Defining R&D needs for ITS implementations in cities

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Executive summary

The review of ITS (Intelligent Transport System) applications in other continents has showed that Safety and Environmental issues are among the most relevant topics addressed. In particular, Safety objectives, e.g. safety applications related to vehicles, infrastructures, and human, are present in all the ITS strategies across the world areas. These conclusions are consistent with the cross country comparison carried out by the SAFER project [1], which outlined the importance of Safety issues in Europe and US.

Supporting the integration of transport modes (i.e. favouring inter-modality) and improving transport management are the two other ITS objectives lagging behind Safety and Environment. Curbing congestion and improving the public transport system are the next ITS objectives to rank in the higher positions, in particular in Japan [1].

Concerning the type of technologies, the analysis shows that the technologies favouring the integration of information, e.g. wireless technologies, broadcasting technologies, etc, seem to represent the new frontier for ITS applications (in US, Japan and Korea).

It should be stressed that the countries in which Intelligent Information Systems play an important role (e.g. Japan, Korea) view ITS as one component of a suite of IT (Information Technologies) applications or infrastructures which are deemed to transform their societies in a broader sense, i.e. supporting mobility, communication and increasing economic growth. As a consequence, these countries have designed consistent long-term policies and strategies for digital transformation in general and ITS development in particular, putting them on the top list of national priorities. The urban and metropolitan areas have consequently benefited of all that, in particular in terms of higher modal shifts towards public transport.

It is worthwhile to note that the other countries lagging behind in ITS applications, e.g. China, are embarking in ITS strategies along these paths. More specifically, in fast developing countries as China and India, Intelligent Transport Systems applications in the highly congested urban areas are primarily designed to improve the shift of passengers to public transport (through better information, connections, multi-modality, public transport prioritization and transport planning).
The comparison of **ITS architecture** shows that the in the most advanced countries the ITS architecture is more detailed and open to take into account the most technological developments.

In the European case, similar in that to the US, the ITS architecture must ensure that the local actors (at country and local level) can be part of the system, ensuring standardization.

The comparison of **technological trends** shows shown that the countries with stronger tradition in ITS developments are investing in new generation of vehicle-to-Infrastructure Integration and vehicle-to-vehicle integration.

Wireless technologies, favouring ubiquitous connectivity, multiplex broadcasting, location-based tracking feature in GPS-enabled phones to access a Web sites (that presents a list of available public transportation options) are at the forefront of the technological trends in the most ITS developed countries.

The consideration of the **organizational and political factors** stresses that the degree of centralization in ITS decision-making authority may be one the most important policy factor for the success of ITS applications.

The implication for Europe is that the complex structure of the EU compared to the federal States or small countries, may raise organizational challenges, in particular as far as the co-ordination with stakeholders and the standardization of ITS applications are concerned. The situation at urban level confirms the need for standardization. How to match the need for standardization (which means similar services for the European citizens at similar costs) with the local (urban) responsibility for urban mobility policies represents one of the key challenges to be faced.

The lessons drawn from the success stories of Japan and South Korea teach that the potential of ITS can better be realized if the deployment in Europe is realized along the lines of more integration, targeted investments (R&D) and standardization. For the European urban areas it will be important to ensure the consistency of the ITS applications (to be supported according to the subsidiarity principles) with the framework objectives and the technical requirements (standardization) as outlined in the ITS Directive 2010/40/EU.
1 Introduction

The report is structured as follows: the worldwide review of ITS applications is carried out in the chapter 2. Given the broad geographical scope, it must be stressed that this review cannot be considered exhaustive. The review takes as reference the worldwide breakdown in homogeneous world regions as developed by the OECD/ITF, which in its analysis of worldwide trends in CO2 emissions from transport classifies the following regions:\(^1\):

- EU Area (EU15 plus Accession countries, Candidate countries and New Member States)
- North America (Canada, Mexico and United States)
- Asia Pacific Area (Australia, Japan, Korea, New Zealand)
- 10 top-ten CO2 emitting countries non OECD Area (China, India, Iran, Indonesia, South Africa, Brazil, Saudi Arabia, Thailand, Kazakhstan)

Therefore, the ITS worldwide review focuses on USA, Australia, Japan, Korea, New Zealand, India, China.

The chapter 3 analyses the cross-country comparison, focusing on how much the countries are committed to use ITS applications and for which types of ITS objectives. The countries in which there is a strong tradition in using ITS applications, e.g. Japan, Korea, the US and recently China, are expected to address a wider range of objectives compared to the countries in which the commitment towards ITS applications is more recent (Australia, India and New Zealand).

The chapter 4 discusses differences and commonalities between the ITS solutions adopted in Europe and at world-wide level focusing on three aspects:

1. The ITS architecture (national level)
2. The ITS applications (technological trends), viewed in perspective (local and metropolitan level)
3. The organizational context, with reference to the R&D expenditure (national level)

\(^1\) The report is “Greenhouse gas reduction strategies in the transport sector”
1.1 The methodology adopted in this report

This Deliverable aims at reviewing the ITS applications in non-European countries, providing a world-wide overview of ITS solutions. The methodology for carrying out the review is shaped by the COUNDUITS general aims. In particular, by the others, the following objectives are relevant:

- to analyze the objectives behind the implementation of ITS applications for the management of urban traffic control
- to analyze the tools whereby the ITS applications are implemented
- to formulate hypothesis on future development of such applications

The sources of the review are mainly represented by governmental plans, metropolitan and urban transport plans, experts communications and dedicated web sites on ITS applications, addressing the use and the development of ITS applications often tested by metropolitan and urban actors.
2 ITS research in other continents

This chapter reviews the ITS applications at urban and metropolitan level outside the European geographical boundaries. The wide geographical scope of the review and the several approaches according to which the ITS applications can be reviewed, e.g. focusing on business systems and architecture, strategy and organization, etc, make necessary the preliminary definition of the analytical framework of the review, whereby the aims and the limitations of the ITS review are clearly identified.

The framework of the review is shaped by the CONDUITS general aims. In particular, by the others, the following objectives are relevant:

- to analyze the objectives behind the implementation of ITS applications for the management of urban traffic control
- to analyze the tools whereby the ITS applications are implemented
- to formulate hypothesis on future development of such applications

Moving from that, the conclusions about which type of insights for the development of R&D need for European cities will be drawn.

The implication arising from the CONDUITS general aims is that the review of ITS applications outside Europe mainly focuses on the identification of ITS objectives and tools, with a view on their long-term development and their implications for the R&D needs. This framework will also allow to address one of the main task of the analysis: the comparison with the European case, which has been basically conducted (see the Deliverable 2.2) through the understanding of the objectives and tools in implementing ITS applications in the main European cities.

The sources of the review are represented by metropolitan and urban plans, usually fostered by governmental plans, addressing the use and the development of ITS applications.

Given the broad geographical scope, it must be stressed that this review can not be considered exhaustive. Facing with the problem of providing a comprehensive overview at worldwide level, the review has firstly identified the world area to be assumed as target of
the analysis, focusing on the most representative cases in each area, and without the ambition of providing detailed reviews for each countries belonging to that area. For example, concerning the South-East Asia area, the review focuses on Japan and Korea, leaving aside countries with similar developments, e.g. Singapore, whose pioneering ITS applications of congestion pricing in place in its city center since 1975 have contributed to be a world leader in electronic road pricing.

The criteria for the identifications of world area are in part based on the insights of the history of ITS applications, which must acknowledge the important contribution from countries in which the development of high-technologies has been relevant, e.g. the South-East Asia (e.g. Japan, Korea) and the USA.

Furthermore, socio-economic variables, i.e. high population levels and economic growth rates (in particular in the long term period) in urban areas, represent important criteria as well. It is the case of the today’s emerging economies, the so-called BRIC (Brasil, India and China). In 2050, it has been forecasted\(^2\) that in terms of purchasing power parity (PPP) India and China will outgrow the USA (but not in per capita terms), and in these countries growing urbanization rates will represent one of the main challenges to overcome. In such a context, the review of how ITS applications are considered to play a role, i.e. with which objectives and tools, can shed the lights on the ITS applications in world urban areas projected to be future leading players.

All in all, the ITS worldwide review takes as reference the worldwide breakdown in homogeneous world regions as developed by the OECD/ITF, which in its analysis of worldwide trends in CO2 emissions from transport classifies the following regions\(^3\):

- EU Area (EU15 plus Accession countries, Candidate countries and New Member States)
- North America (Canada, Mexico and United States)
- Asia Pacific Area (Australia, Japan, Korea, New Zealand)
- 10 top-ten CO2 emitting countries non OECD Area (China, India, Iran, Indonesia, South Africa, Brazil, Saudi Arabia, Thailand, Kazakhstan)
- Other countries

The OECD/ITF breakdown is a combination of geographical proximity and level of transport

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\(^2\) See The Economist, “GDP per person, forecast”, January 15th-21st 2011
\(^3\) The report is “Greenhouse gas reduction strategies in the transport sector”
sector CO2 emissions (to be considered as an indicator of transport volumes and activities). Therefore, it represents a useful guidelines for a worldwide analysis of ITS applications.

Leaving aside the EU Area (thoroughly analyzed in the Deliverable 2.1 and 2.2) and the residual category Other countries, the ITS worldwide review focuses on the following countries by worldwide region:

<table>
<thead>
<tr>
<th>Worldwide region</th>
<th>Country considered in the ITS review</th>
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<tbody>
<tr>
<td>North America</td>
<td>USA</td>
</tr>
<tr>
<td>Asia-Pacific Area</td>
<td>Australia, Japan, Korea, New Zealand</td>
</tr>
<tr>
<td>10 top-ten CO2 emitters</td>
<td>India, China</td>
</tr>
</tbody>
</table>

### 2.1 North America

#### 2.1.1 ITS Applications and Future Developments in US

**General context and trends**

It has been acknowledged [2] that the United States lacked in the past of a comprehensive strategy at a national level to support ITS development and deployment.

The reason basically lied in the assumption that the private sector could have well developed and deployed these technologies by itself. Compared to the US situation, from this point of view, it may be said that other countries, just like Europe, Korea, Japan, etc, may have benefitted at least of two aspects:

1. strong government leadership and greater funding,
2. the capability to commit private operators in public-private partnerships initiatives.

It should be taken in the duly account that an effective ITS development at national level implies the facing of a significant number of challenges, i.e.

- to ensure system interdependency (technical constraints)
- network effect (governing the complexity)
- funding (to mobilize the necessary resources)
- political, and institutional challenges (co-ordination with industry and private operators, high transaction costs)

Some ITS applications, it has been stressed [3] such as ramp meters or adaptive traffic
signals, can be effectively deployed locally, but the vast majority of ITS applications, and in particular the ones for which the most extensive benefits to the transportation network may be guessed, must operate at higher scale, often at a national level, and must involve adoption by the overall system and by individual users simultaneously, raising complex system coordination challenges. The US ITS Strategic Research Plan 2010-2014 [4] released by the United States Department of Transportation may represent a landmark event for changing the overall approach for ITS development.

In fact, in the intention of the policy makers, the ITS Strategic Research Plan has been re-designed to achieve a vision of a national, multi-modal surface transportation system which should be able to connect transportation safety and clean environment through vehicles, infrastructure and passengers’ portable devices. ITS applications are expected to maximize safety, mobility and environmental performances.

Briefly, the core of the ITS strategy is IntelliDriveSM, which is a suite of technologies and applications that uses wireless communications (short range communications devises - DSRC-) to provide connectivity with and between vehicles; between vehicles and roadway infrastructure; and among vehicles, infrastructure and wireless consumer devices.

The objectives pursued by the system are the following:

- **Safety**: There are over 5.8 million crashes per year on U.S. roadways, resulting in 37,000 deaths annually. It is estimated that these crashes have a direct economic cost of $230.6 billion and are the leading cause of death for ages four to 34. IntelliDriveSM safety applications, using vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications technology based on Dedicated Short Range Communications (DSRC), are designed to increase drivers’ situational awareness andreduce or eliminate crashes by advising or warning drivers of dangerous situations.

- **Mobility**: Traffic congestion is an $87.2 billion annual drain on the U.S. economy, with 4.2 billion hours and 2.8 billion gallons of fuel spent sitting in traffic, the equivalent of one work week and three weeks’ worth of gas every year. IntelliDriveSM, using V2I capabilities and anonymous information from passengers’ wireless devices relayed through DSRC and other wireless transmission media has the potential to provide transportation agencies with dramatically improved quality and quantity of real-time traffic, transit and parking data, making it easier to manage transportation systems for maximum efficiency and minimum congestion. IntelliDriveSM could also enable travelers to change their route, time and mode of travel, based on up-to-the-minute conditions, to avoid traffic jams.

- **Environment**: Tailpipe emissions from vehicles are the single largest human-made source of carbon dioxide (CO2), nitrous oxides (NOx) and methane. Vehicles that are stationary, idling and traveling in a stop-and-go pattern due to congestion emit more
than those traveling in free flow conditions. IntelliDriveSM environmental research is designed to provide data that transportation managers can use to better understand the potential environmental impacts of transportation management decisions made in real time.

The ITS tools supporting the implementation of the ITS Research Strategic Plan (including the assessment of the resources allocated) assumes the following multi-year research activities:

**Vehicle-to-Vehicle (V2V) Communications for Safety**: This research will investigate key questions such as are vehicle based safety applications using V2V communications effective and do they have benefits. The investment will be up to $11.5 million.

**Vehicle-to-Infrastructure (V2I) Communications for Safety**: This research will investigate similar questions about V2I communications, with an initial focus on applications based on the relay of traffic signal phase and timing information to vehicles. The investment will be up to $9.3 million.

**Real-Time Data Capture and Management**: This research will assess what traffic, transit and freight data are available today from various sources, and consider how to integrate data from vehicles acting as "probes" in the system. The goal is to accelerate the adoption of transportation management systems that can be operated in the safest, most efficient and most environmentally friendly way possible. The investment will be up to $1.995 million.

**Dynamic Mobility Applications**: This research will examine what technologies can help people and goods effortlessly transfer from one mode of travel (car, bus, truck, train, etc.) or route to another for the fastest and most environmentally friendly trip. The research seeks to make cross-modal travel truly possible for people and goods, and enable agencies and companies to manage their systems in light of the fact that people and goods will be changing modes often. The investment will be up to $8 million.

**Road Weather Management**: This research will consider how vehicle-based data on current weather conditions can be used by travelers and transportation agencies to enable decision-making that takes current weather conditions and future weather forecasts into account. The investment will be up to $4.6 million.

**Applications for the Environment**: Real-Time Information Synthesis (AERIS): This research will explore how anonymous data from tailpipe emissions can be combined with other environmental data. The goal is to enable transportation managers to manage the
transportation network while accounting for environmental impact. The investment will be up to $1.93 million.

**Human Factors:** Additional technology in vehicles may have the potential to overload drivers and increase safety risks. This research will examine the extra burden that in-vehicle devices may put on drivers, with the goal of minimizing or eliminating distraction risks. The investment will be up to $3.525 million.

**Mode-Specific Research:** This research program includes active traffic management, international border crossing, roadside infrastructure, commercial vehicles, electronic payment and maritime applications. The investment will be up to $6.35 million.

**Exploratory Research:** This research program includes safety research for rail, technology scanning, and a solicitation for new research ideas. The investment will be up to $2.5 million.

**Cross-Cutting Activities:** This program includes architecture, standards, professional capacity building, technology transfer, and evaluation. The investment is up to $14.1 million.

The following table summarizes the ITS objectives and the main technological trends envisaged in the ITS Strategic Research Plan 2010-2014.

**Table 1: ITS Strategic Research Plan objectives and ITS technology trends in US**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Trends in ITS technologies</th>
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<tr>
<td>• Safety focus</td>
<td>• Wireless technology</td>
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<tr>
<td>• Curbing congestion</td>
<td>• Strong consumer market</td>
</tr>
<tr>
<td>• Environmental awareness</td>
<td>• Fast pace of innovation</td>
</tr>
<tr>
<td>• Road pricing and financing alternatives</td>
<td>• Expectation for major information</td>
</tr>
<tr>
<td>• Emphasis on performance measurement and management</td>
<td>• Ubiquitous connectivity</td>
</tr>
<tr>
<td>• Transportation impacts on livability</td>
<td>• Person-to-person networking</td>
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</table>
The National ITS Architecture that represents the definitive framework that will guide deployment of intelligent transportation systems in the U.S. for the coming years is the following:

- The National ITS Architecture defines a set of functions (or processes) and information flows (or data flows) that respond to the user service requirements discussed.
- Processes and data flows are grouped to form particular transportation management functions and are represented graphically by data flow diagrams (DFDs), or bubble charts, which decompose into several levels of detail.

A simplifies example (Traffic management process) of the ITS Architecture are provided in the next figure:

![Diagram of ITS Architecture](image)

Source: [4]

**Figure 1; Interaction of Traffic management with other high level processes**

Each bubble in the logical architecture is a process that describes some logical function to be performed. As shown in the Figure 1, there are eight high level processes that are connected to the Traffic management function.

The figure does not show all the connections between processes, but focuses on the
Manage Traffic process (which includes traffic signal control functions), identifying how it interacts with the eight other high level processes that form the ITS Architecture.

It is important to stress that the ITS Strategic Research Plan 2010-2014 has established specific implementation rules to ensure a smooth implantation of the strategy. Namely:

- to implement technical languages in the ITS projects to be conformed to the National ITS Architecture and Standards. This rule establishes a process for implementing the legislation through the existing planning and project development processes.
- to guide the implementation of ITS projects in their specific areas to gain effective transportation planning benefits. The ITS projects must be based on proven approaches and validating the proposed concepts. So while for particular locations these concepts may be new, they are based upon successful, proven approaches.
- to define the rules on the basis of which a project complies (or whether there is limited direct oversight, whether a recipient has established procedures to ensure compliance) with the requirements of the ITS Architecture and Standards Rule/Policy.

According to the implementation rules, recipients that have deployed ITS have to develop and document their Regional ITS architecture. Regions that have not yet deployed ITS will have four years from the date their first ITS project advances to final design. It is recommended that State and local agencies work with their operating field offices to determine the best schedule for implementation.

In general, it may be concluded that the ITS implementation plan reflects the objective to institute a process that is focused on ensuring that the results of ITS research become commercially viable and are adopted by the transportation community.
Overview at urban and metropolitan level

The following picture depicts the situation at 2007 in some metropolitan area in the US.

![Map of US showing automated lane control applications in 2007](image)

Source: [5]

**Figure 2: Automated Lane control applications in the US (2007)**

The picture shows that at least two combinations of Lane Control Management techniques were applied in most of the US metropolitan areas. This evidence points out the importance of curbing congestion in the US.

A 2009 Reason Foundation study in the US [3] found that reducing congestion and increasing travel speeds enough to improve access by 10 percent to key employment, retail, education, and population centers within a region may increase regional production of goods and services by one percent. The study also reported that achieving “free-flow traffic conditions” around key urban and suburban destinations in eight U.S. cities—Atlanta, Charlotte, Dallas, Denver, Detroit, Salt Lake City, the San Francisco Bay Area, and Seattle—could increase the economies in those cities alone by $135.7 billion and generate close to $9 billion in new tax revenues.
The Urban Mobility Report [6] alarmingly reported that “congestion is still a problem in America’s 439 urban areas. The economic recession and slow recovery of the last three years, however, have slowed the seemingly inexorable decline in mobility. Readers and policy makers might be tempted to view this as a change in trend, a new beginning or a sign that congestion has been “solved.” However, the data do not support that conclusion”.

In fact, the report goes on:

1. First, the problem is very large. In 2009, congestion caused urban Americans to travel 4.8 billion hours more and to purchase an extra 3.9 billion gallons of fuel for a congestion cost of $115 billion.
2. Second, 2008 appears to be the best year for congestion in recent times; congestion worsened in 2009.
3. Third, there is only a short-term cause for celebration. Prior to the economy slowing, just 3 years ago, congestion levels were much higher than a decade ago; these conditions will return with a strengthening economy.

The objectives addressed through the strategies to curb congestion at urban level include environmental and safety aims as well.

This is confirmed by the New York’s programs involving the following ITS applications:

The Clean Pass Program:

- Innovative, multi-agency (NYSDOT, NY DMV, NYSDEC) program
- Allow eligible low-emission, energy-efficient vehicles to use the 40-mile Long Island Expressway High Occupancy Vehicle (LIE/HOV) lanes regardless of the number of occupants in the vehicle.
- The program will result in an estimated reduction of 6,000 tons of greenhouse gas emissions and savings in excess of 500,000 gallons of gasoline.

The INFORM (INformation FOR Motorists) Program, considered among one of the nation's largest and most advanced traffic information systems for motorists covering Long Island's 50-mile central corridor. The objectives include:

- to help improve vehicle travel times, coordinate traffic flow and limit the amount of congestion.
- to gather information regarding accidents, construction, and suggestions of alternate routes, for example, in order to direct traffic from overloaded highways to less congested roadways and thus move traffic more efficiently.
to provide better information to decisions regarding trips. This intelligent transportation system will be implemented in stages, as DOT adds various highway monitoring and traffic signal control systems to the network.

The TIM (Traffic Incident Management) Program encompasses the environmental, economic and safety objectives:

- congestion reduction, through applications supporting the travel Demand on System capability, opening traffic lanes quickly
- air quality benefits, through reduction in gasoline consumption
- safety, avoiding Secondary Accidents

### 2.2 Asia-Pacific Area

#### 2.2.1 ITS Applications and Future Developments in Japan

**General context and trends**

Japan shows widespread TS applications. As of June 2009 [7] the numbers of ITS on-board units that have been installed into vehicles are:

- Car navigation systems: about 35 million;
- ETC (Electronic toll collection system): about 26 million;
- VICS (Vehicle Information and Communication System): about 24 million.

Concerning the Car navigation system, the Japan’s Smartway system is capable of combining the knowledge of a vehicle’s precise position with location-specific, real-time traffic information. The Smartway system also provides visual information of road conditions ahead, via live camera images of tunnels, bridges, or other frequently congested areas. The Smartway system evolved extremely fast, from a concept in 2004, to limited deployment in 2007, to national deployment in 2010. At least 34 million vehicles have access to real-time, in-vehicle traffic information in Japan.

It must be stressed that Japanese citizens can use the Internet or their mobile phones to access comprehensive real-time traffic information about almost all highways in the country through an integrated road traffic information provision system. The Web site features maps that display a broad range of traffic information, including warnings about traffic restrictions, congestion data, weather conditions on roads, and repair activity. Japan has also focused on providing real-time traffic information during natural disasters and has
designed mechanisms to automatically feed data about such events into Smartway and VICS. Concerning the ETC, the about 26 million vehicles (about 68% of all vehicles regularly using Japan’s toll expressways) are equipped with on-board toll-collection units. Japan in fact operates a single national standard for electronic toll collecting, thus ensuring nationwide system compatibility. This design decision has been crucial in expanding electronic toll collection so that private companies, such as parking garages or gas stations, can offer electronic payment options. Japan also regularly uses variable pricing, easy to implement electronically, so that prices can be changed to reflect traffic conditions and thus manage congestion.

Concerning the VICS, it can be considered as one of the most prominent ITS application in Japan. It represents the nationwide deployment of widespread adoption of Telematics car navigation systems. The Vehicle Information and Communication System Center (VICS Center), is a government established non-profitable organization, providing a digital data communication system with road traffic information to drivers via telematics units. The following figure shows how the VICS operate:

Source: HTTP://WWW.VICS.OR.JP

Figure 3: The VICS system in Japan
The expected results arising from the VICS concern effects on reduction of congestion, decreased number of accidents and reduced consumption and carbon dioxide emissions.

The following table shows the long-term commitment of the Japanese government to the VICS system, involving Information Technology policy package and comprehensive strategies.

<table>
<thead>
<tr>
<th>Year</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Overall framework for ITS</td>
</tr>
<tr>
<td>1996</td>
<td>VICS service begun</td>
</tr>
<tr>
<td>2001</td>
<td>ETC service begun</td>
</tr>
<tr>
<td>2004</td>
<td>Smartway Proposal</td>
</tr>
<tr>
<td>2005</td>
<td>IT policy package</td>
</tr>
<tr>
<td>2006</td>
<td>New IT Reform Strategy</td>
</tr>
<tr>
<td>2007</td>
<td>Smartway 2007</td>
</tr>
<tr>
<td>2008</td>
<td>Trials of driving safety support systems throughout Japan</td>
</tr>
<tr>
<td>2010</td>
<td>Nationwide deployment</td>
</tr>
</tbody>
</table>

The success story behind the VICS may be considered paradigmatic of the Japanese approach to the ITS development.

It has been stressed [8] that the leadership of the national government has been crucial in developing the VICS program through the coordination of national public-private architecture with uniform communication protocols, and the development of a nationwide traffic digital network.

In fact, the public-industry-academic coordination, initiated by the public sector, has been decisive in the success of VICS. The main reason behind the success of the Japanese traffic information system, VICS, is the division of responsibilities between the public and private sectors. These sectors agreed upon what was for the most part a natural division of roles and tasks. In essence, VICS was organized through the cooperation of various tasks, as follows:

• equipment on the road infrastructure
• information collection (road operators and the police)
• information processing (private bodies under government supervision).
• development and sales of the on-board unit.
A second important success factor for VICS, beside the strong public-private partnership factor, has been the nationwide installation of beacons along the roadside.

With reference to that, the government has assumed the technical and financial responsibility implementing radio and optical beacons to provide two-way communication linkages with the in-vehicle devices without financial compensation in order to boost private sector involvement in car navigation systems.

Furthermore, in order to promote user acceptance, the public sector has also provided traffic detections and surveillance information, channeled to the VICS center, and the update traffic information (from the VICS center) to the vehicles.

It may be concluded that the importance ascribed to ITS at the highest levels of government, the number of citizens benefitting from use of an wide range of deployed ITS applications, and the maturity of those applications, make ITS development one of the pillar of technological progress.

In terms of future strategies, the most relevant implication for the development of ITS is the “Long-term Strategic Guidelines “Innovation 25” decided by the cabinet on June 1, 2007.

In such a framework, one of the projects concerns the “Realization of a safe and effective road and traffic system using information and telecommunications technology,” which aims to accelerate the development and diffusion of ITS technologies in order to realize further improvement of road transport safety, innovation of urban transport systems and advanced logistics systems. The task force for this project, consisting of academic and business experts as well as government officials, formulated the roadmap in June 2008. As for innovation of urban transport systems, for example, the roadmap exemplifies the sharing of data collected by probe cars, the implementation of pilot projects for ITS use in some model cities, etc.

Concerning the ITS Architecture, the “Outline of Innovation Promotion Policies in the Field of Land, Infrastructure, Transport and Tourism” (no English translation is available), formulated by the government on May 25, 2007. The “Outline” is considered to place an important milestone in establishing standardized platforms, including geographical and location information infrastructure as well as information and telecommunications networks.

In terms of main objectives, the “Innovation 25” mainly focuses on the broad promotion of innovation in Japan, and in such a framework the “Outline” aims to facilitate innovation in
transport. In particular, it has been stressed [2] that, according to the “Innovation 25”, :“By 2025, ITS will have been constructed that integrate vehicles, pedestrians, roads, and communities; and that have made traffic smoother, eliminated traffic congestion, and almost entirely eliminated all traffic accident fatalities”.

Summing up, the following table summarizes the ITS objectives and the main technological trends envisaged in the “Innovation 25” strategy.

**Table 2: ITS objectives and technology trends in Japan**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Trends in ITS technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>•Safety focus</td>
<td>•Multiplex broadcasting</td>
</tr>
<tr>
<td>•Curbing congestion</td>
<td>•Radio wave beacon</td>
</tr>
<tr>
<td>•Environmental awareness</td>
<td>•Infrared beacon</td>
</tr>
<tr>
<td>•Integrating transport modes</td>
<td>• Provision of regional traffic information</td>
</tr>
<tr>
<td>•Improving Urban transport system</td>
<td></td>
</tr>
<tr>
<td>•Raising revenues</td>
<td></td>
</tr>
</tbody>
</table>

**Overview at urban and metropolitan level**

In 2006-2007 the Ministry of Land, Infrastructure and Transport invited municipalities to participate in proving tests, and 25 municipalities were chosen by the "Machi Meguri Project Study Committee", mainly consisted of academics.

The following projects have been selected (a complete overview is provided in [9] . Test operation of ETC for motorcycles is being conducted by monitors in Tokyo, Kinki, and Chubu Metropolitan Areas to assess the operation and check the safety and operation of communication devices. Toll discounts are provided for certain road sections to motorcycle drivers who use ETC cards until ETC on-board units for motorcycles reach the market and full scale deployment of ETC for motorcycles can start.

Many drivers feel that paying charges at parking lots is troublesome, particularly elderly drivers who struggle to lean out of the vehicle’s window to pay. Smooth and cashless payment at public parking lots is being deployed using the conventional ETC on-board units or a combination of an ITS on-board unit and an IC credit card.
In April 2006, a private company started a parking lot payment service by using some of the functions of existing on-board units. In fiscal 2005, prior to the deployment, field trials were conducted in the three metropolitan areas of Tokyo, Osaka and Nagoya.

On-demand buses are operated between sections and at times requested by users, making regional transportation much more convenient. In Shimanto City, Kochi Prefecture, the on-demand "Nakamura-machi Bus" started full-scale operation since July 2000. Users inform the bus operator of their desired boarding time, and start and end stops by telephone, fax, or terminals installed at major public facilities, and then wait at a bus stop building at the designated time.

In Shio-machi (presently Shio District of Hodatsushimizu-cho), reservation-based on-demand shared taxis and circular route buses were introduced since March 2003, when loss-making commercial bus routes were closed down. To improve the efficiency of receiving reservations and determining taxi routes, a system that integrates GPS and computer telephony was introduced. Users call the center to reserve a seat in a taxi, which then comes to pick them up at specified places. A ride within the village costs just 300 yen per person.

2.2.2 ITS Applications and Future Developments in Australia

General context and trends

According to an important government review of the ITS in Australia [10], it has been acknowledged that while Australia may lead the world in certain aspects of ITS research (e.g. traffic management), it may lag behind with reference to other aspects (e.g. interoperability of different toll collection systems).

Several ITS initiatives have been implemented by various governments in Australia. Some examples currently operating in Australia, including:

- Adaptive traffic control systems, to provide priority for road-based public transport vehicles;
- Freeway management and information systems, to reduce delays due to traffic incidents;
- Electronic fare collection systems, to improve the convenience of public transport travel and reduce system costs;
- Electronic Tolling;
- In vehicle navigation and information systems, to assist drivers and reduce unnecessary travel;

In addition, the government review informs, there are several ITS trials currently being conducted on Vehicle Collision Avoidance Systems, Remote Vehicle Guidance Systems and Automated Highway Systems. Other major ITS projects include a national tolling working group, a national trucking location and access study, an in-car driver awareness program, bus information systems and an urban freight study.

In terms of national Architecture, the government designated as a ‘National ITS Corridor’, certain roads of national significance, such as the Hume Highway, the Federal Highway and the F3, and that such corridors have installed on them ITS technology; to be used to test integrated ITS infrastructures.

The government recommendations as far as the supporting of ITS development is concerned include the following:

- identifies strategic directions and national priorities;
- identifies funding options; and,
- recommends appropriate institutional and legal arrangements to give effect to national ITS policy and programs.

The government also recommended to establish an ITS implementation bureau as an executive agency directly responsible and accountable to the Minister for Transport and Regional Services.

The government recommended that the specific responsibilities of this bureau must be to:

- act as a national forum for resolving differences in standards, an approaches;
- coordinate Commonwealth government activity in the area of ITS;
- develop and implement national ITS policy, including identifying national goals;
- set standards for inter-operability and national architecture;
- coordinate R&D; and,
- provide assistance to other Commonwealth agencies to facilitate the export of ITS technology.

Concerning the likely future developments, the cornerstones of the strategy to develop ITS applications is mainly political:
identifies strategic directions and national priorities;
identifies funding options; and,
recommends appropriate institutional and legal arrangements
to give effect to national ITS policy and programs.

Table 3: ITS objectives and technology trends in Australia

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Trends in ITS technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Safety</td>
<td>• Developing standards ensuring Interoperability</td>
</tr>
<tr>
<td>• Traffic management</td>
<td>• Smart card technologies</td>
</tr>
<tr>
<td>• Passenger information</td>
<td>• Technologies supporting modal integration</td>
</tr>
<tr>
<td>• Integrating transport modes</td>
<td></td>
</tr>
<tr>
<td>• Raising revenues</td>
<td></td>
</tr>
</tbody>
</table>

Overview at urban and metropolitan level

ITS have been developed and implemented in a number of Australian metropolitan and urban areas

Melbourne

In 2002, ITS applications have been installed, e.g. a computer controlled dynamic speed limit system on the Western Ring Road in Melbourne. The aim of the system is to monitor traffic congestion and calculate the best traffic speed that will optimize traffic flows [10]. The speed limits are transmitted to drivers via a series of 80 roadside electronic signs.

ITS applications should also improve the use of public transport, to be reached through the following applications:

- route coverage, frequency/span of service, reliability, speed and coordination
- information, comfort and convenience, ticketing
- in outer suburbs and growth areas - basic services (local bus services, some rail extensions)
- in middle and outer suburbs - circumferential links (cross town buses, modal interchanges)
- in inner and middle suburbs - travel efficiency (service improvements, including priority for on-road public transport).
• Increase in public transport use will be supported by TDM initiatives (see Action 2) including:
  • expansion of the TravelSmart program
  • introduction of Green Travel plans
  • promoting walking and cycling, especially for short trips
  • integrated urban development with a focus around activity centers (such as Transit Cities).

Queensland

A number of ITS projects have been implemented in Queensland, and others are under development. ITS projects implemented include:

• The Pacific Motorway, a world-class transport link between Brisbane and the Gold Coast, which encompasses a range of ITS applications.
• The Ship Reporting System, a world-first mandatory ship reporting system which monitors ship movement along Queensland’s Great Barrier Reef.
• The South East Busway, a dedicated two-lane roadway stretching through Brisbane’s south-east suburbs for the exclusive use of buses, utilizing a range of ITS technologies.

STREAMS, the Queensland Department of Main Roads’ integrated intelligent transport system. It is installed throughout Queensland and manages both freeways and more than 1000 signalized intersections. STREAMS provides ITS services including freeway and surface street traffic management, incident management, passenger information and driver information, traffic signal management - adaptive coordination plan selection, adaptive movement control, public transport priority and VIP and emergency vehicle priority.

Other ITS trials are under development in Queensland. These include:

• Intelligent Access System which will enable the Queensland Department of Main Roads and Queensland Transport to expand work on remote monitoring of heavy vehicles via satellite tracking to encompass an electronic compliance monitoring regime. This system will form a platform for a national approach.
• Maroochydore Parking Guidance System which will assist motorists to find parking around the Sunshine Plaza at Maroochydore, located on Queensland’s sunshine coast.
• Mt Molloy Load Limit Information Sign which will provide timely and accurate information to motorists during times of wet weather.
• Palmerston Highway Heavy Vehicle Safety Advisory System which is designed to educate drivers about their behavior and to influence them to drive more safely.
The ITS technologies under development in Queensland include: road flood warning, variable message and mobile telephone messages, combining Bureau of Meteorology data with that from flood plain and Queensland Main Roads road terrain data, to predict road availability and water hazards.

**New South Wales**

A number of ITS systems have been installed in New South Wales, the most significant of which is Sydney Coordinated Adaptive Traffic System (SCATS). This system was commissioned in 1972. SCATS coordinates and controls over 3000 intersections by continually adjusting the phasing of traffic lights so that they respond to traffic flow and traffic incidents. The RTA advised the committee that SCATS is recognized as the world’s leading traffic signal control system, being used in over 80 cities throughout the world.

The RTA is developing an enhanced software package, SCATS 2, to take advantage of modern software, hardware and communications technologies. This software provides all of the functions of the existing system as well as new facilities to provide for future advanced traffic management needs, including provision for dynamic bus priority. Other ITS technologies in use in NSW include:

- The Safe-T-Cam™ system enables the identification of truck drivers violating speed limits by photographing and then ‘reading’ the number plate.
- F6 Fog Detection System, which uses sophisticated detection systems and Variable Message.
- Signs (VMS) are used to advise motorists of poor visibility, excessive speed, and when a motorist is too close to the vehicle ahead.
- Electronic Toll Collection on, for example, the M2, M5, and the Sydney Harbour Bridge. Toll charges are levied electronically as vehicles pass through toll plazas. Manual toll-booths also exist.

Since 1998/99 incident management initiatives have included the expansion of closed circuit television coverage, automatic incident detection facilities, Variable Message Signs (VMS) and Variable Speed Limits (VSL). These initiatives commenced with the completion of the pilot M4 Motorway scheme.

The major traffic management resource within the RTA is the Transport Management Centre (TMC) situated in Sydney’s inner South. The TMC enables the RTA to take an innovative and integrated approach towards the management of the NSW road network. The TMC also provides a command capability for managing the transport task of special events such as the Easter Show and the Olympic Games.
Victoria

A variety of ITS applications have been installed on the Victorian road system, by VicRoads. These have included:

- Drive Time (a real time traffic information sign);
- Variable message signs;
- Incident detection systems;
- Ramp metering; 16
- Freeway condition signs;
- Ice detection systems;
- Closed circuit television cameras; and
- Roadside speeds check systems.

VicRoads installed a computer controlled dynamic speed limit system on the Western Ring Road in Melbourne. This system will monitor traffic congestion and calculate the best traffic speed that will optimize traffic flow. The speed limits will be transmitted to drivers via a series of 80 roadside electronic signs. VicRoads also advised the committee that the Geelong Road Project would also incorporate a number of ITS applications.

Western Australia

Successive Western Australian administrations have implemented ITS policies and as a result, a number of ITS technologies have been installed in Perth. These include:

- Computerized Traffic Control Signals which are based on the SCATS system in Sydney. This system monitors traffic flow, adjusts the timing and coordination of traffic signals and reports signal faults 24 hours per day. The first traffic signals were connected to SCATS in 1983 (on the Albany Highway), and the coverage has continued to grow to the extent that all traffic signal installations in the State (approximately 730 sites) are now connected.
- CCTV - Monitoring systems. Closed circuit television cameras (CCTV) have been installed throughout the metropolitan area as part of the development of Perth’s Intelligent Transport Systems. The cameras – so far 41 have been installed – provide valuable real time information on road and traffic conditions to the trained operators at the Traffic Operations Centre, who monitor them 24 hours per day. Video images from the various camera sites are also broadcast on this web site as part of Traffic and Road Information.
- Traffic Operations Centre. A modern, purpose-built facility that manages the Perth metropolitan road network and the control systems associated with the Graham Farmer Freeway tunnel.
Variable Message Signs (VMS) are used to deliver on road information to motorists in real time. The types of VMS range from simple one or two line message signs to fully variable signs that can include graphical displays pertaining to traffic conditions, current freeway travel speeds and road safety messages.

Traffic and Road Information is an internet based system that allows users to obtain road information and report faults. Information that can be obtained via the web site include: images from CCTV cameras, congestion status, freeway speeds, traffic and roads conditions reports, and road works.

HERO - Highway Emergency Response Operations. The aim of HERO is to improve the safety and efficiency of Perth’s freeways by minimizing disruption to traffic caused by incidents.

Weigh In Motion System, Fremantle. This system uses an electronic scanner and automatic weighing equipment to weigh trucks, monitor speeds and identify the vehicle. Vehicles carrying containers into and out of the port of Fremantle register the legal capacity of the load and have an electronic tag fitted to the windscreen. The system helps prevent damage to roads and vehicles.

Trialing New Technologies. Main Roads Western Australia has trialed a number of new ITS technologies. These include: Video Traffic Detection where video cameras are used to detect the movement of vehicles on roads and freeways. Video detectors can replace more conventional systems that usually use inductive loops to register vehicle movement.

Another technology trialed is intelligent pedestrian crossing signals that automatically cater for all users. Pedestrian User Friendly Intelligent (or PUFFIN crossings) automatically detect the presence of pedestrians crossing the road and will allocate extra time to the walk phase if needed.

2.2.3 ITS Applications and Future Developments in Korea

General context and trends

It has been stressed [3] that the South Korea’s government has acknowledged the importance of ITS (and Information technology in general) to drive economic growth and improve the citizens quality of life. In 2004, for example, South Korea announced a strategy that identified key IT areas, including ITS, to prioritize investments. On top its strategic plan, South Korea also created a national ITS master plan.

This attention has also been supported with relevant investments. South Korea has in fact allocated a $3.2-billion investment, equal to an average of about $230 million annually, from 2007 to 2020.
As a result, the South Korea targeted strategy in ITS development (real-time traffic information provision, advanced public transportation systems, and electronic toll collection) has contributed to make it a world leader in ITS.

Among the important ITS projects, the following ones can be pointed out [2]:

- South Korea’s Expressway Traffic Management System, which collects real-time traffic information and transmits it to the country’s National Transport Information Center (NTIC) via a high-speed optical telecommunication network deployed specifically to support the country’s ITS infrastructure. Collected and processed traffic information is provided to South Korean citizens free of charge through various channels, including variable messaging signs, the Internet, and broadcasting. The NTIC Web site offers an interactive graphic map that citizens can access to see a consolidated view of traffic status on the country’s roads. Real-time traffic information is available not only on expressways but also on national and urban district roads. Almost one-third of all vehicles in South Korea use onboard vehicle navigation systems.

- Public transportation information systems, particularly for buses, are highly deployed in South Korea. Seoul alone has 9,300 on-bus units equipped with wireless modems and GPS position detectors. About 300 bus stops communicate with Seoul’s central traffic operations management center via wireless communications to provide an integrated, up-to-the-second view of Seoul’s bus transportation network. The service includes bus arrival time, current bus location, and system statistics. Bus stop terminals are equipped with liquid crystal display message screens to alert riders of bus status and schedules. South Koreans regularly use the location-based tracking feature in their GPS-enabled phones to access a Web site that presents a list of available public transportation options; the system recognizes where the passenger is located and provides walking directions to the nearest option.

- South Korea’s Hi-Pass electronic toll collection system, which covers 260 toll plazas and more than 3,200 kilometers of highway. Five million South Korean vehicles use Hi-Pass, which has a highway utilization rate of more than 30%. Hi-Pass covered 50% of highways in 2009, will cover 70% by 2013, and be available nationwide thereafter. South Koreans can also use their Hi-Pass card for paying for parking and buying gas and other products.

A in the most advanced countries, cooperative ubiquitous networking technology is emerging as a new paradigm for national technological programs. Several efforts are being made to prepare for the advent of a ubiquitous network society including government
investment, research and development and trial projects.

In those countries are implementing high-tech urban development projects - including smart cities and intelligent cities - suitable for their infrastructure and environment. The prospects for Korea look very bright. The country ranks in fact fifth in the share of the global construction market and second in the ICT Development Index. Korea has a strong potential to lead the global market by taking advantage of its strength in both fields.

To promote the industry at the national level, the Korean government has finalized the first Comprehensive U-City Plan (2009-2013) outlining the policy vision, basic direction, national steering systems and strategies and key tasks for each developmental phases. Three policy goals can be outlined:

1. Effectiveness of urban management: The plan aims to establish high-tech urban spaces and intelligent city management systems by integrating U-City technologies into urban infrastructure facilities.
2. Foster as new growth power industry: The U-City industry will be promoted as a new growth engine to enhance national competitiveness and create jobs.
3. Advanced urban services: The plan also looks to improve the quality of life through U-City-based urban services including finely customized services for residents.

To achieve these goals, the government has established four implementation strategies - each with a detailed list of tasks. The strategies relate to preparation of institutions, development of core technology, support for industry growth and creation of relevant services.

1. **Institutional support:** The government seeks to promptly consolidate a comprehensive institutional basis for the industry regarding planning, construction and management. This requires various guidelines for effective planning and management as well as effective measures to protect private information and prevent disasters, damages and infiltrations. For information connections and compatibility, which are key to U-City technologies, clear standards for information, core technologies and individual services should be set up. Another important task in this area is promoting the use of U-City information among private sectors, thus raising the information utilization rate.

2. **Development of core technology:** The government seeks to provide R&D supports early to localize and foster core source technologies. Strategic assistance will be directed to localization and export of core U-City solutions involving information
collection, processing and utilization. The government is pouring 104.4 billion won into U-City R&D from 2007-12. New technologies will be swiftly put into test beds to examine their feasibility. The government will support tests of solutions, coordinate functions of related government ministries and branches, and promote common use of results from different ministries, thus maximizing the synergetic effect of innovation.

3. **Support for industry growth**: The government seeks to generate new jobs and boost national competitiveness by supporting and promoting the U-City industry. The government will support model cases of U-City construction and prepare a base to export U-City. The government`s important task is producing a professional workforce. It will nurture high-quality researchers and skilled workers in the sector and train local government officials with U-City capabilities. The nation will also play a leading role in expanding international networks such as "U-City World Forum" and offer overseas road shows and exhibitions.

4. **Creation of relevant services**: The government seeks to improve living conditions through practical services. It will develop new services and improve functions through R&D activities and public surveys. To find out diverse, creative services and disseminate them among local entities, the government will encourage active private-sector engagement in U-City planning and operations. Phased strategies

In the South Korean strategy, government support should be directed toward the provision of individual U-City public services, arrangement of institutions and nurturing human resources. In the expansion stage, the government needs to push industrial sophistication strategies including export support to develop it into a new growth engine business.

For the period of the first Comprehensive U-City Plan (2009-13), the government is expected to spend 490 billion won. While trying to secure the necessary budget, the government needs to actively induce private corporations’ participation. The state’s role should be focused on core infrastructure, technology development, legal and administrative institutions, supportive measures and human capital, while private businesses concentrate on advancing customized services. For systemic and effective policy implementation, the Ministry of Land, Transport and Maritime Affairs should be in charge of establishing overall plans and coordinating policies and other ministries are required to develop U-City services in their specific areas.

The following table summarizes the ITS objectives and the likely technological trends in South Korea.
Table 4: ITS objectives and technology trends in South Korea

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Trends in ITS technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Transportation Safety</td>
<td>• Development of travel time estimation of HOV lane</td>
</tr>
<tr>
<td>• Traffic management</td>
<td>• Data integration providing information on weather, congestion</td>
</tr>
<tr>
<td>• Passenger information</td>
<td>• Forecasting high-risk accident areas</td>
</tr>
<tr>
<td>• Integrating transport modes</td>
<td>• Wireless infrastructure</td>
</tr>
<tr>
<td>• Environmental issues (weather forecasts, sustainability)</td>
<td></td>
</tr>
<tr>
<td>• Equity issues (favoring elderly and disabled people)</td>
<td></td>
</tr>
</tbody>
</table>

Overview at urban and metropolitan level

The list of local governments showing initial interest in becoming U-cities includes Unjeong, Busan, Daejeon, Dongtan and New Songdo City.

Seoul

Seoul has been pushing its own U-city project since 1998 in the western district of Sangam-dong, which is being developed as a research and development hub for the high-tech industry.

The City of Seoul has created TOPIS (Traffic Operation and Planning Information System) to provide traffic data and to support traffic decisions by combining and connecting various traffic information sources. The National Department of Construction and Transportation and related research institutes have researched the potential of archiving traffic historical data and its applications.

New Songdo City

New Songdo City is a new international town that it is building for completion in 2014. ITS applications play an important role in supporting the transportation planning [11]:

- Improving the information to City bus services
• Providing the infrastructure for electrical vehicle charging stations integrated with parking garage designs to facilitate the transition to low emissions transportation.

**Unjeong**

In this city, the involvement of private operators in ITS applications is important. The Korea National Housing Corporation and KT will jointly invest 90 billion won to build the latest wireless infrastructure, such as "fiber-to-the-home" and broadband networks, by 2009.

Ubiquitous cities are being promoted in the "Cyberport" of Hong Kong and "multimedia super corridor" of Malaysia, but Unjeong is the first ubiquitous city for residential purposes, an official at the Korea National Housing Corporation said.

It must be stressed that local governments may have region-specific plans.

**Busan city**

The Busan city government plans to spend between 850-960 billion won to revamp Busan into a high technological city by 2010.

The plans will focus on providing ubiquitous and co-operative technological environment around the port area and convention/exhibition centers, as well as offering integrated transportation services, based on next-generation technologies including IPV6 and radio frequency identification.

Plans to introduce an intelligent transportation system, home networking, tele-medicine, a disaster prevention/management system and a pollution control system by 2020 have been designed.

**Jeju**

Jeju is likely to focus on the applications of ITS services to improve tourism. U-traffic, u-museum, u-park and u-coupon are four major targets that the Jeju provincial government would like to achieve. As a provincial government which started ITS services for the first time, Jeju plans to introduce a u-traffic system based on RFID technologies. The system will allow residents to access traffic information anytime, anywhere, the government said.
2.2.4 ITS Applications and Future Developments in New Zealand

General context and trends

In New Zealand, road and surface transportation are important, due to a historically car-dependent way of transportation. In the near future, taking in to account the projected increase in efficiency, productivity and economic growth, ITS solutions are required to manage increasing congestion of major urban highways and routes, not to mention the around 400 road deaths every year, and increased carbon emissions.

This brief review of the New Zealand general context helps to explain the vision in which the New Zealand Transport Strategy can be encompassed [12]. In particular, this vision is underpinned by the following four principles and five objectives:

Principles:

1. Sustainability
2. Integration
3. Safety
4. Responsiveness

Objectives:

1. Economic Development
2. Safety and Personal Security
3. Access and Mobility
4. Public Health
5. Environmental Sustainability

Furthermore, supporting the New Zealand Transport Strategy principles and objectives the Land Transport Management Act 2003 stated that Transfund (Land Transport New Zealand) must be satisfied that any program it approves must contribute to the following:

- Assist economic development.
- Assist safety and personal security.
- Improve access and mobility.
- Protect and promote public health.
- Ensure environmental sustainability.

How ITS applications fit with this strategy ?.

The following nine target areas have been identified as of particular relevance to the
application of ITS in New Zealand.

- Congestion Relief
- Demand Management
- Incident Management
- Compliance
- Safety
- Route Security
- Quality and Efficiency
- Travel Time Reliability
- Environmental Mitigation

The study [13] provided a framework for the future national ITS architecture. Such a framework is in the form of a list of user services and sub-services in which the future ITS Architecture might consist of. It is a framework tailored for the New Zealand environment and this implies that the list (validated with stakeholders) can be considered feasible and able to shape the future ITS panorama in New Zealand.

The long list of potential applications includes the following:

Traffic management systems

- Traffic network flow monitoring and management
- Vehicle-based sensing supporting traffic management systems
- Parking management
- Pedestrian and cycle management
- Traffic control
- Environmental conditions management
- Operations and maintenance
- Automated dynamic warning and enforcement

Driver monitoring systems

- Fatigue monitoring system
- Driver behavior monitoring
- Electronic driving hours logbook system
- Vehicle monitoring systems
- Real-time monitoring system (RTMS)
- Engine management
- Vehicle safety and control systems
- Vehicle-based collision avoidance
- Infrastructure-based collision avoidance
Commercial transport operator and fleet services

- Commercial vehicle administrative processes (CVAP)
- Electronic road user charging
- Automated over dimension and overweight permit system
- Online hazardous materials register
- Operator rating system
- Weigh in motion (WIM)
- Electronic clearance
- Roadside check facility (weigh station)
- Roadside inspections system
- Commercial freight management

Public transport services

- Near Real Time Timetabling
- Fixed route passenger operations
- Integrated ticketing
- Multi modal coordination
- Multi-modal connection protection
- Demand responsive passenger transport (taxis etc)

Emergency management and enforcement services

- Personal and public transport security
- Public security
- Automated emergency notification
- Remote power down
- Emergency response management
- Emergency vehicle priority
- Emergency response chain
- Hazardous material planning and incident response
- CIMS emergency support system

Electronic offence detection systems

- Digital speed cameras
- Intersection cameras
- Automatic number plate recognition (ANPR)
- Roadside inspections
- Electronic crash reporting
- Electronic offence subsystem
Electronic payment services

- Electronic toll collection
- Electronic parking payment
- Electronic fuel payment
- Passenger transport services payment

Traveler information service

- Real-time ridesharing information
- Traveler business directory
- Parking facility management
- Autonomous route guidance
- Dynamic route guidance

Combining the objectives of ITS implementation and the long list of potential applications (future trends), the resulting table is the following:

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Trends in ITS technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Curbing congestion</td>
<td>• Electronic user charging technologies</td>
</tr>
<tr>
<td>• Better Traffic demand management</td>
<td>• Digital technologies</td>
</tr>
<tr>
<td>• Incident risk assessment and safety</td>
<td>• Monitoring systems</td>
</tr>
<tr>
<td>• Travel Time reliability</td>
<td></td>
</tr>
<tr>
<td>• Environmental mitigation</td>
<td></td>
</tr>
</tbody>
</table>

Summing up, the New Zealand has a wide range of ITS already in use. However, many of these systems use older stand-alone applications that are consistent with the function originally conceived but lack of interoperability. On the other hand, many other systems are interoperable but have not been integrated for commercial sensitivity, political and cost reasons.

The future ITS architectures should be able to improve **fuel efficiency**, **fuel consumption**, decreasing **carbon emissions**, reducing **delays and congestion**, enhancing **safety** and providing **traveler information and security**.
Overview at urban and metropolitan level

Auckland

The Auckland ramp project provides a good example of how ITS initiatives may reduce congestion on key Auckland network segments.

- Unplanned incident detection capabilities are included in the traffic network flow monitoring sub-service in the Wellington and Auckland advanced traffic management systems (ATMS). This service includes the regional coordination with other traffic management and emergency management centre.
- In addition to standard surveillance capabilities, it includes sensory functions that detect wrong-way vehicles and other special surveillance capabilities that mitigate safety hazards associated with reversible lanes. The user sub-service includes the field equipment, physical lane access controls, and associated control electronics that manage and control these special lanes. This user sub-service also includes the equipment used to electronically reconfigure intersections and manage rights of way to address dynamic demand changes and special events. An example is the Auckland Harbor Bridge
- Multimodal coordination: it is intended to improve on-time performance of the public transport system to the extent that this can be accommodated without degrading overall performance of the traffic network. A bus priority solution has already been implemented in Auckland by the Auckland Regional Transport Authority

2.3 BRIC countries

2.3.1 ITS Applications and Future Developments in India

General context and trends

The India urban population is currently around 30%. Projections combining economies grow; rapid urbanization may lead the urban population to over 60% before it begins to stabilize. In absolute terms, it is projected that India’s urban population would grow to about 473 million in 2021 and 820 million by 2051.

In such a context, it is reasonable to assume that cities must not only meet the mobility needs of the current population but also provide for the needs of those yet to join the urban
population.

The Government of India has launched the National Urban Renewal Mission (NURM) that inter-alia seeks to bring about comprehensive improvements in urban infrastructure, committing substantial funds for this purpose and requiring a series of reforms that would make the investments sustainable.

The objective of this policy is to ensure safe, affordable, quick, comfortable, reliable and sustainable access for the growing number of city residents to jobs, education, recreation and such other needs within our cities. This is sought to be achieved by:

- Incorporating urban transportation as an important parameter at the urban planning stage rather than being a consequential requirement
- Encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved
- Improving access of business to markets and the various factors of production
- Bringing about a more equitable allocation of road space with people, rather than vehicles, as its main focus
- Encourage greater use of public transport and non motorized modes by offering Central financial assistance for this purpose
- Enabling the establishment of quality focused multi-modal public transport systems that are well integrated, providing seamless travel across modes
- Establishing effective regulatory and enforcement mechanisms that allow a level playing field for all operators of transport services and enhanced safety for the transport system users
- Establishing institutional mechanisms for enhanced coordination in the planning and management of transport systems
- Introducing Intelligent Transport Systems for traffic management
- Addressing concerns of road safety and trauma response
- Reducing pollution levels through changes in traveling practices, better enforcement, stricter norms, technological improvements, etc.
- Building capacity (institutional and manpower) to plan for sustainable urban transport
- and establishing knowledge management system that would service the needs of all urban transport professionals, such as planners, researchers, teachers, students, etc
- Promoting the use of cleaner technologies
- Raising finances, through innovative mechanisms that tap land as a resource, for investments in urban transport infrastructure
- Associating the private sector in activities where their strengths can be beneficially tapped
• Taking up pilot projects that demonstrate the potential of possible best practices in sustainable urban transport

The role of ITS in such a context can be examined through two projects [14]:

1. **The integration of ITS applications in the transport policy**, which is made possible through the development of Traffic Information and Management Control Systems (TIMCC). TIMCC would be the backbone of the future transport system. It would enhance accessibility, efficiency, interoperability, security, emergency response, multi-modal transport, etc. and reduce congestion and environmental pollution. It would also collect, store and archive real-time traffic data, which can be further analyzed and used for decision making for Comprehensive Mobility Plan.

2. Besides, the government of India has launched two initiatives JnNURM and NUTP to move India’s development trajectory onto a more sustainable path. Both these initiatives are focused on improving urban mobility across different states in India. ITS and TIMCC have been identified as one of the promising strategies to deal with the projected growing use of the existing urban transport system. ITS applications for Public Transport, for Parking management, for Traffic light operations, for Non-Motorized Vehicles and Travelers’ information will be among the main focus for pursuing sustainable urban mobility.

It has been stressed [15] that considering the future potential benefits of Intelligent Transport System (ITS) applications, positive impacts towards sustainable and balanced transportation solution could be envisaged. Intelligent Transport Systems (ITS) consist essentially in the application of computer and communications technologies in the context of the transport system. ITS technologies enable gathering of data or intelligence and then providing timely feedback to traffic managers and road-users. Furthermore, ITS applications may result in improved safety to drivers, better traffic efficiency, reduced traffic congestion, improved energy efficiency and environmental quality and enhanced economic productivity.

As part of these projects an embedded Centre of Excellence on ITS will be created at CDAC, Thiruvananthapuram, which would function as a national resource centre in the country. In pursuing this objective, the necessary infrastructure will be created at the Nodal Centre. The infrastructure and the spillovers of the ITS technologies and applications will be made available to the interested industries for their commercial exploitation.

The following table shows the main ITS objectives and the likely technological development in India.
### Table 6: ITS objectives and technology trends in India

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Trends in ITS technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Curbing congestion</td>
<td>• Wireless Traffic Control System</td>
</tr>
<tr>
<td>• Better Traffic demand management</td>
<td>• Second Generation Area Traffic Control System</td>
</tr>
<tr>
<td>• Improving the use of public transport</td>
<td>• Real Time Traffic Counting &amp; Monitoring System</td>
</tr>
<tr>
<td>• Developing multi modal transportation</td>
<td>• Intelligent Parking Lot Management System</td>
</tr>
<tr>
<td>• Environmental mitigation</td>
<td>• Advanced Travelers Information System</td>
</tr>
<tr>
<td></td>
<td>• Intelligent Transit Trip Planner and Real-time Route Information</td>
</tr>
<tr>
<td></td>
<td>• Red Light Violation Detection System</td>
</tr>
<tr>
<td></td>
<td>• Intelligent Traffic Congestion Management System using RFID</td>
</tr>
</tbody>
</table>

### Overview at urban and metropolitan level

The ITS development and implementation for Indian cities is initiated with collaborative projects between the department and research and academic institutions having requisite expertise. As part of this ambitious initiative 8 sub projects have been identified by CDAC, Thiruvananthapuram (nodal agency) with IITs (Chennai and Mumbai) and IIM, Kolkata as the other participating agencies. These 8 state-of-the-art sub projects have been initiated for development and demonstration through field implementation to the end users.

The projects are managed under the TIMMC and the Jawaharlal Nehru National Urban Renewal Mission.
The TIMMC project

The main objective of implementing TIMCC “Traffic Information Management Control Centre” is to cooperate with related institutions and agencies of transportation, law enforcement and emergency/event services in order to reach the following objectives:

- Improving the quality and reaching of mass transit travel as an end-to-end service.
- Improving air quality through regular monitoring and management.
- Improving parking systems through better management, information and access.
- Improving shared data and tools available to Delhi traffic police, MCD, NDMC, DDA, etc.
- Upgrading and standardizing traveler information services for more informed travel not just to give passive information like about congested areas, but dynamic interactions like alternatives routes or modes available, timings, cost, etc.

The following table shows the areas for which the applications of ITS applications are foreseen.

<table>
<thead>
<tr>
<th>Areas where ITS Technologies are used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Advanced traffic management applications</td>
</tr>
<tr>
<td>2. Emergency response and management systems</td>
</tr>
<tr>
<td>3. Road / infrastructure monitoring &amp; management</td>
</tr>
<tr>
<td>4. Public transport monitoring, management and passenger information systems</td>
</tr>
<tr>
<td>5. Commercial Vehicle operations (CVO) for tracking, monitoring, managing fleets, especially hazardous materials</td>
</tr>
<tr>
<td>6. Road and rail route planning</td>
</tr>
<tr>
<td>7. Advanced Traveller Information Systems</td>
</tr>
<tr>
<td>8. Environment monitoring and management</td>
</tr>
<tr>
<td>9. Electronic road pricing systems</td>
</tr>
<tr>
<td>10. Active and passive vehicle safety technologies</td>
</tr>
<tr>
<td>11. Parking management system</td>
</tr>
</tbody>
</table>

Source: Department of Information Technology, Ministry of Communication and Information Technology, Government of India
The Jawaharlal Nehru National Urban Renewal project [16]

**Buses for City Transport**

- **Urban Bus Specifications**
  - Low floor (400mm), semi low floor (650mm) and standard buses (900mm) as against prevailing 1100mm floor height (truck chassis)
  - ITS features
    - LED sign boards
    - Audio visual passenger information
    - Multiplexing, On board diagnostics
    - Cameras, integrated controller
    - GPS, GPRS, Smart card ticketing machines

- **Economic stimulus package**
  - Funding procurement of buses for urban transport under JnNURM.
  - 15260 modern buses sanctioned under economic stimulus package at a cost of US $ 1020 Million
  - Waive state & local taxes on public transport (upto 16%)
  - 61 mission cities Covered; about 4000 buses are on road - 31st Dec '09
  - City buses planned for 118 more 200 thousand + population cities

  34 new cities to get organised city bus service

Source: [16]

### 2.3.2 ITS Applications and Future Developments in China

**General context and trends**

It has been stressed [17] that the ITS research in China starts late, but with the worldwide spread of intelligent transportation Technology applications, China has also accelerated the pace of intelligent transportation technology research.

On one hand, Beijing, Shanghai, Shenyang and other big cities successively introduced from abroad some of the more advanced urban traffic control and road monitoring system; on the other hand, the government has established institutional bodies and set up a co-
operative framework, such as the State Planning Commission, the CST organizational development Real-time Adaptive Urban Traffic Control System HT-UTCS, the Shanghai Jiaotong University and Shanghai, all developing ITS applications in cooperation with traffic police corps SUATS system.

Furthermore, the traffic Intelligent Transport Systems Engineering Research Center, on behalf of Intelligent Transport System in China is set up to participate in international standardization activities, and now being carried out in China the standard system framework of the Intelligent Transportation Systems research.

Currently, traffic problems are common problems faced by countries in the world. Traffic congestion caused great waste of time, increase environmental pollution. Most cities in China, the average speed has dropped to 20km / h below, and some sections or even only 7 ~ 8km / h. China has witnessed a rapid increase in the number of vehicles travelling on the nation's highways over the last few years, which inevitably has caused traffic jams and accidents.

The following results are expected from ITS applications:

- ITS applications can streamline 'door to door' transportation solutions at urban and intercity short-distance passenger and freight transport.
- ITS may improve the set up of efficient transportation infrastructure,
- The use of detection, communication, computer, control, GPS and GIS and other modern high technologies, can improve transport infrastructure and transport equipment, reducing traffic accidents.
- Traffic management applications are considered to spread clusters of innovations: the traffic management system; management facilities modernization; network management tools, information, intelligence; management efficiency.

The strategy to overcome the barriers to ITS development in the present historical condition is based on the following steps:

- Intelligent Transport Systems applications need a solid foundation for development, in particular, should be to strengthen research in basic theories of ITS. It is important to strengthen cooperation with ITS operators and industry, allowing the exchange with the more advanced countries in the international ITS development
- To improve the national of ITS coordination. China's transportation system is still fragmented, i.e. railways, highways, civil aviation, public security, construction management and other departments run often separately ITS applications. In order to overcome that, it is necessary to set up a national strategy involving relevant departments, academics, business and research sector. In such a context, the
establishment of 'ITS China' organizations, similar to the United States, ITS America, Japan and the European ERTICO organizations, to formulate a consistent China ITS development strategy, objectives, principles and standards, would be needed. In particular the development of technical specifications related to ITS and the overall development planning, ITS technologies and products to achieve interoperability, compatibility and interchangeability, to strengthen the government’s macro-control in order to reduce local conflict of interest and the waste of limited funds.

- To foster R&D. With the further development of ITS, in the 21st century will undergo major changes in transportation, while the corresponding different levels is the demand for professionals in the past, very different, this should be the strengthening of domestic universities and research institutes the field of transportation and ITS foreign exchanges and cooperation in sending its staff to study and training.
- To provide the necessary resources. The current urgent need to address the problem as a shortage of funds in developing countries should be overcome in China starting with individual ITS projects with higher returns, ITS in urban traffic management system; advanced public transport operating systems; vehicle control and security systems and advanced logistics management systems.

The standardization issue.

The on-going standardization work in china includes: the research of ITS standardization development strategy, the constitution of national and trade standards, the applications status and standardization requirement of some technology areas in ITS, the research of testing technology.

In the national key project of the tenth Five-Year Plan “ITS Development Strategy and Standardization Research”, the research on ITS standardization development strategy of China has been included as a sub-project, which concerns the definition of ITS standardization scope, the influence of ITS standardization, the background of standardization in China, the analysis of their problems and the requirements, the general aim and phases aim of ITS standardization, and the guarantee system.

The research on the ITS development strategy should make clear the direction of the development of ITS standardization, the aim of each phase and ITS standardization.

The future of ITS standardization in China appears to be based on the following steps:

- To speed up the constitution of ITS standards. China should constitute ITS standards under the direction of the National Standardization Administration Committee and the related government departments. The emphasis on the standardization should
be on the protocols for data exchange and communication, interfaces in system integration, related standards in traffic control, definitions of transportation information, DSRC and standards for basic definitions.

- **To improve the cooperation with the related standardization committees.** ITS architecture implies the integration of various instruments and systems requiring significant standardization procedures. Examples are the Traffic Engineering Facility Standardization Technical Committee, the Telecommunication standardization committee, and the Traffic management standardization committee.

- **To support the participation to the set up of international standards.** The ITS Standardization Technical Committee and the secretariat of ISO/TC204 should organize committee members and enterprises to participate in the constitution of related international standards. The Committee should send experts, when necessary and available, to related international standardization organizations to participate their work.

- **To raise funds for ITS standardization** from several channels; from the government, from enterprises and social organizations.

- **To plan standardization-related projects and program applications.** According to the national reformation direction for the standardization work, standardization technical committees should mainly ensure the application of national standardization program. Therefore, the secretariat should collect the proposal of related departments, committee members and enterprises for advices, and cooperate with other standardization committees, then apply the standard constitution program based on these work and the ITS standardization architecture.

Summing up, the following table shows the ITS objectives and the future technological trends.

**Table 7: ITS objectives and technology trends in China**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Trends in ITS technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reducing congestion</td>
<td>• ITS Standardization protocols</td>
</tr>
<tr>
<td>• Traffic demand management</td>
<td>• Traffic management applications</td>
</tr>
<tr>
<td>• Improving the use of public transport</td>
<td>• Technologies for integrating transport modes (Pt fleet management, transfer points, information exchange)</td>
</tr>
<tr>
<td>• Developing multi modal transportation</td>
<td></td>
</tr>
<tr>
<td>• Environmental mitigation</td>
<td></td>
</tr>
<tr>
<td>• Safety</td>
<td></td>
</tr>
</tbody>
</table>
Overview at urban and metropolitan level

The Shanghai EXPO 2010

The World Exhibition (EXPO) 2010 has been held in Shanghai from May 1 to October 31 2010 with the theme of “Better City – Better Life”. This has represented an excellent example of ITS applications at urban level [18]. The traffic information service centre has been designed to be able to provide a number of services such as traveler information services via websites, displays on-board public transport vehicles and at bus stops, and kiosks at interchanges, etc. An EXPO ITS system has been designed to support six main functions as shown in the following figure.

Source: [18]

Figure 4: 13 EXPO Transport ITS system framework
Construction of Transit Metropolis, and Promotion of Urban Smart Growth in Nanjing

Nanjing is facing challenging choice for urban development and development of urban transport [7]. The following figure shows how demand for transport is increasing continuously.

![Changes in total trips and number of trips](image)

Source: Yang Yongliang, Construction of Transit Metropolis, and Promotion of Urban Smart Growth, ITF, 2010

It is expected that by 2030, the population in Nanjing metropolitan area will surpass 11 million.

In such a context, Nanjing a new strategy concerning urban development and construction process is needed. The cornerstones of such strategy are the following:

- Construction of transit metropolis;
- Public transport will be expanded with priority from “public transport in urban areas” to “full-range public transport” in the metropolitan area;
- New forms and use of the urban space structure will be needed, using the rail transport nodes as the cores for arranging the urban functional centers.

ITS applications will serve the main strategic goals: to construct transit metropolis with a multi-level public transport network by combining the national railways, the urban rail and the bus public transport into an integrated one, with high efficiency, high quality, and high compatibility.

Better use of information, integration, higher safety level, reducing travel time will be the
pillars with which ITS application will serve the future strategies. The Nanjing example is going to be followed in other cities across the country (36), that are running ITS applications in order to achieve the implementation of urban traffic intelligent control as the main instrument to ensure 'smooth flow of work', and that will be gradually extended to more than 100 cities nationwide.

**Intelligent Transport System (ITS) on Hong Kong's nationwide road network.**

The Government of Hong Kong-China is funding the multi-phased ITS and the development of the project began in 2001. The Hong Kong ITS project will ensure safety and efficiency in the country's transportation system when completed in 2010. The ITS project will streamline the traffic operations on major highways, road tunnels and urban roads.

Hong Kong's road network is one of the busiest in the world and it is not easy for the Government to build new roads on hilly terrains. The public transportation system in Hong Kong carries more than 7.7 million passengers per day on the existing road network and this leads to frequent traffic congestion.

The important ITS solutions include the implementation of the Transport Information System (TIS), extension of ATC, installation of TCSS and setting up the Traffic Management and Information Centre (TMIC). The other key features of the Hong Kong ITS project include the journey time indication system, and red light and speed enforcement cameras [19].

According to the plan, the ATC and TMIC are scheduled to be completed by 2006 and the TCSS by 2010.

As part of the development of the Hong Kong ITS project, TCSSs are being installed at Island East Corridor and Tolo Fanling Highways, while five TCSSs at Cheung Sha Wan to Tsing Yi, Sha Tin to Tsing Yi, North Lautau to Yuen Long, Tsing Yi North Coastal Road, Penny's Bay, Airport Tunnel and Aberdeen Tunnel are being upgraded.

The expansion works of ATC / CCTV systems at Taipo, North District, Tuen Mun and Yuen Long have been completed. The renewal of ATC / CCTV system for Hong Kong Island was also done as per the plan. The combined ATC control centre is being integrated with TMIC. The Traffic Control and Surveillance System will be formed by a combination of the following:

Traffic system along Route 8, including cameras (for monitoring, speed control and vehicle detection), dynamic traffic information panels (to provide users with up-to-date information
and speed limit information).

A traffic management control centre from which the traffic situation can be monitored. All traffic details will be processed at the centre and projected onto a large screen, together with camera images. The controls for all the traffic systems will also be housed here.

**The Beijing 2008 Olympic Games ITS trial**

In the context of the Olympic Games in Beijing [18] the local and national authorities faced strong transport tasks. In particular, the tasks focused on four areas, involving the need to design the overall traffic management policy:

1. the reduction of the total number of motor vehicles stage by stage,
2. the establishment of Olympic Special Lanes,
3. public transit assurance measures, and
4. the distribution of goods

It should be considered that Beijing is China’s second largest city in terms of population, after Shanghai. The population of Beijing has been on the increase ever since the People’s Republic of China was founded in 1949. In 2001, the population was 11.2 million. After 6 years, the total population has grown by 8.0% to 12.1 million in 2007. The above figures do not include the commuting population. If commuting population were taken into account, the population of Beijing has reached 17.4 million in 2007. One of the factors that resulted in the increase of population is due to the reform of the household registration system that led to a surge in marriages between residents in Beijing and those from other provinces. The average population growth rate is 1.3% from 2001-2007. The trend is expected to continue in the next few years.

Therefore, the socio-economic context of the city is challenging. Looking at transport, with over 7.5 million in the city proper and estimates of at least 17 million present in the conurbation, Beijing has been undergoing rapid growth. This has been mirrored in car registrations that have been increasing by over 15% each year, despite the road infrastructure space being increased by 3% annually.

With nearly 3.3 million motor vehicles on the road and nearly 4.9 million drivers, traffic in Beijing is difficult to manage. The Olympic Games obviously worsened the transport toll. 500,000 – 850,000 additional people were estimated to visit the city during the Olympic Games, worsening congestion, which was expected to be the great problem.

The key objective of the Beijing Olympic Games focused on controlling the expansion in road
traffic in the City to reduce levels of road congestion, improve the environment and ensure travel times for key members of the Olympic family during the Games.

The ITS applications at the Beijing Olympics focused towards the set up of an integrated, intelligent traffic-control-and-management system based on real-time traffic data and communication, online GPS or GIS information, and global coordination and optimization strategies. The goal was to develop and implement prototype and deployable ITS modules, platforms, and integration techniques for the Beijing Traffic Command and Dispatching System that could significantly reduce traffic congestion, travel time, and air pollution. The following picture depicts the subsystems architecture for traffic guidance, monitoring and dispatching.

![Subsystems Architecture for Traffic Guidance, Monitoring and Dispatching](source: [18])

It should be stressed that, besides the application of conventional system analysis and decision-making techniques, the Beijing trial also included the use of new and advanced methods in developing the subsystems, i.e. intelligent control techniques, agent-based control and programming, game theory, data mining, data fusion, fuzzy logic, neural networks, and genetic algorithms.
The software platform and integrated development environment have been developed for both online and offline operations for network communication, system configuration, data collection, monitoring and inspection, simulation and forecasting, and information analysis and broadcasting, as well as traffic control, guidance, and dispatching.

In terms of results, it must be stressed that during the Olympics Games, the day vehicle travelling in Beijing cut down on nearly 1.95 million vehicles, other than changed the traffic flow composition significantly.

The implementation of traffic control measures led to reduce the car share in the road traffic flow. The proportion of cars reduced from 60.16% to 50.85% (decreased 9.31%). Meanwhile, large-sized coaches had an increase from 1.09% to 1.46%. On the other hand, a huge number of large-sized coaches to meet the travel demand of Olympic volunteers, athletes, and officials occupied the roads. However, these large-sized coaches, including 2.2 thousand prepared by the Organizing Committee and the remainder coming from cities all around China, did not affect road congestion. It is worth pointing out in fact, that the percentage of buses increased by 1.17% during the Olympics, as bus departure frequency was highly raised (the number of departures amounted to 167 thousand from 152 thousand per day) and there were 34 newly-added special bus lines connected to stadiums. Additionally, more integration of public transport was reached, i.e. ticketed spectators were free to take the bus, subway, and special bus lines for stadiums on that day. Convenient public transit absorbed more car users, which led to the reduction of cars’ sharing rate. At the same time, another part of car users turned to non-motor vehicles on the evidence that the proportion of non-motors grew from 6.68% to 13.63%.
3 Cross country comparison

The cross-country comparison aims at identifying the key characteristics of ITS implementations (objectives and tools) in a cross-country perspective. The approach is qualitative, i.e. summarising the results discussed in isolations for each country through two tables (Table 8 and Error! Reference source not found.) in which the key results are identified and compared.

The first table (Table 8), shown in the next page, focuses on the prevailing ITS objectives. These objectives have been identified as a result of the review of ITS applications, currently applied and viewed in perspective. They must be considered as a short list of most desired ITS objectives, either quoted in national plans for ITS development or present in case studies. In any case, it must be stressed that the ITS short list is drafted according to subjective evaluations, made after reviewing the available literature, and that it is likely that the full consideration of missed documents and strategic programmes could have changed the situation.

The column and the row “Frequency” posted on the table allow to quantify the frequency with which respectively the countries have indicated ITS objectives and how much specific ITS objectives have been indicated.

Therefore, reading the table by columns, it is possible to guess how much a country is committed to use ITS applications, while reading the table by rows it is possible to rank the ITS objectives in terms of how much they are important in defining ITS national strategies.

Concerning the countries’ commitments in ITS, the table shows that, not surprisingly, the countries in which there is a strong tradition in using ITS applications, e.g. Japan, Korea, and, recently, the US and China, the ITS applications are expected to address a wider range of objectives compared to the countries in which the commitment towards ITS applications is more recent (Australia, India and New Zealand).

Concerning the ITS relevance, it is interesting to stress that Safety and Environmental issues are the objectives that show the higher frequency. In particular, Safety, which is present in all the ITS strategies across the world areas.
These conclusions are consistent with the cross country comparison carried out by the SAFER project [1], which outlined the importance of Safety issues in Europe and US. Supporting the integration of transport modes (i.e. favouring inter-modality) and improving transport management are the two ITS objectives lagging behind Safety and Environment. Curbing congestion and improving the Transport System are the next ITS objectives to rank in the higher positions, in particular in Japan [1].

It is interesting to note that the countries for which ITS development is recent and technologically less developed (India, China, New Zealand) the ITS objectives seem to follow a similar pattern: be focused on the same “basic” ITS basket of service: Safety, environment, Congestion, PT more Integration and Transport management.
### Table 8: Cross-country comparison of ITS objectives

<table>
<thead>
<tr>
<th>ITS Objectives</th>
<th>US</th>
<th>Japan</th>
<th>Australia</th>
<th>Korea</th>
<th>New Zealand</th>
<th>India</th>
<th>China</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety focus</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>7</td>
</tr>
<tr>
<td>Environmental issues</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
</tr>
<tr>
<td>Integrating transport modes</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>Transport management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>Curbing congestion</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>4</td>
</tr>
<tr>
<td>Improving Urban transport system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>4</td>
</tr>
<tr>
<td>Road pricing and financing alternatives</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Passenger Information</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Transportation impacts on livability (equity)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Emphasis on performance measurement and management</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Frequency</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>
Best Road Pricing technologies, major passenger information, emphasis on performance measurement and management (e.g. travel time); equity issues (elderly and disadvantage people) seem to be in the priority agenda of countries with stronger tradition in ITS development.

The second table (Error! Reference source not found.) provides hints about the future trends in ITS applications according to a cross-country perspective.

The table shows that to the extent we move from the countries with stronger tradition in ITS developments to the weaker ones, the future technological trends focus on mature products, e.g. electronic charging technologies and traffic management technologies (in India and China). Technologies favouring integration of information, wireless technologies, broadcasting technologies, seem to represent the new frontier for ITS applications (in US, Japan and Korea).

Using the following classification of the most prominent ITS technologies [3], it can be said that the Vehicle-to-Infrastructure Integration (VII), the Vehicle-to-Vehicle Integration (V2V), the Advanced Traveller Information Systems and the Advanced Transportation Management systems are the ITS categories in which the technological trends will be more pronounced (in US, Japan and Korea).

<table>
<thead>
<tr>
<th>ITS Category</th>
<th>Specific ITS Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Advanced Traveler Information Systems (ATIS)</td>
<td>Real-time Traffic Information Provision</td>
</tr>
<tr>
<td></td>
<td>Route Guidance/Navigation Systems</td>
</tr>
<tr>
<td></td>
<td>Parking Information</td>
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<tr>
<td>2. Advanced Transportation Management Systems</td>
<td>Traffic Operations Centers (TOCs)</td>
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<td>(ATMS)</td>
<td>Adaptive Traffic Signal Control</td>
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<tr>
<td></td>
<td>Dynamic Message Signs (or “Variable” Message Signs)</td>
</tr>
<tr>
<td></td>
<td>Ramp Metering</td>
</tr>
<tr>
<td>3. ITS-Enabled Transportation Pricing Systems</td>
<td>Electronic Toll Collection (ETC)</td>
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<tr>
<td></td>
<td>Congestion Pricing/Electronic Road Pricing (ERP)</td>
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<td></td>
<td>Fee-Based Express (HOT) Lanes</td>
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<td></td>
<td>Vehicle-Miles Traveled (VMT) Usage Fees</td>
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<td></td>
<td>Variable Parking Fees</td>
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<tr>
<td>4. Advanced Public Transportation Systems (APTS)</td>
<td>Real-time Status Information for Public Transit System (e.g. Bus, Subway, Rail)</td>
</tr>
<tr>
<td></td>
<td>Automatic Vehicle Location (AVL)</td>
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<td>Electronic Fare Payment (for example, Smart Cards)</td>
</tr>
<tr>
<td>5. Vehicle-to-Infrastructure Integration (VII) and</td>
<td>Cooperative Intersection Collision Avoidance System (CICAS)</td>
</tr>
<tr>
<td>Vehicle-to-Vehicle Integration (V2V)</td>
<td>Intelligent Speed Adaptation (ISA)</td>
</tr>
</tbody>
</table>

Source: [3]
Drawing conclusions, it should be stressed that the lesson learnt from the major countries in which Intelligent Information Systems play an important role (e.g. Japan and South Korea) is that these countries view ITS as one of a suite of IT applications or infrastructures which are able to transform their societies, driving economic growth. As a consequence, they have focused on establishing consistent policies and strategies for digital transformation in general and ITS development in particular, making them part of national priorities. The urban and metropolitan areas have benefited of all that.

Other important pre-conditions behind the success of these countries are the following:

- To develop a national ITS technical architecture that can serve as basis for the implementation of ITS application at lower level, e.g. Regional, Metropolitan, Urban, etc
- To raise funding for the deployment of ITS infrastructures, e.g. broadband, etc, setting up efficient regulative framework for a better development. Funding R&D is important as well.
- To foster interoperable standards for ITS (to be linked to the need of consistent ITS architecture)

It is worthwhile to note that other countries lagging behind, e.g. China, are embarking in ITS strategies along these paths.
Table 9: Cross-country comparison of ITS technological trends

<table>
<thead>
<tr>
<th>ITS Trends</th>
<th>US</th>
<th>Japan</th>
<th>Korea</th>
<th>Australia</th>
<th>New Zealand</th>
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<tr>
<td>Wireless technology</td>
<td>X</td>
<td></td>
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<tr>
<td>Ubiquitous connectivity</td>
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<tr>
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<td>Radio wave beacon</td>
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<td>Infrared beacon</td>
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<tr>
<td>Provision of regional traffic information</td>
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<td>Interoperability</td>
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<td>Smart card technologies</td>
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<td>Development of travel time</td>
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<td>estimation of HOV lane</td>
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<td>Data integration</td>
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<td>Forecasting high-risk accident</td>
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<td>Wireless infrastructure</td>
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<tr>
<td>Digital technologies</td>
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<tr>
<td>Monitoring</td>
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<td>ITS Trends</td>
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<td>Electronic user charging technologies</td>
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<tr>
<td>Wireless Traffic Control System</td>
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<tr>
<td>Second Generation Area Traffic Control System</td>
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<tr>
<td>Real Time Traffic Counting &amp; Monitoring System</td>
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<tr>
<td>Intelligent Parking Lot Management System</td>
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<td>Advanced Travelers</td>
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</table>
### ITS Trends

<table>
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<tr>
<th>ITS Trends</th>
<th>US</th>
<th>Japan</th>
<th>Korea</th>
<th>Australia</th>
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<tbody>
<tr>
<td>Information System</td>
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<td>Red Light Violation Detection System</td>
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<tr>
<td>Intelligent Traffic Congestion Management System using RFID</td>
<td></td>
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<tr>
<td>Technologies supporting modal integration</td>
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</tbody>
</table>
4 Commonalities and differences between ITS solutions adopted in Europe and worldwide

4.1 The EU framework for R&D and ITS architecture

The Intelligent Transport Systems solutions implemented in Europe and destined to become important components of new and more efficient transport services in the near future have spread over a large transport recipients and modes. Namely:

- Concerning air transport, the SESAR work program, a new-generation of air traffic management system, part of the single European sky initiative, was launched in 2004 to reform the organization of air traffic control in European airspace. SESAR will introduce new communication, control and computing technologies between the ground and aircraft, which will optimize the work of air traffic controllers and pilots.
- The River Information Services (RIS), which is aimed at the implementation of information services in order to support the planning and management of traffic and transport operations (Directive 2005/44/EC of the European Parliament and of the Council of 7 September 2005 on harmonized river information services (RIS) on inland waterways in the Community [Official Journal L 255, 30.9.2005].
- Concerning the rail transport, the European Rail Traffic Management System (ERTMS) and Telematics Applications for Freight (TAF-TSI) have been gradually introducing automatic train protection system (ATP), in order to replace the existing national ATP-systems; and GSM-R, a radio system for providing voice and data communication between the track and the train, based on standard GSM using frequencies.
- Shipping has introduced SafeSeaNet and Vessel Traffic Monitoring and Information Systems (VTMIS) and is progressing towards an Automatic Identification System (AIS) and Long-Range Identification and Tracking (LRIT)
- Road transport, finally, has experienced ITS applications from private and public operators mainly in the field of Electronic Data Collection

Furthermore, it is important to mention several other examples of specific ITS applications in the fields of road safety, interoperability and fraud protections fostered by EU legislation:
- Digital tachograph: in all new EU commercial vehicles since 1 May 2006 implying records of driving times and rest periods of professional drivers.
- The eCall: a common European platform for emergency call generated manually or automatically. A planned Directive mandating eCall devices in all new vehicles by end 2014 has been designed.
- Tracking and tracing of livestock transport: Council Regulation 2005/01/EC on animals welfare protection during transport and related operations.

The development of Cooperative Systems in Europe is being supported by several projects (mainly in the area of Safety):
- Cooperative systems: CIVIS, Safespot, COOPERS, C2C CC, COMeSafety, Pre.Drive C2X, SimTD, ETSI TC ITS
- Intelligent vehicle systems: HAVE-IT, e Value, FOTS, FESTA, TeleFOT, FOTNet

However, despite the pervasiveness of these initiatives, which have involved several stakeholders (private and public), citizens and member States governments, it has been stressed the lack of a coherent European framework for interconnection between road and the other transport modes. More specifically, in order to avoid “the emergence of a patchwork of ITS applications and services” [20], some step have to be taken in terms of major geographical continuity, interoperability of services and systems and standardization. All this should facilitate pan-European applications, secure accurate and reliable real-time data and an adequate coverage of all travelling modes.

Two recent initiatives (an EC Communication and a Directive) have marked a change in the general EU approach towards major co-ordination in ITS development:

1. On 16 December 2008, by adopting an Action Plan on deployment of Intelligent Transport Systems in Europe for road transport, with a particular focus to the integration of road transport with other transport modes [20].
2. On 6 August 2010, publishing the Directive on the framework for the deployment of ITS in the field of road transport and for interfaces with other modes of transport.

The Action Plan suggested a number of targeted measures (classified according to six action areas) designed to improve market penetration of ITS applications and services in Europe. The six priority areas are the following:
This Action plan should be interpreted in the light of other European Commission initiatives such as the Action Plan on Freight Transport Logistics, the Action Plan on Urban Mobility, the Galileo deployment, the Greening Transport Package, the i2010 initiative on Intelligent Cars, eSafety, the 7th Framework Programme for Research and Technological Development, eCall, the European Technology Platforms and their strategic research agendas, CARS 21.

Concerning the Directive 2010/40/EU, it aims at developing at a faster pace the adoption of innovative transport technologies across Europe. The fields considered most promising for efficient ITS applications are the following:

- Congestion (e.g. Traffic management, Road Use Charging).
- CO2 road emissions (e.g. access management, eco-driving, co-modality (seamless integration of transport modes in a “Single Transport System”).
- Fatalities and Injuries (e.g. Electronic Stability Control (ESC), ADAS (lane keeping, speed alert/adaptation, V2I...), emergency call (eCall).

Through this framework, the European Commission is going to establish for the coming years several specifications (functional, technical, organizational, etc) whereby the compatibility, interoperability and continuity of ITS solutions across the EU can be achieved.
Five priority areas have been identified:

1. Multimodal travel information services;
2. Real-time traffic information services;
3. Data and procedures (minimum universal traffic information free of charge to users);
4. Harmonized provision for an interoperable EU-wide eCall;
5. Safe and secure truck parking places: Information/Reservation services.

It can be said that the Directive implicitly recognizes that historical heritage, i.e. the composition of the European Union in several Member States, may act as a barrier to the full exploitation of the potential of ITS application. The preamble to the Directive (art. 23) states that “Since the objective of this Directive, namely to ensure the coordinated and coherent deployment of interoperable Intelligent Transport Systems throughout the Union cannot be sufficiently achieved by the Member States and/or the private sector and can therefore, by reason of its scale and effects, be better achieved at Union level, the Union may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty on European Union”.

The procedures indicated in the Directive concern:

- delegated acts (Art. 290 TFEU)
- based on standards (where appropriate)
- impact assessment prior to adoption

The implications for Member States are the following:

- to ensure use of specifications when ITS is deployed
- to cooperate in respect to priority areas
- to be subjected to obligation only after adoption of co-decision proposal

The following two Actions will imply relevant implications in terms of better standardization requirements:

Action 4.1 - Adoption of an open in-vehicle platform architecture.

The adoption of an open in-vehicle platform architecture for the provision of ITS services and applications, including standard interfaces will imply in fact the activity of relevant standardization bodies.
Action 4.2 - Development and evaluation of cooperative systems.
The development and evaluation of cooperative systems will imply the definition of a harmonized approach and the assessment of deployment strategies, including investments in intelligent infrastructures.

Concerning the R&D supporting activities, it should be stressed that the cornerstone of the EU strategy is the RTD Research Activity in the context of the Framework Research Programme. Serving the scope of supporting ITS research, a lot of resources have been invested in this area, i.e. for nearly 20 years (from 2002 to 2009 (FP6 and FP7), they are estimated in more than € 300 million (ITS Conference 2010).

Concerning the ITS architecture, it has been stressed that, compared to the other countries (US, Japan) the creation of a common ITS architecture in Europe started late (mid-90s). The key challenge is now to harmonize the several applications deployed at country and urban level [13].

The European project KAREN [21], funded under the 4th Framework Programme (1994-1998) set the scene for the definition of a common Framework Architecture supporting intelligent transport system (ITS). The platform was conceived to offer a basis for a European integrated approach to ITS.

After that, the European ITS Framework Architecture is currently being maintained by the EC Funded Project E-FRAME (2008-11), (http://www.frame-online.net/) which has extended the Framework Architecture for Cooperative Systems. This project has also taken over many of the tasks previously undertaken by the FRAME Forum for its duration and other EU R&D projects. Namely:

- COOPERS project (Co-operative Systems for Intelligent Road Safety) http://www.coopers-ip.eu/
- SAFESPORT Integrated project (Cooperative vehicles and road infrastructure for road safety) http://www.safespot-eu.org/
- CVISproject (Cooperative Vehicle-Infrastructure Systems) http://www.cvisproject.org/

The following picture provides an overview of the overall implementation process within the FRAME context.
It must be stressed that the current approaches mainly focus on ITS Road applications.

4.1.1 The focus on the urban level

In this overall framework, a specific role has been designed for developing ITS applications for the European urban areas.

In particular, the Action Plan on Urban Mobility COM (2009) 490 has identified 20 Actions classified in six Themes (1. Promoting integrating policies, 2. Focusing on citizens, 3. Greening urban transport, 4. Strengthening funding, 5. Sharing experience and knowledge, 6. Optimizing urban mobility to support sustainable mobility through ITS applications in cities and regions.

Source: [22]

Figure 5: ITS implementation process within the EU ITS Architecture framework E-FRAME
The background of the Action Plan on Urban Mobility lies in the Action Plan on ITS deployment of Intelligent Transport Systems in Europe examined in the above chapter; in particular as far as the Action 6.4: “Urban ITS Platform” is concerned. This action in fact aimed at promoting urban ITS and providing broader guidance and technical support to the implementation. The Action 6.4 quotation is the following: “Set-up of a specific ITS collaboration platform between Member States and regional/local governments to promote ITS initiatives in the area of urban mobility” [20].

The key ITS applications identified in the Action Plan on Urban Mobility and considered as key drivers for addressing congestion, environmental problems, safety and social issues in the European urban areas are the following:

- Travel and traffic information
- Electronic payment and ticketing
- Traffic management and demand management
- Road pricing
- Urban logistics
- Public transport operations
- Enforcement

The above ITS applications may be classified in four main groups:

1. Traffic and Travel Information
2. Smart Payment Systems
3. Traffic Management
4. Urban Logistics

The current status, i.e. situation, problems, challenges, of urban ITS deployment has been outlined in the proceedings of the Expert Group on ITS, established in the context of a more general road map accompanying the implementation of the Action Plan on Urban Mobility⁴.

The following important framework conditions for the deployment of ITS in cities have been stressed by the Expert Group [23]:

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⁴ The road map includes Workshops with stakeholders, bilateral meetings and the establishment of an Expert Group on ITS to support the European Commission in its work relating to the Action Plans on ITS and Urban Mobility (two years of mandate)
• Diversity of European cities: taking into account local needs, objectives and targets and supporting local policy objectives
• Customer- and market-orientation: efficient provision of affordable, useful services with sufficient user acceptance and financial viability
• Complexity of ITS: although technology can always be improved, the main immediate challenges are not technical but economic and organizational
• Interoperability and continuity: highly desirable to assure safety, reliability and competitiveness - even if local ITS systems mainly serve the local market; important role for standards

It may be observed that the framework conditions at urban level stress two important (interlinked) aspects:

1. The intrinsic large difference among the European cities, according to geographic location, wealth, size and different tradition in ITS applications. This diversity, which is also compounded by different institutional contexts, i.e. degree of financial autonomy, relationships with the central/regional government, etc, make unlikely European one-size-fits-all approaches (or top-down solutions)
2. The unquestionable fact that autonomous decisions at urban level in a context of fast technological developments and fragmented uptakes produce a patchwork of ITS applications. The need for standardization and integration, even if in a context of ITS services provided basically at local level, has been raised as a consequence.

How to match the need for standardization (which means similar services for the European citizens at similar costs) with the local (urban) responsibility for urban mobility policies represents one of the key challenges.

The indications drawn by the EC documents and Expert Group activity allow defining the guidelines for reaching an efficient trade-off between standardization and local decisions.

Support of the EC, basically through:
• promoting the deployment of urban ITS (local policy objectives)
• supporting the dialogue between public and private stakeholders
• providing guidance and technical support (in particular, focusing on the technical standardization and interoperability of the solutions)
• favoring exchange of best practice
• stressing the consistency with ITS Directives
4.2 Comparison with the non-European countries

The comparison with the non-European countries focuses on two aspects:

4. The ITS architecture (national level)
5. The ITS applications, viewed in perspective (local and metropolitan level)
6. The organizational context, with reference to the R&D expenditure (national level)

The approach is to outline differences and commonalities.

4.2.1 ITS Architecture

ITS architecture brings together in a common framework three different levels:

1. The physical architecture, (the base level of the overall architecture) specifying the relationships between systems and subsystems
2. The logical architecture (or functional architecture), in which the services provided are specified in terms of data required and information flows
3. The reference architecture is the top-level description of users, actors and services (and how they interact)

The ITS architecture main task is to streamline the relationships between actors and services, providing services at lower costs, favoring integration, updating with new technologies, reducing capital and operating costs, etc.

However, in order to reach a good integration, the pre-condition is that the stakeholders (public and private) can exchange information and co-operate.

The following table summarizes the objectives and the characteristics of the ITS architectures\(^5\) for three countries examined in the above chapters: US, Japan/South Korea and Australia.

\(^5\) Details can be found in [13]
Table 9: ITS architecture in Europe, Japan, Korea, Australia and the US

<table>
<thead>
<tr>
<th>Countries</th>
<th>Japan/South Korea</th>
<th>Australia</th>
<th>Europe</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>• to integrate the system</td>
<td>• to identify components and actors</td>
<td>• to allow a coherent deployment of local/national ITS applications</td>
<td>• to provide a common framework for planning ITS applications</td>
</tr>
<tr>
<td></td>
<td>• to ensure upgrading</td>
<td>• to increase awareness among stakeholders</td>
<td>• to set up harmonized rules</td>
<td>• to set up harmonized rules</td>
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<td></td>
<td>• to promote standardization</td>
<td></td>
<td>• to promote standardization</td>
<td>• to promote standardization</td>
</tr>
<tr>
<td>Characteristics</td>
<td>• focus on detailed system specifications (physical architecture)</td>
<td>• focus on top level specifications (reference architecture)</td>
<td>• focus on high level framework (reference architecture)</td>
<td>• focus on the functional level (logical architecture)</td>
</tr>
</tbody>
</table>

The table shows that in the most advanced countries (Japan and South Korea) the ITS architecture is more detailed and open to take into account the most technological developments.

On the contrary, to the extent that ITS applications are less pervasive (Australia), the ITS architecture is mainly oriented to specify the framework that allows the ITS actors to be part of the system, increasing awareness of the potential benefits.

In the European case, similar in that to the US, the ITS architecture must ensure that the local actors (at country and local level) can be part of the system, facilitating the standardization.

The following picture depicts the state-of-the-art of the ITS standardization in US, Japan and US.
4.2.2 Technologies

The comparison of the technological trends is based on the findings of the previous chapters (see Error! Reference source not found.).

In that table it has been shown that the countries with stronger tradition in ITS developments (i.e. Japan and South Korea) are investing in new generation of vehicle-to-infrastructure Integration and vehicle-to-vehicle integration. Wireless technologies, favouring ubiquitous connectivity, multiplex broadcasting, location-based tracking feature in GPS-enabled phones to access Web sites (that presents a list of available public transportation options) are at the forefront of the technological trends in the most ITS developed countries.

The EU technological trend is based on the development of mature applications, Travel and traffic information, Electronic payment and ticketing Traffic management, demand management, road pricing Urban logistics, Public transport operations Enforcement, using advanced technologies (e.g. Dedicated-Short Range Communications wireless technology). All in all, it can be said that Europe is making a concerted effort to catch up the most developed countries.
4.2.3 Organizational and political factors

In a cross-country perspective, the challenges hampering the EU to reach the most advanced ITS developed countries seem to be more organizational or political than merely technical.

From a political point of view, the review of non-European countries ITS applications has shown that Japan and South Korea, for example, have benefited from having a strong policy commitment to develop IT (Information Technology) in general (and ITS as a particular development area) for more time than Europe.

This is confirmed by the cross country comparison carried out by the SAFER project, with reference to ITS applications in the important area of Safety [1]. Looking at the conclusions, it can be read:

- Compared to Europe, in US and Japan there is a stronger direct governmental support if ITS applications
- In Europe the support in indirect, via the European Commission initiatives and R&D funding
- This leads to a larger, but overlapping, number of projects in Europe
- In Japan, furthermore, the projects end with a product and deployment stage more likely than in Europe and US, in which the theoretical and demonstration stages prevail.

It has been stressed [3] that the degree of centralization in ITS decision-making authority may be one the most important policy factor for ITS success. In fact, the importance of centralized ITS decision-making is relevant at least from two perspectives:

1. many intelligent transportation systems applications, e.g. electronic toll collection, in order to produce higher benefits need to face system coordination problems, and may require scale and need to be implemented at a nationwide level. For example, Japan operated a single national standard for electronic toll collecting, thus ensuring nationwide system compatibility.
2. On the other hand, local or state/regional actors may not have the same willingness to innovate or invest in ITS, and even if they do they are unlikely to have sufficient funding or the ability to reach sufficient economies of scale. For all these reasons, national level vision, leadership, and coordination are essential for ITS success.

Furthermore, a strong commitment in Information Technology development can provide the infrastructure backbone for the development of several applications, like the
development of broad-band and telecommunication networks. For example, it should be considered that South Korea was ranked in 2008 as one of the world’s most advanced information and communication technology infrastructures [24].

Investments in R&D also play an important role. Japan and South Korea have devoted relevant resources. It has been estimated that South Korea has pledged a $3.2-billion investment, an average of about $230 million annually, from 2007 to 2020 and Japan invested approximately $645 million in ITS from April 2007 to March 2008 and $664 million in ITS from April 2008 to March 2009 [2]. The aggregate ITS spending at all government levels in the United States in 2006 was approximately $1 billion, most of it spent at the state level. As a percentage of GDP, South Korea and Japan each invest more than twice as much in ITS as does the United States.

The complex structure of the EU compared to the federal States or small countries, raises organizational challenges, and in particular as far as the co-ordination with stakeholders and the standardization of ITS applications is concerned.
5 Conclusions

The European Commission has proposed new legislative initiatives (e.g. the Directive 2010/40/EU and the Action Plan on Urban Mobility) to accelerate and harmonize ITS deployment, aiming at ensuring concerted contributions from the stakeholders and a strong coordination with the Member States.

The lessons drawn from the success stories of Japan and South Korea teach that the potential of ITS can better be realized if the deployment in Europe is realized along the lines of more integration, targeted investments (R&D) and standardization. At urban level it is important to ensure the consistency of the local ITS applications (to be supported according to the subsidiarity principles) with the framework objectives and the technical requirements (standardization) outlined by the ITS Directive 2010/40/EU.

Other important pre-conditions behind the success of these countries are the following:

- To develop a national ITS technical architecture that can serve as basis for the implementation of ITS application at lower level, e.g. Regional, Metropolitan, Urban, etc.
- To raise funding for the deployment of ITS infrastructures, e.g. broadband, etc, setting up efficient regulative framework for a better development. Funding R&D is important as well.
- To foster interoperable standards for ITS (to be linked to the need of consistent ITS architecture)

In terms of cross-country comparison, it has also been stressed [1] that USA and European ITS projects usually end with a demonstrator or theoretical results, while Japan ITS projects end with a product and a deployment phase. This raises the issue of which governance framework is most suitable to ensure higher levels of measures implementation. The Japan success story in ITS implementation acknowledges the important role of the public-private-academic partnership. It has been shown in fact that “universities and research institutes have conducted basic research and basic technological development from a mid-term governmental perspective and industry has pursued process innovation and product innovation that responds/anticipates consumer needs. In this context the strengthening of ties between universities, considered as the birthplace of new knowledge and industries, which apply and commercialize it, was seen as crucial by Japan’s Government “[8].
Furthermore, it should be considered that local or state/regional actors may not have the same willingness to innovate or invest in ITS, and even if they do they are unlikely to have sufficient funding or the ability to reach sufficient economies of scale. For all these reasons, national level visions, leadership, and coordination are essential for ITS success. The implications for Europe is that the complex structure of the EU compared to the federal States or small countries, raises organizational challenges, in particular as far as the coordination with stakeholders and the standardization of ITS applications are concerned.

Thereby, taking into account for all these reasons, it is important that the implementation of the measures in the EU Action Plan on Urban Mobility will call for an adequate governance structure. This implies that Member States should aim at reaching agreement on a common ITS agenda and on methods to proceed from plans to coordinated implementation, for example by way of concerted investments and initiatives.

It should be stressed that the countries in which Intelligent Information Systems play an important role (e.g. Japan, Korea) view ITS as one component of a suite of IT (Information Technologies) applications or infrastructures which are deemed to transform their societies in a broader sense, i.e. supporting mobility, communication and increasing economic growth. As a consequence, these countries have designed consistent long-term policies and strategies for digital transformation in general and ITS development in particular, putting them on the top list of national priorities. The urban and metropolitan areas have consequently benefited of all that, in particular in terms of higher modal shifts towards public transport.

Concerning the likely technological developments, it can be said that wireless technologies, favouring ubiquitous connectivity, multiplex broadcasting, and location-based tracking feature in GPS-enabled phones to access a Web sites (that present a list of available public transportation options) are at the forefront of the technological trends in the most ITS developed countries. From this perspective, i.e. the development of more developed cooperative systems, the EU situation is promising. In fact, the development of Cooperative Systems in Europe is being supported by several projects (mainly in the area of Safety), that cast a positive light on positive future developments:

- Cooperative systems: CIVIS, Safespot, COOPERS, C2C CC, COMeSafety, Pre.Drive C2X, SimTD, ETSI TC ITS
- Intelligent vehicle systems: HAVE-IT, e Value, FOTs, FESTA, TeleFOT, FOTNet
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