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ROAD NETWORK OPERATIONS & INTELLIGENT TRANSPORT SYSTEMS

LAUNCHING ITS

ITS DEPLOYMENT STRATEGIES

Developing an ITS Strategy
Financing and Procurement
Planning an ITS Programme
Architecture and Standards
Data Needs
Communications
Project Planning
Priority Projects

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ITS DEPLOYMENT STRATEGIES

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There is no single definition of what constitutes a developing economy. The World Bank refers to geographical regions – and classifies countries according to gross national income:

- low-income
- lower-middle income
- upper-middle income
- high income

These terms do not imply that the economies in each group are at similar levels of development or that they face the same challenges to make best use of their road transport networks. (**See** Common Challenges)

WORLD BANK COUNTRY INCOME DATA

The World Bank's Development Indicators database provides a wealth of information on all 188 World Bank member countries – and another 26 economies with populations of over 30,000. The assignment of countries to the four income groupings – from low to high – is made on 1st July each year.

The potential for improvements in transport infrastructure and road network operations – and the role of ITS – will vary from country to country, depending on geographical and climatic conditions, social and cultural factors, level of development of the road network and the extent of planned investment, and the mix of vehicle types competing for road space. It will also be determined by differences in the economic policies, income per head of population, and available human resources (technical, operational and management skills).

From an economic perspective the value of the transport network (and the need for further investment) can be judged by how well it connects and serves:

- urban and rural centres of population
- industrial and commercial locations
- sites for mining, mineral extraction, oil fields,
- areas of natural resources – such as agriculture, forestry and fisheries

- transport nodes such as ports, airports, road and rail freight terminals
- recreation, tourist venues and sport complexes

There is no single, common ITS deployment strategy appropriate to address the different needs of countries across the world – with economies in varying stages of development. Local, national and regional factors will determine whether ITS is an appropriate investment – as well as how it should be designed and deployed. For instance – even within a single country:

- regional differences can be very large — for example, the State of São Paulo has a much higher income and vehicle ownership than the Brazilian national average
- the rate of change in economic and transport development can vary considerably — for example, over the past 25 years, in the Czech Republic incomes have increased and there have been major improvements to the road network

Often in developing economies, development of infrastructure is a higher priority than traffic management to promote economic development and the movement of people and goods. Road network operations become essential when traffic levels increase to the point where they have negative impacts – such as congestion, accidents and vehicle overloading. The focus shifts towards making best use of available road capacity in all conditions, at all times. (**See** What is Road Network Operations)

Before embarking on ITS, countries need to have in place some basic traffic management measures – such as lane markings and designed junction layouts. It will help to learn from neighbouring countries' experience of ITS to identify proven solutions.

Several common trends affect transport in developing economies which will have an impact on the scale of RNO activities and the scope for ITS deployment:

HIGH LEVEL OF ROAD ACCIDENTS

In many developing economies, road accidents are significantly higher in relation to traffic volumes, compared to high-income countries. For example, in 2002, the World Health Organisation (WHO) reported that 90% of all road traffic deaths occurred in low and middle-income countries – despite their share of world vehicle ownership being less than 50%. There are various contributory factors, including:

- high numbers of vulnerable road users – such as pedestrians, cyclists, scooters and animal transport – sharing road space with motor vehicles
- low level of traffic enforcement
- the large proportion of heavy vehicles on the road network

IMBALANCED TRANSPORT MODE UTILISATION

In many developing economies, passenger transport is provided as much by mini buses, taxis and auto-rickshaws – as it is by more conventional public transport modes, such as buses and rail. For example, in Egypt:

- more than 55% of public transport trips in Cairo are carried by shared taxis and minibuses compared with the underground metro and public buses (40%)
- trucks transport most freight flows – with little carried by rail, water or air

INSTITUTIONAL WEAKNESS AND FRAGMENTATION

Many developing economies are characterised by weak and fragmented institutions for tackling urban and national transport problems. Development of ITS will be difficult without putting in place strong institutional coordination mechanisms to:

- establish transport policies
- resolve organisational issues
- set investment priorities
- identify funding resources for major transportation investments including ITS measures

INADEQUATE FINANCIAL ARRANGEMENTS

Many developing countries have insufficient funds and are unable to access satisfactory financing arrangements resulting in lack of investment in transport facilities, poor cost recovery, and low levels of private sector investment in transport infrastructure and services. Governments in some countries also highly subsidise gasoline and diesel fuels which tends to encourage growth in car ownerships and personal transport at the expense of higher capacity collective transport – such as buses.

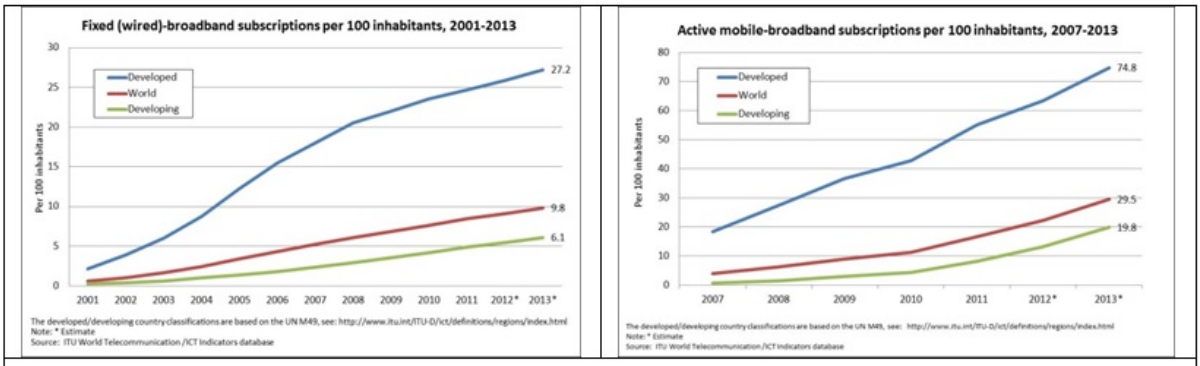
In any budgetary processes the value and urgency of ITS deployments have to be assessed alongside more conventional transport infrastructure projects. Decision-makers in many countries favour traditional transport infrastructure projects using public funds. They will often little experience or understanding of the potential role of ITS deployments – and the possibility of mobilising private financing.

Countries experiencing major changes impacting on the transport sector may be open to new concepts such as ITS in response to new challenges. For example, increased deployments of ITS on roads is often associated with road tolls and electronic payment. The World Bank reports that in many developing economies, electronic tolling systems have been implemented as a means of financing traditional transport infrastructure investments and ITS deployments – such as traffic management and traffic information. (**See** Financing and Procurement)

AVAILABILITY OF ICT RESOURCES

Countries differ in their level of uptake of Information and Communication Technology (ICT) resources which impacts directly on deployment of ITS. Low cost telecommunications with wide geographical coverage for fast and reliable data transmission is a pre-requisite for ITS –forming part of its basic info-structure. (**See** Telecommunications and ITS Technologies) In some countries, such as Egypt, the ICT infrastructure needs to be significantly improved and expanded to accommodate large-scale ITS deployments. In contrast, in a high-growth, high-investment country, such as China, the level of ITS deployment is enabled by large investments in transport and ICT resources.

The International Telecommunication Union (ITU) – the United Nations agency for information and communication technologies – maintains an ICT statistics website which compares ICT trends and deployments in various countries. The figure below provides an overview of ICT trends in terms of fixed (wired) and mobile broadband subscriptions and makes comparisons between China, Egypt, Germany and the USA.



	Fixed (wired)-broadband subscriptions per 100 inhabitants	Mobile-cellular subscriptions per 100 inhabitants	Mobile-broadband subscriptions per 100 inhabitants	Individuals using the Internet (%)
China	13	81.3	17.2	42.3
Egypt	2.7	115.3	26.9	44.1
Germany	34	131.3	41	84
USA	28	98.2	74.7	81

Global Trends in penetration of Information and Communications Technologies (Source: International Telecommunications Union's ICT-Eye Website)

The graphs show that developing and emerging economies have much high growth rates in ICT than high-income countries – in particular for mobile cellular and mobile broadband use.

ADVICE TO PRACTITIONERS

The World Bank has produced a series of Technical Notes providing advice on ITS deployments for developing economies (**See** Worldbank ITS Technical Notes). They cover:

- an introduction to ITS and guidance on its applications
- a two stage selection model for ITS applications
- innovative approaches to the application of ITS
- ITS Standards
- system architecture
- ITS applications around the world

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DEVELOPING AN ITS STRATEGY

ITS investments almost always involve a wide range of stakeholders and interest groups from the public, private, and non-profit sectors. In some countries, the research, academic and non-profit institutions also play a key role because of the involvement of advanced information and system technologies, and the level of coordination that this requires.

Getting the ITS deployment strategy is essential for the effective and timely deployment of ITS measures – and to avoid wasted time and resources. This requires an understanding of the purpose and objectives of road network operations. (See Purpose and Objectives) Particular issues that need to be addressed include:

- strategic planning (**See** Strategic Planning)
- project appraisal (**See** Project Appraisal)
- organisational roles and responsibilities (**See** Stakeholders)
- consideration of financial and contractual issues (**See** Finance and Contracts)
- monitoring and evaluation of projects and programmes (**See** Evaluation)
- consideration of legal and regulatory issues (**See** Legal and Regulatory Issues)

Investment in ITS is not an end in itself. The use of ITS must be cost-effective and compatible with the policy aims and objectives of the overall national transport strategy. In many countries, transport master plans make no reference to ITS applications and services. Proposals for ITS-based services that serve travellers and other road users can add substance to transport strategies in terms of practical measures for their delivery.

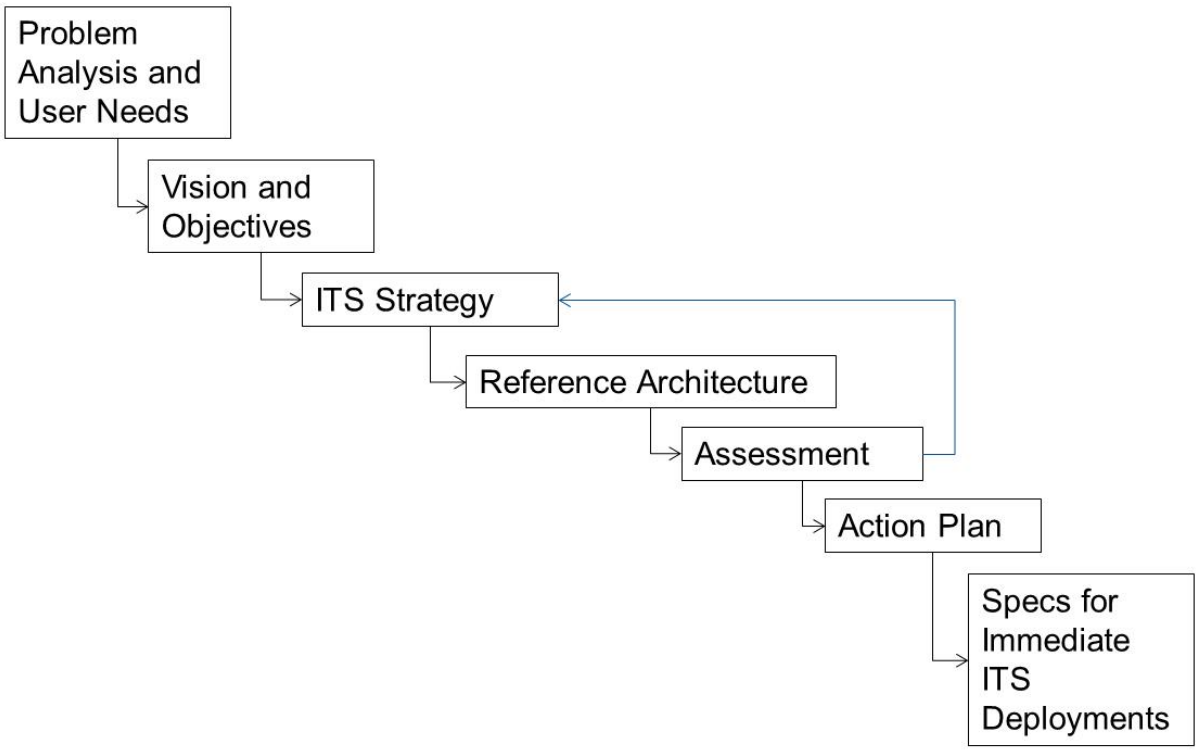
To ensure that ITS is not overlooked in the transport planning process, a well-considered and easily understood ITS Strategy is required that shows the direct links with the national transport strategy. In summary, the reasons for developing an ITS national and/or regional deployment strategy, are to:

- agree the transport policy objectives that intelligent transport will support in practical terms
- identify specific transport problems, requirements and needs – where ITS can provide more cost-effective solutions than alternative (non-ITS) measures
- create a common understanding of the role of ITS in short and long-term transport planning horizons
- define the principles and points of emphasis for the deployment of intelligent transport systems – such as the legal and organisational framework, ITS architecture and standards
- clarify the roles of the various stakeholders and develop models for joint working and co-operative partnerships
- outline the priority projects in different ITS domains and the criteria for investment, performance monitoring and impact evaluation – to be included in an ITS deployment programme (**See** Planning an ITS Programme)
- provide an action plan to give effect to the ITS deployment programme and fulfill the strategy's objectives

ITS Strategy for Egypt

In Egypt, a national ITS Strategy is being developed by the Ministry of Transport encompassing a

clear vision and priorities for the deployment of ITS services in the short-term, medium-term and long-term. The ITS Strategy is clearly defined with project packages clearly specified for immediate implementation.



An Example of Approach for Developing an ITS Strategy

The development of an ITS Strategy should, if possible, evolve through a consensus process involving multiple stakeholders to understand their expectations, priorities and boundaries. Careful planning will take into account the local culture and transport profile so that ITS can be adapted and customised to meet the particular needs. (**See** Basic ITS Concepts)

One of the important lessons learned from ITS deployment is that resolving institutional issues is a key to success, and addressing them takes time and commitment. The advice is “Do not start too late. Involve all key stakeholders early on.”. This can help anticipate and resolve technical and institutional issues. Mechanisms such as steering groups and pilot projects can help win the support of major stakeholders for ITS deployments.

Countries in the early stages of deploying ITS can take advantage of this hard-learned experience – by seeking to understand stakeholder and user needs as the outset of any ITS development and addressing institutional issues early on. (**See** Regulatory Framework)

According to World Bank Technical Notes, for ITS to be successfully introduced, a number of institutional prerequisites must be met – in some cases, legislation and institutional change may be necessary:

- ITS needs to be coordinated with existing laws and regulations – such as those governing traffic and vehicle safety standards, data ownership and privacy, competition and procurement (**See** Legal and Regulatory Issues)
- new (IT-related) procurement procedures may be required to purchase software and electronic devices that are different from established methods used for procuring road infrastructure (**See** Finance and Contracts)
- provision must be made for training senior managers, professional and administrative staff to develop and administer ITS-based applications and services (**See** Staffing Levels and Professional Capacity Building)
- the viewpoints of consumers and other users need to be understood and incorporated into ITS deployment (**See** Users of ITS)
- an ITS promotional organisation at the national or regional level (such as ITS-America, ITS-Europe, ITS-Japan and other ITS associations) is helpful to promote concepts of ITS to the public and encourage public-private partnerships for deployment (**See** Coordination Mechanisms)

Key elements in the process of establishing an ITS strategy are:

POLITICAL AND ORGANISATIONAL ISSUES

The development of an ITS strategy is heavily dependent on the political and organisational framework in a country and region. Cooperation and coordination among relevant government agencies is essential to deployment of ITS but may require clarification of roles and responsibilities. Some stakeholders may view a proposal for ITS negatively and need to be won over. For example:

- there was local opposition to electronic tolling introduce to fund infrastructure development in Trondheim, Norway – even though there was an established practice of tolling for new tunnels and bridges
- some local communities in California were worried about the environmental consequence of increased traffic levels resulting from an investment in ITS (such as smart traffic signal control and better navigational aids)

Overcoming opposition requires political commitment to convince stakeholders that their concerns are understood and taken into account.

REGIONAL STRATEGIES

ITS deployment should not be seen as a “singular” exercise, but rather connected to similar ITS deployments which should be consistent in terms of standards (and architecture) to ensure harmonised data exchange and a common “look-and-feel” for the road user. Harmonised deployment of ITS requires active partnerships between stakeholders.

A regional ITS strategy covering several regions within a country or several neighbouring countries is necessary to achieve harmonised deployment and use of ITS services. The size of the region and the complexity of transport operations that need to be integrated will determine the levels of interoperability required. (**See** Integrated Operations)

International freight operations and electronic toll collection for trucks moving across borders within the region benefit from interoperability based on common standards and harmonised back-office systems. In regions which do not have an agreed ITS strategy in place, the risk of fragmented deployment of various ITS systems of different standards is high.

Certain regions around the world have cooperated to develop regional ITS strategies – such as ERTICO in Europe, ITS America and ITS Canada in North America, ITS Japan and ITS Australia in Asia Pacific. Countries in the European Union have developed a legal framework to achieve greater harmonisation.

HARMONISATION OF ITS IN EUROPE

The European ITS Directive (Directive 2010/40/EU of 7 July 2010) provides a legal framework for the deployment of ITS services across Europe.

Priority areas:

- Optimal use of road, traffic and travel data
- Continuity of traffic and freight management ITS services
- ITS road safety and security applications
- Linking the vehicle with transport infrastructure

Priority actions:

- EU-wide multimodal travel information services
- EU-wide real-time traffic information services
- basic (road safety related) universal traffic information free of charge to users
- an interoperable EU-wide automatic accident alert & location system (eCall)
- Information services for safe and secure parking places for trucks and commercial vehicles.
- Reservation services for safe and secure parking places for trucks and commercial vehicles

Information about the European ITS Directive and ITS Action Plan is available on the Commission's website.

In the Middle East and North Africa (MENA), no regional ITS strategies have been agreed between the various countries but regional ITS associations – such as ITS Arab – have an important guidance role in facilitating harmonised regional deployments. Many Arab Gulf states that were pioneers in ITS deployment now face a situation where there is a mix of legacy systems and standards – without harmonised specifications. ITS Arab has begun work on developing an ITS system architecture to help ensure some compatibility of specifications for ITS deployments in future in the MENA countries.

Many countries, such as Argentina and Malaysia, have recently created national ITS organisations. Other countries in Africa, apart from the long-established ITS South Africa, have recently created national associations to jump start ITS programmes and integrate key players at a national scale (such as Nigeria, Ethiopia and Egypt. Many of the new associations have received support from established international associations. For example, ITS Egypt received good support from ITS South Africa and ITS UK.

INSTITUTIONAL STRENGTHENING

Technical and administration capacity-building measures for staff involvement in ITS planning and deployment must be part of the ITS Strategy. Without this the necessary expertise to plan and oversee the implementation of ITS projects, will be missing. In several cases, the use of independent third-party expertise – to provide guidance, training and manage the design and deployment of immediate ITS deployments – is a way to ensure effective capacity building. (See Professional Capacity Building)

IDENTIFICATION OF KEY PLAYERS

The importance of effective liaison with all potentially interested parties and stakeholders cannot be

overstated. From the outset the key public and private sector stakeholders should be identified and consulted as part of developing the national ITS Strategy. Deployment plans should be thoroughly discussed and assessed with them – as well as the general public – to ensure widespread support and buy-in of the proposed deployments. (**See** Policy Framework Analysis)

Key players can often be grouped into seven major categories:

- Public Administrations: many countries have centralised structures at the national level – such as ministries or road authorities – and municipalities and regional administrations at the urban and regional levels. Police services – who are often the main agency for traffic enforcement – may operate at both national and local levels. Emergency and incident management services can be part of the public administration (though they may also be private companies). Many countries have still to develop integrated plans for road incident management and emergency response (**See** Emergency Plans and Emergency Response)

- Infrastructure Operators: cover all organisations responsible for managing and operating transport and telecommunication networks. In many countries, a mixture of public and private infrastructure operators exist – making their integration challenging without agreed and workable cooperation arrangements (**See** Business Framework and Telecommunications)

- Transport Operators: cover all companies operating public transport and freight fleets for the different transport modes. In many countries, freight operations are not regulated making it difficult to introduce comprehensive freight fleet management services (**See** Passenger Transport Operations and Freight and Delivery Operations)

- Service Providers: cover all organisations providing services in travel and information, vehicle breakdown and driver assistance, and motor insurance. In many cases, service providers are private companies who respond to customer needs and market opportunities (**See** Location Based Services)

- Industry: in countries such as China and Malaysia, a healthy IT-related industry has evolved through government commitment and major investment. In other countries, investment in IT is underdeveloped in terms of both the knowledge base and available resources

- Research Institutes: cover all organisations involved undertaking research in information and communication technologies, transport planning, traffic management and ITS. These institutes are a catalyst for developing ITS deployment plans and pilot projects. For example, in China, Egypt, Korea and Singapore, major universities and research institutes are heavily involved in the planning and development of ITS solutions, as well as leading pilot deployments

- User Groups: cover all end users of transport infrastructure and services including the associations representing transport operators and freight logistics companies. In many developing economies, representation of travellers views – as consumers of transport services – to decision making bodies is minimal with the possible exception of automobile clubs. The needs and requirements of vulnerable road users – such as pedestrians and cyclists – also need to be considered (**See** Vulnerable Road Users)

INTERACTION WITH STAKEHOLDERS

Expectations of what ITS can achieve can be unrealistically high. It is important to provide clear and realistic figures on expected impacts – based upon international ITS deployment best practice – and to take a staged approach. It is also important to anticipate changes in stakeholders' needs and requirements over time.

Active dialogue is needed to identify each stakeholder's interests in the deployment of ITS – their

perceived problems, expectations, roles and responsibilities. Within each organisation it is essential to identify the staff with the understanding and skills to engage with ITS. This requires professional development, awareness raising, training and education in the broadest sense about ITS – of technicians, decision makers (including the politicians), senior management and administrators. (**See** Professional Capacity Building)

National ITS Forum in Egypt

In Egypt, a national committee of all key players was set up by the Ministry of Transport for high-level coordination of ITS development. The committee was established at ministerial level, with the authority to influence the decisions of the key organisations and agencies regarding adoption of a national ITS architecture, data exchange formats and the use of international standards.

ITS CHAMPIONS

Effective dialogue between stakeholders is the means for transforming organisational arrangements from concept into reality. A lead organisation (and sometimes a lead individual) may need to act as a champion for ITS to push forward deployment plans and coordinate the actions that will contribute to achieving a common ITS vision.

Often ITS champions will be individual experts having had experience of ITS development and deployment at the international level and with a desire to advance deployment in their home country. Individually they can contribute their experience but with the support of national Ministries and organisations they can mobilise stakeholders to help solve transport problems. An ITS study tour to countries where ITS is widely deployed can help raise awareness and understanding of its possibilities.

A national or regional task force of the major players, with high-level political backing, can also help to develop voluntary agreements and memoranda of understanding (MOUs) between operating partners on matters of common concern.

ITS Champion – Hefei, China

Within Hefei China, a major champion of ITS deployment was the Research Centre for Software Engineering Technology in Anhui Province – one of the main technology centres of development in the city. International cooperation – between the German Aerospace Centre (DLR) and other German partners with Hefei's municipal traffic police, Department of Communication and other partners – led to an ambitious ITS programme being developed. It was integrated within the city's traffic and transport investment plans.

ENABLING LEGISLATION

Enabling legislation may be necessary to create and support new organisational frameworks so that public agencies and (sometimes) the private sector can work together in a structured manner with transparent and clearly defined roles and responsibilities. Any significant policy initiatives and legislation are usually the outcome of a process of consultation and consensus-building among major ITS stakeholders and interest groups. For example, the table below shows the allocation of roles and responsibilities for motorway traffic management in England and Wales – between the traffic police and the road authority – under new legislation introduced in 2005.

Police and Road Authority Roles and Responsibilities (UK)

New legislation in the UK created "Traffic Officers" invested with powers to undertake certain traffic management tasks previously carried out by the police – such as to:

- stop traffic and close roads, lanes and carriageways
- direct and divert traffic and pedestrians
- place and operate traffic signs
- manage traffic at traffic surveys – stopping vehicles and asking drivers about their journeys (used to develop and plan future investment in the transport system)

1. Control office functions			2. On-road activity			3. Central functions
Incident management	Monitoring road network	Support to drivers	General on road duties	Controlling traffic flow	Other services	Planning and control functions
Major incident management/ deployment	Use of CCTV for incident management & criminality	Providing network information to media	Managing criminal activity	Dealing with abandoned vehicles	Escorting high risk vehicles	Developing protocols and standards
Minor incident management/ deployment	Use of CCTV to monitor traffic flow	Tactical diversion sign setting	Management & investigation of fatal & serious collisions	Removal of damaged/ broken down vehicles	Escorting abnormal loads	Contingency planning
(ERT) Telephone call handling	Real-time traffic management	Strategic sign setting	Management & investigation of minor collisions	Providing mobile/ temporary road closures	Monitoring roadworks	Routing of abnormal loads
Incident sign setting			Enforcement of road traffic offences	Clearing debris and animals	Special events	Planning fixed traffic management
Liaison with TMC/roadside service providers			High visibility patrols e.g. vulnerable motorists	Repairing & improving the infrastructure (road safety)	Road user education	Planning for roadworks

KEY
Police
Highways Agency
Shared

Source: Highways England, UK

The establishment and maintenance of an ITS programme can be greatly facilitated by a policy commitment to multi-year funding for ITS activities. Without this kind of commitment a strategy for ITS deployment will be difficult to sustain because of start-up capital costs and year on year operational costs.

Enabling legislation supports the introduction of policies and procedures for ITS applications that:

- require enforcement
- involve financial transactions
- raise issues of competition or procurement, legal liability and privacy (**See** Legal and Regulatory Issues)
- create incentives for the private sector to enter the ITS market

LEVEL OF ICT RESOURCES

The strategy for ITS will be dependent upon the development of the national Information and Communications Technology (ICT) infrastructure. It is necessary to have a basic level of technology in place that includes the communications infrastructure, communication standards and data models. Good practice is to synchronise ITS development goals with the roll-out of ICT generally.

ITS consists of a wide range of services and products, some of which are now very well established (such as traffic signal coordination). Adapting applications to local conditions is always necessary – for instance, so coordinated traffic signals work in mixed traffic of cars, two-wheelers and non-motorised vehicles. Transport agencies have an important responsibility to lead this adaptation in their instructions to consultants and suppliers.

STAGED APPROACH

In countries starting a national ITS deployment programme, it is always advisable to adopt the "THINK-BIG, START-SMALL" approach. Countries need a comprehensive ITS Vision and strategy encompassing all levels of ITS services that can evolve as circumstances change. The focus will be those applications that contribute directly to the achievement of transport policy goals and operational improvements. The successful introduction of ITS should be staged over a number of years to allow for adaptation in response to technological development, changes in policy priorities, economic growth, and greater requirements for integration as new ITS functions are introduced and existing functions evolve.

A Staged Approach in Hefei (China)

China has a strategy of introducing state-of-art technologies in transport. In Hefei, after an analysis and assessment period to develop ITS plans – an ambitious ITS deployment programme was proposed for huge investment in road and public transport infrastructure and services. The strategy requires wide-spread deployment of advanced traffic monitoring and control equipment across the city's road network.

Stage one focuses on traffic monitoring and involves a programme of data collection based on traffic probes (Floating Car Data) using more than 7,000 taxis and trucks covering the Hefei urban road network. The data are utilised in digital and multimedia broadcasting of traffic information and for public transport planning.

Staged progression of ITS deployments gives the opportunity for stakeholders and users to gain confidence in the new systems and lay the ground for future plans. This can include developing small-scale pilot

deployments of priority ITS services to demonstrate their viability and to fine-tune the designs and operational arrangements – in preparation for wide-scale deployment.

Initial steps in Egypt

The Egypt ITS Strategy includes the Cairo Ring Road which has an annual average daily traffic of more than 120,000 vehicles per day and is amongst the most heavily used roads in the national network. It was chosen as the first pilot ITS project in Egypt for the deployment of integrated traffic detection and management measures on more than 90 km of roads. Its significance – apart from its importance in easing many of Cairo's traffic congestion problems – is as a pilot deployment for testing and developing the necessary technical and operational requirements in anticipation of extending ITS to other road corridors.

DEVELOPING AN ITS STRATEGY: CASE STUDIES

ITS Strategic Planning, Abu Dhabi, United Arab Emirates

ITS Vision, Czech Republic

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FINANCING AND PROCUREMENT

Many countries suffer from a lack of finance in general – and in particular, a shortage of funds for investment in ITS which has to compete with traditional road infrastructure programmes that absorb a large portion of available funds.

Some countries have overcome the problem by concentrating on the building of toll roads – which generates revenue that can be directed towards funding other road infrastructure and ITS services – such as traveller information and traffic management. Electronic toll collection (ETC) is often one of the first ITS applications. In other countries there is reluctance to charge road users directly – or at a level necessary to cover the cost of the investment.

Many countries seek International Financing Instruments (IFIs) – grants and loans – to support ITS deployment programmes. In other cases, public-private participation cost-sharing schemes are developed to attract investors and system integrators to participate in the set-up and operation of ITS schemes. Electronic fee collection can be bundled with traffic management schemes – if the business model is robust enough.

There are some fundamental considerations that need to be taken into account when comparing ITS investments in industrialised countries with investments in countries with emerging economies. For example:

- the ratio of labour to capital costs may be much lower (sometimes more than ten times lower)
- foreign exchange to pay for specialised equipment may be in short supply which may affect affordability and slow down deployment
- the opportunities offered to private sector to invest in ITS service delivery

A variety of funding instruments can be used for the deployment of ITS. The selection will depend on the countries' individual circumstances and the nature and scale of the proposed scheme. The level and pace of development of ITS technologies is rapid and may represent a barrier to public agencies decision making on deployment. Tapping into private sector technical and management skills and financial resources can help public authorities to engage effectively. In the case of a public-private partnership (PPP), both sides share risk as well as potential benefits. (**See** Financing ITS)

The infrastructure costs of some measures – such as traffic management, traffic enforcement and public transport management – are absorbed largely by the public sector. The advantage of involving the private sector is to benefit from their ability to manage the design, deployment and operation of the ITS measures through cost-sharing arrangements.

In other cases – such as services for electronic road pricing, fleet management and traveller information – the private sector may be willing to invest directly on the basis of providing a self-sustaining (revenue-funded) service.

INCENTIVES FOR PRIVATE SECTOR

One important role for government is to set the policy framework on commercial engagement in ITS. The private sector needs to be confident that the policy framework is stable so that risks will be manageable and investments have a good prospect of achieving a reasonable return. Government is responsible for identifying where private sector investment is welcome – and establishing the ground rules and institutional arrangements within which business has to operate. This may involve offering incentives.

In countries where private companies have experience in operating transport terminals and links, the

opportunity to develop public private partnerships for ITS deployments may be easier. For example:

- in China and Egypt, the level of private sector involvement in developing and managing transport services is not yet high due to a lack of clear guidance and rules that ensure a level playing field for all service providers
- in contrast countries such as Malaysia, Indonesia, Latin American countries and South Africa have a good track road in private sector participation in ITS deployments – notably electronic fee collection schemes

PROCUREMENT AND CONTRACTING

In many emerging countries, design-build procurement and contracting schemes are traditionally used. Many road transport operators are not familiar with other forms of procurement and contract – such as:

- turnkey ITS solutions readily available with little adaptation
- service-level agreements that specify the minimum levels of functionality and performance

International Financing Instruments (IFIs) often require applicants to use internationally recognised forms of contract and arbitration – such as those supported by the International Federation of Consulting Engineers (**See** FIDIC) – with which road authorities may not be familiar. The key to adopting these more innovative contracting mechanisms is to provide staff in procurement and contracting with the necessary training. (**See** Procurement and Contracts)

Developing Procurement Skills in Egypt

In Egypt, specialised training has been organised for staff in contract departments at the Ministry of Transport. Procurement regulations have been adapted to enable private sector participation in transport infrastructure and operations.

PLANNING AN ITS PROGRAMME

In most countries as traffic volumes increase and the roads get more congested there is pressure on the authorities for better traffic management and control of congestion. Highway authorities, road operators and urban road network managers everywhere need to deliver better road management. This involves all the activities involved in building, maintaining and making best use of the roadway assets.

One of the aims of road management is to ensure that traffic can continue to travel – in a manner that is safe, efficient, reliable and which causes the least damage to the environment. When designing a programme that supports this aim the road operator will need to address a number of practical considerations – such as how to:

- monitor and keep track of traffic and road conditions in the network, day-by-day, hour-by-hour and – on some occasions when there is major disruption – minute-by-minute
- maximise operational safety and efficiency of the road network including the safety of personnel who have to work on the roads
- minimise negative impacts of disruption caused by recurring congestion and non-recurring incidents within the road network
- provide road users with the information necessary to support their decisions on travel and relieve stress while driving

These are universal issues for road network operations. They are about keeping traffic on the roads running safely and efficiently and taking into account the level of service experienced by the road users.

Typically, the programme will be built on a number of distinct principles that will shape the priorities:

- knowledge: as a basis for investment – to monitor and manage traffic on the network
- safety and security: to control the traffic and analyse accidents
- education: to promote and enforce safety on the roads, encourage good driving habits and a high level of compliance with traffic rules
- vehicle maintenance: to reduce vehicle breakdowns and improve road safety– and so reduce accidents and emergencies; for freight transport a priority may be to improve security against hi-jack and criminal activity as well as road safety
- rapid response: to incidents – notably in the “golden hour” when lives can be saved and providing information to reduce secondary accidents to lessen inconvenience to other road users

ROLE OF ITS

ITS can make a positive contribution to these road management objectives. With relatively modest investment (compared with the cost of building a new road) ITS can significantly improve road network operations, optimise the use of available infrastructure, raise revenue and improve road safety. ITS can help to:

- keep track of traffic movements through network monitoring – with the aim of optimising the use of the roadway and the available capacity
- provide information to road users about hazards and disruption affecting the road network – so they can adapt their travel plans
- create a reliable revenue stream (through electronic tolling) that supports a forward-looking programme of road investment
- help improve driver behaviour – for example through:
  - safety and in-vehicle technology that encourages safer driving
  - encouraging compliance with traffic regulations and developing policies that support better

enforcement

Road users want safe, reliable, and seamless journeys. They are not interested in the geographical boundaries between one transport authority's network and another. This means that transport networks need to be integrated across geographical boundaries between different transport operators and administrations. ITS deployment may be multi-modal, multi-jurisdictional, and in some cases, international. This may involve bringing together local, regional, national road authorities and the operators (which may by concession-holders). (**See** Integrated Operations)

Most countries engaged in ITS deployment have formal ITS programmes at the governmental level – and/or the non-governmental level through anetwork of National ITS Associations. These programmes aim to promote ITS as a reliable and effective tool for solving transport problems – by ensuring consistency and synergy among ITS projects, continuity of funding, and generating public acceptance and new investment.

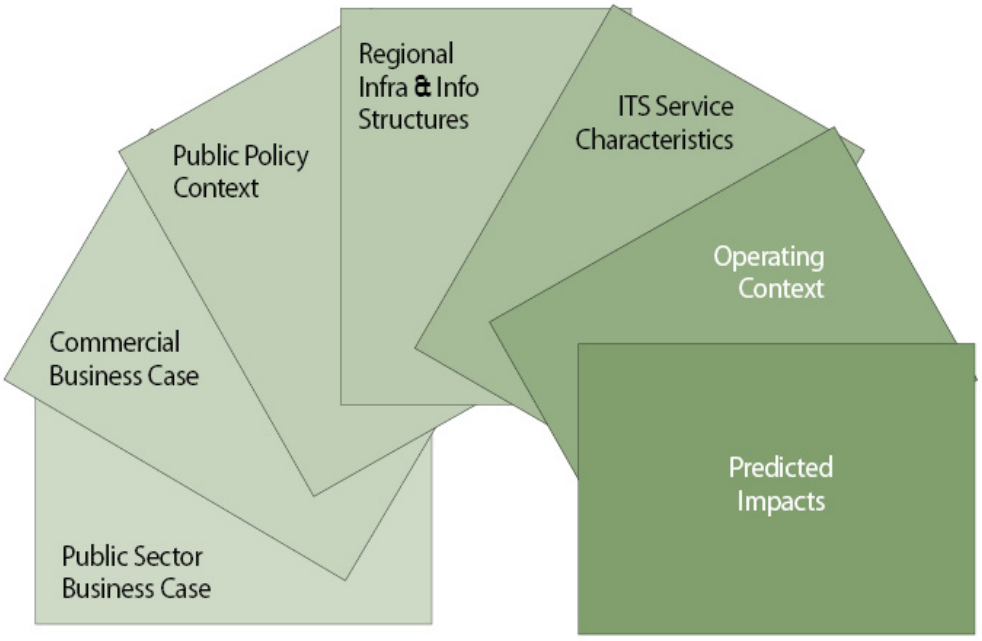
When formulating an ITS programme, priority services need be clearly identified in terms of overall relevance to goals and objectives, scope, requirements, and expected impacts. Priority services need to be "packaged" within clearly defined deployment projects that specify their scope, scale, functional and performance requirements and budget. (See PDF 9201 Hefei City Traffic Management System Case Study) Projects will need to show they meet the criteria for funding by national or international funding schemes. (**See** Budgeting and Affordability)

Keys to Success

The key to success can be summed up in four simple rules:

- ITS needs to be incorporated into the mainstream transport planning and investment cycles (**See** Strategic Planning)
- project finance needs to take account of capital investment and ongoing maintenance and operational costs – ideally planned on a whole-life cost basis with an allowance for upgrade (**See** Funding ITS)
- private sector knowledge and experience in delivering ITS projects and operating ITS-based services offer an opportunity to fill any skills gap – and private finance can be mobilised through partnerships and out-sourcing
- ITS needs innovative procurement methods in the public sector – that involve multiple evaluation criteria to award a contract on the basis of best value rather than lowest cost – judged against the essential performance requirements (**See** Procurement)

The figure below illustrates the different factors that need to be considered when planning a programme of ITS deployment.



Principal Dimensions of ITS Deployment

PUBLIC SECTOR BUSINESS CASE

The public sector business case assesses the value of the investment to the community and its affordability from the perspective of the road authority. Expenditure using public funds raised from local, regional or national taxation, has to be justified. It is likely to have to demonstrate the link between the public policy goals and the predicted impacts of the service. Socio-economic impacts are likely to dominate, but other practical factors will come into play. Assigning a monetary value to all benefits may be difficult. (See Weighing the Costs and Benefits) An alternative approach is to draw on the results of evaluations of similar projects. (**See** Guidelines and Techniques)

COMMERCIAL BUSINESS CASE

In the case of a public private partnership the commercial business case needs to be made. This will turn on rests on the return on investment and the profitability of the operation as a whole, including any monies received as a subsidy or through sponsorship. A return on capital and recovery of operating costs are both essential for any scheme to be commercially viable. A decision to progress the project will depend on a risk assessment of all uncertain factors including the availability of ITS infrastructure and the costs of creating and maintaining it. (ITS Technologies and Contracts) Other factors to take into account include:

- market potential
- the ownership, cost and reliability of data sources
- the clarity and stability of government policies
- the impact of the legislative and regulatory framework
- whether there are institutional barriers that might impede the project
- the risk of competition and technological obsolescence
- the expected profile of revenue streams over time
- the road and regional authorities' assessment of the proposed ITS service

PUBLIC POLICY CONTEXT

Transport policy relates to all subjects within the administrative control of a diverse range of government bodies at the national, regional, city and rural level – for example, the planning and operation of local roads and public transport networks, parking policy, traffic and travel information, provision for the elderly and disabled, road safety policy and environmental factors. Transport goals and objectives are not the only consideration – because ITS contributes to economic development through the exploitation of Information and Communication Technologies (ICT).

Public authorities need to create a framework for the assessment of potential ITS application – from the point of view of the specific local deployment and from the perspective of the city or region as a whole. The public sector can also help create a positive business framework to stimulate the market – for example, by clarifying the institutional setup (organisational and regulatory issues). A practical example would be to facilitate data collection by commercial fleet owners and other operators – by authorising the use of privately funded and privately managed probe vehicles or other infrastructure, such as toll tags, to monitor conditions on the network. (**See** Probe Vehicle Monitoring)

REGIONAL ITS INFRASTRUCTURE AND INFO-STRUCTURE

The infrastructure for ITS is made up of a number of different enablers. For the systems to work, ITS services need all the basic components in place, fully and reliably operational. For example a lack of basic infrastructure affecting any part of the information supply chain will lead to poor-quality information service. (See Data and Information)

The technical requirements include:

- reliable broadcast and mobile communications links, including the Internet, for transmitting data and information to and from the users and their vehicles (**See** Telecommunications)
- intelligent infrastructure and the means for vehicle location (fixed beacons or satellite navigation, with corresponding on-vehicle equipment) (**See** Navigation and Positioning)
- a well-developed infostructure consisting of location referencing systems, data dictionaries, digital maps and data exchange protocols (**See** Basic Info-structure)
- dedicated wireless and fibre optic links for high bandwidth applications such as transmission of CCTV pictures (**See** CCTV)
- real-time data capture: traffic monitoring, pollution monitoring, weather monitoring (**See** Weather Monitoring)
- the people and buildings to provide ITS services – such as traffic control centres, vehicle fleet controllers and dispatchers, travel information centres (**See** Operation Centres and Operations and Fleet Management)
- common support services, such as electronic payment systems, vehicle tracking, load and driver identification, enforcement and security systems (**See** Technologies and Processes and Automatic Vehicle Locator)

ITS SERVICE CHARACTERISTICS

ITS is service-driven. They are dependent on the availability and affordability of enabling technologies and infrastructure – such as telecommunications, smart card payment and the supporting automated payment clearance systems. They will have a profound impact on the cost and risk profile of ITS services and products.

An ITS service which requires investment in a major infrastructure may fail because of the financial barriers and technical risks. If the operational cost and revenue model or longevity of the supporting

services is uncertain then the venture may be judged too risky. As with any other business, the promoters will be looking for a clear path to successful and profitable delivery.

The viability of an ITS service deployment will be influenced by the level of functionality required, the service profiles – such as 24/7 (24 hour operations, seven days a week) – and the levels of service offered to the users (for example, 100% availability with real-time data). For example, for an ITS travel information service, there are many variables. (**See** Travel Information Systems) These include:

- the extent and depth of transport network coverage
- whether it is single travel mode or multi-modal coverage, or for general or specialist use.

A number of issues need to be considered:

- will it be a narrowly focussed (niche) service or a broadly based public service?
- will there be positive or negative road safety implications?
- what added-value services are to be offered (tourist features, emergency call-out, location-based yellow pages look-up)?
- will the service be pay-per-use or subscription, or free at the point of use; or financed by sponsorship?
- is the ITS service "static" with a low refresh rate – or "dynamic", updated frequently in real-time?
- will the user be able to interact with the ITS service?
- what choice of user interfaces and equipment is to be supported?

Smart Solutions for Traffic in Cairo, Egypt

In Egypt, an activity was launched to engage the young technical community in understanding and developing smart solutions for traffic problems in Cairo. The initiative, "Cairo Transport App Challenge", was supported by the World Bank and the Ministry of Communication and Information Technology, the Ministry of Transport and the Egyptian technical community. Young professionals were asked to develop, test and market smart phone applications to improve transport in Cairo – to make it less congested and safer for drivers, passengers and users of public transport. Technical and business mentorship was provided to the applicants. The challenge began with a workshop at Egypt's Technology Innovation and Entrepreneurship Centre (TIEC) in September 2012 – and resulted in more than 24 submissions and more than 850,000 followers on social network sites. Experts and mentors shortlisted 10 finalists, with the "most popular" app being chosen through online voting.

OPERATING CONTEXT

The operating context is the basic organisational, regulatory and institutional framework for the ITS service and is the key to ensuring a viable and workable system. For example:

- regulations or administrative requirements may impede data collection
- a lack of standardisation or quality control procedures may produce unreliable quality in the data streams
- excessive cost of data acquisition may inflate operating costs to the point where the service is not viable

A well planned service operation needs sound allocation of risk, appropriate cost sharing, sustainable

service pricing and a commitment to quality delivery for the end user. A service which is too costly for the user will have low market penetration which will limit the impact of the service with respect to policy and commercial goals and undermine the public and private sector business case for funding.

INTER-AGENCY AGREEMENTS

Practically all ITS services involve the cooperation and/or coordination among multiple transport agencies. Even in the case of single-mode management, multiple agencies under different jurisdictions may be involved. It is good practice to document in some detail the agreed allocation of roles and responsibilities – and exactly how each agency will operate in relation to the others. This can be done in formal interagency agreements to avoid misunderstanding in the future.

Public/private partnerships are often needed. These can range from informal agreements between the parties to cooperate on day-to-day operational tasks – to more formal contracts and/or memoranda of understanding on information sharing and provision of services. (**See** Public Private Partnerships)

Establishing a group of individuals with decision making powers, who can represent the key stakeholder organisations, provides a forum for reaching consensus on roles and responsibilities in terms of how to deliver and manage ITS-based operations.

Inter-agency Agreements in Egypt

In ITS Egypt, formal agreements are being developed between:

- the Ministry of Transport and Ministry of Interior to establish roles and responsibilities to enable joint development and operation of the planned Traffic Management Centre
- the national road authority and Egypt Telecom to allow for access and use of telecommunication networks and service for the ITS deployments on the road network (**See** Case Study "ITS Strategy for Egypt")

PREDICTED IMPACTS

Predicted impacts are the forecast effects that the proposed ITS service will have on transport systems and their users. These should relate to the transport and related public policy goals – and in the case of a partnership with the private sector – the commercial business objectives. The benefits might be to individuals – such as reduced travel time, perceived reliability of public transport services, or information which is personalised. Policy-related benefits to the community should also be considered – such as improved civic image for inward investment or safety benefits through better incident notification. (**See** Valuing the Benefits)

PLANNING AN ITS PROGRAMME: CASE STUDIES

Urban Traffic Management, China

ITS Strategy, Egypt

ARCHITECTURE AND STANDARDS

An ITS architecture provides an analysis of the technical and organisational requirements in support of a planned approach to ITS at the national or regional level for consistent deployment of ITS. System architecture provides a basis for learning about ITS and reaching consensus among stakeholders on the ITS development process. (**See** Basic Concepts and What is ITS Architecture)

One of the very first steps in the development of an ITS architecture is to involve all major stakeholders to understand, define and agree:

- user requirements
- the scope for ITS deployment and the options
- significant organisational requirements and the division of roles and responsibilities
- technical performance requirements
- a programme for developing the prioritised ITS user services

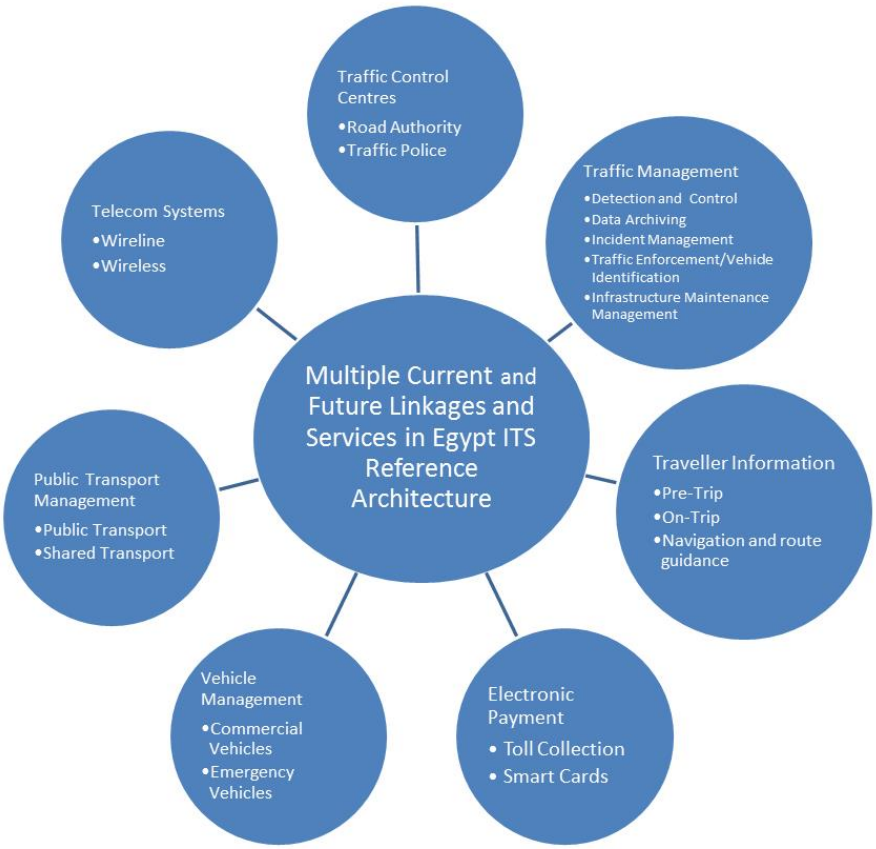
An advantage of developing an ITS architecture is to engage with users and stakeholders at the outset of developing an ITS investment programme. It provides a strong push for establishing the necessary institutional and organisational arrangements to deliver and support the services. In recent years, countries with rapidly developing economies – such as Chile, the Czech Republic, and Mexico – have developed national ITS architectures involving their respective stakeholders.

A top-level ITS architecture will act as a reference to guide the development of the detailed ITS design for the various services. For countries starting to develop a national or regional ITS programme of investment, a top-level architecture will clarify:

- where to make the investment by mapping the user needs
- specifying high-level functions for the various ITS services and the data flows and control logic needed to meet the functional requirements
- generating a concept of operations that describes who provides and who receives which ITS services and what interactions are necessary to support the service delivery. (**See** How to Create One?)

The ITS architecture will form a stable and open basis for the development of a design for the selected services to ensure compatibility, consistency and interoperability in ITS investment programmes. This has been the case in Hefei, China – and also in Egypt, where an architectural sketch for ITS planned services provided a starting point for developing the technical requirements needed for the delivery of ITS systems.

The figure below provides an overview for developing the national architecture proposed for ITS deployment in Egypt in the short and medium-term.

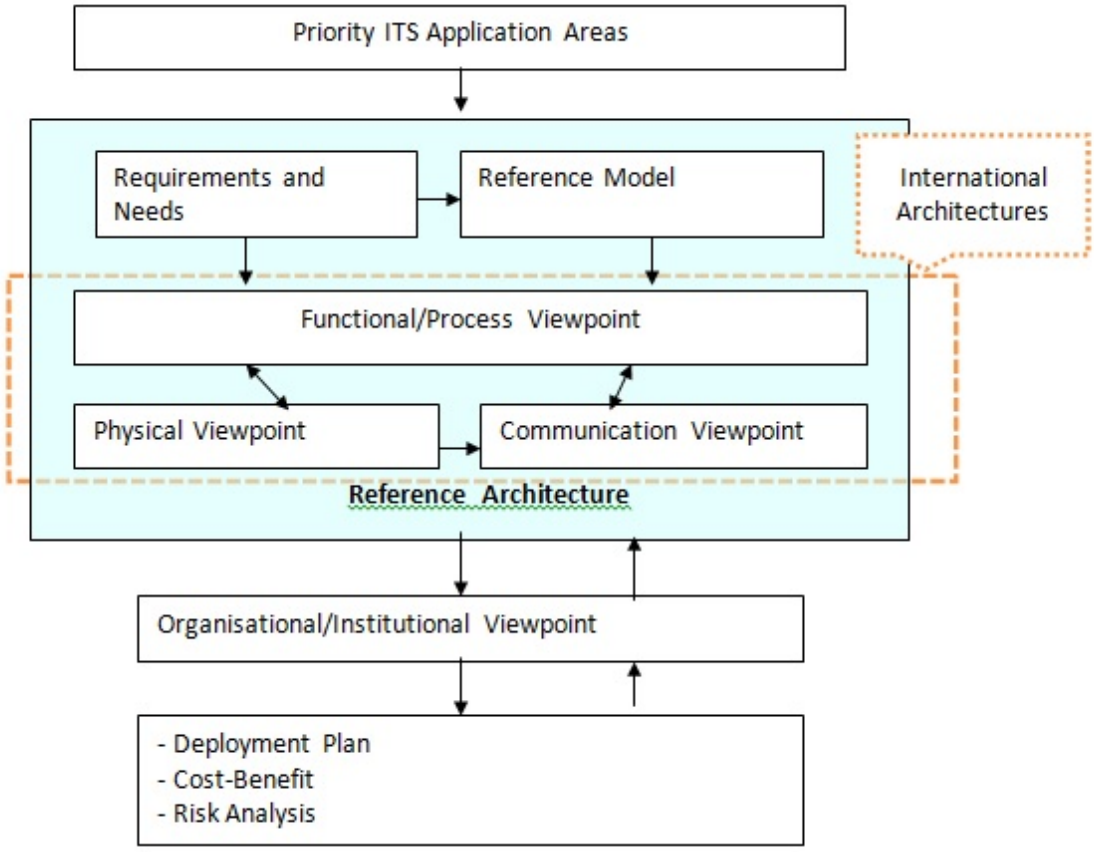


High Level Architectural Sketch for Egypt ITS Programme

International Architectures

In most cases, after agreement on the scope for ITS deployment (as shown in the architectural sketch above), a country will develop the ITS architecture by adapting a specific international architecture to fit their needs. There are two commonly used alternatives. (**See** Using the US Architecture and Using the FRAME Architecture)

In Malaysia, the national system architecture is largely based on an adapted form of US National ITS Architecture (**See ITS Malaysia**). In Egypt, the national ITS architecture is being developed on the basis of the ISO/TC204 reference architecture (See Object Oriented Architectures Why Create One) together with the European ITS Framework Architecture (FRAME). The figure below [provides an overview of the system architecture framework for ITS in Egypt.



Outline of the Egypt ITS Reference Architecture

Many countries have already made substantial investments in ITS – typically an urban traffic signal control system. These are often now so-called “legacy systems” which have to be integrated into the national architectures to secure a level of interoperability. In some cases, this is not possible where the system uses its own developed (proprietary) standards rather than open standards. It is possible that a lack of interoperability will make it necessary to phase out the legacy systems. The acquisition of new systems should proceed on the basis of open and international standards.

Development and Maintenance

Low to middle income countries are likely to find it difficult, too time consuming and expensive to commission an ITS architecture that covers all priority services at once. The World Bank’s Technical Notes recommend the creation of a “step-by-step” approach to ITS deployment in emerging economies. This means that the ITS architecture can be developed incrementally as new requirements become a priority and new technical solutions are available. In this way the architecture becomes the means mechanism for shaping the future of ITS. As deployment proceeds, development of the ITS architecture lays the groundwork for well-controlled, compatible, expandable, and interoperable ITS services.

ITS architecture should be a living document requiring continuous monitoring and adaptation as user needs, services and functional requirements evolve – and system requirements expand and technology upgrades become available.

In some cases, national ITS associations have taken on the role of developing and maintaining the national ITS architecture. For example, ITS Malaysia is in charge of maintaining the ITS architecture.

International Standards

The ITS architecture shows clearly the key processes which require a standardised interface – in particular for communication, data, and data exchange. Selection and adoption of appropriate international standards is essential to ensure harmonised deployment of ITS services at local, regional and national levels. In many emerging economies, multiple vendors compete for market access to supply ITS and often try to impose their own (de-facto or proprietary) standards. (**See** About Standards)

REFERENCE SOURCES

IDOM Group for European Commission “ITS Strategy Plan for Egypt- Draft Inception Report” Europeaid/120707/C/SER/BR, Ministry of Transport, Cairo, 2013

ISO/TC204. Reference Model Architecture for the ITS Model, Parts1-6, ISO #14813

DATA NEEDS

Timely sharing of traffic and transport information through electronic systems is a cornerstone of ITS network management projects and integrated network operations. It requires sufficient investment in traffic monitoring and surveillance technologies by the agencies responsible for road network operations. It also requires agreement on a set of common standards for data exchange: message sets, protocols, location referencing. Software models and telecommunications protocols are also crucial, but are driven by much larger markets than ITS – these non-transport-related developments need to be monitored and taken into account.

It is necessary to choose data communications standards and protocols that are common to all control centres, including the police and emergency services. This requirement will impact on any existing TCC operated by the police or municipal authorities – possibly involving an upgrade of legacy systems. An ITS Strategic Plan for the country or region will need to address these issues and make recommendations. (**See** Developing an ITS Strategy)

It is important to ensure the level of data availability and quality for the planned ITS services. Coverage and quality of data impact directly on the quality of ITS measures deployed.

In many cases, data can be shared by multiple ITS services. For example, traffic control measures – such as lane control systems – can be coupled with traffic enforcement systems that use the same traffic monitoring and camera installations. Similar options for integration are electronic fee collection, traffic flow monitoring and traffic information services.

There are national and international guidelines and standards on data coverage and data quality and how the data is coded – including:

- ITS America's data coverage and quality indicator guidelines for the deployment of advanced traveller information and management systems
- the ISO Standard – ISO/TR 21707:2008 – which specifies the terminology to define the quality of data exchanged between data suppliers and data consumers – this applies to traffic and travel information services and traffic management and control systems – in particular, where open interfaces exist between systems
- ISO TC204 Committee has developed standards for ITS data classification registries to provide unambiguous definitions of data concepts

In many countries, budget limitations prevent comprehensive investment in the infrastructure and organisational arrangements needed to achieve adequate data coverage and quality. Decision makers need to understand that ITS services will underperform if data quality and coverage is poor.

TRANSPORT NETWORK DATABASES

Considerable investment is needed in data collection – and in software development to map the transport network and complement the data generated by traffic and vehicles. ITS requires reliable databases of road network links, interconnections and other features, supported by a sound location referencing system. Without an inventory of stop locations, for example, it is not possible to offer point-to-point journey planning for public transport. Similarly for road information, reliable coding of the network is needed for incident detection and emergency response. Wherever possible, collection, location referencing and storage of data in a database – for use by the road network operator – should be co-ordinated and should be compatible with data on the road network held by public transport operators, emergency services and other organisations that service the road network.

Transport network databases need constant maintenance to keep up-to-date. Careful checking is essential to avoid errors which can lead to features being incorrectly located.

TRAFFIC MONITORING REQUIREMENTS AND OPTIONS

Often, there it is necessary to implement traffic monitoring over a large area – to cover points on the network experiencing traffic congestion and safety problems. A variety of technical solutions are available. Some, like inductance loops embedded in the roadway, are long established. Others are very new and innovative. Each of these methods has strengths and weaknesses that should be fully evaluated for their cost-effectiveness and reliability, taking into account local climatic conditions, maintenance and operational requirements.

New data sources do not negate the necessity of having permanent network monitoring infrastructure in place, to provide timely and accurate information about traffic flow and conditions on critical parts of the road network. Project planners will need to consider the extent of network coverage and the level of resolution required – in terms of road links and nodes to be monitored and the degree of resolution for specific time-periods.

Priority should be given to road sections with high traffic flows and high occurrence of incidents. Traffic monitoring and transmission of data in real-time will make it easier to respond rapidly to accidents and emergencies. For road safety or other operational reasons, it could be a priority to equip known hot-spots – in advance of comprehensive network-wide coverage.

Any traffic monitoring system will need operational support – in the form of a contractor to supply and maintain the equipment, software and provide the data integration services that will provide network monitoring “intelligence”.

Fixed detection

Traditionally traffic surveillance is provided by a network of fixed traffic detection systems (loops, radar, cameras and other above-ground detection). Equipment reliability and the requirement for maintenance over time are key considerations in making choices. A regional maintenance contract will be necessary to cover the fixed installations.

Point-to-point journey time data for the network (historic and in real-time) is a useful resource for journey planning and logistics support. Continuous non-invasive point-to-point tracking of individual vehicles is now possible at very low cost. Some road authorities use aggregated data (made anonymous) displayed on VMS to provide drivers with an expected journey time between key points on the network.

Vehicle tracking and data capture techniques include ANPR license plate recognition cameras or – more recently, point-to-point monitoring of Bluetooth signatures. Bluetooth sensors have been used successfully for point-to-point average speed monitoring as a cheaper alternative to Automatic Licence-Plate Recognition. (**See** Vehicles and Roadways)

Floating Car Data

An increasingly attractive option for large scale data collection at relatively low cost is the use of Floating Car Data (FCD). The widespread availability of smart-phones that incorporate GPS has made it easy to obtain data on vehicle paths, speeds and journey times. A fleet of vehicles equipped with a location

system, like GPS, can act as “traffic probes” that provide a rich source of data for monitoring network conditions in real-time and for keeping track of network performance. Data on point-to-point route choice and journey times (made anonymous to protect privacy) will contribute to network planning, incident response, traffic management and control.

Crowd Sourcing

Social networks and “Crowd sourcing” can also be used to gather information on network conditions using smart-phone applications. Crowd sourcing of traffic data is still in its infancy but represents an important opportunity where there is no investment in fixed detection. A road operator could explore cooperation with developers of smartphone applications to produce a valuable service to road users in the region.

EXAMPLES OF INNOVATION

China

In the city of Hefei, China, a total of more than 3,000 public vehicles were equipped with GPS and GSM mobile telecommunications to continuously provide on-line traffic data to the control centre. The data were then merged with camera and loop data to enable good coverage of the urban road network.

South Africa

In South Africa, a national ITS network monitoring and management scheme was developed by the South African National Road Agency (SANRAL). This scheme covers over 560 km of national road networks in the three regions of Gauteng, Kwazulu-Natal and the Western Cape. Under a BBFO contract (Design, Build, Operate and Maintain), the project includes:

- incident detection and management
- traffic control and management – through upgrade of existing CCTV, VMS and motorway ramp metering
- upgrade of three traffic management centres
- obtaining traffic information from external sources – such as as travel times from individual vehicles passing toll gantries
- dissemination of traveller information services.

Philippines

In Cebu, in the Philippines, a pilot project is being developed in collaboration with the Metro Cebu Taxi Operator Association, using GPS-enabled mobile phones in a sample group of taxis – to support traffic data collection and dispatch. By tracking the vehicles’ travel speeds and locations, traffic status data is collected. The application benefits the participating taxi companies by incorporating a visual interface showing their vehicle locations – providing support for their taxi dispatch operations.

China

In Hefei China, a high penetration rate of more than 5,500 probe vehicles (police patrol cars, trucks and buses) are deployed in combination with loops, radar and cameras – to collect data. The objective is to develop and implement an up-to-date traffic management system – which integrates traffic data collection and the broadcasting of traffic information services to traffic operators, travellers and drivers. The Floating Car Data (FCD) System, enables the user to visualise the traffic flows and assess the traffic situation – and then broadcast traffic information to road users through Digital Multimedia Broadcasting (DMB). This uses TPEG (Transport Protocol Experts Group) – a coding standard for detailed traffic and journey information.

Egypt

Crowd sourcing is becoming an important data source for traveller information services – and is increasingly popular in Egypt as use of the internet and smart phones become more widespread. It provides a platform for informing the public about the status of traffic.

DATA COLLECTION CONTRACTS

For some road operators, it will be more efficient and cost-effective to arrange a service contract with a specialist company to provide a dedicated data collection and traffic monitoring service – rather than developing it as an in-house activity. A feasibility study to assess the merits of a partnership with the private sector to develop their traffic surveillance services – is often helpful.

A contract for data collection operations can include performance-based requirements – where the contractor receives a payment incentive when the required level of service is achieved, or a financial penalty when it is not. Potential contractors are required to propose their own solutions and designs – and provide proof-of-concept to demonstrate compliance with requirements. This results-based approach depends on strict data quality benchmarks being defined in the contract – including data types, network and time period coverage, quality indicators (such as data accuracy, confidence, delay or latency of communication), availability, breadth and density of coverage.

REFERENCE SOURCES

ITS America (2000) Closing the Data Gap: Guidelines for Quality Advanced Traveler Information System (ATIS) Data available on-line at: http://ntl.bts.gov/lib/jpodocs/rept_mis/13580.html

ISO/TR 21707:2008. Intelligent transport systems -- Integrated transport information, management and control -- Data quality in ITS systems

COMMUNICATIONS

Data and telecommunications are the backbone of ITS deployments – providing the basis for system integration and regional deployment. Communication technologies are becoming more sophisticated – with increased capability at lower cost. The trend is shifting away from fixed communications (phone lines, cables) to mobile (radios, Bluetooth, mobile phones, WiFi) and use of the Internet.

A well-defined communication architecture coupled with use of standards for data exchange and physical interfaces helps ensure a harmonised approach to ITS deployments at the road-side and control centres. The choice of communications for ITS deployments is constrained by the type and capacity of communications networks that are available. The basic considerations for comparing and choosing between those available will be:

- bandwidth
- cost
- coverage of the road network
- latency (communications speed and delay)
- one-way or two-way communications
- continuity and reliability
- cybersecurity
- vulnerability to natural and man-made disasters.

Deployments must comply with any regulations imposed by the communication regulatory bodies and service companies.

There are two important levels of data communications to consider:

- area-level: information and data communications between operational centres
- local-level: data, command and control communications between roadside ITS equipment and a control centre

Area-level data communications are governed by the agreed data dictionaries and data exchange protocols – for example, the data communication protocols that link the road operators' control centre with control centres operated by the police and emergency services. Road operators can share data through data exchange mechanisms as DATEX or have a common data base/data warehouse where all authorities can take out their data needs and inputs. An example is the Dubai Data Warehouse (Big Data) project in the Middle East.

Local-level data communications require the road operator to adopt communications standards and protocols for the control systems that are used across the network using open standards so far as possible – for example, data communications for traffic signals and VMS that are carried by the roadway telecommunications infrastructure

The use of high-volume communication links is limited by the lack of fibre-optic coverage and the type of the public switched telephone network. In many cases, a mixture of wireless, copper-wire and fibre-optics are used to transport data flows between the physical components of ITS at the road-side, traffic control centres, and in vehicles.

Some countries may have invested strongly in 3G/4G cellular communications networks and smart devices with low cost telecommunications. This provides a strong base for the development of services when basic data collection and traffic monitoring systems are not yet in place – equipped vehicles can provide data on speed, weather, incidents and journey times, all of which have value for journey planning and network

monitoring.

If possible, the ITS deployment programme should not be locked into any single form of communication technology or equipment supplier. This is an area where ITS standards are critical. The choice of standards for data and communications protocols is important as an effective way of ensuring flexibility and independence of equipment supply. Poor choice of standards leading to lock-in removes the opportunity for market testing of equipment supply and economies through competitive tendering.

Use of existing infrastructure for general-purpose telecommunications reduces the time and cost to introduce ITS – and accelerates the benefits delivered to ITS users. At a later stage – with increased deployments – the use of dedicated telecommunication infrastructure can have advantages in terms of increased performance, reliability and flexibility in developing business models. (**See** Telecommunications)

ITS Communications Infrastructure in Egypt

In Egypt, the telecommunication regulatory authority in association with Egypt Telecom is actively involved in developing a communications architecture for ITS. For the deployment programme, level-of-service agreements cover the performance of the existing wired and wireless general-purpose communication networks (such as coverage, latency, packet loss and communications cost). These are to be included in an inter-agency agreement on the development of a proprietary fibre-optic cable network for the priority road corridors in the coming years.

REFERENCE SOURCES

Yokota T. and Weiland R. (2004), ITS Technical Notes for Developing Countries; Technical Note 5: *ITS System Architectures for Developing Countries*, World Bank

PROJECT PLANNING

As ITS implementation progresses from programme to project level, project planning comes into focus. This needs to cover consideration of institutional pre-conditions, the financial commitments, enabling technologies, early actions, and strategies for mitigation of any risks.

To effectively plan and deliver ITS in support of road management – the organisation responsible for project planning (such as the road authority, road operator or city authority) will need to develop a capability in a number of key areas:

- policy and planning – for example a dedicated Network Operations Planning Division – to set the strategic requirements for ITS and road network operations – and establish operating policies. For example, the headquarters team will negotiate high-level agreements with transport and other ministries and regional authorities, and develop partnerships with leading stakeholders (such as the traffic police and emergency services). Most importantly it will secure the budget for ITS projects
- a procurement and contract management team to manage the placement of contracts, conduct negotiations with potential contractors and organise the procurement of ITS-related equipment, software systems and communications. The ITS contracts team will need technical support to prepare contract documents, evaluate supplier proposals and keep track of delivery and performance
- a technical consultancy to provide technical support to the procurement and management teams to help specify the IT, communications equipment and ITS infrastructure. This could either be a specially recruited in-house team – or – more likely – an external resource that is retained on contract to provide advice on the deployment – for example:
  - the detailed functional specifications for a contract to design, build and operate a control centre
  - technical requirements for the supply, installation and maintenance of ITS equipment – such as, cameras for Closed-Circuit Television (CCTV) or for Automatic Number-Plate Recognition (APNR)

ITS covers a wide range of products and services – some of which are now very well established, for example, traffic signal coordination or motorway tolling. In all deployments, including well-proven applications, adaptation to local conditions is always necessary. This is to ensure that the application will be viable in the local context – such as the mix of traffic using the roads, norms of driver behaviour, observance of traffic law and levels of enforcement, as well as general standards of road infrastructure and its maintenance.

Transport agencies in developing economies have a lead role in identifying what local adaptations are likely to be required. If necessary, agencies can draw on the experience of visiting experts – working with local consultants – to provide an in-depth analysis of the local requirements and transportation needs. Often this is a sound basis for long-term cooperation.

Specifying these local requirements is a central part of the procurement process and will involve engagement with consultants and instructions to suppliers. The analysis will describe the requirements (such as tolerance of climatic conditions, reliability of energy supply and communications, maintenance skills, and protection against vandalism). This will inform the development of the functional and technical specifications for equipment, operations and maintenance.

“Working” and “Workable” Projects

The first step in basic project planning is to set clear objectives and targets for ITS services, taking full account of local requirements – including any dependencies (for example – whether different systems will be required to be interoperable, now or within the planning horizon). These objectives and targets need to

be agreed by all key stakeholders who are directly affected. This lays the foundation for subsequent steps – which will include the definition of interagency agreements, time scales and expectation management and evaluation criteria.

Priority should be given to implementing “priority projects” – which are assessed as:

- “working” – in terms of satisfying all technical and non-technical requirements and relevance to user needs
- and “workable” – in terms of the ability to secure finance, let contracts and manage deployment

In many cases, ITS projects are “bundled-in” with large scale investment projects for improving road transport infrastructure – to provide the necessary platform for deploying the service. For example in:

- Hefei, China, the coordinated development of major road infrastructure and Bus Rapid Transit (BRT) schemes included the provision of advanced public transport management and information services on the road corridors
- Egypt, the upgrade of major intercity routes into expressways provided the impetus for traffic monitoring, traffic management and electronic fee collection on the upgraded links

Use of Field Trials and Pilot projects

Some countries will be unfamiliar with the concept of an ITS project that is specified on the basis of performance and service criteria – and which may require system integration of equipment packages and technologies, as well as suitable contractual and financing schemes for effective delivery. Small-scale field trials may be necessary to determine the suitability of ITS hardware and systems in the local context – before making a large-scale procurement – of, for instance, variable message signs and other equipment for network management.

In many situations, proof of concept can be demonstrated and political support secured by means of a pilot project. This is compatible with a “Staged” approach. (**See** Developing an ITS Strategy) Pilot projects are appropriate for assessing project viability and applicability to the local context – and provide a basis for “training and educating” key staff who will be involved in future ITS deployments. A pilot project can lead to adaptation and fine-tuning of various aspects of a deployment: technical, organisational, financial and contractual procedures.

Conditions for Success

ITS deployments will involve new institutional working arrangements – as well as new technologies. Institutional barriers will need to be overcome through careful planning and negotiations between those who will be most closely involved in project delivery and ongoing operations. This may involve innovation in project planning, financing, and effective public-private partnerships. Coping with so many new demands, may require a paradigm shift in the approach of a road authority or other public agency – affecting their roles and responsibilities and involving new ways of working. This may take time to become established. Project development, in these cases, may require considerably more time than, at first, anticipated.

In response to the challenges there are a number of procedures that will contribute to the success of project selection and planning:

INTER-AGENCY COORDINATION

Coordination, in general, is not strong between the organisations with a part to play in road transport and those providing infrastructure and services for Information and Communication Technologies (ICT). Each body is likely to have its own priorities, established methods of working and administrative procedures. It is often necessary to create new business units that cut across traditional lines of responsibility within and between agencies to achieve a coherent approach with integrated deployment. (**See** Planning an ITS Programme and Inter-agency Working)

PUBLIC CONSULTATION

Involvement of user groups and the general public – who will be affected by the deployment of an ITS application or service – is often not undertaken at all, or starts very late in the project development process – and may put the project at risk. For example, the introduction of electronic tolling or controlled motorway procedures (lane or speed controls) would require the users to take-up the service and comply with its requirements. The scheme's objectives could be jeopardised if road users choose to ignore or avoid the ITS-based application.

To prevent this, it is in the interests of the promoters to consult widely and explain and champion the benefits through the use of mass media (TV, radio and advertising campaigns), meetings and other methods of consultation – perhaps using websites and social media. (**See** Assessment of Benefits and Case Study: Stockholm Congestion Tax)

CLEAR DEFINITION OF THE PROJECT

In some cases, ITS Strategy is seen as a "wish-list" of ITS services with projects outlined in general terms on the basis of scope, coverage and deployment plans. A clear description of candidate priority projects – in terms of location, deployment plan, technical and non-technical requirements and standards, costs, expected impacts, business model, financing options and contractual mechanism – is in many cases lacking or prone to changes over time and if there is a change of decision-maker.

To be viable for financing and deployment, projects should be clearly specified in terms of the objectives and scope, functional and operating requirements, standards to be used, partnership agreements and other roll-out plans, financing and contractual terms. When defining projects, it is advisable to include baseline measurements that can be used to evaluate performance before and after the ITS deployment (for example, introduction of electronic tolling may lead to a reduction in lost revenue). A common problem can be the lack of baseline data on which comparisons can subsequently be made easily. (**See** Indicators)

In both Hefei, China, and Egypt, baseline traffic conditions were assessed and forecast impacts were estimated to identify ITS projects for priority implementation. Those projects having the highest beneficial impact on baseline traffic conditions on the road and public transport networks were prioritised.

FINANCING AND CONTRACTING ARRANGEMENTS

Without budgetary planning and a commitment to release funds, a project cannot proceed.

In emerging economies, public funds are often needed to catalyse private investment. To avoid a situation where funding problems are the source of delays, a planned approach to project finance is often needed to encourage sure private sector investment. (**See** Budget and Affordability)

Where possible, budget calculations for projects should be done on a whole “life-cycle” basis – taking into account initial capital costs as well as the costs of operation, management and maintenance – with an allowance for technology upgrade. The need to include operational and maintenance costs (which, for ITS, may be more than 10% of the capital cost) may not be appreciated by those road network authorities that traditionally concentrate on building and maintenance of road infrastructure – rather than its operation. (**See** Road User Services and Quantifying the Costs)

Contracting arrangements to supply equipment, operate services – and perhaps, design, build, operate and maintain the ITS systems – need to be put in place. The terms of contracts should aim to minimise project failures, control costs and handle known risks effectively. (**See** Procurement)

MECHANISMS FOR PROJECT DELIVERY

ITS deployment programmes need an organisation with the capability to set-up, monitor and enforce the contract requirements. In many cases, the appointment of an independent system engineer is of utmost importance to ensure proper delivery of the project by the contractor and mitigate risk in an effective manner. (**See** Managing ITS Implementation)

Appointing an ITS Programme Manager to coordinate stakeholder inputs provides a focal point for communication about the project with the public, media and other interested bodies. The Manager’s responsibilities may extend to supervising the ongoing operation of ITS services. In some cases it may also be desirable to commission a full evaluation of the project’s impacts to provide data to demonstrate success and leverage finance for further ITS investments.

POST-HOC EVALUATION

For many countries ITS projects are in the early stages of deployment – and the economic and social benefits to an emerging economy have often not been quantified. A good understanding and application of evaluation procedures will help strengthen the case for funding commitments for further deployments. Evaluation is a way to obtain evidence and capture the experience of early deployment projects. (**See** What is Evaluation)

In summary, evaluation provides the basis for:

- testing the assumptions used in making the case for the investment
- obtaining “real-life” data to inform future investment decisions
- considering the lessons learned (inter-agency working agreements, allocation of roles and responsibilities and areas of underperformance and unanticipated risk, viability of the business case including public-private partnerships)
- assessing the contribution of the investment to the efficient operation of the transport network

While the case for evaluation is clear, a common mistake is to treat it as an optional extra and begin work too late with insufficient opportunity to collect before and after data. Part of the justification for carrying out a pilot project is to make a full evaluation of its benefits before committing to scaled-up deployment.

PRIORITY PROJECTS

In prioritising the projects that will form part of the ITS deployment programme, it is advisable to select those that have the greatest potential to make a positive impact on major transport challenges – such as road safety and the efficient movement of people and goods. The World Bank advises that projects should be:

- demand-driven, so that the introduction of ITS meets real user needs
- affordable, using a level of technology appropriate to the country or region, focusing on projects with the greatest return on investment, and making good use, wherever possible, of the experience of other countries
- staged and flexible – to allow for growth as demand increases and resources permit, and not overly ambitious in the early stages
- open to private sector participation

There will be strategic and transport policy objectives to fulfil and constraints to be factored into project selection – such as:

- the degree to which the investment in ITS supports national, regional and local transport strategies and other government priorities
- how far the investment will deal with major weaknesses in road transport and contributes to improved transport operations
- the benefits and cost-effectiveness of the proposed project(s) in meeting policy objectives and make visible improvements
- the financial viability and institutional stability for the investment
- project readiness for implementation

There may be a need to demonstrate the potential of the selected investments – perhaps through a pilot project – before making a major commitment to roll-out.

Practical criteria that will influence the selection of projects include:

- availability of qualified staff (in-house or external expertise) to coordinate the planning and delivery of ITS projects (**See** Project Planning)
- the availability, capacity and usage costs of Information and Communications Technology (ICT) infrastructure (**See** Communications)
- budgetary constraints – affecting the timing of the project, even for high priority projects with highly-positive impacts (**See** Finance and Procurement)
- public acceptance – public misunderstanding or opposition may prevent or undermine the viability of some ITS projects, such as those requiring payment or enforcement (**See** Road User Needs)

Public, politicians and user groups often want to influence ITS project selection and definition. In some cases, politicians may want to focus ITS deployment on certain road corridors and investment projects they consider to be key. Sometimes these “pet projects” will not offer best value and can consume a high proportion of the budget allocated for ITS deployments. To avoid this, the planning team must identify and apply certain essential selection criteria. Only projects that pass the required threshold for each of these criteria – including cost-effectiveness and public acceptance – should be prioritised. (**See** Appraisal of ITS projects)

TRAFFIC CONTROL

Network monitoring, management and control are at the heart of road network operations. (**See** Network

Monitoring, Traffic Control and Operational Activities)

Traffic control has always been seen primarily as a responsibility for the police – closely related to their duties to maintain public safety and enforce the law. A road operator who is proposing to introduce new methods of traffic management and control – for example computerised signal controls, VMS and a Traffic Control Centre – will need to secure the support and full cooperation of the police.

In many TCCs, police and road agencies share positions in the control room to allow for integrated traffic incident detection and traffic management capabilities on the basis of common road-side ITS infrastructure. This is the most common way to share functionality.

Long-standing procedures and reluctance to change – can be barriers to the sort of cooperation that road network management requires. Two ways of overcoming resistance is to:

- ensure clarity and understanding of the benefits to each participating agency arising from cooperation – pilot projects and field trials are one way that the various parties can work together and come to appreciate each other's position
- develop an inter-agency agreement in parallel – so that each party retains its own responsibility to serve the public as before, without surrendering control of its own systems and information

Experience shows that agreement on the allocation roles and responsibilities – such as between the traffic police and the road operator – will help the operator develop its capability to manage traffic on the network. Projects that are urgent and important from a road management perspective – are better delayed until this sort of agreement is in place.

Advanced traffic management systems are the base for launching many other ITS user services. A high priority in many countries is integrated transport corridor and urban area management – coupled with incident management and enforcement against speeding and traffic violations. Urban traffic management is increasingly commonplace.

Traffic Surveillance

CCTV camera surveillance is used for known hot-spots, such as – at-grade road-rail crossings (where a railway crosses a road or highway at a level crossing) and heavily trafficked road sections. Internet Protocol Television is an option that reduces costs considerably. It is likely that there will be a good case for developing shared facilities to meet the operational requirements of both the road authority and the police. Experience shows that CCTV coverage is particularly useful for network operations in the following situations:

- where there are high traffic flows with recurrent congestion or queues at junctions, interchanges, or where the number of lanes reduces
- at interchanges with high traffic flows where there are converging/diverging movements – or construction features such as sharp bends
- at locations such as tunnels – where traffic congestion or accidents may create dangerous environmental conditions
- on exposed bridges or motorways at locations where inclement weather conditions – such as high cross winds – frequently occur making conditions hazardous

EXAMPLES

China

More than 30 cities in China have advanced urban traffic control systems with smart detection. Speed and red light enforcement cameras are also common in most large Chinese cities.

Hong Kong

In Hong Kong, an integrated network management approach has been developed. ITS network deployments include:

- the implementation of the Transport Information System (TIS)
- area traffic control systems on urban roads
- installation of traffic control and surveillance systems along the major motorways and tunnels
- setting up the Traffic Management and Information Centre (TMIC).
- a journey time indication system
- red light and speed enforcement cameras

TRAFFIC CONTROL: CASE STUDIES

Using ITS on Motorways, Slovenia

Smart Intersections, Moscow, Russia

Urban ITS, Istanbul, Turkey

Traffic Control Systems, Pune, India

ITS to Prevent Bridge Strikes, Qatar

ROAD SAFETY

Many countries have a poor road safety record – making accident mitigation and enforcement measures a high priority, accompanied by road safety awareness campaigns. (See Road Safety)

Road safety measures need to be supported by reliable accident data of consistent quality to ensure effective deployments and analysis of their impact. Where toll roads exist, the data may be fairly complete, in contrast to other parts of the road network. In some countries, data may be recorded where the police have relatively easy access to the accident locations – but coverage may be poor elsewhere.

The World Road Association's on-line Road Safety Manual is designed to help countries – at every stage of infrastructure development – to achieve their road safety targets. It is aligned with key pillars of the United Nations Decade of Action for Road Safety 2011-2020:

- Pillar 1: Road Safety Management
- Pillar 2: Safer Roads and Mobility
- Pillar 4: Safer Road Users

New approaches to road safety – the "forgiving road system" – take into account, the vulnerability and fallibility of people. This "Safe System" approach requires everyone to share responsibility for road safety outcomes – for example, the public agencies responsible for road network planning, design, management, emergency response, automobile manufacturers, road users, enforcement bodies. Technology solutions need to be designed as part of a comprehensive road safety programme, if they are to have a sustainable impact.

Priority measures to enhance road safety include:

- speed management and control on road sections with large speed variations and high level of incidents
- traffic monitoring and automatic incident detection and management on critical road sections
- automated enforcement systems – such as speed control, red light running and heavy vehicle compliance checks – to accompany traffic management measures
- schemes that are adapted for vulnerable road users – including detection of the presence of pedestrians and cyclists and traffic signal schemes to include vulnerable road users in the signal timing plans.

Many countries are deploying extensive automated traffic enforcement schemes to curb traffic violations – in an effort to reduce the large number of road accidents. Speed enforcement schemes are popular in many countries but they need to be designed with care. (**See** Speed Management)

ROAD SAFETY: CASE STUDIES

Data to Improve Road Safety, Indonesia

Technology for Driver Training, Tatarstan, Russia

Road Safety Traffic Law Enforcement, Tatarstan, Russia

In Malaysia, a study was undertaken to evaluate the impacts of automated speed

enforcement. It showed that the benefits of automated enforcement are often focused on the road sections where the cameras are installed. Driver compliance was significantly lower in non-enforced sections – creating potential new black spots. Reliable accident reporting systems have value in enhancing understanding of conflict and behavioural issues and in identifying common causes of accidents and developing effective countermeasures.

FREIGHT TRANSPORT

Road freight transport is high in many countries. In Egypt, it accounts for over 75% of total freight transport movements. Owners and operators of commercial vehicle fleets are increasing relying on technology to better plan their logistics operations – to keep track of deliveries and know exactly where their vehicles are located. (**See** Freight and Commercial Services)

GPS can be used to track commercial vehicles to improve efficiency of operations and protect against theft. In Brazil, a law mandates that all new vehicles shall be equipped with tracking technology to encourage the development of fleet management solutions.

In addition to tracking and tracing of vehicle movements, anti-theft and vehicle recovery – new applications are being deployed in Brazil that enable fleet managers to monitor how a vehicle is being driven. This includes technologies to identify a driver and determine which drivers are compliant with regulations or not – and driver behaviour, such as hard braking or fast acceleration. Web services are offered by companies in Brazil that help fleet operators to plan routes, set alarms for certain incidents/events, monitor performance and keep track of fuel consumption and payments.

Enforcement against Overloading

Vehicle overloading above the permitted axle weight is a common problem in many countries. For the road network operator the need to reduce the amount – and extent – of vehicle overloading is of strategic importance because of the excessive damage it causes to the road structure (the “road pavement”). According to a report by Chile’s Ministry of Public Works – for every million dollars that the Chilean Government has invested in truck weight enforcement, US$20M is saved in maintenance of principal highways and US$27M saved on costs to repair secondary roads.

Enforcement against is supported by ITS technologies. It requires a means of measuring the axle loads on trucks and heavy vehicles –to identify overloading. Given the difficulty of finding suitable locations for fixed weighbridges, there is increasing interest in making use of “Weigh-in-Motion” (WIM) techniques.

WIM systems are still in their infancy and need to be trialled – not least so that the enforcement authority can develop integrated, practical procedures to support the implementation of a WIM scheme – which covers:

- how to identify, intercept and detain any offending vehicles
- the kind of field operation is needed
- how to arrange back-office support to follow-up with vehicle owners, collect fines and impose other penalties

A combination of WIM and fixed weighbridges is likely to be the best way forward. System type approval for weigh-in-motion equipment is necessary to certify accuracy and reliability. Enforcement procedures must be sufficiently robust to withstand challenge in a court of law. A field trial of the scheme may be necessary to test equipment and establish procedures. A potential outcome of field trials could be to highlight the need to amend traffic law so that evidence from weigh-in-motion equipment is acceptable in court. (**See** Weight Screening and Equipment Certification)

PASSENGER TRANSPORT

Modernisation of public transport is a high priority for most emerging economies. (**See** Passenger Transport)

Public transport improvement schemes can mean new tramways and metro lines. On the roads, the measures include priority for buses and trams, coordination with traffic signals, real-time information systems, and on-board load monitoring. GPS-based monitoring systems are being used to provide better fleet management and smoother integration between different public transport modes. This technology can form the basis of other systems – such as arrival time notification for passengers at bus stops and on-board real-time information systems.

The systems are often based initially on investment in vehicle location systems – that bring immediate benefits to bus and tram operators. Real-time information and other advances build further on this – for example, electronic ticketing and sensors which measure passenger numbers boarding and alighting at each stop. The systems may be phased in on specific bus routes and tram lines – one at a time – but should be designed from the start as area-wide systems. This ensures that they are technically capable of being extended across the full transport network – rather than limited to an experimental route. (**See** Passenger Transport Operations)

Bus Priority

Bus lanes are widely used to implement bus priority schemes and travel demand management – and ITS systems play a key role in their back-office arrangements (for example, for enforcement). Careful planning of bus and High Occupancy Vehicle (HOV) lanes is needed for maximum effectiveness – to overcome barriers to successful deployment – such as:

- lack of adequate space for the bus priority lanes and costly enforcement operations
- un-intended impacts leading to increased congestion and accidents, after conversion of a general-purpose lane to bus, minibus and taxi-only use

A city or region considering installing a bus priority network should take all of these factors into account.

Electronic ticketing

Regions that have a high proportion of users on public transport offer a potential for successful use of non-cash MOPs. (**See** Passenger fare payment) Examples are:

- Cape Town (South Africa) (**See** MyCiti)
- Bogotá (Colombia) (**See** Transmilenio)

Ride Sharing

Promotion of car sharing can help tackle recurring congestion – with relatively little capital investment. Increasingly, internet portals and smart phone applications are used as the basis for ride-sharing schemes. Car sharing is very active in Central and South America and car sharing applications are becoming more widespread across Europe and in other countries such as India, China and Egypt.

Bus Rapid Transit

In Hefei, China, the introduction of Bus Rapid Transit (BRT) schemes supported wide-spread usage of public transport fleet management systems, electronic ticketing and information services. In Cairo, Egypt,

the development of underground metro lines stimulated the adoption of smart ticketing systems and traveller information systems.

In Johannesburg, South Africa, a comprehensive, integrated ITS programme supports the Rea Vaya Bus Rapid Transit (BRT). This consists of GPS-based Automatic Vehicle Location (AVL), an operations control centre, traveller information, CCTV for security and station management, scheduling packages, traffic signal priority schemes, and fare collection.

PASSENGER TRANSPORT: CASE STUDIES

Automated Fare Collection, Bucharest, Romania

Integrated Smartcard Ticketing, Riga, Latvia

Public Transport & Bus Rapid Transit, Sao Paulo, Brazil

ELECTRONIC PAYMENT

Electronic payment is a well-tried option to improve the efficiency and effectiveness of tolling schemes on roads. (**See** Electronic Payment)

Electronic toll collection systems (ETC) have been deployed in many countries – and the motivation is often the revenue stream it provides for investment in other infrastructure. Often ETC deployment is based on a state-owned enterprise contracting a private sector operators to build (or upgrade) the road and operate the tolling scheme. (**See** Public-Private Partnerships)

Electronic toll collection schemes require careful planning. The objectives must be clearly set and prioritised. All technological options (such as DSRC, GPS, licence plate readers, smart cards) should be considered. Winning public support is essential. This requires engaging the public and stakeholders – explaining and promoting the scheme, and encouraging constructive and well-informed discussion about the proposed project. (**See** Technologies & Processes)

For ETC systems that coexist alongside manual toll collection, incentives need to be provided for non-users to opt for ETC – for example by offering discounts on tolls and tags or providing exclusive toll-gates dedicated to ETC users.

For non-stop free-flow ETC systems, the routine cooperation of almost every user is necessary – since it is financially prohibitive and impractical to enforce if there are too many violators. If public acceptability for tolls is low, and the risk of payment evasion is high – a physical barrier to control the flow of vehicles is likely to be the most practical option, even if an accurate vehicle register exists. To work well, ETC requires a high proportion of vehicles with registered accounts – and high level of understanding and acceptance

amongst road users, that they have to pay. (**See** Back Office Arrangements and Enforcement)

A firm policy on exemption requests for any payment scheme is also necessary. Granting too many exemptions puts a heavy burden on the remaining users, who have to pay more to make up for the free users.

Smart Card and Mobile Phone Payment

In some developing economies, banking systems may not be well integrated. In this case, a stand-alone smart card system provides an attractive option for public transport ticketing – and is a way to encourage multi-modal use of public transport – is a single card payment scheme. Payment schemes using mobile phones are another option and have been successfully introduced in several countries for public transport and parking payment.

An example is in Beijing, China, where the city pioneered a new Near Field Communication (NFC)-based way of paying for bus and subway rides. It is known as an "e-Surfing Traffic Card" programme. It combines near-field communication with a programme that pairs riders' traditional electronic fare cards with their mobile phone devices. This allows customers to pay for fares using their phones and an existing fare card balance. It also allows them to pay for rides and reload their cards using their mobile phones and near field communication portals located throughout the city.

ELECTRONIC PAYMENT: CASE STUDIES

Upgrading the Toll Road System, Turkey

Free-Flow Distance Based Electronic Toll Collection, Taiwan

Near Field Communications for Public Transport Ticketing, Turkey

TRAVELLER SERVICES

Pre-trip and en-route traveller services are of growing importance in countries with emerging economies. (**See** Traveller Services)

Traffic information services are available in almost all countries with ITS deployment programmes. The combination of high market penetration of the internet, broadband and mobile cellular phones – along with increasing private vehicle ownership – provides a user base. (**See** Travel Information Systems)

An attractive and economically cost effective means of broadcasting traveller information services across limited road sections – is the use of FM radio subcarrier. In China, Digital Audio Broadcasting (DAB) is increasingly used to transmit traveller information to users. (**See** Radio)

Advanced traveller information systems require the developer to be responsive to user requirements. Travellers need high-quality information about their journeys – before and during their trips. Important features include route guidance, information on location-based services en-route, congestion, likely delays, planned and unplanned events impacting on the road network, and weather conditions. (**See** Location Based Services)

The quality of travel information involves a range of criteria, all of which are important to users:

- accuracy
- timeliness
- cost
- coverage
- continuity of service
- relevance to the user
- ease of use

Travel information providers have found that comprehensive and continuous coverage is very important for their users – whilst traffic information from motorways and other main roads needs to be collected and made available in real-time, 24 hours a day, seven days a week.

Social networks – for example, Facebook and Twitter – can play an important part in road network management as channel for providing information about:

- the occurrence of traffic incidents and disruption to the network (such as flooding and other road closures)
- warnings of planned road closures and bridge maintenance
- reports and forecasts of exceptional traffic congestion and long delays

The road operator manages the links between public-sector data availability (open access) and public/private sector value-added services (paid access or free at point of use).

Variable Message Signs

Electronic Variable Message Signs (VMS) – placed at the roadside or mounted on gantries above the road – are a primary means of reaching drivers in real-time with advisory or warning information. Older forms of VMS relies on text – but modern VMS makes use of LED technology to display pictograms.

Public investments in VMS can be justified to achieve safety objectives – or manage congestion, when there are long traffic delays and high traffic volumes. VMS for warning drivers about incidents or congestion, are generally installed close to known trouble spots and at strategic points on the network where routes diverge. (**See** Use of VMS)

TRAVELLER SERVICES: CASE STUDIES

Travel Information System, Attika, Greece

Real Time Passenger Information, Macedonia