway are integrated with railway transportation that is 150 km long and planned to be reach 449 km by end of 2019. All these three road, rail and sea commuting alternatives are carrying daily around 12.7 million public transport and 7.8 million private transport passengers.

Connection between road, rail, and seaway has been developed tremendously in the last few years due to mega projects that are completed

- **3rd Bosphorous Bridge;** which is the widest suspension bridge in the world with 59 meters. The bridge is now on use and a rail system has planned to be constructed in the near future. The rail system will be connecting Marmaray (undersea railway), metro, two existing airports and third airport that are going to be built.

- **Marmaray,** a 13.6 km long rail line submerged under the Bosphorus connecting between Asia and Europe. This mega project has connections with existing metro infrastructure and bus lines.

- **Eurasia Tunnel,** a 14.6 km long road tunnel submerged under the Bosphorus decreased the journey between two continents on the highly travelled D100 Highway connecting main roads used by private cars, taxis and minibuses.
CHALLENGES IN ISTANBUL

Population in Istanbul has grown by 8.7% since last 5 years. Moreover, the number of vehicles on the roads has also reached to 3.5 million as of 2016 from 2.7 million in 2011.

**Congestion:** In a city as metropolitan as Istanbul, traffic volumes are increasing and leading to congestion on both main and side roads. Especially in the peak times, travel times are extended a lot, safety in traffic is disrupted and hazardous emissions are being exposed heavily. As a result, the authorities search for the best way possible to enhance traffic flow with optimum solutions to expand the road network.

The traffic flow is basically handled through three main arteries. However, all these roads are subject to slow downs and disruptions due to many connections and cannot serve as a transit route. Below image depicts the main highways of Istanbul.

In a city as metropolitan as Istanbul, traffic volumes are increasing and leading to congestion on both main and side roads. Sprawl towards suburban areas is happening for also Istanbul, however to go to work, school and hospitals in emergency situations the facilities are existent in the city centers this leads to increase in travel time and create congestion in the peak hours. Istanbul currently consume 58.6 hours in traffic in the peak hours according to 2016 INRIX results, 17th city that is living congestion related delays globally. However, Istanbul has improved its rank in TomTom Traffic Index to 6th in 2016, from 1st place in 2014 by lowering congestion level to 49% from 58%.

**Topography:** Topographically, Istanbul has a unique challenge toward uninterrupted traffic flow also because of being located in between two continents Europe and Asia. The challenge stems from the fact that many people have to cross bridges while commuting to work every day.

**Parking:** Parking on the other hand is another challenge in Istanbul due to limited area. Drivers in Istanbul spend a considerable amount of time searching for a parking area. According to June 2017 figures, there are 3.6 million registered vehicles in Istanbul city. As a result, available parking locations are hard to find special and considerably expensive is the city center. This is causing both time and total cost of ownership of the vehicles next to the fuel and repair costs. Considering vehicles take their 90% of time in parking of their lifecycle, the infrastructure and systemized solutions are very important for a mega city Istanbul.

**Construction Sector:** In 2016, the Turkish economy has grown at rate of 3.5% and it helped the growth of the construction sector simultaneously; not only construction of mega projects but also housing and shopping mall projects. Besides, there is an initiative based on Istanbul for urban transformation that targets old buildings to be renewed and replaced by new ones. However, this construction growth causes road blockage and management problems due to higher amount of heavy commercial vehicles to be on roads.
Logistics: Mid and heavy duty trucks are representing the 18% of the number of total vehicles per day on the roads. Even though there is a regulation for commercial vehicles to be prohibited from main highway and its connecting roads in hours between 6-10 am and 16-22 pm except 3rd bridge and highway, it is still affecting traffic management in permitted hours.

Safety: In 2016, there had been 16 thousand accidents involving death or personal injury and 32 thousand accidents resulting in material damaged according to Security General Directorate statistics in 2016.

Technology Integration & Cybersecurity: The biggest challenge of all is that all aforementioned challenges should integrate into a single platform to work integrally. Adoption of different technologies and systems that are incapable of co-operating is increasing the magnitude of this challenge. The integration of different transport modes, different vehicles and infrastructure mainly evolved as V2X systems are quite challenging due to arising of several connected problems such as cybersecurity, big data analysis, and its correct interpretation.

As solutions to above challenges in Istanbul, tracking of existing behavior of traffic has been evolving fast and creating innovative models for changing circumstances during the past few years. It is a medium to long term process to reach goal of efficient, safe, and environment friendly transportation.

Advanced Traffic Management Systems (ATMS)
Signalization is one of the key elements of advanced traffic management systems. With the stable growth in total number of intersections over the last 15 years, the number reached to 2,142 by 2016 which are working via signalization in multi plan, demand-base reactive, dynamic, flash and adaptive modes. All signalized intersection points located in the city of Istanbul are kept on the geographic information system and can be monitored and managed online through the intersection control system and the Traffic Control Center (TKM) http://tkm.ibb.gov.tr/en.

The functional features of control systems in Istanbul are as below:

- Monitoring city traffic in real time,
- Immediately receiving traffic density information,
- Real-time monitoring and management of signalized intersections,
- Providing visual and audio information of traffic intensity
- Informing the drivers in the traffic of instantaneous changes,
- Providing traffic and road status information to users via web and telephone,
- Monitoring of regional traffic conditions
- Conformity to e-transportation concept
- Route to alternative routes with information on the right time

KEY ITS SOLUTIONS IN ISTANBUL

To overcoming Istanbul city traffic challenges the application of ITS was introduced in the late ‘90s and has been improved since. ITS applications in Istanbul nearly all the ITS areas that are globally available.
In order to such management, Istanbul is using different ITS components such as cameras, traffic enforcement systems (EDS), detectors and bluetooth sensors.

<table>
<thead>
<tr>
<th>ITS components</th>
<th>Number of ITS components in Istanbul, 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>761</td>
</tr>
<tr>
<td>Tunnel Camera</td>
<td>455</td>
</tr>
<tr>
<td>EDS</td>
<td>439</td>
</tr>
<tr>
<td>Detector</td>
<td>863</td>
</tr>
<tr>
<td>Bluetooth Sensor</td>
<td>419</td>
</tr>
</tbody>
</table>

In 2010, full adaptive traffic management system (ATAK) has been introduced in Istanbul to prevent discontinuation in traffic by arranging periods of traffic signals dynamically with real time intervention. Currently, ATAK is providing fuel and time saving equivalent of 37 million USD yearly.

After ATAK started its operation in 2013 in one of the connections, improvements are stated as such:

<table>
<thead>
<tr>
<th>Improvement Parameter</th>
<th>After ATAK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>20% decrease</td>
</tr>
<tr>
<td>Delays</td>
<td>30% decrease</td>
</tr>
<tr>
<td>CO Emissions</td>
<td>18% decrease</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>15% decrease</td>
</tr>
<tr>
<td>Average Speed (in congested area)</td>
<td>35% increase</td>
</tr>
</tbody>
</table>

Traffic detection systems (TEDES) and Tunnel Control Centers are the other key ATMS applications widely used in Istanbul. The traffic enforcement systems (EDS) are installed in 439 points and it’s breakdown by different types can be seen in below table.

<table>
<thead>
<tr>
<th>EDS Type</th>
<th>Number of Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Light Enforcement</td>
<td>155</td>
</tr>
<tr>
<td>Hardshoulder Enforcement</td>
<td>97</td>
</tr>
<tr>
<td>Parking Enforcement</td>
<td>89</td>
</tr>
<tr>
<td>Speed Enforcement (Corridor)</td>
<td>40</td>
</tr>
<tr>
<td>Reverse Direction Enforcement</td>
<td>18</td>
</tr>
<tr>
<td>Tram Lane Enforcement</td>
<td>16</td>
</tr>
<tr>
<td>Mobile Enforcement</td>
<td>11</td>
</tr>
<tr>
<td>Offramp Enforcement</td>
<td>6</td>
</tr>
<tr>
<td>Pedestrian Crossing Enforcement</td>
<td>3</td>
</tr>
</tbody>
</table>

**Advanced Traveler Information Systems (ATIS)**

The instant traffic density data obtained from Traffic Control Center, the meteorological data obtained from automated road and meteorology surveillance sensors and the infrastructure works information obtained from road networks are processed and presented on Digital Traffic Density Map.
The generated map is published via the Web, enabling drivers and passengers to be directed to alternative routes for economical and comfortable travel.

This map is also available on mobile platforms which are IBB Mobile Traffic on IOS and Android applications that provide traffic information in 530 points within Istanbul. This has been downloaded by 9.9 million users as of 2017.

IBB has also developed a mobile navigation application for all transportation modes from private cars to mass transportation which provides information about Istanbul’s all ITS applications such as traffic cameras, closed road segments, traffic estimation for next 60 minutes and so on. It has been downloaded by approximately 600,000 users following its release in 2017.

Beside that to solve parking problems, a mobile application has introduced to show empty parking spots in the parking lots that are close or around streets in a pilot region and expected to expand into other regions of Istanbul.

**Advanced Public Transportation Systems (APTS)**

APTS in Istanbul covers multimodal coordination, transit vehicle tracking, real time location tracking, informing passengers on stations about location of vehicles, fare collection through an electronic system.

At the bus stations, there are electronic panels showing the bus timelines. Expected arrivals of buses to the specific stop are possible to track, thus making it easier for passengers to plan their route even during heavy traffic.

Istanbul card a fore mentioned electronic payment system. This is an electric card working with radio signals (RF). Istanbul card can be used in nearly all modes of public transport such as road, rail and seaway. First electronic card used in 2011, now serving to 20 million electronic card holders. Istanbul Card has been also used for parking payments, taxis and other social services.

Also for taxis iTaksi is developed by ISBAK (Istanbul IT and Smart City Technologies Inc.) for the IBB and is operated by ISPARK on behalf of the IBB.

iTaksi membership is mandatory for all Istanbul taxis and taxi drivers. Installation of iTaksi equipment (the iTaksi tablet, security camera and a panic button for the driver) on the vehicles has started and all Istanbul taxis will be equipped with iTaksi system.
Advanced Transportation Pricing Systems (ATPS)
Electronic Toll System (ETC) in Istanbul is being used on highways and bridges connecting Bosphorus. The automated toll collection system is active since 1999. It has been improved since and changed couple of times to serve better without disrupting the traffic. As of 2017, multilane free flow ETC systems are introduced on several points.

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

Other application of CVO is roadside inspection stations that are built to inspect weight recognize plates and inform drivers to drive safely under the highway regulations.

As of 2016 December, number of M2M members was 4 million all over the country. An M2M connection basically connects vehicles with a simcard and collects location through GPS satellites, vehicle sensors such as fuel consumption and sends it to operating body.

In addition, it has the regulation that gives digital tachographs mandatory helps to track working hours and also helps to drivers to check their route via GPRS integration. Since 2007, earth-moving trucks of city are mandated to have telematics devices and are monitored by IBB. There are around 10,000 trucks are monitored through this regulation.

This is necessary especially for school buses and work services. To address and overcome the logistic and construction challenges in the growing Istanbul economy, partnership with telecommunication companies enables M2M connections all over Turkey.
The world’s urban population has increased rapidly in the 21st century which is projected to reach two-thirds of the total by 2050 and this brings numerous challenges to cities, in meeting the needs of their growing populations. Among them, transportation becomes one of the major topics as it directly impacts the citizen life quality. The city governments have adopted many new solutions, evolving in parallel to technological advancements and they are continuously seeking innovative improvements to transportation quality. And as the transportation problems get more and more complex the urge to implement intelligent solutions becomes inevitable.

Along with construction of new roads, bridges and tunnels, Intelligent Transportation Systems (ITS) are key to address transportation related challenges and in all over the world, from smallest to mega cities, new systems are being installed to manage transportation. The use of ITS is not only improving the quality of transportation in cities, but it also contributes to the economic progress.

Aiming to show the examples of global best practices of intelligent transportation systems, in this whitepaper, Frost & Sullivan has selected cities from 3 different continents such as London, New York, Singapore and Istanbul. Frost & Sullivan analysed the transportation policy and practices of these cities in order to understand how they oversee these challenges and what intelligent transportation system best practices do they implement. In all of the cities analysed, ITS is classified under different categories varying from traffic management, public transportation, traveller information to pricing systems, commercial vehicles operations, emergency management to maintenance and construction management. Each category has major benefits to cities’ transportation challenges such as improved safety, better traffic flow, lower transportation cost, better environmental quality, increased business activity, greater user acceptance, better planning information and better travel information.

Among the cities analysed within this whitepaper, Istanbul is one the most vulnerable cities to transportation and traffic challenges, being the only mega city of Europe with its 15 million population and 99% urbanization rate. In the last decade, vast amount of investment have been made by the city government, not only on the mega projects such as 3rd Bosphrous Bridge, Marmaray and Eurasia Tunnel, but also on intelligent transportation systems – which had started with signalization in mid 90s and today became one of the world’s best practices. Istanbul is using wide range ITS applications and technologies in the most effective way to improve transportation quality and safety for their citizen.
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ABOUT ISBAK:

ISBAK Istanbul IT and Smart City Technologies Inc. has been established by the Istanbul Metropolitan Municipality in year 1986 with the purpose of providing project design and implementation services through traffic and system engineering.

ISBAK is one of the leading Smart City solution providers in Turkey. As a subsidiary of Istanbul Municipality, its solutions serve more than 15 million people living in this city. The company now aims to transfer its 30 years experience in Intelligent Transportation Systems (ITS) into Smart City solutions and become ‘Architect of Smart Cities’ in Turkey and in the World.

ISBAK believes that each city has different problems which require different solutions. In line with this, the company help cities be smarter and more resilient by providing solutions tailored to their specific needs. ISBAK also offers consultancy services and carry out R&D activities to continually improve its offerings.

ISBAK offers a broad range of Smart City solutions in Turkey and abroad:

- Intelligent Transportation Systems
- Transportation Planning and GIS
- Safe City Management System
- Smart Lighting System
- Tunnel Management System
- Fleet Management System
- Consultancy for Smart City Transformation
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