ITS Technical Note
For Developing Countries

Technical Note 1
ITS for Developing Countries

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Introduction

The purpose of this ITS Technical Note is to introduce Intelligent Transport Systems (ITS) to decision makers and planners in developing countries. It also aims to increase their awareness of both the benefits of and prerequisites of ITS. The Note also discusses the ability of developing countries to move rapidly and economically from conventional methods of highway construction to the construction of intelligent road systems and public transport systems that combine physical infrastructure with information technology.

This Note is one of five ITS Technical Notes and serves as an introduction to the other Notes. The five ITS Technical Notes are intended to provide a high-level introduction to ITS.

Section 1 of this ITS Technical Note provides an introductory discussion of ITS and of the current status of ITS in various world regions.

Section 2 discusses the potential benefits of introducing ITS. It focuses on the long-term, society-wide benefits that ITS can provide and ways that ITS can provide more immediate benefits to individuals by helping to make surface transportation more affordable, more reliable, and more efficient.

Section 3 describes the key factors that allow developing countries to leapfrog directly to an ITS-enabled infrastructure in ways that may not be available to more developed countries. It also discusses the prerequisites for successful ITS deployment, including skills and knowledge requirements and related institutional and technological issues that must be addressed.

Section 4 provides a summary, conclusions, and recommendations.

1 Facts on ITS – ITS “Culture”

This section introduces the overall idea of ITS and describes how it has been adopted in various regions around the world. There are many different approaches to introducing and deploying ITS, including some differences between developed and developing countries.

1.1 ITS Definition

Like many other parts of business and government around the world, the construction and operation of transportation systems is being transformed by computers, sensors, and communications technology – collectively called information technology (IT). The application of IT to surface transportation is called “Intelligent Transport Systems” (ITS). ITS provides the ability to gather, organize, analyze, use, and share information about transportation systems. In the modern world, this ability is crucial to the effective and economical construction and operation of transportation systems and to their efficient use.

- IT can be very helpful in conceiving, planning, and building new parts of the transport system. This use of IT is not specifically ITS, but it is very helpful in laying the groundwork for introducing ITS

- ITS is being incorporated by manufacturers in “intelligent equipment” that can be installed as part of the transportation infrastructure to gather and disseminate traveler information, control traffic signals and variable message signs, electronically collect tolls, and help manage the system

- ITS provides vital support in operating transportation systems, including traffic management, pavement monitoring, oversight of system maintenance, and more effectively and reliably managing public transport

- ITS can store and evaluate archived data about the transportation system that is useful to planners who are evaluating transportation system improvements or to others evaluating safety aspects of the roadway

- ITS also provides a wide array of in-vehicle technology to improve the safety, productivity, and comfort of road travel. In addition, a new direction for ITS in developed countries is worth watching. This is a new focus on using wireless communications to help vehicles and the infrastructure cooperate with each other to enhance safety and the ability to manage the infrastructure well.

ITS can be divided into nine subject fields:

- Traveler Information: Services to support traveler decision-making before and during a trip: which travel mode to use, starting time, specific route, etc.,

- Traffic Management: Management of traffic flow on roads

- Demand Management: Services to reduce traffic demand
on roads and congestion in city centers by charging for road use and promoting use of other travel modes

- **Road Management**: Physical maintenance of roads and pavements, including repairs, snow clearance, etc.

- **Advanced Driving Assistance**: Automated systems to improve the performance of the vehicle and the driver to make driving safer

- **Electronic Financial Transactions**: Services to allow automatic electronic payment of tolls and fees, primarily on roads and bridges, but also to enter restricted city centers and sometimes to pay for parking charges, drive-through meals, etc.

- **Commercial Vehicle Management**: Services to support fleet and freight management, including fleet management and automatic safety and credential checking at borders

- **Public Transport Management**: Services to improve the convenience and performance of public transport, such as schedule management and common fare payment mechanisms

- **Incident and Hazard Response**: Services to respond to accidents and other emergencies such as dispatch of ambulances, fire trucks, etc.

It should be noted that as ITS evolves, some applications may not neatly fit into any of these categories and that, as such, it is important to be flexible. ITS is a series of approaches to meet the needs of the operators and end users of the transportation system – meeting these needs responsively is more important than adhering to strict categories.

There are some prerequisites to successful ITS introduction and deployment, including the existence of certain institutional and technological capabilities.

An important consideration is that these ITS capabilities do not all have to be adopted in a particular city or country, and selected capabilities do not all have to be implemented at once. The successful introduction and deployment of ITS can be done selectively, step by step, as resources permit. Section 3.3 of this ITS Technical Note and ITS Technical Note 5, provide guidance on what to do first and how to proceed in a variety of situations.

### 1.2 ITS Around the World – ITS Regional Culture

The basic reasons for introducing ITS are similar everywhere in the world. These include:

**Efficiency**
- Enhancing mobility for both people and freight
- Reducing traffic congestion
- Managing the transportation infrastructure more effectively and economically

**Safety**
- Reducing the number and severity of crashes, to lower the number of traffic-related deaths and injuries

**Environment**
- Reducing the environmental impact of cars, trucks, and buses, by reducing fuel consumption and emissions

The world regions which led the introduction of ITS – Europe, the U.S., and Japan – use approaches that have many features in common, including:

- An interest in pursuing advanced technology and applying it to social and economic problems
- A desire to expand the capabilities of the transportation system in a well-integrated manner
- A strong desire to expand existing markets and open new ones
- A belief that the best results are produced through the cooperative efforts of industry, government, and academia

However, each world region also has its own individual approach to introducing ITS -- its own “ITS Culture.”

**Europe**

Europe has a long tradition of applying technology, including computers and communications, to broad social issues including safety and mobility. As Europe continues to move toward a common continental economy, ITS is playing an important role in lowering barriers for the movement of people and freight throughout Europe. ITS is regarded both as a transportation tool and as part of Europe’s Information Society.

Europe has been able to introduce transport control technology to advance social goals. This includes using technology to limit the speed at which trucks can travel and “intelligent speed adaptation” which advises vehicles of safe speed limits and has the capability to limit driving speed. Europe is taking a very aggressive approach to traffic safety, with the objective to halve the number of traffic fatalities by 2010 and aim for “zero traffic fatalities” by 2020. This is part of a public-private sector initiative called “eSafety” that is being led by the EU’s Information Society Directorate. eSafety’s objective is to improve road safety by using Intelligent Vehicle Safety Systems, and it has established a timetable for the Europe-wide adoption of in-vehicle systems like antilock brakes, electronic stability control, automatic crash notification, etc.

Europe has been very successful in establishing partnerships to conduct tests and demonstrations among European national and city governments, vehicle manufacturers and suppliers, and universities. Europe has also succeeded in establishing a robust industry for ITS infrastructure systems and end-user products, with customers worldwide.

Europe is attempting to reform the way it charges for the...
use of the road infrastructure, although this process is still regarded as very controversial politically. An EC directive called Eurovignette prescribed moving toward a road-charging system, starting with heavy trucks, based on vehicle weight, distance traveled, and other criteria. This has been experimentally introduced in Germany and Switzerland, and there are plans to introduce it in the UK in 2006. Although huge interest has been expressed for these schemes, there are continuing arguments about their consistency and fairness.

Europe takes a very active and aggressive role in regional and international ITS standards activities to advance its ITS technology in the world market. The European Committee for Standardization (Comité Européen de Normalisation – CEN) has a technical committee (TC278 – Road Traffic and Transport Telematics) focused on ITS standards issues. TC278 works in close cooperation with the ITS Technical Committee (TC204) of ISO. Many ITS standards items are developed in parallel by ISO/TC204 and CEN/TC278.

Like other parts of the world, Europe has had little success in introducing telematics (wireless delivery of information and services to vehicles). Several attempts to develop telematics services by vehicle manufacturers and wireless carriers have been unsuccessful. General Motors’ OnStar service is attempting to enter the European market, but is far from being profitable. A few companies in the UK (Trafficmaster and ITIS) and France (MediaMobile) are delivering rudimentary real-time traffic information.

<USA>

The U.S. government recognizes ITS as an important, even crucial part of the future transportation infrastructure. Most U.S. government efforts in this field have aimed at introducing ITS to traffic managers and working toward interoperable traffic management and traveler information systems. ITS has been an important part of major highway transportation laws. These laws set government directions and provide funding for transportation programs. They include the Intermodal Surface Transportation Efficiency Act (ISTEA, 1991) and the Transportation Equity Act for the 21st Century (TEA-21, 1998). The latest version of this highway reauthorization legislation (tentatively called the Safe, Accountable, Flexible and Efficient Transportation Equity Act, or SAFE-TEA) is still being developed, but is expected to be adopted in the fall 2004.

Safety is also an important issue in the U.S., although it is pursued less aggressively than in Europe. The U.S. Dept. of Transportation sponsored an Intelligent Vehicle Initiative to test and demonstrate in-vehicle technology to enhance driving safety. This program has now concluded, but important portions are continuing, namely the development of intersection collision avoidance systems and integrated vehicle safety systems.

The deployment of safety products in the U.S. has been hindered by concerns about product liability lawsuits and, in general, the domestic ITS industry is less robust in the U.S. than in Europe or Japan, especially for ITS in-vehicle and consumer products.

The most important new program in the U.S. is called “Vehicle-Infrastructure Integration.” The objective of this program is to create an integrated, intercommunicating surface transportation system. The system will use wireless communications, primarily DSRC (Dedicated Short Range Communication) to link the infrastructure and its managers with vehicles and their drivers. It will gather and share information about the transportation system to help improve the performance of the infrastructure, vehicles, and drivers. This effort currently includes U.S. DOT, state transportation departments, and auto manufacturers.

Another program that is becoming wide-spread in the U.S. is called “511”. The digits 511 have been reserved as a nationwide telephone number for obtaining traveler information. Several states are already providing 511 services, consisting of current traffic information, weather and road conditions, and public transport information. U.S. DOT is encouraging and helping to fund the national 511 deployment. So far 43 of the 50 states plus the District of Columbia have collectively received over $4 million in 511 planning support.

Since the terrorist attacks of Sept. 11, 2001, transportation security has also been a major issue in the U.S., though most of this focus has centered on air travel. The Bureau of Customs and Border Protection of the new U.S. Dept. of Homeland Security uses ITS to monitor freight crossing into the U.S.

Electronic toll collection (ETC) is becoming widespread in the U.S. as a means to reduce delays at toll barriers and lower the cost of collecting tolls. There are, however, many incompatible ETC systems in the U.S., but there has been some success in making systems interoperable in certain regions (e.g., EZPass in the New York City metro area). One insight from this effort is that arranging compatible technology is not nearly as hard as making compatible organizational and administrative arrangements.

In the U.S., there is great political resistance to changing existing roads from “free” to toll, even though the U.S. is potentially approaching a crisis in funding road construction and maintenance. Funding now depends primarily on a fairly small gasoline tax (less than five cents per liter). The total amount collected is likely to decrease in the coming years as vehicles become more fuel-efficient and begin to use alternative fuels like ethanol and hydrogen. ITS offers the prospect of far more flexible ways of charging for infrastructure use (e.g., based on time of day, level of congestion, required level of service, demand, etc.), but this will require a shift in the thinking of how to fund the development and maintenance of transportation infrastructure.

<japan>

The promotion of ITS in Japan today is led by four Ministries and Agencies. The National position on ITS promotion was laid down in 1995 in the “Basic Guidelines on the Promotion
of an Advanced Information and Telecommunications Society." Japan recognizes ITS as an opportunity to advance its industrial and trade interests as well as a means to improve domestic transportation. Japan pursues international ITS standardization with a view to encouraging international competition and safeguarding Japan’s competitive position.

Japan has been very successful in translating its strengths in electronics technology into successful ITS. The most prominent ITS programs in Japan are the widespread adoption of car navigation systems and the nationwide deployment of the Vehicle Information and Communication System (VICS), which provides real-time traffic information to vehicles. Japan’s complex and congested road system has made these technologies particularly attractive to the driving public. In addition, Japanese consumers have traditionally been early adopters of new technology-based products and services.

Japan’s emphasis on ETC deployment has mainly been to reduce congestion at toll barriers, with less emphasis on improving the efficiency and reliability of collection. Deployment of ETC was relatively late in Japan due to its insistence on having a nationally interoperable system. However, this was undoubtedly a good long-term approach. Japan is encouraging the spread of ETC by discounting electronically collected tolls and by subsidizing the purchase of ETC transponders (making their cost less than US $50). Between May 2003 and May 2004, the number of ETC transponders in service in Japan tripled from 1 million to 3 million, and, as of May 2004, nearly 20% of tolls were being paid electronically.

Dedicated Short-Range Communications (DSRC), which is used for ETC, is also being deployed for use with VICS. The intention is to use this communications infrastructure as a basis for multiple other ITS applications.

**ITS Culture in Developing Countries**

Many developing countries are well on their way to having their own ITS cultures (see Appendix of ITS Technical Note 1). An examination of the three major developing regions (East Asia, Eastern Europe, and Latin America) reveals both common and individual characteristics.

All three regions have introduced basic systems to manage road traffic. These include traffic signal systems, traffic surveillance systems using CCTV, and traveler information systems based on variable message signs (VMS). As expected, systems that provide a high rate of return on investment have the greatest likelihood of being introduced. These include electronic toll collection and fare payment systems, commercial vehicle tracking systems, and bus management systems.

**Regional characteristics include:**

- In Eastern Europe: Road management systems have been introduced to identify road surface conditions, reflecting an emphasis on improving infrastructure maintenance. In addition, the trading of “empty cargo space” has become common, to improve the efficiency of freight logistics.
- In Latin America: Border-crossing systems have been introduced as a result of the regional emphasis on promoting cross-border trade to increase the economic strength of the region.

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1 ITS Technical Note

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2 Types of Benefits of ITS Deployment

This section explains the benefits of deploying ITS in both developed and developing countries.

2.1 Benefits of ITS

Through its use of information technology, ITS offers advantages that are not available in conventional transportation systems. Basically, ITS provides two kinds of benefits. One kind is the resolution of traffic problems, including traffic congestion, air pollution, and traffic accidents. The other kind is improved services for users and increased efficiency of the transportation system and its operators. The introduction of ITS can bring about the following benefits.

- Resolution of traffic problems

Mobility

For a strong and flexible economy, people need the ability to travel between their homes and their workplaces conveniently, reliably, and affordably. People also need to get to school, to shops, and to recreational facilities. Shifting demographics, urbanization, and changes in the patterns of where people live, work, shop, and relax make providing mobility more complex. Mobility is especially important for people with special needs, including the elderly, the poor, the disabled, and people who live in more remote areas. Better mobility improves their quality of life and their ability to contribute to the economy, rather than just to depend on it.

In the global economy, freight moves across oceans and through countries and across borders in trucks and on trains, often changing carriers en route to its final destination. It is important to move freight promptly and efficiently. It is also important to keep track of the location and content of containers and vehicles as they travel and to safeguard sensitive or hazardous cargo.

ITS includes many approaches to enhance the mobility of people and freight in all transportation modes. Traveler Information helps travelers avoid congestion and can help improve traffic conditions. Traffic Management, e.g. the more effective timing of traffic signals, can help increase traffic efficiency. Demand Management, e.g. road and access pricing can help relieve heavily congested urban areas. Commercial Vehicle Management helps to increase security and efficiency not only for carriers but also for related public agencies. There are many more examples as well.

Traffic Congestion

Traffic congestion is a serious problem in all parts of the world. The problem is growing fastest in developing countries where urbanization and the use of motorized vehicles is increasing most rapidly. Congestion causes delays and uncertainty, wastes fuel, results in greater air pollution, and produces a larger number of crashes.

ITS can help to mitigate congestion by helping people plan travel better, by suggesting alternate routes and travel times, by keeping travelers well informed, by leveling traffic loads on roadways, and by helping to respond to and clear incidents more rapidly.

Environmental Impact

Maintaining air quality was once viewed as a luxury of developed countries, which could more easily bear the cost of technology to keep emissions under control. However, the impact of poor air quality, especially on health and productivity, is now recognized as a large cost to all national economies, including developing and transitional economies.

ITS helps reduce the environmental impact of road travel by optimizing trips, reducing congestion and crashes, improving vehicle and driver performance, and helping to manage the transportation system well.

Reducing Fatalities and Crash Severity

Traffic accidents around the world continue to claim hundreds of thousands of lives each year and cause millions of injuries. The personal tragedy of each death is magnified by the economic and social costs of these losses. The World Health Organization estimates that nearly 1.2 million people worldwide died each year as a result of road traffic accidents. Low-income and middle-income countries have significantly higher traffic fatality rates than high-income countries. 90% of road accident deaths are in low-income and middle-income countries.

ITS is helping to shift the safety focus from minimizing the consequences of crashes (through the use of seat belts, head rests, impact absorbing front ends, etc.) to the use of technology to make crashes less severe and to prevent them altogether. The EU has set a goal of “zero traffic fatalities” by 2020 and ITS America has adopted a “Zero Vision” for future surface transportation: zero fatalities, zero delays.

Managing the Transportation Infrastructure

Modern transportation systems are more complex and their parts are more interdependent. The effective management of modern transportation systems requires better, faster, more comprehensive information about the current and future state of the system, and better management and control tools. One specific intent of ITS is to help provide information and tools of this kind. For example, sensors built into the infrastructure and sensors in automobiles can help continuously monitor pavement conditions. By doing so, developing pavement problems can be diagnosed and repaired early before they become worse, cause problems, and require more expensive repairs. Better infrastructure management systems can also help contain costs by more effectively allocating and scheduling maintenance resources. These systems can also provide a more accurate and comprehensive picture of the financial aspects of road asset management.
Improving services for users and increase efficiency of the transportation system and its operators

Reducing Travel Uncertainty

One of the interesting insights realized by transportation planners in recent years is that a major benefit of their programs has been to provide greater reliability and predictability in transport, and not just to get more people to their destinations faster. An unfortunate aspect of most current transportation systems is that travel times, both for people and for freight, can vary widely from day to day. This can be due to weather, demand, traffic incidents, or a large number of other external factors. This uncertainty means that travelers and shippers must allow extra time for worst case possibilities or risk being late at some time. This is disagreeable and expensive. ITS can help reduce travel uncertainty by smoothing traffic (and therefore reducing travel time variance). ITS can also provide improved real-time and predictive information that allows travelers to plan trips better and allows shippers and carriers to plan shipments better. Public transport agencies can stay on schedule better and provide their riders with current and advance information about travel times and connections. In-vehicle navigation systems can incorporate real-time traffic information to dynamically adjust driving routes to optimize trips based on current information.

Increasing Security

A particular transportation-related concern has grown significantly in the last few years. This concern surrounds the security of the transportation system (vehicles and infrastructure) and the security of cargo and people in transit. Containerized freight has been recognized as a particular concern, since containers may be loaded and sealed in far-off locations. Improperly managed containers could contain dangerous materials (explosives, biohazards) intended to cause terrorist destruction in another country. Even legitimate hazardous materials could be hijacked or otherwise misused. Similarly, travelers are potentially at risk, particularly at travel terminals (bus and train stations) and on high-occupancy vehicles (buses and trains).

ITS provides technology to address these concerns through the use of GPS (or other positioning technology), wired and wireless communications, and improved sensors and information systems. ITS can monitor the contents and locations of containers, monitor the cargo and routes taken by trucks, track the location and status of public transport vehicles, and generally support, simplify, and increase the visibility of transport logistics. This is an area in which increased security can facilitate increased efficiency and productivity by standardizing and integrating the processes for managing the transportation of people and cargo.

Increasing Efficiency for Operators

There are many other ways in which ITS can improve the operational efficiency of the transportation system.

One of the most successful and widespread applications of ITS has been ETC. With ETC, drivers establish an account with a toll agency and receive an electronic transponder that identifies their vehicle and their account. When the transponder-equipped vehicle passes a toll collection point, the toll is automatically deducted from the driver’s account. The advantage to the toll agency is lower labor costs, more reliable collections, a more efficient toll operation that will attract more users, and the financial benefit of float (i.e., earnings from toll fees collected in advance, when drivers establish or replenish their accounts). In the long term, ETC opens the possibility of more flexible tolls that can be varied based on time of day, level of congestion or demand, and many other factors.

More generally, ITS provides transportation system operators with better and more current information about the status of the transportation system and better tools to plan, operate, and maintain the system.

Increasing efficiency for users

ITS also helps travelers to be more efficient. For example, the ETC systems mentioned above have advantages for drivers as well as system operators. The immediate advantage to the driver is that there is no need to stop at a toll barrier – the toll can be paid while the car keeps moving. The indirect advantage is an overall decrease in delays at toll barriers for all vehicles, even those that are not using ETC. Similar mechanisms can help other travelers. For example, there is a growing use of smart cards to pay a variety of fees. In many parts of the world, the same smart card can be used as a public transport fare card, for parking, and for other purposes. The smart card is a convenient way for governments to provide travel subsidies to poor or elderly citizens. This can be done by electronically storing money on the smart card or by having the fare collection system adjust the amount collected depending on whose smart card is paying the fare.

A very popular ITS application in developed countries is in-vehicle navigation. An in-vehicle navigation system calculates and delivers driving directions to a destination stated by the driver. In-vehicle navigation systems include a map database, location sensors, a computer, and a user interface (e.g., a touch screen). The user interface lets the driver specify a destination and lets the system deliver directions. Navigation systems can generate efficient routes and help drivers keep from getting lost. In the future, navigation systems will receive real-time traffic information and adapt routes dynamically based on current conditions. As the cost of navigation systems continues to come down, it is expected that these systems will start to appear in developing countries as well.

In general, ITS can provide travelers with better and more current information about the state of the transportation system, both for drivers and for users of public transport. This information will help travelers plan their trips better, make better connections, and, as observed above, reduce the uncertainty of travel.
2.2 Two Kinds of ITS, Based on Two Kinds of Benefits

ITS which provides society-wide benefits – Why governments deploy ITS.

This is ITS which mainly provides society-wide benefits directly by resolving conventional transport issues. These include reducing traffic deaths and injuries, reducing overall levels of congestion, and reducing emissions as follows:

- Improved mobility for people and freight
- Less traffic congestion
- A better managed transportation infrastructure
- Reduced environmental impact of surface transportation
- Reduced fatalities and crash severity

These benefits are potentially very large, and they are properly among the important reasons why governments adopt and promote ITS. For example, systems for traffic management, and demand management could be classified as ITS providing society-wide benefits. This type of ITS involves not only users but also a society. Hence, these adoption is only possible as a result of a political consensus at the social level.

This type of ITS helps to promote the systematic and methodical introduction of ITS, including the adoption of relevant ITS standards. It provides broad-based social and political benefits, justifying the expenditure of public funds. On the other hand, this type of ITS has less immediate appeal to consumers and in the marketplace, because its benefits are long-term, gradual, and less immediately obvious to users, vehicle operators, and the private sector.

ITS which enhances reliability and business efficiency – Why users accept ITS

The second important reason for adopting and using ITS relates to benefits that may not provide significant effects to solve conventional traffic issues but helps to increase quality of services which individual travelers or individual transportation operators can see, understand, and appreciate as follows:

- Reducing travel uncertainty
- Increasing security for freight movement and personal travel
- Increasing efficiency for operators
- Increasing efficiency for users

These benefits include greater reliability and less uncertainty in travel, which makes travel more comfortable and more productive, greater efficiency in operating and using the transportation system, and more secure.

For example, systems for road management, commercial vehicle operation, and public transport management could be classified as ITS enhancing reliability and business efficiency.

The above benefits may be more modest in terms of overall national impact. However, this type of ITS is attractive because individuals receive these benefits more directly and more immediately. In addition, it is often possible to have such ITS available more rapidly and at lower cost than the larger scale efforts represented by ITS providing society-wide benefits. In some cases, this type of ITS has commercial appeal and can be introduced by private sector organizations without the need to spend public funds. Even though ITS applications like electronic toll collection are often operated by public agencies, the fact that they produce revenues (as well as user benefits) makes their introduction much more attractive.

The other reason that this type of ITS is important is that it helps to provide the political and social foundation for ITS providing society-wide benefits. For example, if individual travelers are attracted to wireless entertainment and information products, their purchases can help fund a communications infrastructure that also supports safety and traffic management applications.

This type of ITS can directory benefit individuals or commercial entities/firms. Adopting these fields depends on a sufficient number of individual or commercial entities/firms finding it beneficial to procure the applications.
3 Key Factors for Leapfrogging to the New Infrastructure

Developing countries are often at a disadvantage, relative to developed countries, in constructing the basic infrastructure that provides the foundation for building their economies and societies. This is largely due to the limited financial, technical, and engineering resources that developing countries have available. However, developing countries also have some advantages relative to developed countries, particularly when the infrastructure to be constructed has high IT content.

Developing countries, more often than developed countries, are able to install electronic infrastructure at the same time that physical infrastructure is being constructed. This is far less expensive than retrofitting existing physical infrastructure. Developing countries are also not generally burdened with an outdated in-place IT infrastructure that has to be updated. Developing countries benefit from the continuing rapid decrease in the cost of IT. Building a new IT infrastructure from scratch is often less expensive than updating an existing system. Developing countries can make immediate use of other systems like cellular telephones and the Internet that are spreading rapidly in parallel. Finally, developing countries can take advantage of IT and ITS products and applications which have already been tested and deployed in developed countries and which are now mature, stable, well understood, and starting to become less expensive to acquire and operate.

As a result, developing countries can frequently leapfrog directly to an ITS-enabled transportation infrastructure far more rapidly and far less expensively than developed countries (Figure 1). There are many good reasons for moving aggressively toward this “smart” infrastructure (discussed in Section 3.1), but also many prerequisites that must be met to make this successful (discussed in Section 3.2). This section also discusses Innovative Approaches that developing countries can use to pursue ITS deployment (see Section 3.3 and also ITS Technical Note 3).

3.1 Additional Incentives

Section 2 discussed the wide range of transportation-related benefits that ITS can provide, including broad social and economic benefits (ITS providing society-wide benefits) and immediate benefits to the operators and users of the transportation system (ITS enhancing reliability and business efficiency). In addition, there are social and economic benefits that result from the introduction of ITS that are not specifically transportation related. These are the benefits that come from any general improvement in the technological and economic base of a country. They include:

- Moving toward a Knowledge Economy
- Fostering the IT industry
- Assisting regional integration
- Greater dissemination of IT

Knowledge Economy

A knowledge economy is an economy that places importance on the role of knowledge as an important production factor along with labor and capital. Technical innovation and economic development have traditionally placed primary emphasis on the role of capital. In recent years, however, economic development and smooth market operations have...
often depended more on the ability to gather, organize, and share information than on capital alone. The rapid development of information technology, including ITS, is helping to respond to this need. There is also a strong need for research & development, education, information exchange, and technology transfer. The World Bank is a strong supporter of moving toward this kind of knowledge economy.

**IT Industry**

In many cases, it is more economical for developing countries to import technology from developed countries than to develop the technology domestically. However, there are some cases in which the demand for IT-related equipment, including ITS equipment, can help to foster new domestic industries for manufacturing this equipment. This works best in developing countries which already have at least some base IT industry in place. In addition, ITS equipment and systems require maintenance and renovation throughout their lives, some of which can often be provided by domestic resources. This can also help to build the IT base in developing countries. Plans for developing these industries can be made during the introduction of ITS.

**Regional Integration**

In many developing countries as well as in large developed countries (like the U.S. and Australia), the transportation systems in various parts of the country often developed separately. As a result, the tools used to manage these transportation systems are often incompatible. This makes it harder and more expensive for regions to cooperate effectively with one another (e.g., in time of national emergency). Even within a region, it is often hard for different public agencies to cooperate and coordinate with each other due to differences in procedures and equipment (e.g., radios on different frequencies or using different protocols). The deployment of ITS, especially on a national scale, offers opportunities for the systems and agencies to become better integrated, promoting economies of scale and a greater ability to cooperate and exchange information. This can be seen in Central and Eastern Europe countries, where various ITS applications are used to ensure the compliance to various conditions set for EU accession.

**Dissemination of IT**

When useful technology can be deployed more widely and economically, the entire country benefits. Some technologies, like the internet and cellular phones, are more than just useful—they are important economic enablers. They have brought information and communications services to many people who were formerly excluded. This is particularly important in developing countries where it is more difficult to build more traditional information and communications infrastructure.

One benefit of ITS is that it promotes the wider deployment of IT. At the same time, the spread of IT makes the deployment of ITS easier and more economic. Many ITS services are using cellular telephony for their basic communications medium. This encourages the spread of cellular and helps to keep its costs down. In addition, an increasing number of ITS services, including traveler information, weather reports, and emergency service information can be delivered directly to cellular phones and wireless PDAs, increasing the value of owning one of these devices.

ITS also delivers much of its information to travelers and transportation system operators via the Internet. This includes text, graphics, and images, which provides another good reason for wide internet deployment and helps to spread the cost over more applications. The worldwide availability and low cost of GPS also helps the deployment of ITS since many ITS applications are location dependent. GPS provides location information without any charge, which is particularly helpful in developing countries. In addition, the cost of devices to receive and interpret GPS signals has also gotten very low.

**3.2 Prerequisites**

Deploying ITS in developing countries has many direct and indirect benefits for travelers, shippers, transportation system operators, and the country as a whole. However, introducing ITS is a complex undertaking, and decision makers have to understand the prerequisites for deploying ITS before their decisions are made. These prerequisites are both institutional and technological. Planners and developers in developing countries must have both the traditional and the expanded skills and knowledge for the country to succeed in leapfrogging to an ITS-enabled transportation infrastructure. Having both sets of skills and knowledge makes it possible for planners and developers to understand the interaction between traditional and ITS-enabled transportation and to develop them in parallel, methodically and systematically.

**ITS Requires Additional Knowledge**

As shown in the figure 2, ITS adds further dimensions to all aspects of transportation system construction and deployment. Traditional civil engineering skills are still vital, but they must be complemented by electronics, communications, and software engineering. Traditional road system planning activities must be broadened to accommodate a system architecture that encompasses the electronic infrastructure as well as the physical infrastructure. Traditional standards for road design and traffic signal configuration must be expanded to include standards and protocols for the IT devices and communication systems that go with ITS. Traditional public-sector-driven project management could evolve to include public-private partnerships and private sector deployment as well. A whole new range of institutional issues needs to be considered (see discussion below). Finally, with ITS, operations and maintenance must be performed on electronic devices, software, and databases that ITS incorporates as well as on actual physical infrastructure. Maintenance activities for ITS require somewhat different budgeting and performance skills.
Institutional Prerequisites

For ITS to be successfully introduced in a developing country, a number of institutional prerequisites must be met. Some of these are common to any large public project. Some are specific to ITS.

• An ITS promotion organization is extremely helpful, like ITS America, ITS Japan, and ERTICO/ITS Europe. Many developing countries in Europe, Asia, and Latin America have ITS promotion organizations. These organizations can help form public-private partnerships and introduce and promote the concept of ITS to the public.

• Capital for investment must be secured.

• ITS needs to be coordinated with existing laws and regulations; and, in some cases, new laws, regulations, and institutions may need to be created.

• New procurement rules are required to purchase software and electronic devices which are different from the rules for procuring infrastructure development.

• Provision must be made for training human resources to develop and administer ITS.

• The viewpoints of consumers and other users need to be understood and incorporated into ITS deployment.

Technological Prerequisites

Before embarking on the large-scale deployment of ITS, it is very helpful to have a base level of technology in place. This includes agreements among affected organizations on a number of technology issues:

• Because ITS applications are often information systems that gather data from many sources and distribute results to many users, a common data model is very helpful to avoid confusion and simplify information coordination and exchange.

• Communications standards for data exchange are needed, including data dictionaries, message sets, and protocols. These need to be firm enough to promote interoperability and flexible enough to accommodate rapid technological change.

• ITS applications that need wired or wireless communications may use existing communications infrastructure to reduce the time and cost to introduce ITS. Planners need to make sure that adequate bandwidth and coverage is available for ITS. ITS may require the installation of additional capacity.

• Standards are also being developed for many other aspects of ITS to help provide consistency, enlarge markets, promote competition, and enhance interoperability. Developing countries should look primarily to international standards programs as sources of ITS standards to adopt. Many
developing countries are active participants in ISO/TC204, where most international ITS standards are developed. Some countries can send experts to participate in the drafting of standards documents. Other countries participate by reviewing and voting on draft standards. Some countries act simply as observers. A domestic standards oversight group to coordinate standards participation and adoption is very helpful.

3.3 Innovative Approaches for Developing Countries

There are numbers of innovative approaches to the planning and development of ITS in developing countries. These include the concept of “Affordable ITS”, “ITS enhancing reliability and business efficiency”, the development of a “Step-by-Step Architecture”, and Public Private Partnership. ITS Technical Note 3 provides a thorough introduction to these innovative approaches. The use of these innovative approaches makes it easier to meet the necessary prerequisites and to succeed in “leapfrogging” to an ITS-enabled transportation infrastructure. These approaches are briefly summarized below.

Affordable ITS

The concept of affordable ITS means encouraging decision makers in developing countries to focus first on the ITS applications that (1) can be deployed immediately or in the near future and that (2) can provide the greatest return on investment, in terms of lives and money saved and improved services. Affordable ITS applications will generally have the following characteristics:

• Deployment of an application can proceed in parallel and in cooperation with the development of other road infrastructure and public transportation systems.
• Deployment can make good use of the spread of the Internet and cellular phones.
• Applications are flexible enough to cope with rapid urban development and growth.
• The cost of deployment is moderate, functions are basic and simple, and maintenance is easy.
• Systems can incorporate human work where appropriate.
• Developers can make use of the ITS experiences, architectures, and applications of industrialized countries.

ITS enhancing reliability and business efficiency

The concept of ITS enhancing reliability and business efficiency was introduced in Section 2.2. This type of ITS may not have the large-scale social impact of ITS providing society-wide benefits, but they benefit large numbers of people in many everyday ways and help to ease the introduction of larger and more complicated ITS applications. As a result, this type of ITS can be viewed as a half-way mark toward the introduction of the other type of ITS. It is also typically easier and less expensive to deploy, and they produce benefits rapidly. They help provide the political and social base for the introduction of the other type of ITS.

Step-by-step approach

It is strongly recommended that all countries have an ITS system architecture to serve as a framework for ITS deployment. An ITS system architecture identifies the user services that ITS will provide in a country, the main entities that will provide or receive these services, and the data flows that move information among the ITS components. However, a comprehensive ITS system architecture may be larger and more expensive than a developing country needs. Therefore, a step-by-step architecture approach is recommendable for developing countries.

This step-by-step approach can take either of two directions. The first is to adapt the architecture of another region rather than creating an original architecture from scratch. An architecture that suits a region or country can be created by picking the necessary services and modules from an existing comprehensive architecture. Alternatively, a region or country can start by developing a simple architecture, reviewing it from time to time, and allowing it to develop step by step. The base architecture should be chosen with the aim of future interoperability with surrounding regions/countries.

Public-private partnerships

Many ITS projects are being carried out by public-private partnerships in developed countries. There are many good reasons for forming such partnerships:

• Each sector does the part of the work it is best at
  One example is cooperative vehicle-infrastructure systems, which are being explored in several developed countries. The public sector focuses on the infrastructure part of the work, and the private sector focuses on the vehicle part.

• Risk sharing
  Some of the risks involved in developing new systems can easily be taken by the private sector (e.g., market risks), and some of the risks can more easily be handled by the public sector. By combining public-private schemes effectively, both the public and private sectors can generate benefits specific to their own strengths.

• Collaborative approach
  ITS is a field that requires continuous development of technologies, now as well as in the future. The public, private, and academic sectors each have their own strengths in doing research, which can be mutually reinforced through cooperation.

Done properly, public-private partnerships bring the strengths of each sector together for the benefit of both. The private sector, for example, is generally better at introducing technological innovation and reacting swiftly to rapidly changing technology environments. The private sector is also often more effective in analyzing and marketing data which originates from the data collection activities of the public sector. This is particularly appropriate for traffic and traveler information. The public sector can help reduce the risk of leading edge deployment and encourage more rapid
introduction of technologies like ITS.

In both developed and developing countries, innovative strategies for the deployment of transportation infrastructure have often taken the form of public-private partnerships. One common model for public-private cooperation in infrastructure development and operation is called BOT (for Build, Operate, Transfer). In this model, private companies invest in the construction of infrastructure and, with public sector support, own and operate the infrastructure and collect tolls or usage fees. Once the investment has been recouped, the facility is transferred to the public sector for continuing operation.

Other potential areas for public-private partnerships include:

- Road asset management and maintenance through public sector concessions to private companies
- Cooperative efforts to gather, assemble, and distribute traveler information
- Private sector participation in the administration and execution of wide-area road pricing
- Public encouragement of the freight hauling industry in countries where this industry is not well developed

In most cases, it is not only the transportation system which benefits from this cooperation. Public-private partnerships in surface transportation can also have a beneficial effect on the entire economy both through the improvement of transportation resources and their management and by stimulating industry and commerce. ITS also helps these cooperative activities to function better by improving information flow and by providing better management tools. ITS helps facilitate the administration of cooperative public-private activities and helps the parties communicate better and more effectively with each other and with the public.

For public-private partnerships to be successful, both sides must contribute to the partnership and both sides must benefit from its activities. Some important issues are:

- Responsibilities of each partner must be clearly stated and agreed on
- Respective contributions of money, materials, and effort must be clearly defined
- Contributions, use, and final ownership of intellectual property must be agreed on
- A joint decision-making process and a joint progress review and acceptance process must be in place
- As with any major undertaking, deliverables and schedules must be clearly defined

Each partner may have to make some adjustments in the way it does business. Public sector partners need to seek ways to reduce administrative and bureaucratic overhead and streamline their decision making and procurement process. Private sector partners may need to introduce additional measures to assure accountability and process visibility where the use of public funds is concerned.

By addressing these issues and finding ways to work cooperatively together, the participants in a public-private partnership can all benefit from the resulting synergies.

4 Summary

This introductory ITS Technical Note 1 has tried to demonstrate that Intelligent Transport Systems (ITS) are an important component in the development of future transportation systems in developing countries.

ITS offers the potential for significant society-wide benefits. The benefits of ITS providing society-wide benefits include:

- Improved mobility for people and freight, including greater access to transportation for the elderly, the disabled, and people living in remote locations
- Less traffic congestion
- Greater compatibility of surface transportation with the environment
- Fewer traffic-related deaths and injuries
- A better-managed transportation system

ITS also offers a wide range of immediate and tangible benefits to the people who operate and use the transportation system by adding stability, visibility, information, and control. The benefits of ITS enhancing reliability and business efficiency include:

- Less travel uncertainty, allowing for better planned, quicker, and less expensive travel
- Better security for freight movement and travelers
- Increased efficiency for transportation system operators
- Increased efficiency for users of the transportation system, including travelers, shippers, and freight carriers

By helping to deploy technology in the marketplace, ITS also provides a variety of general benefits that are related to improvements in the information infrastructure and may not be specifically related to transportation:

- Encouraging movement toward a “Knowledge Economy”
- Helping to fostering the IT industry
- Assisting integration of public agencies and regions
- Promoting greater general dissemination of IT

Introducing ITS in developing countries has special challenges and constraints, but also special opportunities. These special opportunities allow developing countries to leapfrog to an ITS-enabled transportation system more rapidly than developed countries and at lower cost. These include the opportunity to deploy ITS in the infrastructure at the same time that the physical infrastructure is being built, the opportunity to make use of mature ITS applications developed and tested in developed countries, and the opportunity to leverage the simultaneous spread of other technology networks like cellular and the Internet.

Successful leapfrogging to an ITS-enabled transportation system depends on a number of ITS principles. ITS should be:

- Demand-driven, so that ITS introduction meet real user needs.
- Affordable, using the appropriate level of technology, focusing on projects with the greatest return on investment, and making good use, wherever possible, of the experience of other countries.
• Staged and flexible, allowing for growth as demand increases and resources permit, and not overbuilding in early stages.
• Public Private Partnership

Nonetheless, introducing ITS can be challenging. Decision makers and planners in developing countries need to understand that deploying ITS requires a variety of additional knowledge and skills beyond those used in traditional construction of road and public transport infrastructure. In addition, there are a variety of institutional and technology prerequisites that need to be put in place for the successful introduction of ITS. Public-private partnerships are often a productive way to approach the introduction of ITS, drawing on the strengths of each sector for the benefit of all.

These ITS Technical Notes provide guidance on the nature of these challenges and how they can be met in developing countries.

**ITS Technical Note 2** provides a decision making model for selecting ITS applications that are appropriate to a particular country or region’s situation.

**ITS Technical Note 3** provide a series of innovative approaches to help a country develop its plan for ITS and conduct the deployment, operation, and maintenance of ITS applications.

**ITS Technical Note 4** introduces ITS standards, including how they help to enable successful ITS deployment, the different types of ITS standards and how they are developed and used around the world, and the approaches to ITS standards that are appropriate for developing countries.

**ITS Technical Note 5** provides an introduction to ITS System Architectures, including an overview of existing system architectures around the world and some approaches for developing countries to create their own ITS system architecture.

The potential benefits of ITS, both at the societal and individual levels, are great enough to warrant careful but energetic consideration by decision makers and planners in developing countries. With thoughtful planning, and with the guidance of these ITS Technical Notes, developing countries can minimize the risks and accelerate the benefits of using ITS to create a better, more responsive, safer, and more serviceable transportation system.