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GUIDELINES FOR THE REGULATORY FRAMEWORKS OF INTELLIGENT TRANSPORT SYSTEMS IN ASIA AND THE PACIFIC

UNITED NATIONS
ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

Bangkok, 2019
The shaded areas of the map indicate ESCAP members and associate members.

The Economic and Social Commission for Asia and the Pacific (ESCAP) serves as the United Nations’ regional hub promoting cooperation among countries to achieve inclusive and sustainable development. The largest regional intergovernmental platform with 53 Member States and 9 Associate Members, ESCAP has emerged as a strong regional think-tank offering countries sound analytical products that shed insight into the evolving economic, social and environmental dynamics of the region. The Commission’s strategic focus is to deliver on the 2030 Agenda for Sustainable Development, which it does by reinforcing and deepening regional cooperation and integration to advance connectivity, financial cooperation and market integration. ESCAP’s research and analysis coupled with its policy advisory services, capacity building and technical assistance to governments aims to support countries’ sustainable and inclusive development ambitions.

*The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.*
GUIDELINES FOR THE REGULATORY FRAMEWORKS OF INTELLIGENT TRANSPORT SYSTEMS IN ASIA AND THE PACIFIC
DEVELOPING REGULATORY GUIDELINES FOR 21ST CENTURY TRANSPORT IN ASIA AND THE PACIFIC

It may be still some time before autonomous vehicles, also called “self-driving” or “driverless” vehicles, take to the roads, but vehicles are already “talking” to each other as they speed along highways and are alerting drivers to prevent collisions. Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Vehicle-to-Everything (V2X) are emerging ‘smart transport’ technologies that enable moving vehicles to communicate with each other as well as with road infrastructure and other objects in order to improve traffic safety and travel convenience.

Intelligent Transport Systems (ITS) use a mix of technologies to make transport safe, smart and green, and are at different stages of deployment across the Asia-Pacific region, where some countries are already recognized as global ITS leaders.

Autonomous vehicles, connected vehicles (V2V, V2I and V2X) and Mobility-as-a-Service (Maas) platforms that promote seamless connectivity are being tested and adopted in China, Seoul, Singapore and Tokyo. Advanced multi-lane, free-flow toll gates are being used in Turkey while Viet Nam is using “black box” cruise control safety systems. A number of countries in the region are using cutting-edge technologies to facilitate smooth traffic flow, keep travellers updated with pre-trip and en route traffic information, and automatically collect tolls.

Although transport of people and goods is crucial for economic and social well-being, it also leads to crashes and traffic congestion, and is a major contributor to CO₂ emissions and air pollution. By improving safety and mobility while reducing health- and environment-harming vehicular emissions, ITS deployment supports regional progress towards the Sustainable Development Goals (SDGs). Road crashes are estimated to cause economic losses equal to about 3 per cent of gross domestic product in Cambodia, Indonesia, Thailand and Viet Nam. Research by the United States National Highway Traffic Safety Administration found that V2V and V2I technologies could prevent more than 80 per cent of unimpaired-driver crashes in all types of vehicles.

However, the effectiveness of ITS depends not just on physical infrastructure and technologies, but also requires a comprehensive regulatory framework that defines the roles and responsibilities of the public and private sectors as well as the R&D community in ITS development and operation.

Regulations also help in integrating current and emerging technologies. This is especially important in the Asia-Pacific region where some countries that are still in the early stages of ITS development are attempting to leapfrog the technology gap. ITS regulatory frameworks support the technical transition period of interoperability and compatibility.

In the Asia-Pacific region, not all countries have adequate regulations to support the planning, development and operation of ITS. This study, supported by the Korea-ESCAP Cooperation Fund, offers guidelines for developing ITS regulatory frameworks in the region. It finds that the region’s growing economic and technological strengths, a large youth population and improving transport connectivity are among the advantages that can help overcome challenges to ITS development.

This study also identifies ITS development opportunities in the region, including advanced traffic management centres, smart mobility, cooperative-ITS, connected vehicles and autonomous vehicles.
EXECUTIVE SUMMARY

Intelligent Transport Systems (ITS) are defined as “an agglomeration of diverse technologies that enhance the sustainability of transport systems in a safer, smarter and greener way”. ITS contributes to increased transport safety, seamlessness and convenience while reducing their environmental impact, thereby supporting core elements of the 2030 Agenda for Sustainable Development.

Some countries in the Asia-Pacific region have emerged as world leaders in testing and deploying advanced transport technologies, but many countries are still in the early stages of adopting ITS while others have yet to initiate the transition towards ITS. A major challenge to adoption of ITS in the region is the lack of adequate regulatory frameworks.

This report assesses the state of ITS development and operation in Asia and the Pacific and offers policy recommendations for establishing ITS regulatory frameworks at the national and regional levels.

Importance of ITS regulatory frameworks

ITS regulatory frameworks are important for three categories of stakeholders in the development and operation of ITS, namely the public, private and academic sectors. ITS regulatory frameworks define the roles and responsibility of each class of stakeholder, setting standards and the direction for future research and development. Regulatory frameworks also help bridge the gap between developing and least developed countries in the region that are in the early stages of ITS deployment and those that are at an advanced stage of ITS operation. This is especially important in the region where some relatively less developed countries are attempting to leapfrog the ITS technology gap. Regulatory frameworks can provide the support during the technical transition period of interoperability and compatibility, and may help to determine the direction of these changes. ITS regulatory frameworks facilitate integration of current and future technologies for efficient ITS development and operation.

ITS development and operation in the Asia-Pacific region

This study reveals four milestones in ITS development in the region – the initiation stage, the take-off stage, the acceleration stage and the maturation stage. The timeline of ITS development in the Asia-Pacific region shows two different groups of countries – one where ITS development has proceeded in sequence from stage 1 to stage 4, and another where this is not the case.

A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for ITS development and operation in the region shows that the strengths and opportunities outweigh the many challenges to effective development, operation and integration of ITS technologies in Asia and the Pacific.
In addition, this report analyses the operation of three specific ITS applications in eight countries in the region – Azerbaijan, China, the Republic of Korea, the Russian Federation, Tajikistan, Thailand, Turkey and Vietnam. The ITS applications reviewed are Advanced Traffic Management Systems (ATMS), Advanced Traveller Information Systems (ATIS) and Advanced Public Transport Systems (APTS).

The study identifies ITS development opportunities in the Asia-Pacific region, including traffic management centres, smart mobility, cooperative-ITS and connected vehicles, and autonomous vehicles. The working of these applications is reviewed in the region together with practical examples from North America and Europe in order to help in formulating policy recommendations for ITS regulatory frameworks in the region.

Goals of ITS development
It is desirable that each country in the Asia-Pacific region develops ITS solutions tailored to its transport priorities in the four main areas of improving safety and mobility, and reducing congestion and environmental risks. The short-term goal of ITS development should be to address urgent transport problems and improve ITS infrastructure in countries that are in the early stages of deploying ITS applications. The long-term goal is to reduce ITS development gaps among countries in the region for providing seamless ITS services across Asia and the Pacific.

Given that the regulations should cover ITS services currently in use in the region, prioritizing ITS applications would help to identify feasible ITS regulatory frameworks. The Asia-Pacific countries can be categorized into three groups according to the level of ITS development, which determines their ITS priorities in the areas of safety, mobility, congestion and environment.

Policy recommendations
This study outlines the following policy recommendations for establishing ITS regulatory frameworks and promoting ITS deployment in the Asia-Pacific region:

- Assess the current status of ITS deployment at the national level;
- Prepare a checklist of existing regulations;
- Identify transport priorities for the country as the basis for prioritizing ITS applications;
- Strengthen cooperation and collaboration with neighbouring countries that have deployed ITS effectively;
- Develop a coordinated and harmonized approach through regional strategies and policy plans to ITS deployment across the Asia-Pacific region.
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1.1 Background

Transport boosts economic and social development by facilitating the movement of people, goods and resources. Sustainable transport is central to the 2030 Agenda for Sustainable Development adopted by world leaders in September 2015.

However, the transport sector is the fastest-growing contributor to CO\textsubscript{2} emissions, as it is the largest global user of energy (36 per cent).\footnote{International Energy Agency, Key World Energy Statistics 2018. Available at https://www.oecd-ilibrary.org/energy/key-world-energy-statistics-2018_key_energ_stat-2018-en (Paris, 2018).} It was the second-largest source (24 per cent) of CO\textsubscript{2} emissions worldwide in 2015.\footnote{International Energy Agency, CO\textsubscript{2} Emissions from Fuel Combustion – Highlights. Available at https://webstore.iea.org/co2-emissions-from-fuel-combustion-highlights-2017 (Paris, 2017).} In particular, CO\textsubscript{2} emissions from the transport sector during 1990-2015 increased by 68 per cent, with the road sector accounting for 75 per cent of transport emissions in 2015.\footnote{Ibid.}
It is projected that the transport sector’s contributions of \( \text{CO}_2 \) emissions in Asia will increase from 19 per cent in 2006 to 31 per cent by 2030.\(^4\) Transport is also a major contributor to air pollution. During 2008-2013, from the 20 countries in Asia that recorded data on PM 2.5 levels in cities, only two countries met the levels recommended by the World Health Organization.\(^5\) As of 2017, non-OECD Asian countries, including China and India, accounted for more than 70 per cent of the increase in transport fuel consumption in non-OECD countries, due to the increase in personal mobility.\(^6\)

Promoting sustainable transport systems is a high priority for countries in the Asia-Pacific region, and Intelligent Transport Systems (ITS) are revolutionizing transport in the region by deploying information technology (IT)-based communications and control technologies. These include state-of-the-art smart transport technologies developed in recent years, such as cooperative-ITS (C-ITS), connected vehicles (CVs), smart mobility and autonomous vehicles (AVs or self-driving vehicles). With an increasing number of ITS-related national initiatives, it is expected that demand for ITS deployments will continue growing in the Asia-Pacific region.\(^6\)

Against this backdrop, in 2017 the seventy-third session of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) adopted Resolution 73/4 on the Implementation of the Ministerial Declaration on Sustainable Transport Connectivity in Asia and the Pacific,\(^7\) which recognized the role of transport systems.

Resolution 72/212\(^8\) adopted by General Assembly in 2017 also stresses “the necessity of promoting the integration of science, technology and innovation into sustainable, integrated, multimodal and intermodal transport systems […] to bring about fundamental, transformative changes to transport systems, including […] information and communications technologies, […]”.

ITS has been adopted in varying degrees by countries in the Asia-Pacific region, with several countries now recognized as world leaders. However, a major obstacle to effective ITS development and operation in the region are challenges to setting up a regulatory framework for ITS.\(^9\) A solid regulatory foundation is a prerequisite to broadly govern the planning, development, implementation and operation of ITS, but the level of understanding of the importance of regulatory foundations is still not high enough in the region.

1.2 Definition of the ITS concept

Because of different priorities in each country for dealing with their transport problems, approaches to ITS development vary that need to be aligned to maximize the benefits gained from ITS. For this, ITS needs to be defined properly to provide intuitive perception about what ITS means to the potential stakeholders.

Given that defining a terminology may reflect practical phenomenon, definitions for ITS also vary by countries and regions, depending on the needs. For example, some definitions for ITS might emphasize the traffic operations perspective,\(^10\) which can be increased by ITS.

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\(^5\) Statistical Yearbook for Asia and the Pacific 2016 (ST/ESCAP/2786).


\(^10\) “ITS is an overarching tool utilizing electronics, telecommunications and information technology to improve transport system operations, which contribute to increased efficiency, safety, productivity, energy savings and environmental quality.” by Johann Andersen and Steve Sutcliffe, “Intelligent transport system (ITS): an overview”, IFAC Technology Transfer in Developing Countries, vol. 33, No. 18 (July 2000).
or the traffic information perspective, which can be provided by ITS.

ITS entails not just simple hardware systems but also the technologies that implement the services. From the grand scheme perspective, ITS can be the overall system that includes technologies, policies, plans, strategies and regulations for better transport systems to address transport-related issues.

Considering such dynamics and the United Nation’s 2030 Agenda for Sustainable Development, ITS is defined in this report as “Intelligent transport systems are an agglomeration of diverse technologies that enhance the sustainability of transport systems in a safer, smarter and greener way.”

### 1.3 Purpose of the study

Consideration of the regulatory aspect of ITS is important to enhancing the wider utilization of such technologies in efforts to achieve sustainable transport systems and, eventually, the sustainable development goals (SDGs) in the context of Asia and the Pacific. Given that regulatory challenges and issues are considered to be one of the barriers to ITS development and operation in this region, this report is aimed at providing policy recommendations at the national, subregional and regional levels which help develop ITS regulatory frameworks in Asia and the Pacific. To achieve this goal, the report analyses the current status of ITS development, based mainly on collected inputs from national experts and publicly available sources. The report also presents a methodological assessment of current ITS conditions and future opportunities in order to set up short- and long-term objectives of ITS development and prioritized services for this region.

### 1.4 Importance of ITS regulatory frameworks

#### 1.4.1 For stakeholders

ITS regulatory frameworks are important for three major stakeholders (figure 1.1)

**Public sector**

ITS regulatory frameworks help the public sector to define the core role and responsibility of each government agency as well as that between the Government and other public agencies. Such concrete definitions are necessary for the public sector to be able to plan and drive ITS-related initiatives and projects. ITS is an aggregate of multiple components in nature. Given that the initial stage of ITS development projects in most countries is led by the public sector, it is important to clearly identify the ITS priority areas. ITS regulatory frameworks can contribute to the effective selection of the leading public agency in specific areas of ITS. For the same reason, as some ITS-related industries may cause conflicts with other existing industries, it is crucial to provide guidelines for ITS industries by designating the responsible public agencies through the regulatory frameworks in order to avoid any potential conflicts in advance.

**Private sector**

Alleviating investment uncertainty for ITS development is a major contribution by regulatory frameworks for the private sector. During the initial phase of ITS development, industrial growth is heavily dependent on guidance by the Government. Therefore, the private sector needs to understand in detail the role and responsibility of the public and private sectors, the fields in which public and private sectors work together, and the standards of relevant technologies for consideration in making their business investment.
In particular, for existing ITS-related industries, including telecommunications service providers and transport construction companies, identifying industrial fields that the public sector would pursue is also crucial to determining whether they will participate in such sectors for the ITS business.

Academic sector
ITS regulatory frameworks can provide overall direction of research for the academic sector. Based on the understanding of the fields that the public and private sectors plan to pursue, the academic sector can develop practical technologies to satisfy actual needs. Further, a well-defined ITS regulatory framework will contribute to securing research funds by having the public sector assign the proper budgets for supporting consistent research for ITS development, including ITS-related technologies and human resources. Given that efficient collaboration among the public, private and academic sectors is required for ensuring better ITS development.
and operation, such regulatory frameworks can effectively define the scope of ITS, the roles and responsibilities of each relevant entity concerned and the future directions of development.

1.4.2 Bridging gaps in ITS deployment in the region

From the viewpoint of Asia and the Pacific, ITS regulatory frameworks in particular can address the limitations in ITS development and operation resulting from various conditions in this region related to economic, cultural and geographical characteristics, and technological preparedness. In particular, countries in the Asia-Pacific region have various differences in terms of ITS advancement. While there are world-renowned ITS leaders that have achieved their developments within the past 20 years, many countries in the region are still at the initial stage of adopting ITS technologies or yet to have opportunities to initiate such technologies. In this regard, ITS regulatory frameworks can contribute to bridging this gap among countries of the region by providing regulatory guidance that can form an effective basis for ITS development and operation, especially in the case of developing and least developed countries.

1.4.3 Integrating emerging ITS technologies

New ITS technologies are being developed rapidly with supporting techniques, such as artificial intelligence, the Internet of Things and big data analytics. Some countries in the Asia-Pacific region are quickly transforming their traditional use of ITS into more automated systems. Even relatively less developed countries are striving to leapfrog the technology gap by absorbing such smart technologies. C-ITS, AVs (or self-driving vehicles) and smart mobility are the representative forms currently being discussed in the Asia-Pacific region, using various approaches. Considering such drastic changes, ITS regulatory frameworks can act as a pillar of mutually inclusive development of ITS during the technological transition period of interoperability and compatibility, and may also be helpful in determining the direction of such changes.

1.5 Potential benefits from ITS regulatory frameworks

With regard to the above-mentioned potential roles of ITS, two main feasible benefits are expected to be gained from ITS regulatory frameworks:

(a) Better integration for current and future ITS technologies. Given that ITS regulatory frameworks can act as the backbone of regulations that define the direction of technology and policy development, including standardization, this can contribute to developing ITS technologies in a coordinated manner. Considering the fact that new ITS technologies are already being introduced, ITS regulatory frameworks will play a pivotal role in bridging previous and new ITS technologies. In addition, enhanced integration can lead to seamless ITS services, both on the country and regional scale, by ensuring smooth exchanges of data and other information;

(b) More efficient and effective ITS development and operation. ITS regulatory frameworks can lead to ITS development and operation in an efficient and effective way. In order to maximize the benefits, various ITS technologies should be merged and operated systemically, for which ITS regulatory frameworks can guide the roles and responsibilities of the relevant entities. Also, ITS regulatory frameworks can support the sustainability of ITS-related investment and research activities by providing long-term strategies and plans.

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2.1 Stages of ITS development in Asia and the Pacific

The Asia-Pacific region consists of a wide range of countries that have different government systems, economic growth levels, population volumes and geopolitical locations. In terms of ITS development, the region ranges from countries with advanced levels of ITS development to countries with few basic traffic operation systems. To review ITS development in Asia and the Pacific, an approach has been taken to define each phase of ITS development at the macroscopic level and evaluate the selected countries’ progress in ITS development.
FIGURE 2.1
ITS development milestones

Stage 1: Initiation Stage
ITS-related activities are initiated by perceiving ITS technologies.

Stage 2: Take-off Stage
ITS plans or ITS development strategies are set up under the lead of the academic and/or public sectors.

Stage 3: Acceleration Stage
ITS-related pilot projects are carried out in earnest in collaboration with public and private sectors, and the feasibility of technologies implemented is evaluated.

Stage 4: Maturation Stage
Regulations, legislation or Acts related to ITS are introduced, covering the extensive integration of ITS technologies, maintenance and operation.

With reference to the ITS technology lifecycle process ("research", "development" and "adoption"), this report proposes four development milestones for ITS for the development of country-level ITS (figure 2.1).

Based on the four critical milestones shown in figure 2.1, the development status of ITS is classified in this report by each milestone in selected countries of the Asia-Pacific region (figure 2.2).


The timeline of ITS development in selected countries shows two different patterns: (a) countries that have experienced in sequence, from stage 1 to stage 4, and (b) countries that have pursued ITS development out of the stepwise process.

Two findings can be directly observed from the ITS development timeline:

- Regardless of the alignment of the sequential process, the countries that have established regulations, legislation or Acts related to ITS are regarded as being at the maturation stage. In other words, having regulations, legislation or Acts relating to ITS is the way to achieving mature ITS services in their countries; and

- Countries following the stepwise process, from stage 1 to stage 4, are generally considered to be ITS developed countries in the region. This means that the four critical milestones might be the way that they have intentionally or unintentionally followed in achieving ITS development.
In addition to the above two direct findings, three secondary observations have been indirectly found:

- Different patterns have been observed among the countries that have reached stage 3 or 4. For example, the Republic of Korea implemented stage 3 before stages 2 and 4, while Turkey completed stage 3 before stage 2. As these two countries already had good ITS facilities, there could have been a sound reason behind this rationale—i.e., they might have decided to test the feasibility of ITS applications with pilot projects, after which they established national plans or strategies to support continued ITS development and operation;

- It should be noted that countries that introduced ITS relatively recently did not follow the above sequence. Some countries skipped stage 1 to start at stage 2 or stage 3 as they might already understand the benefits of ITS from other countries and might have been testing pilot projects or trying to establish national plans and strategies;

- Assuming that those countries which have already reached stage 4 have perceived the importance of regulations, legislation or Acts for ITS, it might be true that the lessons learned have not been fully shared with latecomers in the region. As shown in figure 2.2, countries which have started ITS development in recent years have yet to establish their ITS regulatory frameworks. If the latecomers are aware of the reason why other countries have attempted to introduce regulations, legislation or Acts related to ITS, it is to be expected that the establishment of ITS regulatory frameworks would be noticed by other countries.

2.2 Regional cooperation on ITS-related regulations

Before considering country-specific cases in the Asia-Pacific region, it is useful to explore regional cooperation related to ITS from the regulatory perspective.

As shown in figure 2.2 of this chapter, a few countries in the region might have introduced some types of regulations for ITS on the country scale; these will be specifically examined in section 2.3 of this chapter. However, it is more difficult to identify comprehensive activities on regulations related to ITS at the regional level, which are instrumental in the integration of ITS services and maximizing ITS benefits for sustainable transport development. So far, only intermittent regional-level actions have been observed, including establishing technical standards based on those of the International Organization for Standardization (ISO), participation of a working party under the United Nations Economic Commission for Europe (UNECE) and subregional-level discussions.

ISO, as a representative example of the development of global technical standards, has several member countries from the Asia-Pacific region. ISO carries out technical standard development activities with experts nominated by national bodies. Among the various ISO Technical Committees (TC), ISO/TC 204 is responsible for the overall system and infrastructure aspects of ITS, including standardization of information, communications and control systems in the field of urban and rural surface transport—specifically, traveller information, traffic management, public transport, commercial transport, emergency and commercial services in the field of ITS. As of January 2019, 255 technical standards had been published and 86 technical standards are under development by the direct responsibility of ISO/TC 204. As of January 2019, among a total

19 Haruo Ozaki, Technical Standardization of ITS and Asian Initiatives for Intelligent Mobility, IATSS Research 42 (2018), pp. 72-76.
21 Ibid.
of 29 participating members (P-members) and 29 observing members (O-members), eight countries in the region were registered as P-members\textsuperscript{22} and eight others (excluding Hong Kong, China) countries are registered as O-members.\textsuperscript{23,24}

Apart from activities involving technical standards, some regulations concerning ITS have been discussed at the international level, with mainly European countries by UNECE. For example, the World Forum of Harmonization of Vehicle Regulations (WP 29) incorporates into its regulatory framework the technological innovations of vehicles. In particular, within WP 29, a Working Party on Automated/Autonomous and Connected Vehicles was established in 2018, which is a dedicated subsidiary working group directly related to ITS technologies. Even though WP 29 is under UNECE, some countries from this region participate; specifically, in 2018, 10 countries\textsuperscript{25} of this region attended the 176\textsuperscript{th} session of WP 29,\textsuperscript{26} while six countries of this region attended the first session of the Working Party on Automated/Autonomous and Connected Vehicles.\textsuperscript{27}

Although they are only at the beginning stage of discussions, recent activities at the sub-regional level have taken place. For example, the Master Plan on ASEAN Connectivity 2025 by the Association of Southeast Asian Nations (ASEAN) secretariat includes strategies for achieving the vision of the ASEAN Connectivity 2025 that are related to ITS, such as sustainable infrastructure, digital innovation, seamless logistics, regulatory excellence and people mobility. Among these strategies, regulatory excellence is aimed at responding to the need for good regulatory practices in the preparation, adoption and implementation of rules, regulations and procedures in the ASEAN region, which are aimed at supporting the implementation of key policies for attaining the vision of ASEAN Connectivity 2025.\textsuperscript{28}

From the Asia-Pacific perspective, these actions by some countries have proven the necessity for an ITS regulatory framework. In addition, this will eventually contribute to drawing up overarching regulations related to ITS in a comprehensive way by appropriate intergovernmental leadership.

In this regard, regional cooperation and collaboration have already been emphasized. For example, in the ITS Guidelines for Sustainable Transport in the Asia-Pacific Region by ITS Asia-Pacific, the role of regulation for overall planning of ITS development at the Asia-Pacific level is reaffirmed by the statement that “to provide support for the interconnection, information sharing and application among intelligent transportation systems, ITS architecture needs to be constantly updated and maintained. Regulation on the management of ITS and the overall planning and coordination of key ITS projects should be improved”.\textsuperscript{29} In addition, to be prepared for future ITS technologies, a consistent approach to future regulation at the international level was also emphasized by the Minister for Infrastructure and Transport, Australia, in the High-Level Policy Roundtable during the twenty-third ITS World Congress in 2016.\textsuperscript{30} It is also inspiring that individual countries have recognized the regional

\begin{itemize}
\item \textsuperscript{22} Australia, China, India, the Islamic Republic of Iran, Japan, the Republic of Korea, Malaysia and New Zealand
\item \textsuperscript{23} Indonesia, Mongolia, Pakistan, the Philippines, Russian Federation, Singapore, Thailand and Turkey.
\item \textsuperscript{24} International Organization for Standardization, Intelligent transport systems. Available at https://www.iso.org/committee/54706.html.
\item \textsuperscript{25} Australia, China, Georgia, India, Japan, Kazakhstan, Malaysia, Republic of Korea, Russian Federation and Uzbekistan.
\item \textsuperscript{28} ASEAN Secretariat, Master Plan on ASEAN Connectivity 2025 (Jakarta, 2016).
\item \textsuperscript{29} ITS Asia-Pacific, ITS Guideline for Sustainable Transport in the Asia-Pacific Region (Tokyo, 2013).
\end{itemize}
approach to developing regulations related to ITS. New Zealand, for example, considers a regional approach of regulations with other countries for the integration of ITS to be necessary in order to lead to reduced regulatory compliance costs for New Zealand transport operators and businesses working within the region.

### 2.3 Country-specific case studies

ITS applications prevalent in the Asia-Pacific region were analysed for eight countries, i.e., Azerbaijan, China, the Republic of Korea, the Russian Federation, Tajikistan, Thailand, Turkey and Viet Nam. ITS applications include the Advanced Traffic Management Systems (ATMS), Advanced Traveller Information Systems (ATIS) and Advanced Public Transport Systems (APTS), described below:

(a) **ATMS**

ATMS is aimed at improving traffic flows and safety by maximizing the efficiency of traffic management. ATMS uses a top-down approach through traffic management centres where real-time traffic data are integrated and processed, and the proper responses are determined. To achieve smooth traffic operations, cutting-edge traffic sensing technologies, information communications and data-processing techniques are incorporated for diagnosing traffic patterns and problems as well as for developing optimal traffic management strategies. Real-time operational solutions capable of mitigating traffic issues are provided by diverse information dissemination technologies, including Variable Message Signs (VMS), mobile devices and car navigation systems. A wide array of examples can be found in countries in the Asia-Pacific region, including electronic toll collection, advanced traffic signal control and automatic traffic enforcement systems.

(b) **ATIS**

ATIS keeps travellers updated with pre-trip and en-route traffic information in given areas. Traveller information ranges from incident details (crashes or road works) to real-time traffic conditions (the levels of road congestion). In operational terms, relevant data need to be collected and analysed in order to provide real-time information to the public. Various devices, such as surveillance cameras, fixed sensors (e.g., loop detectors and vehicle detection systems), probe cars and mobile phones collect necessary data. The Internet, radio, VMS, mobile/online services, and navigation devices are the major distributors of processed information to the public in the Asia-Pacific region.

(c) **APTS**

APTS employs diverse information technologies and traffic management strategies for public transport systems. The goal of APTS is to enhance the efficiency and reliability of public transport operations, as well as for users’ safety and convenience. The adoption of APTS is transforming the traditional services of public transport into more streamlined ones. From the perspective of travellers, APTS provides real-time information on public transport services through the Internet, mobile devices and information terminals; users can thus select the most feasible services. Examples of APTS applications in the Asia-Pacific region include urban public transport management, automatic fare collection, automated passenger information, automatic vehicle location and automatic passenger counter systems. Bus information systems offered in many major cities in this region are a primary example.

### 2.3.1 Azerbaijan

(a) **ITS services**

Although Azerbaijan only recently initiated ITS services, an ATMS has already been launched,
mainly in the capital city, Baku, with Closed-Circuit Television (CCTV) surveillance cameras, a traffic signal control system and an Illegal Parking Control System (IPCS):

- A total of 60 CCTV cameras have been installed by the Baku ITS ("NiiM"—Naqiyıyati Intellektual İdareetmə Mərkəzi) project, which can be controlled by the traffic management centre;

- A traffic signal control system, called the "Green Wave System", is connected to the traffic management centre in Baku, with approximately 150 intersections that have traffic signals which are operated using loop detectors. The city has 300 intersections with traffic lights, of which 150 intersections are integrated into the ITS of NiiM and the remaining 150 intersections are operated manually by the traffic police. By a Presidential Decree of 2018, the remaining 150 intersections will also be transferred to NiiM. As of January 2019, work was underway on the integration;

- A total of 44 IPCS cameras were installed in 2010, particularly in the areas with traffic congestion due to frequent illegal parking. In 2018, all the cameras were upgraded, and the total number of cameras was increased to 100.

In 2014, the State Agency of Azerbaijan Automobile Roads proposed the introduction of the first electronic toll collection system on motorway M3 (Alat-Astara). In the near future, turnstiles will be delivered to the country and from 2020, the M3 will become a toll highway.

**VMS in downtown Baku**

As a beginning stage of ITS development, VMS is providing traffic information to drivers in Azerbaijan (figure 2.3). A total of 48 VMS has been installed in Baku, showing traffic density by different colours (e.g., red indicates high congestion).

**APTS**

A Bus Management and Information System (BMIS) is the main ITS service of APTS in Azerbaijan. This system comprises two components, On-Board Equipment (OBE) and Bus Information Terminal (BIT):

- The OBEs have been installed on approximately 2,000 buses operating in downtown Baku. This equipment is built in with a wireless modem and Global Positioning System (GPS). However, as the OBEs have not been operating well technically, the service from BMIS has been discontinued.

- The BITs have been installed at bus stops (around 664 BITs in downtown Baku as of 2017) and are providing bus arrival information to the public (figure 2.4).

**FIGURE 2.3**

VMS in downtown Baku

**FIGURE 2.4**

Map of BITs in Baku City

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Vugar Mammadzada

Vugar Mammadzada

(b) ITS regulations

Only a few regulations related to ITS exist so far. For example, in December 2014, a regulation announcing temporary road closure was approved and issued via the Short Message Service (SMS). This regulation states that information about road reconstruction and repair, public events and crashes must be announced via SMS.

2.3.2 China

(a) ITS services

**ATMS**

China has been operating an extensive ATMS on highways. More than 25 provinces have provincial road network centres that cover a total of 130,000 km of expressways and 400,000 km of highways. Their main functions include traffic monitoring and control (traffic management), highway infrastructure management, toll collection management and settlement, and emergency management. Specifically, around 11,000 sets of traffic flow detection facilities, 39,000 monitoring cameras, 1,700 meteorological monitoring facilities, 200 bridge health monitoring facilities, and 170 cutting slope and road embankment settlement monitoring facilities are being operated. In addition, with strong support from the central Government, in the 1990s an Electronic Toll Collection System (ETCS) based on Dedicated Short-Range Communications (DSRC) was implemented. By 2017, the ETCS covered 130,000 km of expressways in 29 provinces with 70 million users.

The ATMS in urban areas of China has a few unique functions:

- An integrated intelligent traffic management system has been adopted in urban areas in the form of an ATMS that has been developed for special occasions. This system was introduced during the Beijing Olympics in 2008, based on the Integrated Olympic Traffic Information Platform for approximately 20 different forms of traffic information, such as for buses, subways and highways. The real-time roadside information system covers 90 per cent of the regional road system inside the fifth ring road. In Shanghai, ITS was introduced in 2010 to prepare for the Shanghai World Expo. After implementing this system in Shanghai, the traffic flow speed increased by 3 per cent within the central inner city and the provided information showed 92 per cent accuracy. Since 2010, this system has been implemented in about 200 cities in China;

- Recent ITS projects have been incorporated into the framework of smart city plans. More than 300 cities in China have been developing smart city plans, while a total of 586 cities have built ITS centres and 325 cities have built intelligent dispatching platforms based on the Geographic Information System (GIS). In China, there are 95,000 nodes of video monitoring, of which 57,000 have high-definition video qualities. A multiplayer transport operation is possible through a coordination system among various ITS centres;

- In 2011, the Ministry of Transport announced a plan to build an integrated intelligent passenger transport hub, which includes Beijing, Shenzhen, Shanghai, Chongqing, Changsha and Chengdu.

Another ATMS application in China is the GPS network control system, which manages the logistics of critical commercial vehicles. This system monitors whether the tracked vehicles, particularly those transporting hazardous commodities, are on the pre-determined routes. A total of 3 million vehicles are monitored by this system.

**ATIS**

ATIS has been implemented jointly by the private and public sectors. While the provision of the Highway Information System through public websites has been developed by the central Government in about 30 provinces, various forms of traffic information are offered by private companies such as AutoNavi, Baidu.
and Tencent. In addition, for the comprehensive management of logistics system, the public and private sectors are partnering to build a logistics information service platform with 100,000 enterprises and 200 million pieces of transaction data. This platform includes the Northeast Asia Logistics Information Service Network, through which container shipment information will be shared among China, Japan and the Republic of Korea.

**APTS**
The Intelligent Public Transport System, which is the representative form of APTS in China, was initiated by the Ministry of Transport in 2011 with the selection of a public transport metropolis. A total of 11 engineering standards were established that cover on-board intelligent service terminal, electronic bus stop board and data communication protocol including data collection. Nine cities (Beijing, Shenzhen, Zhengzhou, Shanghai, Jinan, Nanjing, Chengdu, Guangzhou and Xian) have piloted this system.

**(b) ITS regulations**
Although China does not have dedicated regulations for ITS, existing national laws, rules and regulations have been amended to enable the implementation of ITS. Such amendments are fundamental principles that play a role in promoting ITS development. Examples are:

- Article 14 of the Road Traffic Safety Law requires passenger-carrying vehicles, heavy-duty trucks and semi-trailers using expressways to be equipped with driver record devices. The Article also states that the penalty for traffic law violations should be based on the ITS evidence;

- Article 10 of the Highway Law states that road management or transport operations should contribute to the promotion of ITS;

- Article 13 of the Administration of Toll Roads states that the number of stations on toll roads should be reduced and operated by computer networking management in order to increase the efficiency of traffic operations. This regulation promotes the implementation of ETCS on toll roads;

- Article 5 of the Urban Public Transport Ordinance promotes the change from public transport systems to intelligent public transport systems by using advanced management methods and new technologies.

Various guidance or implementation principles for ITS can be found in separate regulations. For example, a regulation promoting taxi reservations by mobile devices was established in 2016. This regulation can be considered as a leading regulation in encouraging mobile ITS services in reserving taxis.

**2.3.3 Republic of Korea**

**(a) ITS services**

**ATMS**
ATMS plays a fundamental role in ITS operation in the Republic of Korea and is mostly implemented through equipment or facilities for data collection on vehicles or at roadsides. Various traffic management services have been monitored through ATMS, i.e., traffic flow control, incident management, basic traffic information, care management, automatic traffic control and traffic administrative support. Among these services, care management is the proactive service that identifies and avoids threats that drivers may encounter. Traffic administrative support is used, from the managerial perspective, to help road infrastructure management, pollution control and travel demand management.

ETCS has been implemented since 2005, also known as “Hi-Pass”, which consists of an on-board unit, smart card, toll collection and office equipment. As of 2017, 332 toll booths on the entire national highway system had adopted ETCS.
Since the pilot project for traffic management on freeways (the Freeway Traffic Management Systems) was implemented between 1992 and 1994, ATIS was first fully implemented on the Seoul-Busan highway in 1999. Subsequently, it has been expanded to cover 3,860 km of expressways (100 per cent of all expressways in the country) and 2,554 km of national highways (approximately 20 per cent of all national highways in the country).

As of January 2019, several key services were being provided under ATIS in the Republic of Korea – basic traffic information service, tourist information, traffic information before departure, traffic information while driving, traveller’s guidance, parking information, pedestrian route guidance and bicycle route guidance.

**APTS**

A Bus Information System (BIS) and Bus Management System (BMS) are the major components of APTS in the Republic of Korea. Since the pilot study on BIS was conducted in Seoul in 2005, BIS is currently in operation in more than 40 provinces in the Republic of Korea. BIS mainly provides real-time arrival information to users through GPS devices installed in each bus. The BIS configuration scheme has eight elements – bus information centre, bus vehicle apparatus, bus-vehicle sensors, courier stations, bus company operating terminal, administrative agency operating terminal, other municipal bus connections information and vehicle location system.

BMS offers bus management services in connection with BIS. The comparison of components between BIS and BMS is shown in Table 2.1.

### Table 2.1
**Comparison between BIS and BMS components**

<table>
<thead>
<tr>
<th>Components</th>
<th>BIS</th>
<th>BMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Centre</strong></td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td><strong>Road devices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadside communication</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Bus service information transmission</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td><strong>Display</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station information display</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td><strong>Vehicle equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracking/communication</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Operator interface (display, voice communication)</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Vehicle information display</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td><strong>Traveller’s devices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal communication device (bus information)</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>Air terminal device (bus stop information)</td>
<td>O</td>
<td>X</td>
</tr>
</tbody>
</table>

**ATIS**

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(b) **ITS regulations**

The Republic of Korea has established ITS-related legislation. More specifically, Chapter 4 of the National Transport System Efficiency Act defines the ITS plans and projects, in which Article 73 requires the Ministry of Land, Infrastructure and Transport (MOLIT)
to review and revise the ITS National Master Plan if necessary every 10 years. Further, if there are any key issues in terms of technical and political changes, MOLIT should review and revise the ITS National Master Plan every five years.

The core factors related to ITS that are defined in the “National Transport System Efficiency Act” include:

- Pre-delivery inspection;
- Legal standards for the definition of system standardization;
- Certification of standards and quality, and cancellation;
- Cancellation of the institutes designated for certifying standards and quality;
- Performance assessment criteria of ITS;
- Safety management criteria of ITS;
- Provision of traffic information using ITS;
- Commercialization in overseas and industrialization;
- Construction of integrated national ITS centre;
- Establishment of ITS association and definition on its business scope.

The major components of the ITS National Master Plan are:

- The objectives and goals of ITS development;
- The strategies and plans of ITS development and operation for each transport service;
- The strategies and plans of ITS development and operation for road, maritime and air transport;
- ITS research and development, industrialization and standardization;
- Finance for ITS development;
- Regulations related to ITS.

The National Transport System Efficiency Act covers other aspects of ITS development and operation, including:

- Under Article 73, the ITS plans for road, railway, maritime and air transport should be established based on the ITS National Master Plan;
- According to Article 76, the local Government must submit ITS implementation plans annually to the Minister of Land, Infrastructure and Transport;
- Under Article 77, the Minister of Land, Infrastructure and Transport will designate the responsible agency, if necessary, for effective implementation, design, evaluation and management of the ITS projects.

### 2.3.4 Russian Federation

#### (a) ITS services

**ATMS**

Moscow, the Russian Federation’s biggest ITS city, has various types of ATMS, including a traffic management control centre and a traffic incident detection and monitoring system. A total of 6,741 detectors and approximately 2,500 CCTVs have been installed to monitor traffic flow, and a total of 2,289 traffic signals are used to manage traffic control. In addition, 805 sets of cameras, 34 mobile cameras and 100,000 parking spaces are monitored to manage the traffic law violations.

ATMS has been introduced in Saint Petersburg. The ring road in Saint Petersburg is 142 km in length with 23 intersections, 146 bridges, overpasses and tunnels. The road is equipped with 112 traffic controllers, 550 variable message signs, 44 information boards, 32 roadside meteorological stations, 84 camorders and 514 traffic detectors for managing traffic flows. In addition to the above two cities, the Russian Federation is expanding ATMS to all domestic regions, which is within the framework of the road maintenance system called Dortransnavigatsiya. This system is designed for automated planning of the maintenance of roads and facilities by using navigation control and road machinery. All 34 state-owned institutions have implemented
this system and 9,000 vehicles with on-board navigation and communication equipment are in operation in this system.

As part of ATMS in the Russian Federation, tunnel traffic and bridge traffic management are other focus areas into which much effort has been put. In 2018, the bridge traffic management system was implemented on the Crimea bridge connecting the Crimea peninsula and the mainland of the Russian Federation.

ETCS also has been implemented largely through the strategy of toll road development under the Transport System Modernization 2002-2010 Plan. Much effort has been put into establishing ETCS along the highways – particularly the Europe-West China Corridor and the Pan-European Corridor. There is continuous demand to construct more than 9,000 km of highways, to which the Russian Federation is responded to by constructing 3,000 km and 9,000 km of toll roads by 2020 and 2030, respectively. A representative example of ETCS is the M-4 “Don” highway, which is 1,517 km in length and has four types of toll payment methods (cash, credit card, contactless smart card “T-card” and transponder “T-pass”). Federal highway M-1 Belarus also has ETCS with three methods of toll payment (cash, bank card and transponder).

**ATIS**

ATIS has been implemented extensively in major cities, such as Kazan, Moscow, Saint Petersburg and Sochi. Moscow has 144 spots offering electronic displays with three-minute updated traffic information.

Considering the nature of the country, the weather information system plays an important role in ATIS. The Government launched an automated system for meteorological support in 2007 for the total network of Federal roads.

For example, in the north-western part of the Russian Federation, weather information is provided through 966 weather monitoring systems and 1,371 video surveillance units.

This system monitors the weather conditions on the roads, and provides drivers with traffic and weather information.

Further, the interval of providing weather information depends on the situation. For example, warnings on hazardous natural hydro-meteorological phenomena are announced without delay, while warnings on natural hazard and complex meteorological phenomena are distributed on a daily basis. Details of past and expected meteorological conditions for three-day periods are announced every day while details of the heaviest spring flooding are provided between 1 January and 15 March every year.

**APTS**

A Surface Public Transport Dispatching Control System, which is one of many applications under APTS, has more than 10,000 units equipped with the global satellite navigation system (GLONASS) in Moscow.

In addition, other services under APTS are currently operating in the Russian Federation, such as the Troika card for payments for all means of public transport in Moscow, car-sharing services, parking assistance services (Moscow Parking), real-time taxi reservation services (e.g., Yandex Taxi), real-time public transport information services (Mosgorpass), bike sharing services (Velobike) and public transport ticketing services.

(b) ITS regulations

In 2003, a few private companies established the “Non-commercial partnership ITS-Russia”, which became the platform for the dialogue between businesses, academia, Government and users of ITS services in the Russian Federation.

The first document that set the basis for ITS deployments in the Russian Federation was developed by the Ministry of Transport and approved by the Government of the Russian Federation through the Order No. 1734-R on 22 November 2008, “On the transport strategy
of the Russian Federation for the period up to 2030”. ITS was stated in the fifth section of this document: “The main directions of the state policy in the field of transport”, in item 6 – “Innovative development of transport system: Stimulation of development and introduction of ITS providing effective management of transport streams and vehicles, and the improvement of quality of transport services”. After this document was issued, amendments were made based on pre-existing relevant regulations to supplement ITS-related regulations.

For example, in 2009, the Federal Road Agency (Rosavtodor) developed a document about the development of ITS on federal road networks, which specifically stated that regulations related to ITS should be legislated with three layers of each stakeholder: (a) the authorities (ministries and departments); (b) scientific organizations (carrying out studies and evaluation of the effectiveness of projects during the life cycle); and (c) businesses (implementation of ITS). In 2011, the Government of Moscow issued Decree No. 1 on 1 November 2011, “About the creation of ITS of Moscow”. In 2013, Federal Law No. 395-FZ on the ERA-GLONASS State Automated System, which was approved on 28 December 2013 (and amended on 13 July 2015), established the mechanisms for the formation and usage of ERA-GLONASS system information resources, rights and responsibilities of government bodies and the requirements for interagency data transfer in the course of the system’s operation.

In 2017, the Government of Moscow cancelled Decree No. 1 of 1 November 2011 and issued a new regulation No. 597 on 30 July 2017, “About ITS of Moscow”. In addition, a new strategy, Digital Economy of the Russian Federation, was approved in 2017 in the Government of Russian Federation Decree No. 632 on 28 July 2017, which states that the standardization of transport information in 20 cities should be completed by 2020. Mobile payment systems and unified travel documents are part of the standardization required by this strategy.

2.3.5 Tajikistan

(a) ITS services

ATMS

Since 2013, Tajikistan has implemented its ATMS mainly in the capital, Dushanbe, with a “Safe City” project. Through this project, traffic signals at 70 major intersections, 15 urban checkpoints and 850 video surveillances cameras have been installed, and 100 police patrols have been equipped with GPS units. To enable traffic monitoring and control operations by CCTVs, a traffic control centre was constructed in Dushanbe (figure 2.5).

FIGURE 2.5

Traffic control centre in Dushanbe

Compared to urban areas, the application of ATMS is limited in other areas. However, plans have been established to expand ATMS as part of projects being implemented by multilateral development banks or official development assistance agencies, except for ETCS. They include:

- Traffic monitoring systems are to be established during the second phase of the Central Asia Road Link – Sughd Oblast (Cars-2), supported by the World Bank;
- A unified automated information system was established for risk management at 72 customs border posts in 2011 with assistance from the Asian Development Bank, which is in operation. This system contributes to the advancement of ITS technologies for cross-border services.
by electronic Transports Internationaux Routiers;

- A Weigh-In-Motion (WIM) system is being built for load inspections of freight vehicles from 2015 to 2020, supported by the World Bank. The second stage of the project, which is currently underway, will integrate High-Speed Weigh-In-Motion (HSWIM) technology on the route between Kuchkak and Niyozbek municipalities;

- The installation of an automated intelligent tunnel traffic control system is under discussion with the Japan International Cooperation Agency, which will be implemented in five major tunnels in Tajikistan. The system will integrate ITS technologies to monitor and manage tunnel traffic;

- The first toll road in Tajikistan, the Dushanbe-Chanak highway, was opened in 2010, for which ETCS was incorporated with Radio Frequency Identification (RFID) technology.

**FIGURE 2.6**

Intelligent bus stop in Dushanbe

A passenger information system has been established in Dushanbe to provide bus information since January 2014, under a Memorandum of Understanding (MoU) between the United Nations Development Programme and the Dushanbe Mayor. Information boards have been installed at 25 bus stops, and 60 buses and trolleys have been equipped with GPS. A parking information system is also under consideration for this project.

**APTS**

In addition to the passenger information system, intelligent bus stops which were built in Dushanbe in February 2018 are a unique system of APTS in Tajikistan (figure 2.6). A total of 36 bus stops have become intelligent bus stops with modern facilities, including CCTVs.

In July 2017, an Automatic Fare Collection (AFC) system was launched with a smart card, called “City Card”, for public transport payment and fare allocation. At the beginning of the project, 360 buses and trolleys were equipped with smart card readers and, as of April 2018, all buses can accept payment by using the smart card.

Since a taxi service can be part of a public transport system, a new service for taxi reservations through a mobile application was recently launched. This system enables a customer’s location to be acquired by GPS to reserve the taxi.

(b) ITS regulations

Currently, Tajikistan has no regulations related to ITS, either at the national or provincial level. However, the Ministry of Transport is reviewing ITS-related regulations of other countries in preparation for issuing regulations for ITS. This will be done by the amendment of existing regulations such as the Law of Tajikistan on...
Highways and Road Activities. In addition, information communications technology-related regulations mainly covering electrical communications and information security are also expected to be amended for ITS. Given that ITS is largely private sector-driven, the Law on Public-Private Partnerships, which was adopted in 2012, could be utilized to legislate the regulations for ITS in cooperation with the private sector.

2.3.6 Thailand

(a) ITS services

ATMS

In Thailand, Area Traffic Control (ATC) has been implemented in many urban areas (such as Bangkok, Chiang Mai, Phuket and Pattaya). ATC is the adaptive signal control, which employs real-time traffic data in adjusting timings of traffic signals in road networks, thereby ensuring overall improved efficiency of traffic control. Previously, Bangkok used the Split Cycle Offset Optimisation Technique system in the late 1990s at 61 intersections. The project was later terminated due to a contract dispute and ATC was extended to an additional 200 intersections in Bangkok. The system was also installed in Chiang Mai (40 intersections), Pattaya (23 intersections), Udon Thani, Hat Yai and Phuket (6 intersections) because of its efficiency in traffic control and management. However, most urban signalized intersections in Thailand still operate by either manual or fixed time control.

In the case of national and rural highways, many intersections are now operated by actuated traffic signal control, which is signal timing in response to current traffic flows. On the other hand, expressways and motorways in Thailand are efficiently operated by traffic management centres (figure 2.7). The centres are the heart of Thailand’s traffic data collection and analysis, enabling action to be taken in response to real-time traffic conditions and incidents. Each expressway/motorway section (between 30 km to 70 km) is operated by a sub-control centre. The roads are equipped with CCTVs, sensors and VMS. The centres also have mobile applications for disseminating motorists’ information. The traffic situation is monitored on a real-time basis, and action is taken as and when necessary to deal with emergencies and other situations requiring road management.

There are police traffic command and control centres in Bangkok and some other cities in Thailand that monitor traffic conditions through an extensive CCTV network and respond through police traffic control. The “Bor Kor 02” traffic command centre is the operational core in Bangkok (figure 2.8), which provides integrated command of traffic flow control carried out by local police in sub-districts. The centre provides traffic information via the 1197 traffic hotline. The hotline is also used for receiving real-time incident reports. There are several traffic radio channels in Thailand that are popular for their incident reports.

FIGURE 2.7

Motorway traffic management centre, Thailand

ATIS

Traffic information, such as that concerning traffic conditions (coloured congestion) and road incidents, is collected mainly by road authorities (e.g., from roadside sensors and detectors) and provided to travellers through various agencies in Thailand. Mobile applications and VMS managed by various agencies provide on-road traffic information and trip planning advice.
Although data on traffic and travel conditions are collected by several agencies, the Intelligent Traffic Information Center (iTIC) Foundation collects a broad range of data from the public and private sectors, and releases the information to the public and businesses. The data are received from many sources, such as CCTVs, taxis, and logistics and mobile probes. Real-time traffic conditions and incident situations are broadcast to car navigation and portable navigation devices (figure 2.9) using the Radio Data System-Traffic Message Channel (RDS-TMC) on FM radio frequency.

Mobile applications for traveller information exist in Thailand. For example, the Ministry of Transport has launched a few applications to provide information for travellers. Some applications are popular with the private sector (e.g., Google, HERE and T-Square Traffic) because they contain useful multi-modal information, are easy to access and use, and provide extensive in the areas covered.

More recently, Thailand has required buses, trucks and all public service vehicles to install Global Navigation Satellite System (GNSS) tracking devices that are linked to the Department of Land Transport in real-time. In 2018, around 300,000 vehicles were tracked and recorded. Currently, the data are used for surveillance and enforcement, but can be used to provide real-time traveller information.

APTS

In Thailand, APTS mainly provides electronic payment and public transport information systems. The electronic payment system on public transport is applied in urban rail services in Bangkok. Various payment methods, such as common e-ticket (also known as a smart card), are used on all urban rail transport systems. A “Spider (Mangmoom) Card” (figure 2.10) is used for integrated payments on rail, bus and boat transport. However, currently only two rail lines share this common e-ticket. Other forms of payment have also been introduced for car and motorcycle taxis, such as a credit card and QR code. The Rabbit Card,
the common card for the Skytrain or Bangkok Mass Transit System, can also be used at many commercial stores.

Public transport information systems mainly include bus information through mobile applications. Some applications offered by the public bus authority and private sector give travellers real-time bus information, such as bus routes, travel times and connections.

In addition to Bangkok, many new bus lines have been introduced around Thailand. The new lines often provide travellers with bus information. For example, bus services in Chulalongkorn University (Bangkok) and Khon Kaen University (Khon Kaen) as well as in Phuket and Chiang Mai provide information to riders via mobile applications or smart bus information signs at bus stops.

(b) ITS regulations

Although Thailand has developed ITS master plans – the first ITS Master Plan by the Office of Transportation, and Traffic Policy and Planning (OTP) was for 2005-2014, the second OTP ITS Master Plan for 2012-2017, and the third OTP ITS Master Plan for 2018-2023 – action with regard to ITS regulations has not been comprehensive. In Thailand, it is a widespread practice to pursue matters with a development plan that serves as a guideline for planning, implementation and operation. Three current plans are related to ITS – the Transport Strategic Plan for 2017-2021, Digital Transport Plan 2021 and ITS Development Master Plan for the Bangkok Metropolitan Region, 2018.

The two first plans indicate the importance of concrete and comprehensive regulations for ITS. The first plan contains one strategy for the use of technologies to provide better transport administration and services, and includes ITS in this category. Another strategy in this plan is to revise or develop the regulation system for transport; however, ITS regulations are not considered in this strategy. The programmes to be carried out during 2017-2021 include improvement of service quality with trucks and buses, the regulation of rail and air transport, and an ITS plan for provincial cities.

The second plan, “Digital Transport Plan 2021”, covers the transformation of conventional transport activities and administration into “digital” services. Several directions are advised in this plan, including the advancement of ITS in Bangkok and its surrounding vicinities, and it encourages the construction of a digital transport ecosystem on the digital government platform. In this plan, future actions related to ITS are defined. For example, ITS data are geared towards open sharing through the National Multimodal Transport Information Center. Many agencies would exchange transport data based on this plan.

The third plan, ITS Development Master Plan for the Bangkok Metropolitan Region, 2018, defines many directions for developing ITS in the Bangkok metropolitan area. One activity is for more concrete ITS-related laws and regulations to be developed. Notable activities related to such laws and regulations include guidelines and regulations for open data, autonomous vehicles, Mobility-as-a-Service (MaaS), public sector restructuring and public-private collaboration in ITS projects. This plan
also reviews international ITS standards and outlines some standards for ITS in Thailand.

2.3.7 Turkey

(a) ITS services

ATMS

The most popular application of ATMS in Turkey is for traffic operation facilities such as traffic signals. A total of 2,726 signalization systems are in operation on highways, and 2,281 signalization systems are managed by the traffic management centre in Istanbul Metropolitan Municipality. Several types of traffic signals are currently operated, including fixed-time, semi-actuation, full actuation and green wave.

In response to the increasing interest in smart cities, the Istanbul Metropolitan Municipality considers ATMS to be a major component. A total of 539 monitoring stations for vehicle speeds and volumes have been installed on highways, and analysed information from the stations is provided on maps. In addition, 99 WIM stations are currently in operation for monitoring and controlling overloaded freight vehicles.

By the end of 2018, Turkey had 361 tunnels with a total length of 463 km. Tunnels longer than 500 m are equipped with various tunnel control systems.

To facilitate access to the emergency services, including the traffic emergency service, the Ministry of Internal Affairs is generalizing the emergency call system with the objective of offering a single contact number for all emergency services.

ETCS has been widely applied on all public motorways and is operating as “fully cashless” using Dedicated Short-Range Communication (DSRC) and Radio Frequency Identification (RFID) technologies. The number of users of DSRC and RFID-type systems are 1.95 million and 12 million, respectively. ETCS has been implemented at 99 toll plazas in the country, of which eight use multi-lane free-flow systems (figure 2.11). Since 2014, Turkey has been changing the classic toll gates over to multi-lane, free-flow systems.

ATIS

ATIS utilizes various types of media to provide traffic information in Turkey. The official website of the General Directorate of Highways provides information on road conditions, including road works, closed roads, optimal travel routes and tourism sites plus an online traffic map. VMS is used for disseminating meteorological and traffic information. Radio broadcasting on some road sections and in long tunnels is also used for providing information to road users with regard to traffic and tunnel conditions. Mobile applications, which have become widespread since 2012 with more than 3.5 million downloads, provides a traffic density map, travel times and route distance calculation.

In addition to information provided by the General Directorate of Highways, the Istanbul Metropolitan Municipality and Izmir Metropolitan Municipality provide information on traffic and road conditions. Istanbul Metropolitan Municipality also provides information generated by an intelligent parking system about vacant parking space by mobile application, VMS and a traffic density map. The Istanbul traffic

FIGURE 2.11

Multi-lane, free-flow toll gates in Istanbul
density map also provides information on travel planning, travel times, traffic signals, and locations of cameras and pharmacies. The Izmir Metropolitan Municipality delivers various types of information through mobile applications, such as travel planning, travel times, bus service lines, vacant parking spaces, the location of cameras and pharmacies, road works and crashes.

**APTS**

A public transport management service is the current representative application of APTS by the metropolitan municipalities. This service includes monitoring bus operations, providing information through mobile application, a website and information panels on bus stops as well as electronic payments.

**(b) ITS regulations**

In Turkey, there is no specific legislation dedicated to ITS. However, several regulations exist that enable the establishment of ITS. Also, Turkey is a candidate country for European Union membership, and thus is obligated to adopt the European Union legislation on ITS, including electronic toll collection and tunnel safety:


- Commission Decision of 6 October 2009 on the definition of the European Electronic Toll Service and its technical elements (2009/750/EC);


- Directive 2010/40/EU of the European Parliament and the Council of 7 July 2010 on the framework for the deployment of ITS in the field of road transport and for interfaces with other modes of transport.


Some regulations, such as the Metropolitan Municipality Law, the Law on Services of the General Directorate of Highways and the Highway Traffic Law, are not specifically related to ITS; however, they allow for the installation and operation of some components of ITS. The followings are cases for directly referring to or dealing with ITS:

**(i) Law on Services of the General Directorate of Highways**

- This law determines the organizational structure and duties of the General Directorate of Highways. Pursuant to this law, the General Directorate of Highways establishes ITS on the roads included in its road network.

**(ii) Regulation on Organization and Duties of the General Directorate of Highways**

- In this context, the duties for “the establishment and control of Intelligent Transport Systems such as traffic management and driver information systems for the realization of safe, efficient and rapid traffic management”, “the establishment of management information system for tunnels and large structures”, and “realization or procurement of road pricing, toll collection and the related operations of the toll roads” are assigned to the related departments.

Although not related to legislation, there are also cases where technical documentation for ITS installation has to be prepared. Such documentation includes the technical specifications for ITS to be installed on the state road network of the General Directorate of Highways – for example, cameras, VMS, signalization, management centres, databases and meteorological stations.
The Tenth Development Plan 2014-2018 (Onuncu Kalkınma Planı 2014-2018) proposed that ITS be deployed from 2014 to 2018. Major strategic areas are largely divided into (a) logistics transport, (b) information and communication technologies and (c) urban infrastructure.

For a plan that contains a specific action, the Integrated Urban Development Strategy and Action Plan 2010-2023 (KENTGES Bütünleşik Kentsel Gelişme Stratejisi ve Eylem Planı 2010-2023) was issued in the Official Journal (Resmi Gazete) on 4 November 2010. This action plan covers the following action on the use of information technologies in urban transport systems. Also, this action, which is under the responsibility of the municipality authorities, is intended on the action capacity development and institutional structuring, and valid for the period 2010-2023:

- Action: 5.5.4. – “The regulations shall be made for the efficient use of information technologies in urban transport”, “In the cities, it is required to establish transport control centres, to monitor real-time mobility by Global Positioning System receivers and to notify by communication technologies (Internet, GSM etc.).”


(a) Generalizing ITS on highway networks, the establishment of a traffic management centre in regional divisions of the General Directorate of Highways and a main traffic management centre in the headquarters of General Directorate of Highways;

(b) Completing and optimizing fibre-optic and broadband networks along the highways to promote adequate ITS;

(c) Assigning the specific frequency and leading vehicle manufacturers for integrating vehicle-to-vehicle and vehicle-to-infrastructure communication systems with vehicle electronic systems;

(d) Designating nationwide ITS user services and their logical framework and physical units;

(e) Developing local mobile traveller information systems;

(f) Establishing traffic management centres in metropolitan municipalities within specified standards.

In addition, the 30 metropolitan municipalities in Turkey have each created a strategic plan for their activities during a specific period, but in general for five years. The strategic plan also covers transport-related issues. Municipalities prepare their strategic plans to meet their own needs. ITS-related actions generally focus on components of traffic management systems, particularly signalization systems. The Istanbul Metropolitan Municipality Strategic Plan 2015-2019 (İstanbul Büyükşehir Belediyesi Stratejik Plan 2015-2019) includes the objective of the “Generalization of Intelligent Transport Systems to Include all Public Transportation Vehicles” (Akıllı Ulaşım Sistemlerini Tüm Toplu Ulaşım Araçlarını Kapsayacak Şekilde Yaygınlaştırmak) under the strategic goal of “providing transport services that are accessible, sustainable, qualified, economical, fast, safe, comfortable and human-oriented” (İnsan Odaklı, Erişilebilir, Sürdürülebilir, Kaliteli, Ekonomik, Hızlı, Güvenli, Konforlu Ulaşım Hizmetini Sunmak).

Furthermore, the eleventh Transportation, Maritime Affairs and Communication Forum in 2013 proposed the establishment of intelligent highways on state highways and motorways until 2035 as that would allow vehicles to communicate with ITS and other vehicles until 2035.
2.3.8 Viet Nam

(a) ITS services

**ATMS**

ATMS has been launched in many major cities in Viet Nam, such as Da Nang, Hanoi and Ho Chi Minh, as part of ITS projects. In such cities, traffic monitoring and management systems are being developed with the focus on building a surveillance camera system, traffic management centre and radio system for collecting information and providing it to users.

For example, a pilot scheme to develop a traffic management model on Thang Long Boulevard in Hanoi is in progress. In addition, the traffic management centre in Hanoi handles traffic crashes, traffic information and facility maintenance via vehicle detectors, CCTVs and VMS. Da Nang is also working on a smarter traffic system program for the whole city.

Apart from ATMS in urban areas, the following applications have been implemented on highways in Viet Nam:

- The first freeway management system was introduced on the Cau Gie-Ninh Binh expressway that includes traffic monitoring and control systems for traffic crashes and congestion. This expressway has 30 cameras installed every two kilometres;

- A similar system was also incorporated on the Ho Chi Minh-Trung Luong expressway to monitor and control traffic flow. The traffic management centre for this expressway has 38 cameras and 30 video systems for detecting traffic errors as well as a server that can manage an image processing and network integration system across the 11 expressways in southern Viet Nam;

- Other expressways also have traffic monitoring systems. A total of 58 rotary cameras were installed on the Hanoi-Hai Phong expressway, with two stations located in high traffic-density areas, which automatically observe traffic density. These devices, which have a one-kilometre observation radius and an anti-vibration mechanism, can magnify images up to 32 times. The Noi Bai-Lao Cai expressway has 58 cameras. Cameras for traffic monitoring is also being installed on the Phap Van-Cau Gie expressway;

- For monitoring and controlling overloaded freight vehicles, mobile load testing stations have been built along the highways since 2013. Furthermore, the Ministry of Transport has started to adopt HSWIM on the important national highways.

With regard to ETCS, there are 88 toll stations on national highways, of which 73 toll stations are managed by the Ministry of Transport (56 toll stations are now being operated) and 15 toll stations are managed by local governments. 17 toll stations have free flow systems. In particular, the Cau Gie-Ninh Binh expressway has four toll stations with a digital signage system, lane control system and it can charge information storage servers for 40 lanes.

To improve traffic management (through vehicle monitoring) and safety, most transport-related companies, including cargo and passenger carriers, have deployed a cruise control system, called “black box” in Viet Nam.

**ATIS**

Most expressways in Viet Nam have VMS (a type of full span overhead bridge) managed by public agencies. VMS offers speed limit information, traffic information reminders and distances to destinations. The private sector also provides many services under ATIS. For example, Vietmap provides a free navigation service covering 63 provinces, with the map being updated every three months.

**APTS**

A bus information service has been implemented in several cities of Viet Nam (Hanoi, Ho Chi Minh and Da Nang) as a pilot project. The bus arrival information (identified by GPS) is announced
to passengers when the bus is 500 metres away from the bus stop. Information boards have been installed at 24 bus stops and a SMS is also available automatically every 3 to 5 seconds to provide bus arrival information.

Hanoi, Ho Chi Minh and Da Nang have bus operation centres that monitor bus operations which enables the collection of various data for operation routes, arrival and departure times, vehicle speeds, stop locations, and the status of opening and closing doors. Through the pilot project, the bus drivers are able to communicate with bus operators when necessary through audio cameras.

The Bus Rapid Transit (BRT) system has mostly been provided with APTS. The BRT has been deployed in Hanoi (Kim Ma-Yen Nghia route) since 2017 in response to demands by the city. The BRT will be upgraded and expanded in many other cities in Viet Nam.

(b) ITS regulations
So far, Viet Nam has just a few ITS-related regulations because it has only been implemented recently. Some national standards related to ITS were defined in 2015 – for example, an electronic toll collection system, a highway traffic supervision and management system (including highway traffic management centres) and highway traffic signs.

Considering the limited number of regulations for ITS, Viet Nam is currently at the stage of developing policies to support national science technologies. Some examples that can be used for ITS development are:

- Decision No. 418/QD-TTg: Science and Technology Development Strategy, 2012;
- Decision No. 2457/QD-TTg: National Programme on Hi-tech Development up to 2020, 2010;
- Directive 16/CT-TTg: Enhancing the Capacity to Access the 4th Industrial Revolution, 2017.

In addition, since ITS uses communication technologies, some existing national technical regulations governing the specifications of communication devices can supplement regulations for ITS development.

2.3.9 Lessons learned from country-specific cases
First, the roles of ITS regulatory frameworks are underscored. It should be noted that regulations related either directly or indirectly to ITS provide the basis for ITS development and operation, which will therefore reinforce the rapid adoption of ITS and advances of related technologies. In addition, regulations related to ITS support the establishment of national ITS plans and strategies as well as continuous updating.

Second, regulations related to ITS require the involvement of various entities. This is re-emphasized by the country-specific cases that show the existence of diverse types of regulations for ITS in various fields encompassing transport, ICT, industry and internal administration.

Third, among the countries that already have regulations related to ITS, different approaches are seen. Some countries have amended existing regulations in other fields relevant to ITS technologies, while others have attempted to introduce regulations dedicated to ITS. In the second category, these two approaches have been merged appropriately – i.e., even though the latter countries have regulations directly related to ITS, they have also revised earlier regulations to respond to the requirements for new ITS technologies in a timely manner.

Fourth, the case studies show that various attempts have been made to develop relevant regulations. Although those countries do not have adequate regulations related to ITS yet, they have started to establish regulations where urgent demand exists for the implementation of ITS services.
Fifth, even though some countries have relevant regulations for ITS, the terms, provisions and descriptions used in such regulations do not necessarily meet the specific system requirements for new ITS technologies (e.g., C-ITS, CVs, AVs and smart mobility) and cross-border ITS services, despite the growing demand for such technologies and services in Asia and the Pacific.
3.1 Current ITS status in the region

More than 4 billion people live in the Asia-Pacific region,\(^{38}\) and Asia is expected to have more than 60 per cent of the total world population of 65-year-olds or older by the 2030s.\(^ {39} \) The United Nations has projected that the world’s population could add another 2.5 billion people to urban areas by 2050, with around 90 per cent of the increase located in Asia and Africa.\(^ {40} \)

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39 Business Insider, Asia is expected to be home to more than half of the elderly population worldwide by 2050. Available at https://www.businessinsider.com/asia-will-be-home-to-more-than-half-of-the-elderly-population-2017-9.

Such growth in population and urbanization will create traffic congestion and related negative impacts in the Asia-Pacific region. However, at the same time, more than 60 per cent of the world's youth population live in the Asia-Pacific region.\(^1\)

This high percentage of the younger generation and their positive attitude on adopting technologies bring, in part, new opportunities to address these issues with regard to ITS. This type of situation requires the investigation of the potential of ITS in various categories.

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An analysis of the current strengths, weaknesses, opportunities and threats (SWOT) is given in this chapter in the context of ITS in the Asia-Pacific region (figure 3.1). Once strengths, weaknesses, opportunities and threats are identified, it will be easier to understand the ITS status in the Asia-Pacific region with regard to developing short- and long-term goals and policy recommendations for ITS regulatory frameworks.

### 3.1.1 Strengths

The Asia-Pacific region shows the most rapid economic growth in the world. About two-thirds of the world's population lives in the region. Thus, there are enormous market

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**FIGURE 3.1**

Framework of the SWOT analysis

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid economic growth</td>
<td>Lack of common terminology and standard</td>
</tr>
<tr>
<td>Existence of ITS leading countries</td>
<td>Limited experiences</td>
</tr>
<tr>
<td>Emerging ITS market</td>
<td>Gap of technological readiness</td>
</tr>
<tr>
<td>Adoption of new technologies</td>
<td>Limited basic infrastructure</td>
</tr>
<tr>
<td>Growing start-ups</td>
<td>Lack of plans for ITS</td>
</tr>
<tr>
<td>Rapid adoption of smartphones</td>
<td>Absence of regulations for ITS</td>
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<tr>
<td>Financial opportunities</td>
<td>Low understanding and awareness on ITS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing mobility demands</td>
<td>Passive international collaboration</td>
</tr>
<tr>
<td>Good transport connectivity</td>
<td>Heavy dependency on foreign ITS technologies</td>
</tr>
<tr>
<td>Increasing awareness for energy efficiency</td>
<td>Costs of ITS investments</td>
</tr>
<tr>
<td>High rate of young generation</td>
<td>Growing international competition</td>
</tr>
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</table>
opportunities for ITS technologies in this region. To be specific, according to the analysis of ITS market size, the Asia-Pacific market is expected to grow constantly from US$ 4.55 billion in 2015 to US$ 14.37 billion by 2024 at a compound annual growth rate (CAGR) of 13.6 per cent. As of 2024, the Asia-Pacific market will replace Europe’s position (US$ 12.81 billion) as the second-largest market in the world.

Further, countries in Asia and the Pacific are highly motivated in adopting new technologies, in part led by the young generation as emphasized above. Also, some of these countries are leading the world in this field. For example, some countries in this region (e.g., China, Japan, the Republic of Korea and Singapore) have played significant roles in the development and usage of ITS technologies around the globe. In recent years, Hong Kong, China as well as Seoul, Singapore and Tokyo have been developing, testing and adopting state-of-the-art urban mobility approaches, such as MaaS, CVs and AVs, ahead of other countries. In adopting big data analytics, behavioural science, ride-sharing and electric vehicles, China and Singapore have become frontrunners.

As shown in the International Energy Agency (IEA) report, in 2017, 40 per cent of the world’s electric vehicles on roads were located in China. Many start-up companies utilizing new technologies can also be found in this region. A total of US$ 57 billion has been invested in startups by Chinese unicorns (startups that have attained the status of more than US$ 1 billion invaluation) over the last 5 years as of 2017.

There are many financial supporting opportunities in this region for propelling ITS-related activities through Official Development Assistance (ODA) agencies (e.g., the Japan International Cooperation Agency and Korea International Cooperation Agency) or Multilateral Development Banks (MDBs) (e.g., the Asian Development Bank, Asian Infrastructure Investment Bank and World Bank). Given that ITS development requires financial investment over a specified minimum level, these financial opportunities can trigger the adoption of ITS technologies in some countries in this region, which necessitates financial assistance.

3.1.2 Weaknesses

The successful operation of ITS generally requires a specific minimum level of expertise and technological fundamentals. Even though world-renowned ITS leading countries exist in this region, many other countries still suffer from the lack of fundamentals of experiences, infrastructure and expertise for ITS development. Naturally, a substantial gap in terms of technological readiness among such countries has been created which is in part proven by the recent study dealing with the technological readiness for smart cities in South-East Asia by comparing those in developed countries. From this study, among 10 countries in South-East Asia, only Singapore and, to a lesser extent, Malaysia are far ahead of all other South-East Asian countries, and close to the developed countries in terms of communications infrastructure extensiveness and quality as well as connectivity. Given that such a technological backbone is instrumental for ITS development, this lack of fundamental is hindering the wider deployments of ITS in some countries in Asia and the Pacific.


43 Ibid.


The lack of short- and long-term plans for ITS is also one of the weaknesses noticed in many countries in this region, which in part results from the weak regulatory foundations for ITS at the national and regional levels. Such plans will provide an overarching vision, detailed goals, and short-, medium- and long-term action plans for ITS development and operation. Given that several countries in the region are in the early stages of ITS development, this weakness will create challenges to implementing ITS in many ways. In connection to this weakness, common terminologies and standards need to be developed; regional terminologies and standards would facilitate efficient interactions among ITS applications and seamless services by enhancing the interoperability and compatibility between different systems.

One misconception that has pervaded Asian countries is that ITS requires costly systems that can be adopted only in developed countries. However, given that ITS has been perceived as a cost-effective solution, this misconception could be another weakness resulting from the low institutional understanding of ITS, and the lack of proper knowledge among policymakers.

3.1.3. Opportunities
As already noted above, the Asia-Pacific region has a high percentage of the young generation. More than half of the world’s population using the Internet live in the region, of which more than 70 per cent own a smartphone. For example, the Republic of Korea (at 87.8 per cent) and Japan (at 82.3 per cent) have a high level of Internet penetration among their total populations. The number of smartphone users in the region is expected to reach 1.81 billion by 2021. Considering that the new generation of ITS will be based on mobile technology, this rapid adoption of smartphones in the Asia-Pacific region will provide immense opportunities to expand ITS-related industries.

In addition, various efforts have been implemented to improve transport connectivity, such as the Asian Highway network, the Trans-Asian Railway network, the ASEAN Highway network, and Belt and Road Initiative, all of which will bolster transport-related investments including ITS. Such efforts also deliver improved connectivity between countries, which will forge increased collaboration in ITS roll-outs. In this regard, in recent years various ITS-related activities have been observed at the subregional level such as the ASEAN Smart Cities Network, the Greater Mekong Subregion (GMS) Transport Sector Strategy 2030, the ASEAN ITS Policy Framework, ASEL Transport Development, and the FITSRUS project (Finland-Russian Federation).

Increasing demand for new mobility services, such as smart mobility, is another opportunity in the Asia-Pacific region that, in part, will serve users’ needs for better convenience, accessibility and energy efficiency (also related to environmental issues). This is particularly relevant, given the fact that since 2016 Asian cities have experienced severe traffic congestion, with a 30 to 50 per cent increase in overall travel times when

51 Global System for Mobile Communications, The Mobile Economy Asia Pacific. Available at https://www.gsmaintelligence.com/research/?file=284d018f963d766ca37d014fa9cfb1k&download.
53 ASEAN Singapore 2018, ASEAN smart cities network. Available at https://www.asean2018.sg/Newsroom/ASCN.
compared to a free-flow situation. As a result, new mobility services utilizing ITS technologies have been considered as alternatives for dealing with the problem.

### 3.1.4 Threats

Compared to other regions, the Asia-Pacific region is multi-cultural, multi-religious and multi-linguistic, which frequently lead to passive international collaboration and cooperation. This rationale is also applicable to the enhancement of ITS development at the regional level. It is obvious that even leading ITS countries in this region have weak relationships in collaborating and cooperating in ITS services. Looking ahead, the new ecosystem of C-ITS, CVs, AVs and smart mobility should therefore be considered with this threat in relation to ITS expansion.

Many countries in the Asia-Pacific region rely heavily on foreign inputs because of the lack of ITS technology skills in their own workforce. Undiscerning adoption from the outside might generate inconsistent and unreliable ITS services, which would eventually prohibit the full utilization of ITS technologies in this region. Representatively, without overall direction or multifarious discussions, various investments in ITS development in less developed countries have sometimes been made by MDBs and ODA agencies.

Even though ITS is a cost-effective solution and relatively inexpensive compared with the construction of new infrastructure, it requires a certain amount of investment, which might be burdensome in terms of costs in some countries in the region. In the near future, the situation will occur in which new ITS technologies, such as C-ITS, CVs, AVs and smart mobility, require greater investment by the public and private sectors; therefore, the Asia-Pacific region countries need to be prepared. Further, as defined in this study, ITS is an aggregate of diverse technologies where many companies are currently competing and are expected to increase around the globe. To ensure successfully sustained use of ITS, domestic or regional experience from ITS technologies should be acquired and cultivated to some degree, which will naturally mean competing with others from outside this region.

### 3.2 Emerging ITS trends

Countries in the Asia-Pacific region have introduced ITS at different times and might have differing interests in, and needs from ITS technologies. Given that there are a variety of ITS technologies in place around the world, exploring prevailing or forthcoming ITS applications and technologies would provide guidance on formulating policy recommendations for ITS regulatory frameworks. In this regard, each section of this chapter reviews details of ITS applications and technologies (i.e., traffic management centres, smart mobility, C-ITS and CVs, AVs) with practical examples from North America, Europe, and Asia and the Pacific.

#### 3.2.1 Traffic Management Centres

With growing urbanization, many metropolitan areas around the globe have tried to set up Traffic Management Centres (TMCs) to handle traffic issues. The term TMC, in general, refers to a centre that is equipped with ATMS. However, recently TMCs have adopted new technologies such as an open platform, an open application program interface (API) and advanced security technologies to upgrade to Advanced Traffic Management Centres.

The basic functions of a TMC includes real-time detection, traffic monitoring, adaptive traffic signal and control management, and wireless communications for maximizing capacity of roadway networks, minimizing the impact of incidents to users and proactively managing...
traffic flows.\textsuperscript{59} A TMC pursues security and redundancy without creating potential failures in monitoring traffic conditions, responding timely to traffic issues, influencing the operation of traffic signals, disseminating timely/accurate information (e.g., VMS), and interacting with other transport modes and agencies.\textsuperscript{60} Open API is also being incorporated for better monitoring of traffic operations and detecting vehicles, bicycles, and pedestrians by piloting new detection technology.\textsuperscript{61}

In the United States, the majority of TMCs began operating during the 1990s and 2000s\textsuperscript{62} and many metropolitan areas\textsuperscript{63} now have multiple traffic management centres.\textsuperscript{64} For example, the Georgia Department of Transportation in the United States operates an ATMS called Georgia NaviGAtor (figure 3.2). This system includes traffic cameras, VMS, ramp meters and traffic speed sensors. All the devices are linked by fibre-optic systems that are connected to the TMCs.\textsuperscript{65}

In Europe, the functions of TMCs are similar to the ones in the United States, which are usually operated by public authorities and road operators.\textsuperscript{67} The core roles of TMCs in Europe include strategic corridor and network management, section control, incident management, speed control, ramp metering and hard shoulder running.\textsuperscript{68} Some examples are Sytadin (France) (figure 3.3), Trafik Stockholm (Sweden),\textsuperscript{70} and Traffic Wales (United Kingdom).\textsuperscript{71}

In many countries of the Asia-Pacific region, TMCs are also quite common, but they are at varying levels of development. One recent example can be found in Singapore. An intelligent incident management tool in Singapore, called the Expressway Monitoring Advisory System (EMAS), detects crashes and other incidents promptly, ensures fast response to restore traffic flows, and provides real-time information of travelling times from the entry point to the expressway to selected exits via textual messages and VMS. The Land

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3.2.png}
\caption{Georgia NaviGAtor\textsuperscript{66}}
\end{figure}

\textsuperscript{63} Metro Atlanta area, Metro Austin area, Metro Baltimore area, Metro Baton Rouge area, Metro Boston area, Metro Charlotte area, Metro Chicago area, Metro Cincinnati area, Metro Dallas area, Metro Denver area, Metro Detroit area, Metro Houston area, Metro Jacksonville area, Metro Kansas City area, Metro Los Angeles area, Metro Miami area, Metro Nashville area, Metro New Haven area, Metro New York area, Metro Orlando area, Metro Philadelphia area, Metro Phoenix area, Metro Salt Lake City area, Metro Sacramento area, Metro San Antonio area, Metro San Diego area, Metro San Francisco area, Metro Seattle area, Metro St. Louis area, Metro Tampa area, Metro Tucson area, Metro Virginia Beach area, and Metro Washington DC area.
\textsuperscript{64} United States of America, Department of Transportation, Office of the assistant secretary for research and technology, 2010 Deployment Statistics. Available at https://its2010.ornl.gov/ListTMC.aspx.
\textsuperscript{65} United States of America, Georgia Department of Transportation, Available at http://www.511ga.org.
\textsuperscript{66} Ibid.
\textsuperscript{67} European Commission, Mobility and transport. Available at https://ec.europa.eu/transport/themes/its/road/application_areas/traffic_management_en.
\textsuperscript{69} France, SYTADIN. Available at http://www.sytadin.fr/.
\textsuperscript{70} Sweden, Trafiken.nu. Available at https://trafiken.nu/stockholm/.
FIGURE 3.3
Real-time traffic information system in DiRIF (direction des routes Île-de-France)72

Transport Authority has extended the EMAS scheme to 10 major arterial road corridors for better information dissemination and traffic flow on the road network island-wide.73 Another example is in Australia. There has been a recent announcement of a major upgrade to the TMC in Sydney, New South Wales, which proposes to predictively manage disruption by 2020 with real-time autogenerated congestion alerts to customers.74

3.2.2 Smart mobility
In the past, smart mobility only referred to environmentally-friendly modes of transport, but the meaning of smart mobility has been expanded to one which includes accessibility by any mode to create seamless, efficient and flexible services in response to the user’s demands.75 Combining the concept of smart mobility with various new technologies, such as mobile (i.e., smartphones), multimodal and on-demand mobility services, and electric and autonomous vehicles, is encouraged in order to maximize its benefits.76

Almost the first tool for smart mobility was the smart card system, which is now quite common in many cities around the world. As shown by the case in London, since adopting the Oyster card in 2003, users have experienced more convenient trips by subway without physically purchasing tickets. Similar examples exist, such as the Breeze card in Atlanta, CharlieCard in Boston, Clipper in San Francisco, SmartTrip in Washington, D.C., Access card in Stockholm, Navigo in Paris, and OV-Chipkaart in the Netherlands. According to the advancement of ICT, such initial tools with public transport services have been upgraded by incorporating real-time routing, booking and ticketing services,77 which have saved countless hours for passengers and provided seamless multimodal services.78

The mobile-based mobility service is a representative example of the smart mobility concept, considering the fact that the use of smartphones is constantly growing around the world (e.g., the number of smartphone users is estimated to have reached 224.3 million in the United States in 2017,79 240.3 million in Western Europe in 2016,80 167.2 million)


72 France, SYTADIN. Available at http://www.sytadin.fr/.
75 Siemens, Smart Mobility – a tool to achieve sustainable cities (München, 2016).
in Central and Eastern Europe in 2016, and 1139.8 million in Asia and the Pacific in 2016 because it does not require large-scale public investments and conventional ITS infrastructures. Various applications are available for mobile-based services, including real-time multimodal services, personalized travel information, trip navigations, public transit booking, and payments.

In terms of mobile ticketing, as of 2015 in the United States nearly one-in-five consumers (around 19 per cent) paid for parking fees via mobile applications such as "ParkMobile" and "PayByPhone", which also give a driver the option of paying and managing meter time. In the Miami Coconut Grove in Florida, mobile payment for parking accounted for 70 per cent of all payments for parking in 2016. In most European countries, the use of e-payment for parking is increasing rapidly. As of 2015, these payment methods already accounted for more than 50 per cent (and, in some instances, more than 80 per cent) of payment methods in the majority of the northern European countries. There are many examples from private companies such as ParkMobile, JustPark, RingGO, Parkopedia, PayByPhone, EasyPark, and ParkU.

In Asia and the Pacific, in October 2018, the Ministry of Land, Infrastructure, and Transport in the Republic of Korea partnered with mobile service developers in starting the development of pedestrian safety services using ITS technologies. This service will allow pedestrians to receive nearby vehicle-related information on their smartphones in certain areas, such as bus stops, traffic lights and traffic complexes. In Australia, the Advisory Intelligent Speed Assist (ISA) system, which warns over-speeding vehicles, is utilized through smartphones. Australia also has Right Move Perth, developed by the Department of Transport (the Government of Western Australia), providing information including roadworks, crashes, traffic signal faults, train and bus service disruptions, major events and weather warnings.

The concept of smart mobility also contributes to the creation of new business models with a sharing economy concept. The on-demand ride services (e.g., Uber and Lyft), real-time ride-sharing services (e.g., Carma and Zimride), car-sharing programmes (e.g., Zipcar and car2go), bike-sharing programmes (e.g., Capital Bikeshare in Washington D.C., Divvy in Chicago and Citi Bike in New York, and BIXI in Montreal, Canada), and scooter sharing (e.g., Bird, Lime and Spin) are representative examples of smart mobility services using the sharing economy concept.

Another emerging concept of smart mobility is MaaS. Recent changes in technology, socio-demography, and user behaviour are helping a move towards multimodal transport services – combining existing transport modes (e.g., individual vehicles, buses, trains, bicycles, walking and shared modes). MaaS offers a seamless service across all existing transport modes by providing customized trip information and services. MaaS is based on the concept of “using” transport services, not “owning” transport modes. Considering the fact that ITS industries rely heavily on the cooperation of the public and private sectors, MaaS is expected to provide cost-efficient mobility options to the users, thus reducing expenditures associated with personal vehicle purchase and maintenance.

In the United States, Bridj is providing an on-demand commuter shuttle service with a smartphone application, allowing users to ride a shuttle between home and work during commuting hours. Based on demand, Bridj optimizes pick-ups, drop-offs and routing, which offers a 40-60 per cent more efficient trip than traditional transit. In Canada, some municipal transport authorities offer mobility packages that include bike-sharing and car-sharing which allow a user to save the regular price of public transport by subscribing to the BIXI-AUTO-BUS package.

In Europe, there are also good examples of MaaS pilots. In Finland, a user can access a variety of transport options, from taxis to rental cars, public transport and bike share through a subscription-based integrated mobile application, called Whim. In Germany, the Qixxit application provides all travel options including car-sharing, ride-sharing and bike-sharing which users can compare and choose according to their needs.

In Asia and the Pacific, Singapore is implementing the smart mobility concept. Beeline is a smart mobility platform based on the open cloud, which offers demand-based shuttle bus services for commuters through data analysis tools. Users can reserve seats on buses registered by private bus companies and find the location of the buses with suggested travel routes. With the concept of AVs, Singapore has been developing the concept of Mobility-on-Demand (MoD) as one of the solutions to the first-and-last mile problem. It has tried to integrate existing technologies with new methodology to provide MoD by AVs. A self-driven electric car is used to demonstrate the MoD system, which has been operational since January 2014. In Australia, there are a number of MaaS trials in development with both transport authorities and industries investigating the strong potential for MaaS projects – for example, one research project has been released recently which provides an evidence base to help prepare for the major changes anticipated in the concept of MaaS.

3.2.3 Cooperative-ITS and connected vehicles (V2I, V2V and V2X)

The concepts of Vehicle-to-Infrastructure (V2I), Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) are simple...
telecommunications technology that conducts the wireless exchange of data between vehicle and road infrastructure (V2I), vehicle and vehicle (V2V) and vehicle to various objects (V2X). Enabled by various forms of hardware, software and firmware, these technologies are used to mitigate congestion, reduce fuel consumption and emissions, and increase reliability, mobility and road safety by communicating with infrastructure, vehicles and other objects in response to road conditions.102

In the United States, for more than a decade the National Highway Traffic Safety Administration (NHTSA) has been working with the automotive industry and academic institutions on V2V technologies. In 2012, NHTSA launched a pilot safety study (Safety Pilot Model Deployment103) with tests on nearly 2,800 vehicles mostly with V2V technologies. A total of 27 roadside units along 75 miles of roadway were also installed in this study to test the V2I technologies for traffic signal timing and emergency vehicles. In 2017, the United States Department of Transportation (USDOT) issued a Notice of Proposed Rulemaking (NPRM) that will enable V2V technologies on all new light-duty vehicles. The NPRM had a 90-day comment period and NHTSA received 450 comments that included technology strategy, implementation timing, detailed technical information, cost estimates, potential health effects, privacy and security.104 Although extensive studies regarding the benefits of these technologies currently do not exist, research by NHTSA found that the combination of V2V and V2I technologies potentially addressed 81 per cent of unimpaired-driver crashes in all types of vehicles and 83 per cent in all light-vehicles.105

In Europe, the CAR2CAR consortium of leading European vehicles manufacturers is working on V2V, V2I, and V2X technologies in order to create interoperable standards for all vehicle classes, across borders and brands. For this, the CAR2CAR consortium is working in close cooperation with the European Telecommunications Standards Institute (ETSI) and European Committee for Standardization (CEN).106 Given that congestion in the European Union costs about € 100 billion annually, V2X application is projected to reduce road congestion by 15 per cent.107

Connected vehicles (CVs) refers to cars that “access, consume, and create information and share it with drivers, passengers, public infrastructure, and machines including other cars”.108 By using V2V, V2I and V2X technologies, CVs enable various functions, mainly with regard to safety (e.g., red-light violation warnings and forward collision warnings), mobility (e.g., dynamic speed harmonization and cooperative adaptive cruise control), environment (e.g., dynamic eco-routing and eco-approach/departure at signalization intersections) and weather (e.g., weather response traffic information).109

To benefit from this technology, USDOT has selected three sites to test CVs on improving

vehicle and pedestrian safety as well as traffic flow through Phase 1 of Connected Vehicle Pilot Deployment Programme up to 50 months. A total of US$ 178.8 billion in societal benefits annually is expected if connected vehicle safety applications are deployed across the entire United States vehicle fleet. On top of that, Connected Vehicle Reference Implementation Architecture (CVRIA) has been established in the United States. CVRIA provides “the basis for identifying the key interfaces across the connected vehicle environment which will support further analysis to identify and prioritize standards development activities.” Because CVs have the potential to dramatically reduce the number of fatalities and serious injuries, USDOT is, in particular, focusing on preventing crashes using this technology. USDOT Intelligent Transportation System Joint Program Office (ITS JPO) and NHTSA are working with the connected vehicle industry to develop more efficient and safe connected car environments. USDOT is planning to fund nearly US$ 3.9 billion over 10 years to promote large-scale deployment pilots to test connected and autonomous vehicle systems.

CVs are also a multifaceted industry, with thousands of companies involved. Those industries and companies include automated driving (Bosch, Daimler, Google, Uber etc.), connected cloud service (Amazon, Airbiquity, Cisco Jasper, etc.), connected data (Hortonworks, Qualcomm, etc.), connected fleet management (Accenture, Autosist, Fleetmatics, etc.), connected truck (Bosch, Daimler, Mercedes-Benz etc.) and head-up displays (Carloudy, Corning, Garmin, etc.).

In response to sensitively user’s various demands, a new concept of ITS, called Co-operative-ITS (C-ITS) which surmounts the limited functions of ITS in silos, was created that integrates each ITS application into a fully-connected network, based on V2V, V2I, and V2X technologies. With a comparison of current ITS, in C-ITS, each vehicle communicates with each other, infrastructure and other objects by V2V, V2I, and V2X technologies, respectively. All necessary information is shared with vehicles which can respond quickly to unexpected events on roads. Based on the recent study, experiments on the potential impact of using such technologies showed positive benefits in reducing crashes and fatalities on roads. C-ITS takes transport systems a step further as it takes advantage of the latest enhancements and additional services implied by the connection of systems together.

C-ITS is a European Commission’s initiative to develop a transport automation strategy for the European Union that would provide safer, more efficient and informed road experience for all road users. The European Commission has established a dedicated C-ITS platform to bring representatives from a wide range of stakeholders. This platform has a goal to build a shared vision of options to support the deployment of C-ITS. The European Union has conducted various studies involving research, consultation and data collection exercise, together with the definition of deployment
scenarios in conjunction with members of this C-ITS platform.\textsuperscript{118}

More recently, in a plan called “A European Strategy on Cooperative Intelligent Transport Systems”, the European Commission stated that the full-scale deployment of C-ITS services would be implemented with C-ITS enabled vehicles starting from 2019.\textsuperscript{119} In line with this strategy, the European Transport Safety Council recommended setting targets between 2019 and 2029 in the gradual European Union-wide deployment of C-ITS.\textsuperscript{120}

In Asia and the Pacific, even though only leading ITS countries are proactively developing technologies for C-ITS and CVs (including V2V, V2I and V2X), many such activities are currently being developed. For example, for V2V, V2I and V2X technologies, the Republic of Korea is implementing 5G mobile communication networks that enable data transmission faster than 20 Gbps and mutual transmissions between base stations and devices every 1/1000 seconds.\textsuperscript{121} Seoul has created traffic communication networks on 5G Wave, and Cellular-V2X, offering opportunities for various communication technologies to be tested on real roads.\textsuperscript{122} China is also moving forward with the development of 5G mobile communication technology with the Government’s strong drive and has been actively making progress on establishing international standards on V2X.\textsuperscript{123}

In terms of C-ITS and CVs, countries in the Asia-Pacific region have recently begun research activities, and initiated relevant plans and strategies. For example, the Republic of Korea has initiated strategic plans on promoting the commercialization of C-ITS. According to the National ITS Master Plan 2020, the Republic of Korea is planning to conduct field operation tests of such technologies on highways and urban areas.\textsuperscript{124} The C-ITS pilot project for verification of next-generation ITS technology and service started in July 2014 and will run until 2020.\textsuperscript{125} This pilot project consists of 88 km of road extensions and expressways, national roads and urban roads in Daejeon and Sejong cities. The pilot project\textsuperscript{126} aims to improve driver safety through V2V and V2I technologies.

In China, technology studies on vehicle and road cooperation (e.g., on-board, roadside, communication and control systems) were conducted from 2011 to 2014.\textsuperscript{127} Two national standards (China V2X standards) for C-ITS were released in 2014, and automobile manufacturers, Internet companies (e.g., Baidu, Alibaba and Tencent) and research institutions are currently working together to promote intelligent driving technology.\textsuperscript{128}

In Japan, the concept of C-ITS was verified through regional trials concerning Smartway, Advanced Safety Vehicles and Driving Safety Support Systems (DSSS). In launching the C-ITS projects nationwide, 15 locations had been selected for DSSS as of 2010, and by 2011, 1,600 locations had been selected for the ITS Spot project which was renamed as ETC 2.0 in 2014.\textsuperscript{129}

\begin{thebibliography}{99}
\bibitem{120} Ibid
\bibitem{121} Netmanias, The advent of the 5G era. Available at https://netmanias.com/ko/?m=view&id=blog&no=13306.
\bibitem{122} Republic of Korea, Ministry of Land, Infrastructure and Transport, C-ITS. Available at http://www.molit.go.kr/portal.do.
\bibitem{124} Republic of Korea, Ministry of Land, Infrastructure and Transport, C-ITS pilot project. Available at https://www.c-its.kr/introduction/history.do.
\bibitem{125} Ibid
\bibitem{126} Korea Expressway Corporation. Available at http://www.ex.co.kr/.
\bibitem{128} China, Ministry of Transport, Research Institute of Highway, Current Development Status and Perspectives of ITS in China, 30 March 2017.
\end{thebibliography}
As of March 2018, the number of ETC 2.0 device is roughly 3.7 million.130

C-ITS projects in Australia started in December 2013 when the National Transport Commission (NTC) released its final policy paper on C-ITS. This paper views road safety as the most prominent opportunity for C-ITS with efficiency, productivity and environmental benefits.131 Based on Austroads’ Cooperative ITS Strategic Plan, Australia has continued working to commercialize the deployments of such technologies with some projects,132 such as a small-scale proof of concept in South Australia in 2010 and the provision of advance warning of approaching trains at level crossings. Further, recently, there are more trials in a number of jurisdictions with three projects in particular testing a range of technologies and platforms – Cooperative and Automated Vehicle Initiative (CAVI) in Queensland, Cooperative Intelligent Transport Initiative (CITI) in New South Wales, and Australian Integrated Multimodal EcoSystem (AIMES) in Melbourne.133

3.2.4 Autonomous vehicles

In principle, the autonomous vehicle (AV), also called “self-driving” or “driverless” vehicle, is able to travel without human intervention. Technically, the AV uses satellite positioning systems and diverse sensors (i.e., radar, ultrasonic, infrared, laser etc.) to detect the surrounding environment.134 Identified information is interpreted to find appropriate paths considering obstacles and traffic signage by using wireless networks, digital maps, automated controls in vehicles, and communication with smart infrastructure and the control centre.135

In the United States., at least 41 States and Washington, D.C. have been considering legislation related to AVs since 2012.136 Governors of 11 States have issued executive orders, while 29 States and Washington, D.C. have enacted legislation related to AVs.137 In addition to the legislation, USDOT is pursuing a variety of activities for AVs. In 2017, USDOT selected 10 proving ground pilot sites to encourage testing, validation and information sharing around automated vehicle technologies.138 In 2018, USDOT published Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0) to provide a framework and multimodal approach to the safe integration of AVs into the surface transport system.139 In 2018, USDOT published a Comprehensive Management Plan for Automated Vehicle Initiatives for the implementation of a plan to manage initiatives related to AVs within variously related administrations, such as NHTSA, FHWA, the Federal Motor Carrier Safety Administration and the Federal Transit Administration.140

137 Ibid.
138 United States of America, Department of Transportation, Automated vehicle proving grounds to encourage testing of new technologies. Available at https://www.transportation.gov/briefing-room/dot1717.
In Europe, research projects on autonomous driving, called City Alternative Transport and CityMobil, have been initiated. Germany introduced the concept of automated driving as an objective for 2020 in a Round Table organized by the Federal Ministry of Transport and Digital Infrastructure. The United Kingdom invested £33 million for “driverless car” trials in four cities in 2014 and completed the regulatory review (titled “the pathway to driverless cars”) in 2015.

In addition, the European Commission supports the introduction and deployment of connected and automated mobility by developing policy initiatives, roadmaps and strategies, developing standards at the European level, co-funding research and innovation projects, and infrastructure pilot projects. In 2016, the European Commission members signed the “Declaration of Amsterdam on Cooperation in the Field of Connected and Automated Driving”, establish shared objectives, a joint agenda and proposed actions both for member States and the European Commission in the area of connected and automated driving. In March 2017, 29 European countries signed a Letter of Intent committing to work together on large-scale testing and demonstrations for automated driving.

Because AVs are technology-intensive, many private automobile manufacturers and Internet-oriented technology companies are actively driving towards research and development. For example, vehicles with a limited autonomous driving function are already available on the market (Levels 1 and 2 vehicles by the definition of the Society of Automotive Engineers International), while some Level 3 vehicles are commercially available in certain leading ITS countries. More and more countries are testing Levels 3 and 4 vehicles and some will be available by 2020. The key players in the AV market are mostly the United States and European-based companies, including Google LLC, General Motors Company, Volkswagen, BMW (Bayerische Motoren-Werke), Ford Motor

145 Amsterdam, Cooperation in the field of connected and automated driving. Available at https://www.regjeringen.no/contentassets/ba7ab6e2a0e14e39bbaa77f5b766f9fd1k/2016-04-04-declaration-of-amsterdam-final140661.pdf.
150 “Level 0: The human driver does all the driving, Level 1: An advanced driver assistance system (ADAS) on the vehicle can assist the human driver with either steering or braking/accelerating, Level 2: An ADAS on the vehicle can control both steering and braking/accelerating under some circumstances. The human driver must continue to pay full attention (“monitor the driving environment”) at all times and perform the rest of the driving task, Level 3: An automated driving system (ADS) on the vehicle can perform all aspects of the driving task under some circumstances. The human driver must be ready to take back control at any time the ADS requests the human driver to do so. In all other circumstances, the human driver performs the driving task, Level 4: An ADS on the vehicle can perform all driving tasks and monitor the driving environment essentially, do all the driving — in certain circumstances. The human need not pay attention in those circumstances, Level 5: An ADS on the vehicle can do all the driving in all circumstances. The human occupants are just passengers and need never be involved in driving.” See the details at http://autocaat.org/Technologies/Automated_and_Connected_Vehicles/.
In Asia and the Pacific, China aims to implement autonomous driving technology for all private cars in a cutting-edge metropolis near Beijing by 2035. A new city project is planned exclusively for AVs in Xiongan, which will be a model district designated for developing autonomous driving technology based on artificial intelligence, by providing support for related industries. In Japan, an automated driving system programme was selected in 2014 as part of the Cross-Ministerial Strategic Innovation Promotion Programme for the purpose of developing new technologies that avoid crashes and alleviate congestion. Japan has launched verification tests on autonomous taxis and aims to commercialize autonomous taxis by the 2020 Olympics and Paralympics in Tokyo. In the Republic of Korea, the Ministry of Land, Infrastructure and Transport is building a testbed, called K-City, in which AVs could be tested on real roads. In Australia, the first driverless shuttle bus, “IntelliBus”, which has been going through trials in Perth, is able to carry 11 people at a maximum speed of 45 km/h in controlled environments. South Australia also held the first on-road trials of driverless cars in 2015. The Land Transport Authority in Singapore established the first test site for self-driving vehicle technologies and mobility concept in 2015.

3.3 Development opportunities in the Asia-Pacific region

It should be noted that although the Asia-Pacific region is facing many of the challenges indicated in SWOT analysis, many strengths and opportunities to cancel out such challenges were found that hold strong potential for better integration of ITS technologies, and more efficient and effective ITS development and operation. Growing populations, potential markets, lessons learned, and young resources have the region well-positioned for the successful development of ITS.

Furthermore, as analysed in section 3.2, there are various new ITS technologies currently under development around the world. Some countries in Asia and the Pacific also provide good examples of the use of such technologies, implying that other countries in the region will use them properly sooner or later. Taking into consideration the findings in chapters 1 and 2, development opportunities from the Asia-Pacific perspective are presented below:

- Traffic management centres. It was found that traffic management centres are becoming widespread around the world, including many countries in the Asia-Pacific region. As pointed out by the SWOT analysis, some world-renowned leading ITS countries are in the Asia-Pacific region that already have good experience in establishing traffic management centres and are now advancing the functions of the centres with new technologies. Such advantages can be utilized properly to operate more traffic management centres in the region with...
cooperation from subregional ITS-related activities. Given that the Asia-Pacific region has good transport connectivity networks, such as the Trans-Asian Railway, Asian Highway and Dry Ports, the pursuit of traffic management centres will operationalize these networks. Further, considering the importance of TMCs as a hub for ITS services, including new mobility options, less ITS-developed countries could utilize the opportunity to gain ODA support from United Nations agencies and MDBs for establishing TMCs.

- Smart mobility. As pointed out in the SWOT analysis, the high percentage of the young generation in the Asia-Pacific region can easily adopt new mobile technologies. Given that the concept of smart mobility is mainly based on mobile technologies, which do not require traditional investment and fundamentals, this strength can help promote the concept of smart mobility in most of the countries in this region (regardless of the level of technological readiness), particularly where fundamental infrastructure, funding resources and good experience in ITS services are lacking. In addition, the growing number of start-ups and increasing demands for new mobility services in the region can create more opportunities for developing and implementing the concept of smart mobility. In particular, some countries in the region that suffer from limited accessibility and connectivity of transport services could benefit from new mobility options by providing easy, seamless and convenient services to users. Further, from the government perspective, the concept of smart mobility might mean relatively cheap operational costs in offering transport services from the public sector.

- Autonomous vehicles. Because of the flexibility of developing and least developed countries in adopting new ITS technologies in the Asia-Pacific region, it is expected that the concept of AVs will be smoothly introduced step-by-step in most countries of the region in the future. Given that there are many financial opportunities for technical and capacity-building assistance in this region, the understanding and preparedness of AVs can be enhanced through various activities by MDBs, the United Nations and ODA agencies. In addition, leading ITS countries in this region have already initiated necessary actions including introducing relevant regulations, plans and standards that would be good references for other countries in the region that are lagging behind. In addition, various attempts at start-ups by the young generation and steady efforts for increasing self-development capabilities would contribute to lowering the likelihood of failure. As the Asia-Pacific region is experiencing rapid economic growth and growing ITS market size, the adoption of AVs will create a great synergy effect in addressing traffic and socio-economic issues.
GUIDELINES FOR THE REGULATORY FRAMEWORKS OF INTELLIGENT TRANSPORT SYSTEMS IN ASIA AND THE PACIFIC

CAR SHARING
4.1 Short- and long-term goals of ITS development in Asia and the Pacific

According to an ESCAP\textsuperscript{161} analysis, the Asia-Pacific region can benefit from ITS in four main areas – safety, mobility, congestion and environment. ITS can increase road safety, the seamlessness and convenience of transport, while reducing its environmental impact through enhanced efficiency of transport systems. The socio-economic objectives of transport systems including ITS are depicted in figure 4.1.

\textsuperscript{161} ESCAP, Policy Framework for the Use and Deployment of Intelligent Transport Systems in Asia and the Pacific (Bangkok, 2017).
As discussed in the previous chapters, countries in the Asia-Pacific region have great differences in the level of social and economic development. In particular, each country is facing different issues in the transport sector.

In this sense, it is desirable that each country develops ITS solutions to respond to their major issues; at the same time, improvement of relevant infrastructure and systems to support ITS roll-outs should be carried out. In the long-term perspective, the ultimate goal of adopting ITS in this region is to build a favourable environment, in which the users have streamlined ITS services across countries and borders, and solve transport issues, thereby attaining sustainable transport systems. The gap in ITS development among countries in the region needs to be reduced to attain such long-term objectives (figure 4.1).

It is obvious from chapters 2 and 3 that regulatory support is crucial to enhancing the development and operation of ITS. To achieve the short- and long-term goals of ITS, first and foremost ITS regulatory frameworks should be introduced at an appropriate time. In a practice, the regulatory framework should be prepared for ongoing or upcoming ITS services as a short-term goal, leading to the eventual extension to all ITS fields as a long-term goal.

These short- and long-term goals cover four main areas – safety, mobility, congestion and environment (figure 4.2).

- **Safety** – The highest priority in the short term is to reduce the number of crashes and other incidents using ITS technologies. As there are many countries in the Asia-Pacific region with high casualty rates, the enhancement in estimated GDP lost due to traffic crashes, according a report released by the World Health Organization in 2015, “Global status report on road safety 2015”. Available at https://www.who.int/violence_injury_prevention/road_safety_status/2015/en/.
Short- and long-term goals in four major areas

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<thead>
<tr>
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<th>Short-term objectives</th>
<th>Long-term objectives</th>
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<td>Safety</td>
<td>Low frequencies of crashes and incidents</td>
<td>Reduced potential causes for crashes and incidents</td>
</tr>
<tr>
<td>Mobility</td>
<td>Better accessibility and connectivity</td>
<td>Fully user-oriented seamless, convenient and comfortable mobility services</td>
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<tr>
<td>Congestion</td>
<td>Convenient public transport services/efficient transport management and operations</td>
<td>Zero-congested transport services and traffic operation</td>
</tr>
<tr>
<td>Environment</td>
<td>Improved emissions from the transport sector</td>
<td>Clean energy source for environmentally-friendly transport services</td>
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**ITS regulatory frameworks**
- Better integration for current and future ITS technologies
- More efficient and effective ITS development and operation

| Establishment of regulations related to ITS at the national level | Development of ITS regulatory frameworks at the Asia-Pacific level |

...of safety is urgently required. It is not only developing countries but also many developed countries that need to maintain a high level of traffic safety with low casualty rates. In this regard, reducing major causes of crashes and other incidents that undermine safety will be a long-term objective.

- **Mobility** – It is true that some areas in less developed as well as developing countries still lack of transport services, which leads to significantly low levels of accessibility to education and job opportunities. Even developed countries with ageing or decreasing populations may experience limited accessibility in some areas as a result of the termination of transport services with low profits. In this regard, providing better accessibility and improved connectivity by ITS to those areas is the mobility objective in the short-term. Under the premise of stable fundamental mobility, the long-term objective would be the establishment of fully user-oriented mobility services for seamless, convenient and comfortable transport by maximizing the concept of smart mobility.

- **Congestion** – From the short-term perspective, improving efficiency in transport management and operations, and the modal shift to public transport by ITS would be the practical solution to relieving traffic congestion. Traffic flow optimization by traffic management centres and the provision of real-time bus information or on-demand transport services in given areas would contribute to reducing traffic congestion in an effective way. In the long term, advanced ITS technologies, such as integrated traffic management systems for smart cities, C-ITS, CVs and AVs, would benefit users in terms of zero congestion of transport services and traffic operations.

- **Environment** – Reducing air pollutants including greenhouse gas (GHG) emissions by the transport sector would be the short-term objective. ITS technologies to help optimize traffic management and operations, reduce traffic congestion and increase the...
modal shift would contribute to attaining the short-term objective. Switching to environmentally-friendly vehicles, such as electric or hydrogen vehicles, would require some time and effort, thus making it the long-term objective. In the environmental scheme, the goal of ITS is highly relevant to those of mobility and congestion in the areas mentioned above; therefore, comprehensive consideration is required in long-term goal setting.

4.1.1 ITS regulatory frameworks

Given the fact that ITS regulatory frameworks can contribute to achieving two specific objectives – more efficient and effective ITS development and operation, and better integration with current and future ITS technologies (as covered in chapters 2 and 3) – ITS regulatory frameworks will also directly and indirectly contribute to achieving short- and long-term objectives in the four above-mentioned areas by providing specific ITS solutions. However, as the analysis in chapter 2 shows, not all Asia-Pacific region countries have regulations for ITS, and there are gaps in the development of such regulations. In this regard, establishing regulations related to ITS at the national level would be the short-term objective, while developing regulatory frameworks for ITS at the regional level would be the long-term objective.

4.2 Prioritization of ITS applications in Asia and the Pacific

Given the fact that regulations related to ITS should reflect the level of ITS services currently in use by countries in the Asia-Pacific region, prioritizing ITS applications would be beneficial in identifying feasible policy recommendations for ITS regulatory frameworks. Because of the different stages of ITS development and operation among countries in this region, it is difficult to prioritize ITS services by each country. Instead, three groups can be categorized according to the priority levels of attaining objectives at this moment in the four areas of safety, mobility, congestion and environment (figure 4.3).

- **Group A.** The countries in this group have already benefited from ITS in achieving the majority of short-term objectives and have been developing ITS technologies to attain the long-term objectives. Many investments in ITS have already been made in these countries based on national ITS plans or strategies. In addition, some efforts to establish regulations related to ITS or to amend existing regulations to support ITS development have already been observed in these countries. Given that traditional ITS technologies have already become mature in this group of countries and that they are now looking towards new advanced ITS

- **Group B.** The countries in this group are trying to catch up with the advancement of ITS and to increase investments in this area. Some short-term objectives have either been achieved to some degree or have started to be addressed. Because the countries in this group have implemented ITS projects in silos, only a few long-term objectives are under consideration. Weak ITS plans or strategies at the national level are to be found in this group, and regulations related to ITS may not exist or only be part of existing regulations. In comparison to Group A, the countries in this group may experience heavier traffic congestion, more serious safety issues, and higher growth rates of their populations and economies. At the same time, the level of ITS development with necessary policy support is not mature yet. As the number of personal vehicles and motorcycles per capita is increased in these countries, ITS applications with a focus on traffic management and operations should be pursued. Some examples of ITS applications are advanced traffic management centres (including advanced traffic management systems, advanced...
GOALS OF INTELLIGENT TRANSPORT SYSTEMS DEVELOPMENT AND PRIORITIZED SERVICES IN ASIA AND THE PACIFIC

Country group classification in terms of short- and long-term objectives

<table>
<thead>
<tr>
<th>Short-term objectives</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety</strong></td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Low frequencies of crashes and incidents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Better accessibility and connectivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Congestion</strong></td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Convenient public transport services and operations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Improved emissions from the transport sector</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Long-term objectives</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety</strong></td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Reduced potential causes for crashes and incidents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Fully user-oriented seamless, convenient and comfortable mobility services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Congestion</strong></td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Zero-congested transport services and traffic operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Improved emissions from the transport sector</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Group C.** The countries in this group are aware of the importance of ITS, but only a small amount of investment has been injected so far. The countries in this group should define the directions or strategies they require for achieving the short-term objective with the focus on the urgent issues currently faced. Due to the lack of proper transport services, social and economic growth in these countries may be delayed to some degree. In these countries efforts to set up or amend regulations for ITS have not been properly made. The countries in this group with low ITS development show high population growth rates and rising income levels. A rapid increase in the range of personal transport modes is also expected with high casualty rates caused by crashes.164 As social and economic growth may be hindered in those countries still suffering from the lack of basic transport services and the relevant fundamental infrastructure, the introduction of basic ITS applications and some emerging advanced ITS applications relevant to mobility services and safety needs to be pursued on a preferential basis. Some examples of such ITS applications are traffic management centres (including basic traffic control and monitoring systems, and basic public transport information systems), mobile-based ITS and smart mobility.

164 Approximately 316,000 road traffic deaths occur each year in the South-East Asia region, accounting for around 25 per cent of the world total each year, according to the World Health Organization report, Road safety in the South-East Asia Region 2015. Available at https://apps.who.int/iris/bitstream/handle/10665/249151/SEAR%20Regional%20Fact%20sheet%20on%20Road%20Safety%20FINAL.pdf?sequence=1&isAllowed=y.
GUIDELINES FOR THE REGULATORY FRAMEWORKS OF INTELLIGENT TRANSPORT SYSTEMS IN ASIA AND THE PACIFIC
Intelligent Transport Systems (ITS) aim to improve the safety, accessibility, connectivity and convenience of transport while reducing its adverse environmental impact. National priorities for ITS development and operation addressing the core areas of safety, mobility, congestion and environment range from reduced mishaps, improved connectivity, convenience and emission reductions, in countries that are in the early phases of ITS deployment, to long-term reduction of safety risks and promoting seamless, zero-congestion transport powered by clean energy, in countries with advanced ITS operations.
Given that (a) countries in the Asia-Pacific region have differing sustainable transport priorities and are at varying stages of ITS deployment, (b) regulatory frameworks play an important supportive role in efficient ITS development and operation, including integration of current and emerging technologies, and (c) the need for the region to aim for seamless ITS services across borders, this study proposes the following policy recommendations for developing ITS regulatory frameworks in Asia and the Pacific at national, subregional and regional levels:

1. Identify the current status of ITS development and operation at the national level;
2. Establish a comprehensive checklist of current national regulations relevant to ITS;
3. Identify short- and long-term national priorities of ITS development;
4. Promote cooperation and collaboration on ITS deployment at the subregional level;
5. Develop harmonized approaches to ITS development and operation across Asia and the Pacific.

### 5.1 Preparing national-level regulatory frameworks

**Identification of current status**
The academic and public sectors should lead the identification of a country’s level of ITS development and operation that should guide the formulation of the future directions and strategy for ITS development and operation, and the required regulatory frameworks at the national level. The regulatory frameworks will depend on the stage of ITS development and operation in the country; for example, this should include the outline of an ITS master plan in a country that is in the initiation stage of ITS development and operation.

**Establishment of a checklist**
An examination by the academic and public sectors of existing regulations related to transport, ICT, industry and internal administration should be the basis of amending and modifying these to regulate ITS development and operation. These can eventually be developed into comprehensive and inclusive ITS regulatory frameworks.

### Identification of national ITS priorities and applications

Consultation with the academic, public and private sectors in each country should lead to the identification of short- and long-term objectives of ITS development and specific applications in the four major areas of safety, mobility, congestion and environment as suggested in chapter 4. This should be the basis for the development of the national ITS regulatory framework.

### 5.2 Subregional cooperation and collaboration

Given that many ITS applications, including emerging technologies are in operation in the Asia-Pacific region, there is a need for greater cooperation and collaboration among neighbouring countries to bridge gaps in ITS development and operation within subregions. Such cooperation and collaboration should involve the academic, public and private sectors.

### 5.3 Regional strategies and policy plans

Given that ITS development and operation in Asia and the Pacific has been fragmented, mono-modal and geographically limited, with no overarching strategies and policy plans for developing region-wide and interconnected services, there is a need for a well-coordinated regional approach to ensure: (a) balanced ITS deployment consistent with economics of scale and levels of ITS development and operation (as identified in chapter 4); (b) the provision of effective guidance to the academic, private and public sectors for the future direction of ITS development and operation, and (c) effective preparation for the broader ITS technology, i.e., smart transport technology, options in the Asia-Pacific region.
GUIDELINES
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