Passenger Transport ITS Toolkit

Handbook

Foreword

The **Passenger Transport ITS Toolkit** is part of a comprehensive library of reference and capacity building resources. They have been prepared by the World Bank for policymakers and senior technical managers in urban transport. This particular resource is part of a public transport toolkit suite, including the **Urban Bus Toolkit** and the **Public Transport Fares Toolkit**.

The objective of the toolkit is to provide a basic understanding of all aspects of Intelligent Transport Systems (ITS) for urban passenger transport related to improving both the internal efficiency of public transport providers and the customer service. The toolkit serves as a step by step guide that helps urban transport leaders, and the organizations they lead, to plan, design and implement ITS to improve the efficiency and attractiveness of the passenger transport system in their cities.

It provides capacity development support in understanding:

- The basic characteristics of ITS
- Evaluation of public transport planning, management and operations functions in assessment of the needs for potential ITS applications
- ITS system inputs, outputs, information processing, communications and system architecture requirements
- Estimation of the initial implementation and ongoing operating and maintenance costs of ITS and its benefits

The target users for the toolkit are policy and investment decision makers in cities considering whether to introduce or enhance ITS applications in management of urban passenger transport. The focus of the toolkit is on public transport; it does not seek to address the full domain of ITS applications for other modes such as the private car or freight transport. The applications covered in the toolkit are based on an initial needs assessment relating to the functions that are applicable to the delivery and use of public transport systems. Issues related to fare collection systems are covered in greater depth in that referenced toolkit.

The toolkit is based on field research in the first half of 2011, and thus represents general international practice at that time. However, ITS is a constantly developing sector, both in its applications and its technologies. The interested reader will be able to examine the latest developments through links to live sites that are provided in the website part of this toolkit. There is also a wide range of suppliers of the applications and technologies, and each has their own websites where more information can be found.

This ITS Toolkit consists of three parts:

- A short Companion Guide which provides a brief introduction to the Toolkit and the material it contains, and instructions for the use of the website;
- This Handbook, which provides the policy and investment decision makers with a basic understanding of ITS for urban passenger transport, and guidance for its implementation;
- A Website, which elaborates the contents of this Handbook, and provides more detailed information for the implementer.

The Toolkit has been prepared under the supervision of Ajay Kumar, OP Agarwal and Sam Zimmerman from the World Bank, and has been funded by a grant from the South African Trust Fund for African Energy, Transport and Extractive Industries (SAFETE).

Overview

ITS definition and characteristics

Intelligent Transport Systems (ITS) are a suite of public transport planning, operations management and customer service applications that are enabled by advanced information and communications technologies. They act to enhance the effectiveness, efficiency, and usability of the public transport service offer to the benefit of public transport authorities, operators and passengers.

Intelligent Transport Systems involve customized, situation-specific applications to address specific functions. They utilize a mixture of proprietary and generic technologies for that purpose. They utilize multiple data sources, mostly in real time, and enable a direct affect on outcomes which are usually not possible without the ITS application. The main application areas in conventional fixed route, fixed schedule urban passenger transport are:

- Operations Management;
- Driver Aids;
- Fare Collection;
- Traveler Information;
- Traffic Management;
- Security.

ITS can be used to support other public transport planning and business process functions for conventional public transport. They can also be used to support the unique needs of the operators and users of demand-responsive public transport. Public transport ITS systems often interact with the ITS systems that support other urban transport modes (e.g. commuter rail, metro).

In general, ITS is comprised of a number of sub-systems and technologies, many of which support more than one application. For example, Area Traffic Control (ATC) "smart" traffic signal systems can provide support to public transport priority or automatic public transport vehicle location applications.

Toolkit structure

The toolkit website is comprised of five parts, with interactive linkages among each of these:

- *ITS Program Guidance* – the step-by-step process that should be followed for the Planning; Design; Implementation; and Evaluation of the proposed ITS system.
- *Public Transport Functions* – the public transport planning, operations management and customer service activities that might be supported by ITS systems, considered at the Strategic; Tactical; Operational; Support; and Statistical levels.
- *ITS Applications* – the use of ITS for these functions, clustered as Operations Management; Driver Aids; Fare Collection; Traveler Information; Traffic Management; Security; Demand Responsive Transport; and ITS-facilitated Functions.
- *ITS Technologies* – the technical systems and hardware required by these ITS Applications, grouped as Automatic Vehicle Location; Driver's Console; Operations Control Center; Driver Monitoring; Vehicle Monitoring; In-vehicle Data Hub and Processor; Electronic Fare Collection;

Travel Information Displays; Surveillance Equipment; Vehicle Identification; and Communications.

- *Case Studies* – covering the ten cities or urban areas in which field research was undertaken, namely: Accra, Ghana; Cebu, Philippines; Colombo, Sri Lanka; Dublin, Ireland; Florence, Italy; Izmir, Turkey; Johannesburg, South Africa; Mysore, India; Prince William County, Virginia, USA; and Zurich, Switzerland.

These strands and their component parts are presented in this document. More detailed information is provided on the related website. The website has a number of additional support features, including a Site Map to help the reader to locate relevant material; a Glossary listing abbreviations and acronyms used throughout the text; a listing of References and ITS-related Publications; and links from the Passenger Transport ITS Toolkit website to other resources including the Urban Bus and Public Transport Fares toolkits, and external ITS-related sites.

For the purposes of this toolkit, an "authority" is assumed to be the public entity involved in the strategic planning, investment decision making and regulatory oversight of public transport in the respective metropolitan area or city, while the "operator" is the entity, public or privately held, that actually delivers the public transport services.

User access instructions

This toolkit can be entered in a number of ways, depending on user needs and the purpose of the visit. The following suggestions are made:

Decision-makers

Policy and investment decision-makers in local governments or transport authorities, transport executives, transport regulators, and transport operators should enter the toolkit at the ITS Planning level of the ITS Program Guidance notes. This may lead them to consider the Public Transport Functions that they seek to improve and the ITS Applications that are relevant for that purpose. The ITS Applications section then indicates the necessary ITS Technologies, and hence the further applications that these might support, and also suggest Case Studies in which the applications have been implemented. Arising from this, functional specifications can be prepared.

Transport managers

Managers of the relevant transport bodies charged with designing and developing the selected ITS application(s) should enter the toolkit at the ITS Design level of the ITS Program Guidance notes. They could then avail of the relevant ITS Applications, ITS Technologies, and Case Studies. At the end of this process, they would direct the preparation of a technical specification and procurement documentation. Following the implementation, they would also perform an ITS Evaluation of the system based on the preparation approach suggested in the ITS Program Guidance notes.

Technical task managers

Technical managers charged with the procurement, installation, and operationalization of the specified ITS application(s) should enter the toolkit at the ITS Implementation level of the ITS Program Guidance notes. They are likely to be working with external consultants and contractors with far greater detailed knowledge of the subject, and hence they need their own independent resource better to inform themselves. To that end, they would also avail of the relevant ITS Applications, ITS Technologies, and Case Studies.

Decision process for implementing an ITS program for urban passenger transport

1. Is there an effective strategic framework for passenger transport in your city?

   Not really: Lobby to place passenger transport higher on the political agenda for the city.
   Yes: Proceed to Step 2.
   Resource: Use 'Public Transport Functions' to identify passenger transport strategic issues

2. Does the passenger transport system need to be fundamentally reformed or just improved?
   Reformed: Use the Urban Bus Toolkit: www.ppiaf.org/UrbanBusToolkit
   Improved: Proceed to Step 3.

3. Are there clear priorities for improvement of the passenger transport system?

   Not really: Consult with user groups and operators to identify priority action areas.
   Yes: Proceed to Step 4.
   Resource: Use 'Public Transport Functions' as a framework to assess transport system deficiencies.

4. Is fare collection the priority action area?

   Yes: Use the Public Transport Fares Toolkit:
   No: Proceed to Step 5.

5. Are priority improvement action areas amenable to ITS?

   Not really: Avoid ITS; use less complex, conventional approaches to system and process improvement.
   Yes: Proceed to Step 6.
   Resource: Use 'Public Transport Functions' to assess the benefits and cautions related to ITS for the identified priority action area. Use 'ITS Applications' to understand the suggested approaches in greater detail. Read 'Case Studies' that relate to those applications.

6. Is the priority action area within the Authority or the (private / public) Operator domain?

   Operator: Find incentives to encourage public support for an ITS program through the Authority.
   Authority: Proceed to Step 7.

7. Is the Authority prepared for fundamental changes in the public transport business and service processes to fully use ITS capabilities?

   Not really: Avoid ITS; use conventional approaches to system and process development.
   Yes: Proceed to Step 8.

8. Is there a budget potentially available to implement an ITS program?

   No: Avoid ITS; use conventional approaches to system and process development.
   Yes: Proceed to Step 9.

9. Do you have the management resource available to plan an ITS program?

   No: Commission a Pre-Feasibility Study from appropriately qualified consultants.
   Yes: Empower a management team to execute the planning process and prepare a functional specification and outline budget justification for the proposed ITS program.
   Resource: Use the 'Planning' section of the 'ITS Program Guidance' to brief the management team, or write Terms of Reference for the external consultant. Use 'ITS Applications' to define the technical options for them to consider.

10. Does the ITS program, as planned, meet your set objectives within your resource constraints?

    No: Re-plan the system at a lower scale of complexity and cost; or avoid ITS, and use conventional approaches to system and process development
    Yes: Commission a Feasibility and Detail Design Study to prepare technical specifications and supply-tender documentation, and provide an economic evaluation. Establish functional evaluation criteria, and define base-level metrics.
    Resource: Use the 'Design' section of the 'ITS Program Guidance' to brief the management team, or to write Terms of Reference for the external consultant. Use 'ITS Applications' to define the technical options for them to consider. Use 'ITS Technologies' to identify additional opportunities arising from the preferred approach.

11. Are there other city-level initiatives with which the ITS program would need to be compliant?

    Yes: Ensure that ITS program designers are fully aware of interface issues and protocols, particularly in the domains of area-wide traffic control systems and information and communications technologies.
    No: Proceed to Step 12.
    Resource: Use the 'Design' section of the 'ITS Program Guidance' and 'ITS Technologies' to understand the potential issues in these domains.

12. Does the ITS program, as designed, still meet your set objectives within your resource constraints?

    No: Re-design the system at a lower scale of complexity and cost; or avoid ITS and use conventional approaches to system and process development.
    Yes: Procure and install the ITS system(s), and adapt business processes to take advantage of the opportunities created.
    Resource: Use the 'Implementation' section of the 'ITS Program Guidance' to manage this process.

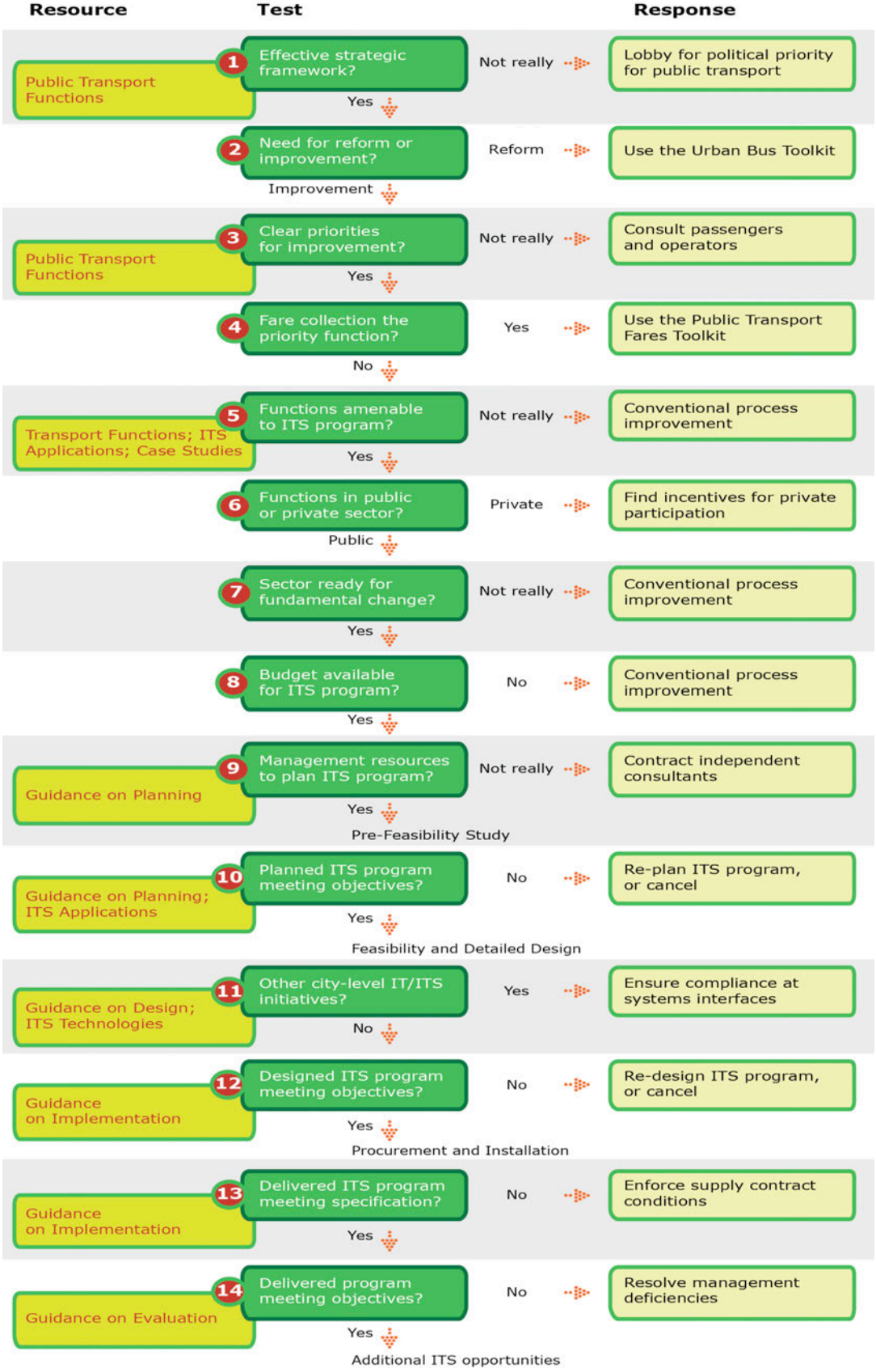
13. Does the ITS program, as installed, meet your contract requirements and technical specification?

    No: Pursue the program contractor(s), and enforce the supply contract conditions.
    Yes: Proceed to Step 14.
    Resource: Use the 'Implementation' section of the 'ITS Program Guidance' for advice in this area.

14. Does the ITS program, as installed, still meet your set objectives within your resource constraints?

    No: Identify where the changes in business and service processes that were planned in the ITS program are not being achieved, and resolve the management issues causing this.
    Yes: Investigate additional ITS opportunities, using the savings from implementation of the initial program to fund their implementation.
    Resource: Use the 'Evaluation' section of the 'ITS Program Guidance'.

Flowchart for decision process



Key Considerations

1. Intelligent Transport Systems are not an end in themselves; rather, they may be an important means for achieving a broader end. It is important to identify the goal(s) for the transport improvement program before examining the appropriateness of an ITS-led approach.
2. Intelligent Transport Systems will not mend a broken or poorly organized urban passenger transport system; ITS can only act to enhance one that is already reasonably effective. For deeper reforms, use the Urban Bus Toolkit: www.ppiaf.org/UrbanBusToolkit
3. Intelligent Transport Systems are only truly effective where there is a willingness to change organizational and operational procedures to take advantage of the opportunities being created. Using technology to do the same things as before will make little difference to the overall outcome.
4. You will only fully understand the potential of Intelligent Transport Systems when you start to change operational procedures, and then you will be able to refine their application. Many cities have only been able to take full advantage of ITS in their second or third implementation programs.
5. Intelligent Transport Systems are usually not cheap to implement, and they might not have an obvious direct financial return. ITS may assist many aspects of the business, though, and enhance the usability of the system and the customer experience so as to retain or increase ridership.
6. All Intelligent Transport Systems have an ongoing management and maintenance cost, which may be quite significant. Unless there is an ability and commitment to meeting these expenditures, and capacity to do these tasks effectively, then an ITS program should be simplified or not implemented.
7. Intelligent Transport Systems are often easier to fund in the public sector, where returns may be evaluated against economic as well as financial criteria. However their opportunity cost should be assessed against other local expenditure priorities, especially where resources are constrained.
8. Commitment to an Intelligent Transport Systems program by an Authority risks capture of the process by its potential suppliers. The Authority needs to develop its own management and technical capability so as to counter this; the ITS Toolkit is a valuable resource for this purpose.
9. It is very difficult to impose Intelligent Transport Systems on private operators unless they can see the potential for direct financial returns. ITS programs focused on ‘control’ of operators are unlikely to prove any more sustainable than similar enforcement measures in the sector.
10. Electronic fares collection may prove to be the Intelligent Transport System with the highest financial return. Any success in this domain could both act as a technical platform and provide funding support for future programs. Use the Public Transport Fares Toolkit for further advice.

Layout of the Passenger Transport ITS Toolkit

This Toolkit consists of five main sections:

ITS Program Guidance

- Planning
- Design
- Implementation
- Evaluation

Public Transport Functions

- Strategic
- Tactical
- Operational
- Support
- Statistical

ITS Applications

- Operations Management
- Driver Aids
- Fare Collection
- Traveller Information
- Traffic Management
- Security
- Demand Responsive Transport
- ITS-facilitated functions

ITS Technologies

- Automatic Vehicle Monitoring
- Driver Monitoring
- Vehicle Monitoring
- In-vehicle data hub
- Electronic Fare Collection
- Traveller Information Displays
- Surveillance Equipment
- Vehicle Identification
- Communications

Case Studies

- Dublin, Ireland
- Florence, Italy
- Izmir, Turkey
- Prince William County, USA
- Zurich, Switzerland
- Johannesburg, South Africa
- Mysore, India
- Accra, Ghana
- Cebu, Philippines
- Sri Lanka

ITS Program Guidance

This Guidance is designed to assist stakeholders who will face decisions about deployment of ITS in urban passenger transport. The primary audience is policy-makers, investment decision-makers and managers of transport authorities and transport operators, but it is also useful for many other stakeholders.

An ITS project is not just a technology project. ITS deployment can have significant impacts throughout the organization. It needs to be viewed from the outset as a corporate project. The design of any ITS systems should respond to clearly-stated needs of the transport authority and/or operator. All of the key policy-makers and senior managers of the transport authority and/or transport operator needed to be involved at every stage, especially at the project formulation stage.

ITS for urban passenger transport consists of a wide range of systems including:

- Operations management systems and control centers
- Traffic signal priority
- Fare collection systems
- Real-time traveler information systems and journey planners
- Demand-responsive transport support systems
- Driving and driver support systems
- Driver and vehicle monitoring systems
- Safety and security systems
- Planning and resource management tools

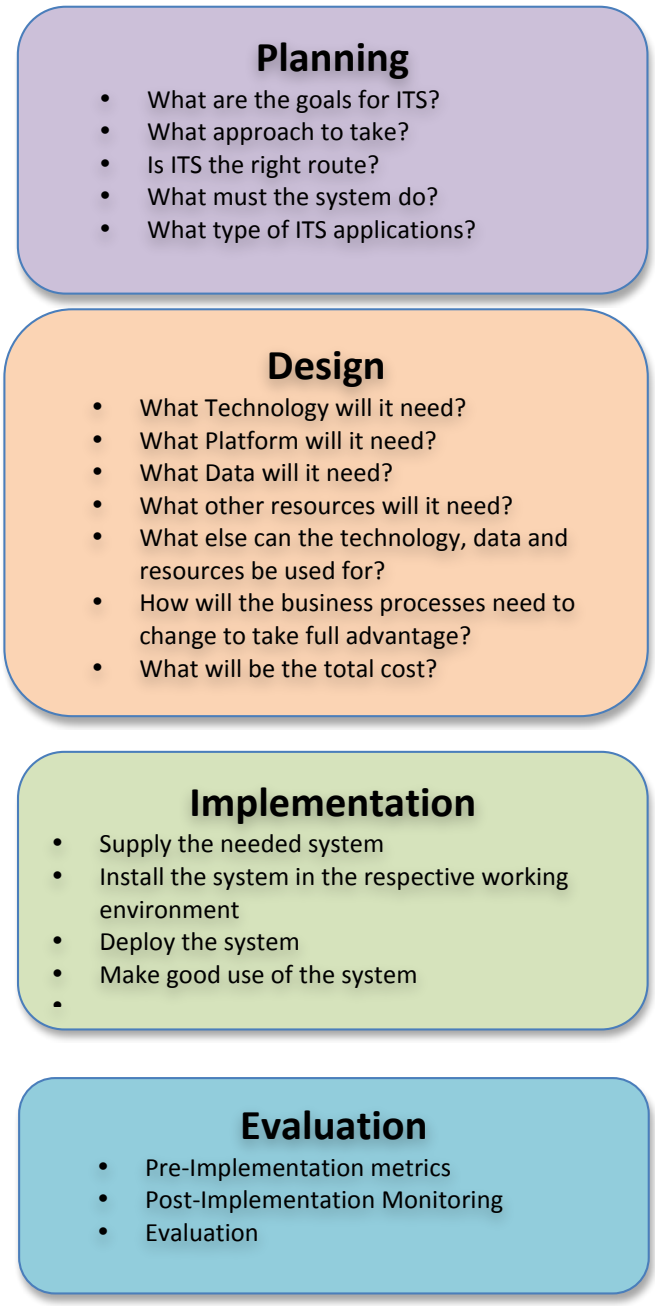
A wide range of international experience has shown that there is far more to ITS than just purchasing and installing equipment. In almost all cases, ITS involves significant change in the business processes of transport operators, and the services offered to the customers. In many cases, the deployment of ITS has led to organizational and business model changes.

This Guidance is structured according to the three main phases of an ITS deployment project, plus an often-forgotten fourth phase (Evaluation):

- Planning
- Design
- Implementation
- Post-implementation monitoring and Evaluation

Each of the four phases is elaborated at two levels. The first level provides concise Guidance, highlighting key actions and messages. The second level provides more detailed guidance on each of the 19 different Guidance themes.

The Guidance is structured as follows:



It is recommended that Toolkit users begin by reading through the first-level material, especially if they are relatively new to ITS. This will provide a good overview of the 'end-to-end process'. It will also introduce many of the key messages, and help users become more familiar with the subject. More extensive guidance can be found in the more detailed second-level pages on the ITS Toolkit website.

Please note that this Guidance section of the Toolkit does not elaborate either on the technical aspects of ITS or on the transport functions to which it might be applied. The technical information is presented in the ITS Applications and the ITS Technologies sections of the Toolkit.

Guidance on Planning

The Planning phase is a structured process to determine what the ITS is required to do, and how this fits within the broader corporate service, operations and management strategy. It begins with the scoping of objectives and requirements, and the scoping of the ITS project. It identifies the functional requirements for the ITS system(s), and develops the technical concept that will be used.

The Guidance presents 5 planning steps:

- What are the goals for ITS?
- What approach to take?
- Is ITS the right route?
- What must the system do?
- What type of ITS applications?

The Planning phase provides a sound basis for the subsequent technical design of the ITS system.

1 What are the goals for ITS?

Themes: Problem assessment; Opportunity analysis

Goal-setting is the first step in purchasing and deploying any ITS. Everyone needs to be clear on the reasons why the ITS system is being bought, and how it is meant to assist the public transport organization, users and other stakeholders. Goal-setting is a strategic task, which should be carried out by the decision-takers and the management layers of the relevant stakeholders.

The Goals of ITS systems vary widely. International experience shows that ITS systems are usually implemented to solve problems (e.g. decline in service quality and disruptions due to traffic congestion), to improve performance (e.g. dispatch management), and to provide information needed for improved management and productivity (e.g. MIS, scheduling). In many other cases, ITS is implemented to introduce new services to the customer (e.g. real-time passenger information) or to avail of opportunities (e.g. link to the traffic signal system for priority for buses).

The Goal-setting process ensures that the key stakeholders have a shared understanding, that the ITS is relevant to the public transport business, and that the technical designers and implementers are given clear guidance.

2 What approach to take?

Themes: Analysis of Needs; identification of necessary functions;

The Goals represent the strategic approach. The next step is to derive a set of Needs and Solutions from the stakeholder Goals.

The 'Needs' are high-level requirements of the organization(s), that set the context in which the ITS system will be designed and deployed. Examples include "achieve higher operating speed", "reduce variability of journey times", or "minimize accidents or unsafe driving". When all relevant Needs have been identified and linked, the stakeholders are in a better position to consider how to solve them. The output of this activity would be a Needs Assessment or User Requirements document.

Having identified the organizational Needs, various Solutions are identified and analyzed. 'Solutions' are the approaches the organization(s) can take to meet their Needs. The Solutions are typically at

organizational, operational or customer services level. For example, if the Need is “reduce variability of journey times”, one Solution could be “establish an effective Operations Management capability”.

The means of implementing the Solutions is part of this consideration. Note that ITS is an enabling technology, and not a solution in its own right. The role for ITS should be carefully considered, including how it relates to the organizational and operational elements of the preferred Solutions.

3 Is ITS the right route?

Themes: Is there a suitable non-ITS alternative? Is there a better balance of technology and method?

It is always worthwhile to consider whether the goals could be achieved without ITS, even where it is certain that ITS will be implemented. The stakeholders should ask themselves: “If ITS was not available to us, how much of our goals could we achieve by improving our organization, our methods, and our personnel?”

In a few cases, it may indeed be possible to achieve the main goals without deploying ITS. In far more cases, the exercise will reveal improvements that should be made whether or not ITS is implemented. Unfortunately, these are often overlooked when the focus in on the new technology.

For example, the real underlying problem could be that units within the organization are not well co-ordinated; that work processes have not been updated in years; that there is weak supervision and little accountability; or that the primary causes of lost trips are breakdowns and absenteeism. These are management issues, and technology will not solve them. More importantly, if they are not identified and resolved in parallel to the technology deployment, the ITS will not achieve the expected benefits.

4 What must the system do?

Processes review; Opportunity analysis; Functional requirements; ITS application potential; Anticipated benefits

Having decided strategic requirements and the tactical response, the next step is to describe in detail how this will be implemented. This is more fundamental than just describing what the ITS equipment itself is required to do. It must begin with a thorough understanding and review of the organizational structure, its business processes, and the operational processes within which the ITS system will sit.

ITS systems are very powerful and potentially business-changing tools. However, two of the greatest and repeated failings of ITS deployment are:

1) systems are designed from the outset to replicate much of how things were done previously
2) insufficient attention (if any) is given to organizational structures and processes changing for the better.

The consequences are that on one hand it misses out the real benefits that the ITS can bring, while on the other it constrains the ITS for the future and leaves it with legacy inefficiencies.

Good practice is to carry out the following steps:

- Carry out a full process review for all of the functional areas within the scope of the ITS analysis
- Carry out an Opportunity Analysis to see where and how these processes and their organizational structures could be improved
- Define all new and amended processes
- Develop the Functional Requirements for the ITS, with clear linkages between the processes and the ITS functions

- Define the new Operating Procedures

This is likely to be an iterative process. The detailed design will provide a greater understanding of the technical opportunities and constraints, costs, and how the ITS will be used in service. It may be necessary to review and revise the Functional Requirements when financial and other implications are clearer.

“Functional Requirements” are a detailed description of the relevant business processes and what the system and its components are expected to do to assist them. They provide the primary reference for the technical design of the ITS.

It is advisable to make a first estimation of the Anticipated Benefits of the ITS. This will give an indication of whether the ITS systems are likely to meet stakeholder expectations, and whether the investment would be justified. If first indications are that the anticipated benefits are insufficient, then obviously it is better to revise the approach before proceeding to design.

5 What types of ITS applications?

Technical concepts; Options analysis; Budget setting; Pre-feasibility

Having determined the functions the ITS system needs to perform, the next step is to develop a number of potential Technical Concepts and assess which one is most appropriate to the specified requirements.

It is very important to keep an open mind at the Technical Concept stage, since there are many possible solutions. The technologies are constantly changing, offering new approaches, new products, and new cost propositions. Predetermining the outcome due to personal preferences, vendor loyalty, determination to use legacy systems, etc. can have significant and avoidable consequences on performance and cost. While there may indeed be benefits from working with long-standing suppliers or utilizing legacy systems, these choices should be outputs from the analysis, and not starting points.

The User Requirements and Functional Requirements will be major determinants of the technical concepts which are considered. Other influencing factors will be current and emerging practice in the transport sector, existing ITS systems, installation environment, available means of communication and data transfer, available IT support, costs, development risk and deployment risk.

The nature of the transport entities may also have a significant impact, especially the corporate form, number of operators and number/size of vehicles. Large, especially subsidized public companies operating big buses are likely to go for “infrastructure heavy” solutions, which involve a significant degree of in-vehicle equipment, centralized computer systems and attendant communications technologies. By contrast, both small companies and operators of small vehicles are unlikely to be able to afford complex systems. They will seek “infrastructure light” or “infrastructure minimal” solutions that are based on low-cost devices (e.g. mobile phones) and use public domain communications channels (e.g. GSM).

An Options Analysis would consist of two phases: analysis of the Technology Concept Options, and then analysis of the Detailed Technology Options. The assessment framework would consist of factors such as functionality, performance, investment cost, lifecycle cost, expandability, complexity, deployment risk.

A preferred Technology Concept should emerge from this process, which would proceed to more detailed design. It may be a practical option to develop the concept as a migration path. In this case, the ITS is implemented at one level and then developed over time as need, technical capacity and funding permit.

A preliminary costing should be prepared and presented to the relevant stakeholders to guage the willingness to finance it, as there is little point in persisting with this approach if the funding will not be available.

Guidance on Design

The Design phase covers all aspects of the detailed technical design and how the system will be embedded in the organization. At the end of the Design phase, all technical issues should be fully determined. A reasonable estimate of implementation and ongoing costs should have been made and approved. It is quite possible that the initial Functional Requirements will be revised as the design process increases the understanding of what can be achieved, or in light of the emerging cost estimates.

The Guidance presents 7 steps in the Design phase:

- What Technology will it need?
- What Platform will it need?
- What Data will it need?
- What other resources will it need?
- What else can the technology, data and resources be used for?
- How will the business processes need to change to take full advantage?
- What will be the total cost?

At the end of the Design phase, the ITS project should be ready to go to procurement. This may still require a final corporate decision to proceed with the proposed project and/or approval of the associated funding.

6 What technology will it need?

Themes: On-vehicle; In stations; On highway; Back-office; Communications

The Technology Concept will have determined the broad approach. The next step is to determine the specific technology solution. This includes the systems to be used; the device types; where they are located; the distribution of function and intelligence; and how the various elements communicate with each other. The output from this step is selection and a detailed description of the ITS technologies to be deployed.

For most entities implementing ITS, especially those doing so for the first time, identifying the needed/suitable technology will draw heavily on current practices within the industry. While some adaptation will always be required, it is normal to identify what other successful Operators or Authorities are using, and to take this as a reference point. This is a safe approach if steps 1 to 5 have already been taken and if there are resulting well-developed Functional Requirements and Technology concept based on an analysis of goals and needs.

The technologies to be used need to be considered from four perspectives:

- *System/sub-system*: The functions performed by the ITS system, e.g. Operations Management, Fare Collection, Surveillance, Precision Docking
- *Location*: Where the technology is located, e.g. on vehicles, at the control centre, at bus-stops
- *Technology type*: The nature of the device, e.g. customer-facing equipment, sensors, data processor, communications device, data storage units
- *Role*: Generate data (e.g. sensor), process data (e. g. card reader), display (e.g. at-stop information display), analyze data (e.g. dispatch support), optimize resources (e.g. scheduling)

Many devices have multiple embedded components and they may perform multiple functions. For example, a suitable GPS-enabled mobile phone may now be sufficient to support AVM functions, where previously it would have required a radio, a GPS unit, a driver interface/console and an integrating

processor. Similarly, individual devices may now perform multiple functions, or a suitable combination of two devices and shared processing may eliminate the need for a third device.

7 What platform will it need?

Themes: System Architecture; Communications

An ITS System consists of many interconnected devices, software and information. At a minimum, they need to be able to connect to each other and exchange information. The ITS systems and sub-systems may need to be able to perform tasks together. In many cases, the new ITS systems will need to interface with the existing or legacy systems of the transport entities, or interface with external systems such as the traffic control centre.

Correct interfacing of systems can only occur if it has been properly planned for. This is one of the most underestimated aspects of ITS systems. It is all-too-often ignored or given minimal attention until procurement or even operation is well advanced, and then problems start to emerge (e.g. during installation). By this stage, it can be very costly and/or time-consuming to resolve. Sometimes, fixing the problems (or even admitting to them) is considered so much trouble that the consequences are left to someone else to solve later and the problems are lived with until they can no longer be ignored.

Examples of avoidable problems (which are often encountered in ITS deployments) are:

- Problems with wiring and installation of different ITS equipment on buses, due to a lack of a comprehensive wiring and communication diagram
- Inability to connect new devices to existing ones because there are not enough physical connector points, and/or the software in the existing devices cannot recognize the new ones
- Inability to interface different ITS systems because the data elements are defined differently and use different coding. A comprehensive data model would have avoided this.

The main ITS “platform” concept elements are:

- The *System Architecture*, which provides a ‘blueprint’ of all the ITS systems and how they relate to each other
- The *Communications Architecture*, which defines both how the systems and devices talk to each other, and the content of the information to be exchanged
- The *Data Model*, which provides a consistent definition of all data to be used in the transport entity, so that each (sub-)system describes the same things in the same way
- *Interfaces*, which define the physical connectivity between devices and the protocols used for information exchange
- *Standards*, which ensure that both Vendors and Clients develop hardware and software in a common way, usually based on international industry consensus

The ITS deployment team will determine the appropriate platform elements. Ideally, they will select international norms that reflect industry practice, and they will select relevant elements of such norms. This can lead to significant benefits in terms of robustness of design, and ability to source different vendors for different ITS (sub-) systems without compromising the ability to interface the (sub-) systems.

It should always be remembered that all reputable suppliers are used to working with international norms and to interfacing with the equipment of other suppliers. It is usually no additional burden for suppliers to conform with standards or to work with other suppliers. In most cases, it only becomes a problem when the Client fails to provide a common framework within which to work, or favours one supplier over the others.

8 What data will it need?

Themes: Data from technology; Existing MIS data; Other data sources

Having defined the platform, it is necessary to define the specific data requirements associated with the ITS systems. The application software of ITS systems is highly dependent on data. It is also the task of many ITS applications to generate, collect, store or transfer data. The data requirements will come into a number of broad categories:

- Support data which the ITS system needs to carry out its functions (background data, configuration data, daily assignment data)
- Real-time or event/transaction-specific data which the ITS requires when it is performing a specific function. It may generate this data itself, or receive it from another device or system
- Data which the ITS system should pass to devices, both for immediate and downstream use

This is a technical task that requires expertise and experience. There is considerable scope for transferring and re-using materials from industry good practice and from other successful ITS systems. Nonetheless, it is very important that any such replication is carefully adapted to the needs of the deployment site, and is fully compatible with the Functional Specifications and the site Technical Design.

9 What other resources will it need?

Themes: Infrastructure; Back-office; Human

Occasionally, an ITS system may be free-standing or can be plugged into existing ITS systems without any other requirements. However, most ITS systems are not independent and they require supporting infrastructure and back-office support. Three particular aspects need to be considered:

- The ITS system may need to share some of the IT platform of the host organization (e.g. servers, communications, operating systems). Platform capacity may need to be increased and additional user licenses purchased.
- The ITS system may need to interface with the existing administrative and/or management IT systems. System software amendments may be needed.
- The ITS systems may also need non-ITS supporting technology including communications, servers, back-office PCs, printers, office software and security software.

These requirements need to be identified, specified and budgeted for as part of the ITS system design and planning.

10 What else can the technology, data and resources be used for?

Themes: Technical concepts; Options analysis; Budget setting

ITS systems, and the data they generate, almost always have the potential to deliver more than they were originally designed to do. It is very important for organizations implementing ITS to be aware of this and to learn how to exploit the opportunities that arise.

Opportunities tend to arise at specific phases - during the design, after implementation, and when new devices or more advanced technologies (e.g., distributed processing) are added. Quite often, the greatest benefit can be gained by other departments of the transport operator, which perhaps did not really understand the ITS at the beginning or whose needs were not included in the analysis. This is why it is essential to include representatives from all parts of the organization in the design phase.

It is advisable to establish a culture of continuous development, which seeks to advance the usefulness, efficiency and productivity of the ITS investments. Many enhancements require only modest investment, and others can actually make cost savings within the organizations. In cases where an enhancement would be expensive or difficult to implement as a stand-alone action, it could be included in a later general upgrade or renewal of the ITS.

11 How will the business processes need to change to take full advantage?

Themes: Functional identification; Business processes review; Implementation plan

The most effective ITS deployment occurs when organizational change, business process change, and ITS deployment are designed together. In these cases, the organizational change leads, and the ITS is designed as a core enabler of the new processes. In other cases, gradual organizational and process changes occur after the ITS deployment, as the possibilities are understood.

Experience in a number of cities has shown that this can be an evolutionary process. At the time of the first ITS implementation, many transport entities are not able to fully envision or appreciate the potential of the ITS or they do not know how to harness it. Following a learning period, the potential can be exploited in subsequent deployments or when they are renewing older systems. The case studies of Zurich, Prince William County and Dublin illustrate this developmental path.

Change to organizations inevitably occurs when ITS systems are implemented. The greatest advantage is achieved when ITS is implemented because the organization seeks to change – and hence the organizational change actually drives the process – compared to some organizations where change is a reaction to a new technology.

12 What will be the total cost?

Themes: ITS application; Support technology; Other resources; Operating costs

The cost of the ITS system needs to be estimated at various stages in the specification and design process. The initial estimate is usually an order of magnitude costing, based on typical costs in the industry. As the design becomes more specific to the host environment, a more accurate estimate of costs can be made. The costs should be considered from three perspectives:

- Initial investment, including both equipment costs and the cost of installation/deployment
- Ongoing operating costs
- “Whole of life” costs, including upgrades and added functionality

It is important to make an accurate assessment of these costs. Failure to do so could lead to serious problems at the procurement stage if the price of the most suitable bids turn out to be well in excess of the available budget. This could lead to cancellation of the project, a major downgrading of the functionality, or a reduced number of locations where ITS devices are deployed.

The three most common causes of cost escalation are:

- Software development turns out to be far more complex (and hence more costly) than originally expected
- “Mission creep” as more and more functions and devices get added to the ITS project
- Fascination with technology (on the part of the leaders or of the technologists), so that more advanced and costly equipment is specified than was really needed to do the job

It is not necessarily a problem if the actual project becomes more expensive than the original estimate, especially as the added-value may also increase. The important point is that any cost escalation is known to the decision-makers, can be justified, and the extra cost is provided for.

A useful source of published information on costs for ITS is published by the RITA (Research and Innovative Technology Administration) unit at the US Department of Transportation. Information on public transport is mostly contained in the Transit Management section. The website contains both full examples and unit costs, as well as relevant contextual information for the detailed cases. In some instances, information is also given for implementation and lifecycle costs.

Guidance on Implementation

The Implementation phase covers all aspects of delivering a fully-functioning system, once the decision has been taken to proceed with the ITS project. This includes procurement, testing, installation, configuration, commissioning, training, and commencing operations.

The Guidance presents 4 steps in the Implementation phase:

- Supply the needed system
- Install the system in the respective working environment
- Deploy the system
- Make good use of the system

At the end of the Implementation Phase, the ITS systems should be fully operational, and the transport organization should have begun to harness the value-added from their investment.

13 Supply the needed system

Themes: Technical specification; Technology and platform; Tendering; Contracting

The procurement of ITS systems is a complex task for which specialist knowledge is required. For first-time implementers of ITS, attempting to do it all in-house is a very high-risk strategy with major consequences if errors are made. It will be necessary to engage some experts for specific tasks. It is strongly recommended to engage independent expertise to support the ITS deployment team.

Potential sources of such expertise are other government/city agencies or departments that have IT and systems expertise; specialist firms and consultants from the communications and other technology sectors who have no vested interest in either the technology choice or the resulting contracts; and experts from transport authorities or operators in other cities or countries. This expertise can also be supplemented by partnering with transport operators or cities who have successfully implemented similar ITS.

Bidding documents needs to be prepared. Detailed specifications of the ITS system will have been developed in the Design phase, and these provide the main technical inputs for the procurement of the ITS systems. As a general principle, the focus in the bidding documents should be on Functional Specifications (i.e. what the system should perform) rather than on complex Technical Specifications (i.e. how the system works).

Suppliers understand ITS technology better than Clients (especially those who do not yet have much experience) and they can tailor the solutions to best meet the requirements. They are more familiar with advances and emerging trends in technologies. Perhaps more importantly, they will have already provided similar applications or devices for other Clients, and they know how to bundle functions, utilities, applications and features in the most cost-effective way. Excessive technical specification by the Client may impose unnecessary design burdens and development cost, and may also inadvertently limit the number of compliant suppliers.

Procurement of ITS should generally follow a two-stage approach. The first stage selects a shortlist of potentially suitable suppliers, who are invited to submit detailed bids in the second stage. In the first stage, the Client should make clear what its preferences are for proven or innovative technologies, for high-end or low-end solutions, the relative importance of cost to functionality, and whether it wants a

simple practical system for immediate application or a basis for future expansion. This will help to focus the supplier offers to what the Client seeks. This also avoids wasting everyone's time and money in preparing and assessing irrelevant proposals.

The selection criteria should be devised in advance of the procurement process, and should be carefully designed to deliver a solution that meets the Client needs. The evaluation and selection team should include relevant experts (internal and external). ITS proposal documentation is lengthy and complex. It needs to be very carefully reviewed by experts, in part to ensure that the best system is selected, in part because the technical proposal is likely to form annexes to the Contract and thus be relevant for many years.

The more complex an ITS system, the more important it is to develop a partnership with the supplier. Contract design and detail needs to reflect this, while still protecting the Client, as capture of the Client by the Supplier is a clear and present danger in all major investment programs.

14 Install the system

Themes: Vehicle adaptation; Fixed infrastructure; Linkages and communications

Most ITS systems include devices that are installed in the vehicles, at roadside locations (e.g. in bus stops), or at public transport locations (e.g. at bus stations). This requires careful planning and advance preparation for works. The most important aspects are:

- Nominate a project manager for all installations. Engage external experience if the skills are not available in-house – attempting to save on this cost is a false economy
- Nominate a Systems Integrator if multiple devices/systems will be installed in the vehicles or at any other location. The Systems Integrator is the nominated entity responsible for ensuring integration, co-ordination and successful interface across the ITS (sub-) systems, and with any relevant legacy and non-ITS systems. The Systems Integrator would typically be either the leading ITS supplier who co-ordinates the other suppliers, or a specialist firm awarded that specific task.
- Develop a comprehensive architecture, network and wiring plan for buses, bus stations, etc. Make it mandatory for all contractors to respect this plan and train their staff accordingly
- Plan in sufficient time for all installation works, especially those in public areas where approvals or way-leaves will be required.
- Avail of advance opportunities to install communications (e.g. fiber optic cables), wiring and power supplies – e.g. when ordering vehicles, when building stations and passenger interchange terminals

15 Deploy the system

Themes: Planning; Business processes; Human resource; Data streams

ITS deployment needs to be carefully planned and properly resourced. A comprehensive plan should cover all aspects of the deployment, and should also have contingencies for known risks associated with the ITS. There is substantial international experience in deployment of ITS, and this should be availed of.

An ITS Deployment Team should be established, resourced and given clear responsibilities. Capacity building is important, and includes both technical training and know-how transfer. Expertise should be brought into the team where it is needed. Installation is a major logistics challenge, and needs to be adequately resourced.

A formal testing regime should be established for the ITS system. This may include prototype test and approvals, but in all cases it should include final product acceptance before the Client agrees to receive and pay for it. All incoming hardware and software should be formally tested prior to installation. It is advisable to install a small batch to test both the installation method and the in-situ performance of the ITS equipment/system. Following a period of initial in-situ test and live running, the ITS system should be formally commissioned.

In parallel to the technical installation, it is also necessary to plan for and carry out training of frontline personnel, back-office system personnel, and end-users.

16 Make good use of the system

Themes: Integration; Optimization

Successful deployment of an ITS system is just the opening stage of an ongoing process. The ITS system represents a major investment, and it is important to make the best possible use of it. Experience shows that it takes quite some time for transport organizations to fully embed the ITS within their organization, and to fully appreciate how to make the best use of it.

Making best use of a new ITS system usually takes place over three phases:

- The first phase occurs in the first 1-2 years. This ensures that the system works reliably, is optimized, and gains credibility with the various users. This is a familiarization phase. There is usually a lot of error resolution and fine-tuning based on experience of actual use.
- The second phase usually begins in the second or third year. The transport entity begins to develop how it uses the ITS system and the information that it generates. New operational strategies will be developed and tested. The operations data will be used to improve schedules. Enhanced analysis and reporting will be performed. Other departments will start to use the data. They will automate the inputs or data transfer to save cost and time and eliminate errors.
- The third phase usually occurs after several years of operation when the transport entity has gained experience, and understands how it can build on the original system. This can include extended functionality, additional technologies, or even new ITS sub-systems

Experience from the Case Studies shows that successful transport organizations develop their ITS systems, and continually seek to gain value from their investment.

ITS users should be aware that their ITS equipment and software often includes or can support more functionality that they had specified (or even knew they were getting). ITS suppliers develop their products to meet the needs of a range of customers. It is usually easier to include all basic features, or at least their interfaces, than to remove everything the Client did not ask for (which risks errors and instability). As a result, Clients often find that they can harness these additional features at little or no extra costs. This is especially the case where there is a good working relationship between Client and Supplier.

Guidance on Evaluation

The post-implementation Evaluation phase enables the transport authority and/or operator to determine what value they have received from their investment, whether this meets or exceeds the original expectations, and whether more can or should be achieved. It assists the stakeholders to identify any aspects that are underperforming compared to expectations, and to target measures for improvement. It also provides valuable feedback for future investments and their design.

The Guidance presents 3 steps in the Implementation Phase:

- Pre-implementation criteria
- Post-implementation and Monitoring
- Evaluation

Following the Evaluation phase, the policy-makers can appraise the value and effectiveness of investment in ITS.

17 Establishment of performance criteria

Themes: Targeted transport functions; other transport functions affected by ITS implementation

ITS systems are implemented to improve performance, to allow new services to be provided to customers, to strengthen organizational capacity, etc. (see objectives and requirements in Steps 1 through 4 above).

It is essential to know whether the expected improvements have actually been achieved. If the actual performance is below expectation, it may be possible to adjust or adapt the system. However, many organizations fail to measure this properly, and as a result they fail to get the properly functioning system that they have paid for.

Suitable performance criteria need to be defined and adopted well in advance of deployment – ideally at the design stage - and included in the supply Contract. The performance of the pre-ITS passenger transport system should be monitored to provide a benchmark, and then the same criteria monitored following deployment.

18 Monitoring

Themes: Performance of ITS application; Performance of targeted transport functions; Impact on other transport functions

Performance monitoring consists of three main activities:

- Measuring technical performance against the technical and functional specification – i.e. has the supplier delivered the ITS system as per contract?
- Measuring effectiveness of the ITS in achieving the targeted functions in terms of the agreed upon criteria – i.e. does the ITS system help the organizational and operational units to achieve the objectives enunciated pre-implementation?
- Determining both positive and negative impacts on functions which were not part of the original project scope

19 Evaluation

Themes: Valuation of performance changes in targeted functions; Valuation of other transport impacts; Comparison with plan projections; Feedback into optimization; Feedback into future ITS planning

ITS systems involve a significant investment, in the form both of capital investment and of organizational commitment. It is strongly advised to carry out a formal evaluation for three main reasons:

- To verify if the expected value of the investment has been realized, and in which areas the benefits exceeded or were below expectations
- To help decisions about future ITS investments
- To learn lessons about the requirements, design, procurement, deployment and utilization, and how these can be improved in the future

It is noted that very few transport entities actually carry out a comprehensive evaluation of their ITS deployments. This is rather short-sighted, since they will inevitably come back to the decision-takers with proposals for future investments – either for additional ITS or to replace their existing systems. If they have not documented the benefits of the first investments, if could be more difficult to gain support for future investments.

Key Guidance Messages for Policy Makers and Transport Leaders

The key Guidance messages for Policy Makers and Leaders can be summarized as follows:

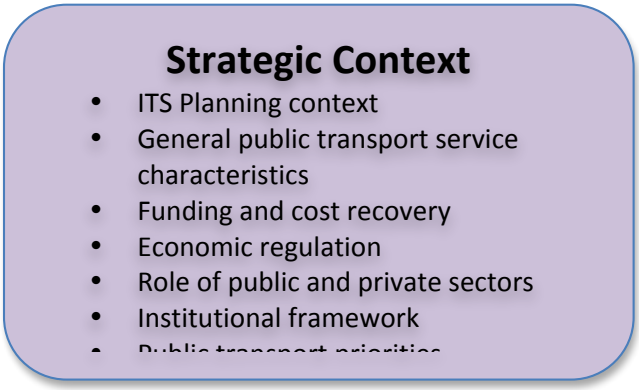
- ITS is a means of changing the business, at customer-facing, operational and back-office layers. The scope includes better ways of operating the bus services, of fare collection, of giving information to passengers, and of managing the administration and planning.
- ITS should be viewed as a corporate project, and not just as a technology project. The direction, oversight and key decisions should come from senior level, and not just from within the technology units. All relevant departments should be involved from the outset.
- The technology is just one component of an ITS project. The organizational structure and operating procedures are at least as important, and all three must be designed together.
- A lot of preparatory work is required in Planning and Design. The functionality of an ITS system (i.e. 'what it does') is more important that the specific technology it uses. The amount of time given to functional design should reflect this.
- Technology choices and specifications should not be made until it is fully understood what the ITS is required to do. Issues such as the communications to use or vendor preference should not be allowed to predetermine the design outcomes.
- Project costs should be estimated at various stages throughout the design process. If the costs exceed the available funding or the expected benefits, decisions need to be taken to revise the requirements or to postpone/cancel the project.
- Procurement should focus on outcomes rather than on devices. Technologies are continually changing, offering new possibilities. Procurement processes should allow for this.
- Implementation is a major task, which must be properly planned and resourced. Adequate time must be allowed for testing, installation and commissioning.
- When ITS has been introduced, the information it generates can transform many business and administrative processes. It takes several years for transport organizations to gain the full benefits. Provision needs to be made to facilitate this.
- ITS projects should be formally evaluated, both to appraise the value of the investment and to learn for any future proposed ITS investments.

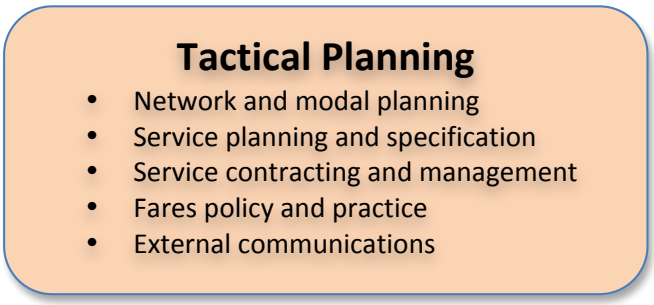
Public Transport Functions

The planning of any ITS program should respond to clearly-stated needs of the transport authority and / or operator. All of the key decision-makers and senior managers of the transport authority and / or transport operator need to be involved at every stage, but especially at the project formulation stage.

This analysis of public transport functions is designed to assist the stakeholders in identifying the priority areas for development of their urban passenger transport system, and whether there are ITS applications that can assist in that process. The Public Transport Functions section has been organized into five parts: Strategic Context; Tactical Planning; Service Delivery; General Support; and Statistical Analysis.

The functional model represents every aspect of the planning and operation of an urban passenger transport system. They may not all be applicable in each city, depending on the institutional framework and the role of the public and private sectors. Where the system is operated by para-transit, many of the functions will not be formalized. The functions will still be carried out in an *ad hoc* manner, although this is not amenable to an ITS program.





Service Delivery

- Vehicle and crew scheduling
- Preparation of vehicles for duty
- Performance of service delivery
- Control of service delivery
- Management of incidents
- Fares collection
- Traveler information
- Security and customer services

General Support

- Traffic and demand management
- Public transport priorities
- Operations control center
- Systems payment management
- Vehicle maintenance
- Inventory management
- Fleet renewal
- Environmental program
- Infrastructure maintenance
- Operator enterprise management
- Operator collective management
- Human resource and development
- ICT and ITS system support
- External communications

Statistical Analysis

- Legal and service compliance
- Financial accounting and reporting
- Consumption monitoring
- Incident analysis

Strategic Context Setting

Description / objective

In setting the strategic context governing development of an ITS system, policy decisions are taken about the nature of public transport provision within an urban area – its goals, targets and constraints. These cover issues ranging from general passenger transport objectives, its target users; the geographic areas to be covered; general service characteristics; system finance, including fares; the nature of economic regulation; institutional frameworks for service provision, planning and regulation; and the extent of traffic priorities. These essentially policy decisions are generally taken at extended intervals, and may reflect changes in the political administration of a city.

To a certain extent, these functional areas are already addressed by the Urban Bus Toolkit that was prepared under PPIAF sponsorship in 2006. However, decisions taken on sector finance and cost recovery define the framework for the Fare Collection Systems Toolkit, and those on public transport priorities will impact that aspect of the ITS Toolkit. The institutional framework is also likely to affect the priorities for any ITS development program, the applications covered, and the implementation process.

ITS applications

There are no **direct** ITS applications that help decision makers make strategic policy decisions. However policy formulation and decision taking may be informed by ITS-facilitated functions, such as travel demand data for network planning from electronic fare collection applications, and general speed and service reliability data from automatic vehicle location technologies.

Advantages and cautions

Some aspects of public transport demand are far easier to identify from fare validation data than from a full household survey. However this only reflects the number of current passengers, not including any potential travelers dissuaded by the system characteristics. It says little about detailed demand (e.g. trip purpose) and passenger characteristics (e.g. age, income) – and hence is not a totally sufficient basis for strategic planning.

Tactical Planning

Description / objective

This is a class of function supporting specific tactical decisions about the specification of the transport service network, and its user interface, so as to meet the strategic goals that have been set. It therefore covers network definition; routes; interchanges; service timetables; vehicle types; fare collection systems; and external communications. These decisions are also generally taken at extended intervals, but subject to regular review and amendment as a city grows. The framework for demand responsive (and special-needs) transport has also been included at this level.

A number of these functions can be assisted by the use of intelligent transport systems. However, the greater relevance to the toolkit lies in defining functional specifications for operations and general support level activities within the system. Again decisions regarding fares policy and practice are addressed in greater detail in the Fare Collection Systems Toolkit.

ITS applications

There are no **direct** ITS applications supporting these functions. However network and modal planning and service planning and specification may be facilitated by data generated by electronic fare collection

and automatic vehicle location technologies respectively. Further, service contracting and management may usefully involve ITS in monitoring service-contract compliance. ITS applications may also be chosen in the domains of fares policy and practice and external communications.

Advantages and cautions

The tactical planning level does not justify investment in ITS systems or technologies in its own right. However the justification for ITS applications may be supported by benefits in this domain when the investment case is being prepared.

Service Delivery

Description / objective

This level has been taken just to cover the operational and user interface aspects of service delivery, and not the general support services that enable or facilitate operations. It therefore covers the rostering of buses and crews; their preparation for service; managing the service delivery; managing disruptions; and the customer-facing services, including fare collection, traveler information and security. All of these functions are carried out on a routine basis, mostly to a daily or continuous schedule.

These functions are undertaken by all public transport operators, whether in the formal or para-transit sectors, though the systems applied will vary from the sophisticated to the *ad hoc* depending on the sector (formal or informal), operator scale and structure. Again all functions related to fare collection are covered in greater detail in the Public Transport Fares Toolkit.

ITS applications

This is the passenger transport level with the greatest range of ITS applications and ITS-facilitated functions in widespread international practice. Vehicle and crew scheduling and preparation of vehicles for duty can be facilitated through ITS, and performance of service delivery can be assisted by driver aids. Operations management covers control of service delivery (e.g. dispatching, real time supervision) and management of incidents. Electronic fare collection and real-time traveler information are further applications, and security and other customer services can be facilitated by surveillance equipment.

Advantages and cautions

The use of ITS applications in these domains greatly increases accuracy and productivity, as well as enabling functions in real time that could not otherwise be provided. However these applications are not a pre-requisite to the provision of effective and efficient transport, and most involve significant investment costs that should be subjected to critical analysis where financial resources are scarce.

General Support

Description / objective

This level has been taken to cover the range of functions that are needed to support the delivery of public transport services. It therefore covers traffic and operations control; management of payment systems; fleet (and facility) asset management and environmental programs; infrastructure maintenance; and the management of operating entities and systems. These functions range from the routine to the periodic, and have their own tactical and operational perspectives.

Many of these functions would be carried out by an integrated public transport enterprise, and some by a passenger transport authority. However virtually all of the functions would be sub-contracted within a

para-transit operated system, and some might not be provided at all where there is no transport authority or equivalent city institution in place. Management of payment systems will again be addressed in more detail in the Public Transport Fares Toolkit.

ITS applications

There are very few **direct** ITS applications at this level of passenger transport, as most support activities are carried out away from the network or ongoing operations, or involve agencies remote from the public transport system. However ITS technologies such as automatic vehicle location and vehicle systems monitoring can be used to support public transport priorities and vehicle maintenance planning respectively.

Advantages and cautions

The operations support level does not justify investment in ITS systems or technologies in its own right. However the justification for ITS applications may be enhanced by benefits in this domain when the investment case is being prepared.

Statistical Analysis

Description / objective

This functional area involve use of the data generated by the various transport functions and uses them to provide fundamental inputs to management information system and business process improvement. The domains covered include legal and service compliance; financial reporting; consumption monitoring; and incident analysis.

ITS applications

Intelligent transport systems are both driven by and generate data, and the output data from one application may also act as the input for another or enable ITS-facilitated functions.

Advantages and cautions

The challenge is to get the systems to communicate with each other, share data and commands, and hence to integrate a wide range of systems and technologies so that they can work together effectively. This is the role of system architecture and data models that are covered in the Design section of the ITS Program Guidance notes.

Technical Resources

The technical resource sections of this Toolkit consider ITS from two related perspectives:

- ***ITS Applications*** (this section). These are the functional aspects of ITS systems.
- ***ITS Technologies*** (next section). These are the specific devices, software and platform tools used to deliver the ITS Application.

The *ITS Applications* section describes **what** the ITS does and **how** it does it. From this perspective, technologies are simply a means of implementing the Application. As far as the Application is concerned, specific technologies are interchangeable, and could be replaced over the Application's lifetime.

It is important to appreciate that the ITS Applications could be delivered on different technical platforms. An ITS Application such as Operations Management could be delivered on an advanced technology and communications platform (e.g. as in Dublin, Florence or Zurich), but a somewhat simpler version could be delivered on a low-technology, low-cost platform (e.g. as in Sri Lanka).

The ITS Applications have far more in common from one location to another than ITS Technologies. Although the low-technology approach might not be able to support all of the functionality of its higher-technology counterpart, the principles, broad functions, mode of use and data types may be quite comparable.

Further, supporting technologies may evolve or be replaced over time, enabling the functionality and capacity of an ITS Application to be increased. It may be possible to continue to use the Application's original software even as the underlying ITS Technology base is changed (as in Prince William County). In this sense, ITS Applications have a much greater degree of permanence over time than the implementing Technologies, which are in a state of continual change.

ITS Applications

This section presents the main ITS Applications that are currently in use in Urban Passenger Transport. The focus is on ITS used for buses, although many of the applications are also used in similar manner by trams and urban rail systems. Many of the ITS Applications are readily usable by the para-transit sector. However, despite the apparent high value-adding potential, at present the use of ITS in the para-transit sector is virtually non-existent.

A total of 41 ITS Applications are presented here. For coherence, they are presented in seven clusters:

- Operations Management
- Driver Aids
- Fare Collection
- Traveler Information
- Traffic Management
- Security
- Demand Responsive Transport

The full set of ***ITS Applications*** is:

<table>
<tr><th>Operations Management</th><th>Driver Aids</th><th>Fare Collection</th></tr>
<tr><td>• Automatic Vehicle Monitoring
• Route Condition Monitoring
• Schedule Adherence Support
• Service Contract compliance
• Driving-standards compliance
• Emergency/incident management
• Dynamic rescheduling</td><td>• Schedule Adherence Support
• Collision warning and avoidance
• Precision Docking
• Economic driving assistance
• Vehicle condition monitoring
• Passenger surveillance</td><td>• Travel sales and payment
• Fare calculation and charging
• Travel authorization and evidence
• Interchange / transfer authority
• Interchange / transfer rebate
• Revenue accounting and distribution</td></tr>
<tr><th>Traveler Information</th><th>Traffic Management</th><th>Security</th></tr>
<tr><td rowspan="2">• Traveler information on PC/Internet
• Traveler information on phones/PDAs
• Real-time information at stations/terminals
• Real-time information at bus-stops
• Real-time information in vehicles
• Vehicle-stop announcement
• Dynamic journey planners
• Alert services
• Emergency/incident advice</td><td rowspan="2">• Traffic Signal Priority
• Access Control
• Interface with adaptive traffic control systems
• Public transport lane/facility violation monitoring</td><td>• In-vehicle surveillance
• At-station surveillance
• Running-way surveillance
• Infrastructure/facility surveillance</td></tr>
<tr><th>Demand Responsive Transport</th></tr>
<tr><td></td><td>• Booking and Reservations
• Traveler assignment
• Route optimization
• Customer pick-up/drop-off management
• Revenue recovery and administration management</td></tr>
</table>

Each ITS Application is described in the Toolkit from three perspectives:

- Objectives and functionality
- Technologies, data and resource required to deliver the Application
- Benefits and cautions related to the Application

The material draws mostly on current practice within the urban passenger transport sector. The description of each Application also indicates the Case Studies where the Application is active and, for some, additional relevant cities are identified. Where available, web-links are provided to relevant reports and other resources.

ITS-facilitated Functions

Bus companies carry out a wide range of non-ITS functions, many of which are computerized. These functions are not usually categorized as ITS. They are broadly in three groups:

- Resource planning and management
- Service performance
- Administration, MIS and audit

When ITS systems are implemented, these non-ITS functions often receive much of their input data from the ITS systems (e.g. trips / kms operated by vehicle, daily revenue by route / driver, fares transaction records). In some cases, the non-ITS functions can also provide baseline or assignment data to the ITS systems (e.g. the scheduling system provides the timetable information to the AVM system).

The relationship between these ITS and non-ITS functions have three main implications:

- The ability to use data generated by the ITS systems can lead to major cost and productivity savings within the administration. As the ITS data is already in electronic format, it can the transferred directly, quickly, and eliminate human / input errors.
- The high level of data transfer requires a structured approach to system architecture, data models, data transfer, data storage, and data quality. All of the ITS and non-ITS systems need to be considered together.
- Some ITS-facilitated functions may be acquired during the ITS procurement. In other cases, the interfaces between the ITS and existing non-ITS software systems are developed within the ITS project. The ITS project scope needs to fully consider all such possibilities.

This section presents the non-ITS Functions that are closely related to ITS and which are facilitated by the ITS systems.

The ITS-facilitated Functions cluster consists of ten Applications:

- Network planning
- Service scheduling
- Service performance analysis
- Service contract management
- Systems Payment Management
- Payroll functions
- Vehicle maintenance scheduling
- Fuel consumption monitoring
- Management Information
- Revenue Protection

ITS Technologies

ITS Technology resources in this Toolkit

The technical resource sections of the Toolkit consider the ITS from two related perspectives:

- ***ITS Applications*** (previous section). These are the functional aspect of the ITS systems.
- ***ITS Technologies*** (this section). These are the specific devices, software and platform tools used to deliver the ITS Application.

The *ITS Technologies* consist of a wide range of physical devices, their embedded software, and their means of communication. They are the means of implementing the ITS Applications.

This section presents the main ITS Technologies that are currently in use in Urban Public Transport. The focus is on ITS used for bus, although many of the applications are also used in similar manner by trams and urban rail systems. Unlike the ITS Applications, only a limited number of the ITS Technologies are relevant or readily usable by the para-transit sector (e.g. due to cost, complexity, technical support requirements). At present the use of ITS in the para-transit sector other than certain "Smart Phone" applications is virtually non-existent.

A total of 31 ITS Technologies are presented here. For coherence, they are presented in nine clusters:

- Automatic Vehicle Monitoring
- Driver Monitoring
- Vehicle Monitoring
- In-vehicle data hub and processor
- Electronic Fare Collection
- Traveler Information Displays
- Surveillance Equipment
- Vehicle Identification
- Communications

Each ITS Technology is described from three perspectives:

- Objectives and functionality
- Technologies, data and resource required to deliver the Application
- Benefits and cautions related to the Application

The material draws mostly on current practice within the urban passenger transport sector. The description of each Technology indicates the Case Studies where the Technology is active, and for some, additional relevant cities are identified. Where available, web-links are provided to relevant reports and other resources.

The full set of ***ITS Technologies*** is:

Automatic Vehicle Monitoring	Driver Monitoring	Vehicle Systems Monitoring
• Automatic Vehicle Location • Driver's Console • Operations Control Center	• Driving hours and rest periods • Driver inputs and dynamic outputs	• Passenger boarding and loading • Fuel-usage rate • Technical status
In-vehicle data hub and processor	**Electronic Fare Collection**	**Traveler Information Displays**
• In-vehicle data hub and processor	• Automatic Vehicle Location • Smart-card and card recharger • Smart-card validator and display • SMS or bar-code on smart-phone • Bar-code reader	• Public display on vehicles • Voice announcement systems • Infotainment systems • Personal display on smart-phone or PDA • Public display at terminals and stop
Surveillance Equipment	**Vehicle Identification**	**Communications**
• Static video cameras • Remote-controlled video cameras • Digital video (loop) recorder • Computerized image processing	• Automatic number plate recognition • Vehicle intelligent tag/transponder	• Between the vehicle systems • Vehicle to and from control center • Vehicle to and from stop shelter • Vehicle to traffic signal or AWTCS • Data download from vehicle • Data communication between facilities

Development and evolution of ITS Technologies

ITS Technologies use a combination of information, communications, hardware and software applications to perform operational, management and safety functions, and to deliver services to travelers. New technologies continually emerge, usually with increased and faster processing power, increased memory and storage, increased functionality (or similar functionality in a smaller or cheaper unit), and enhanced software options.

This poses some interesting challenges for policy-makers, decision-takers and practitioners who are considering implementation of ITS, or who are faced with technology choices and/or investment decisions. One choice is to play safe and stick with 'tried and trusted' technologies. Another is to embrace new technologies, to actively seek opportunities for new functions and services, to find lower cost options, and to avail of generic, non-proprietary solutions.

There is no easy answer to making this choice, and each case needs to be reviewed on its merits. Four basic principles are suggested:

- Monitor national and international practice in ITS – i.e. become informed and keep up to date

- Engage independent, expert advice (see Guidance on Implementation, Section 13, 'Install the Needed System')
- When considering implementation of innovative technologies, verify all claims made by suppliers and proponents. Visit sites that have already deployed them (in the non-transport sector as well, if relevant) and meet with counterparts to get a proper understanding of the benefits and challenges.
- If a new technology appears risky, think twice about using it. Poor performance or unreliability of the ITS may seriously compromise the core public transport business.

The ITS considered in this Toolkit has its focus on urban bus services. However, in contrast to the ITS Applications which are mostly specific to the urban passenger transport sector, ITS Technologies are increasingly 'generic'. Components and sub-systems are likely to be used in very many sectors other than transportation (e.g. GPS receivers, CCTV, touch-screens). Software applications are developed on the same platform and often use the same utilities as applications in non-transport sectors. In many cases, communications are handled by general public networks. Many of the vehicle support and management technologies have initially been developed in the general automotive sector, or in the trucking/logistics sectors. Even systems that appear to be specific for the urban bus sector (e.g. handheld ticket issuing machine, driver's console) usually consist of generic components and sub-systems, packaged to suit the bus operating environment.

This offers great advantages in cost (due to high volumes), standardization, development, robustness, reliability, and technical support. Occasionally, "game changers" emerge which lead to fundamental change in the technology approach and even the applications offered in urban bus services. Examples of "game changers" include GPS, the internet, smart cards, GSM, and the proliferation of personal handheld devices (including mobile phones).

A wide variety of devices are used, with an increasing level of integration and increased efforts to establish a common system architecture approach (although in practice many suppliers continue to avoid making their systems truly open). Many of the benefits arise from systems and sub-systems being able to share data and function collaboratively. Since the mid-1990's, ITS systems have increasingly moved from sector-specific, proprietary products to generic elements – initially adopting GPS and mobile communications; then smart cards, GIS and the internet; and more recently hand-held devices ("Smart Phones") and apps. A new generation of ITS systems and services is emerging, based on light infrastructure, distributed processing and apps, which would fundamentally alter both the cost and the platform concepts. As these emerge, they will open the use of ITS to operators in developing countries where investment cost has been prohibitive until now.

At the ***generic level***, there are a number of fundamental concept options (which in turn have many variants):

- "Infrastructure heavy" using *dedicated* support platforms. This typically involves a significant degree of in-vehicle equipment, significant off-vehicle equipment, dedicated communications infrastructure and extensive sector-specific software and applications
- "Infrastructure heavy" using *generic* support platforms. This typically involves a significant degree of in-vehicle and off-vehicles equipment. The difference to the first option is that it uses 3rd party communications infrastructure (e.g. GSM/GPRS), utilize public/3rd party facilities where possible (e.g. GIS/mapping, internet, general payment and clearing services), and utilize sector-specific software and applications only where necessary
- "Infrastructure light" with extensive exploitation of data. This typically involves a moderate level of in-vehicle equipment (e.g. location device and voice/data communication), moderate/low level of

off-vehicle equipment, software and applications that utilize the data for real-time and post-event analysis and integrate with off-the-shelf IT packages.

- “Infrastructure minimal”. This typically involves inexpensive in-vehicle equipment (GPS-enabled mobile phones), public communications channels (GSM, GPRS), and uses inexpensive software to provide practical operations and administration functions. Although a minimalist technology approach, it may still support creative and pragmatic functionality.

These need to be considered in the Planning phase of an ITS program.

Case Studies

A set of Case Studies has been prepared to illustrate how ITS is being used in practice. The sites have been selected to provide diversity in environment, operator type, scale, ITS implemented, and degree of experience with ITS.

The Case Studies are presented in three clusters:

- Sites where ITS is well established:
  - Dublin, Ireland
  - Florence, Italy
  - Izmir, Turkey
  - Prince William County, USA
  - Zurich, Switzerland
- Sites where ITS is currently in first deployment:
  - Johannesburg, South Africa
  - Mysore, India
- Sites which are considering the use of ITS and/or carrying out some initial testing:
  - Accra, Ghana
  - Cebu, Philippines
  - Sri Lanka

This section provides an overview of the ten Case Studies. It presents the main points of context, ITS programs implemented, and lessons learned (for the sites where the ITS has been deployed).

Each Case Study is presented in detail on the ITS Toolkit website. The information includes:

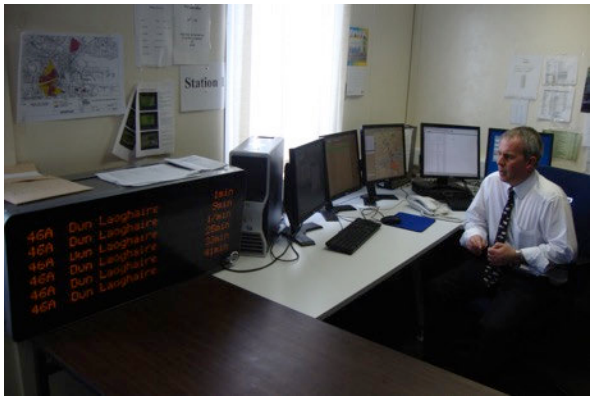
- *Contextual information*: Regulatory environment, operator information, basis of service organization and procurement, basis of financial support
- *ITS*: Overall ITS approach, individual ITS systems implemented, technical details, means of operations management
- *Implementation experience*: Preparation, procurement, installation and implementation, post-implementation experience, lessons learned, benefits achieved

It is strongly recommended that decision-makers and practitioners familiarize themselves with these Case Studies and with other sites that have implemented ITS. There is a vast array of experience that can be drawn on – not all of it was without problems, but all of it is valuable. It is clear that the program implementers are willing to share what they have learned with their counterparts in other cities and regions.

Dublin, Ireland

Overview

- Dublin Bus is the publicly owned operator of the bus network in Dublin. It operates 980 double-deck buses in the city and hinterland of Dublin.
- Dublin Bus has a 5-year Public Service Obligation contract with the National Transport Authority
- Performance measures are now linked to PSO payments, and will place increasing pressure on operational quality.



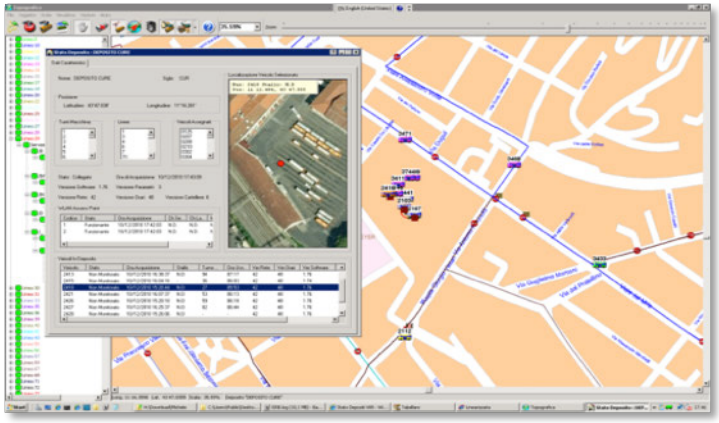
- The company has implemented extensive ITS over the course of two decades. Electronic Ticket Machines were first implemented in 1989 and have provided the backbone of the on-bus intelligent network.
- Vehicle location and voice/data communication capability have been added to provide the platform for a new AVLC system. This is based on a centralized Control Centre that manages services on a real-time basis.
- The AVLC supports real-time passenger information on internet and at bus-stops. The RTPI server and at-stop displays are managed by the city.

- The ITS has been based on the business and operational requirements.
- The AVLC is in its first full year of operation, and has not yielded quantified resource or operational benefits

Florence, Italy

Overview

- ATAF is the Municipality-owned bus operator of the City of Florence, serving the Metropolitan Area and some hinterlands towns.
- Since 2005, services are provided under Service Contract to the Province of Florence, for which ATAF joined with Li-nea and some smaller operators in a special purpose entity.
- The Contract has quantitative and qualitative performance requirements, in particular in relation to volume of service and punctuality. It also places quite extensive service and event reporting requirements.



- ATAF first introduced AVLC in 1984 to about 100 of its buses. The AVLC was updated in 1996 and extended to the full fleet of about 400 buses. This included GPS, trunked mobile radio, and enhanced AVLC functions.
- A new procurement was launched in 2006 for a total AVLC replacement, at-stop RTPI units, and internet/mobile travel information applications. It also procured a limited amount of video-surveillance and traffic signal priority facilities, which may be extended later.

- Phased deployment has commenced in 2009 with the new AVLC Control Centre already fully operational. It contains a major functionality upgrade.

Izmir, Turkey

Overview

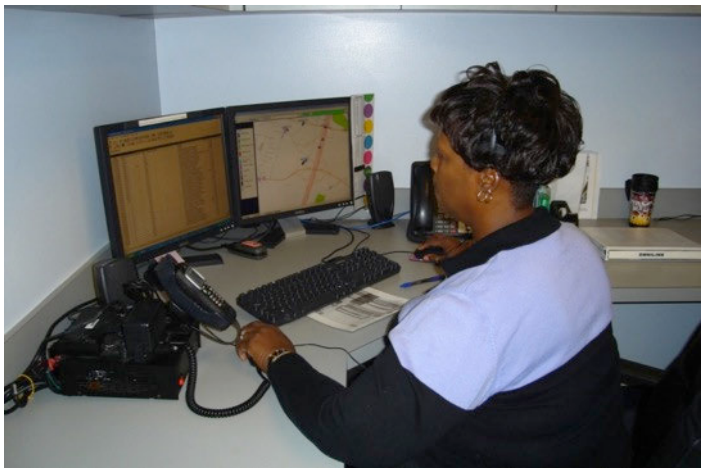
- ESHOT is the municipal-owned operator of the bus network in Izmir and its surrounding service area. It operates a fleet of 1,560 buses, including 410 from its associate Izulas.
- The bus network forms part of an integrated transport system including Metro, Rail, Ferry, and local para-transit. Integration has been developed since 2000, and suburban rail was included in 2010.
- The Izmir Metropolitan Transport Co-ordination Centre was established in 2006 for the planning, co-ordination and determination of routes; ESHOT is represented on this body through its General Manager.

- The company has implemented extensive ITS since 1999, when smart-card ticketing was first introduced. The ticket validators have provided the backbone of the on-bus intelligent network.
- Vehicle location and voice/data communication capability have been added to provide the platform for a new AVM system. This is based on a centralized Control Centre that manages services on a real-time basis.
- The AVL supports real-time passenger information on buses and at bus-stops. The communications capability is also utilized for surveillance.
- AVL data is also utilized for fuel issue monitoring and bus maintenance scheduling.

Prince William County, Virginia, USA

Overview

- PRTC is the transit commission for an area of eastern Virginia adjacent to Washington DC.
- PRTC uses a fleet of 139 buses to provide commuter bus services to Washington (OmniRide) and local flexible bus services in Prince William County and the Manassas area (OmniLink). Service operation is contracted out.
- OmniLink services are demand-responsive transport (DRT) operated as route deviation (flex-route) for general use including riders with disabilities. Trips are pre-booked from 2 hours to 7 days before travel and about 30 percent of demand responsive trips are standing orders.
- First implementation of ITS at PRTC was to support the DRT. It included booking, routing and dispatch software, and in-vehicle data terminals.
- The ITS evolved with the addition of GPS, improved communications, and new back-office software capacity. Rudimentary GPS tracking was extended to the OmniRide commuter services.

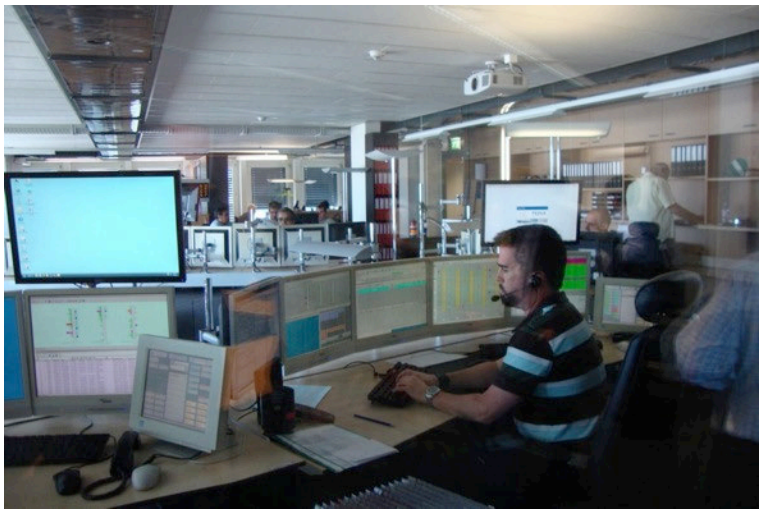


- A new procurement has been launched in 2011 for significant enhancement of the ITS systems, including CAD/AVL system- and service-wide and installation of new MDTs in all vehicles.
- Benefits attributed to ITS include the ability to offer DRT with short pre-booking time, better on-time performance, increased efficiency, increased ridership, improved working environment and enhanced data collection.

Zurich, Switzerland

Overview

- Public transport in Zurich is provided by VBZ, a multi-modal operator of trams, trolleybuses and buses. Trams form the backbone of the system.
- Since the mid-1970's, the City of Zurich has committed to a strongly pro-public transport policy, giving it high priority in streets and at junctions
- The basic concept is that the City provides an excellent operating environment, and VBZ should operate on-time services within that frame



- ITS is central to Operations Management and high-quality, on-time services. VBZ first implemented ITS in the early-1970's.
- The ITS is integral to the VBZ operation, and to the organization, business processes, operating procedures, data, and management. The approach has matured over the four decades as they gain better understanding of what they can do, embed it in the organization, and evolve the technology.
- VBZ has evolved from using ITS to just know where their vehicles are, to precision operation with on-time running and transfer assurance

- Passenger information is extremely well-developed, prior to the trip, at stops and in the vehicles. It provides a seamless and ubiquitous guidance.

Johannesburg, South Africa

Overview

- Rea Vaya is the BRT network in Johannesburg. Phase 1A is operational, linking the township of Soweto to the CBD. Phase 1B is under construction and expected to be operational during 2012. Rea Vaya is developed by City of Johannesburg.
- The Rea Vaya network consists of Trunk Routes that operate exclusively on the BRT running way, Complementary routes that operate both on and off the BRT running way, and Feeder Routes that bring passengers to the BRT for transfer.
- A new Bus Operating company (PioTrans) has been formed, whose shareholders are from the minibus taxi owners displaced by the Rea Vaya services. City of Johannesburg has entered a 12-year bus service operating contract with PioTrans, who are paid a per-kilometer fee for the provided services.

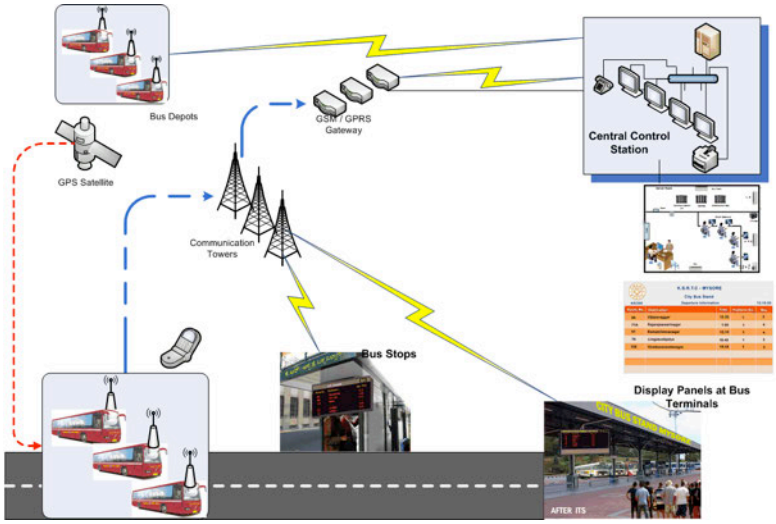
- A comprehensive, integrated ITS program supports Rea Vaya BRT. This consists of GPS-based AVM, operations control centre, traveler information, CCTV for security and station management, scheduling package, traffic signal priority, and fare collection.
- By end-2011, the AVM, Operations Control Centre, CCTV and scheduling systems are fully operational. The traveler information system and traffic signal priority systems are expected to come on-stream during 2012.
- An Automatic Fare Collection (AFC) system has been procured and is currently under deployment (operational by end-February 2012). The AFC is based on EMV (i.e. bank-issued) smart cards. Value-loading will take place at stations, vendors and banks.

- The vehicle to control centre communications takes place over the local GSM network, while the stations and their devices use fiber optic cable.

Mysore, India

Overview

- KSRTC is the State Transport Commission for the State of Karnataka, India. It operates about 7,000 buses on intra- and inter-state bus services.
- MCTD is a division of KSRTC, providing urban bus services in the city of Mysore, using a fleet of about 400 buses out of 3 depots and 6 bus stations
- KSRTC are currently implementing an ITS system at MCTD covering all of the fleet and the services. The order has been placed and the system is scheduled to be fully operational by end-December 2011.
- The ITS system consists of AVLC based on GPS, GSM/GPRS, and real-time passenger information at bus stations, bus stops, and in-vehicle;
- A Central Control Station (CCS) is being established at the main bus station, which will manage services along the routes and at outer terminals. Platform dispatchers will be retained at the bus stations.
- KSRTC is procuring a Project Management Consultant to support the implementation process
- An extensive Monitoring and Evaluation program is being procured to examine the implementation phase, the system and service performance, and the longer-term impacts. This will assist KSRTC in taking decisions about deployment of ITS elsewhere in their operations.



Accra, Ghana

Overview

- Urban passenger transport in Ghanaian cities is provided primarily by minibuses (tro-tros) which are individually owned, but are highly organized at route level through Unions. This has provided a stable system that is well understood by the customers. Nonetheless, there are limitations in vehicle and service quality that need to be addressed.
- Large vehicle service provision is currently limited to the parastatal Metro Mass Transit and some bus companies with low market share.
- Major sector reform is underway, primarily through the Ghana Urban Transport Project (GUTP). This includes regulatory and institutional development, a BRT corridor from the west of Greater Accra to the CBD, and improved bus routes with some bus priority on other corridors.
- The local authorities (Assemblies) have taken on the regulatory role and are implementing a new Permit system; hitherto, the sector had been self-regulating. This places new management, monitoring, enforcement, administration and planning requirements on the Assemblies.
- The tro-tro sector will need to develop Permit compliance capacity, both on the ground and in administrative/reporting terms. It also needs to improve the quality of its vehicles and its services
- Both the BRT and the Permit Type B Routes will require the formation of new operating entities, new operating methods, and new operational capacity. In addition, a BRT Management Entity will be formed.
- These are all likely to require ITS for Operations Management, Fare Collection, Passenger Information, and post-event analysis. The pressing timescale may require decisions on ITS in advance of these entities being established and in a position to define their functional requirements.
- The current baseline for ITS is low, with no ITS and very little computerized systems currently deployed in UPT. There is not currently an active ITS supplier base in Ghana.

Cebu, Philippines

Overview

- Passenger transport in the Philippines is regulated through franchises issued by central government Department of Transport and Communications (DOTC) and its agencies.
- The primary urban passenger transport mode is the Public Utility Jeepney (PUJ). This is typically a 16-seater converted US Jeep. Outside of Metro Manila this is the sole urban passenger transport mode.

- The PUJ industry is fragmented consisting of a high percentage of single-owner operators. Membership associations exist but are not wholly subscribed to and offer little more than administrative functions.
- DOTC seeks to achieve increasing efficiency in the provision of passenger transport. Its first focus is on regional services (more often run by larger companies). Thereafter, increasing levels of control and organization would be applied to urban transport first in Metro Manila.
- During 2011, regional services centered upon Manila are being fitted with GPS to enable operators to locate vehicles operating over long distances.
- DOTC propose to assist Manila-based urban PUJ owners to fit GPS devices so that PUJs can be monitored. Current plans include cash incentives to owners. It is planned that information will be collected centrally by DOTC and information made available to owner/operators.
- In the medium term, this information will be used to restructure the PUJ network as route franchises come up for renewal. In the longer term, this information might be linked to an area-wide traffic control system.
- Urban transport fares are cash based. There is no electronic information and only basic static information. There is currently no fleet control.

- The development of a BRT in Cebu has provided an information base from which to work, and an ability to explore means by which the passenger transport network can be reorganized to achieve efficiency gains.
- The Cebu BRT Pre-Feasibility Study (2010) identified the need for ITS solutions for operational management, fare payment, and co-ordination with the City's urban traffic control system (SCATS). It is estimated that the BRT will be operational by 2014.
- The World Bank is progressing with a study (expected late-2011) that demonstrates the use of low-cost mobile vehicle tracking systems in Cebu. This study could provide transport regulators and operators with a means to improve the performance of informal sector Jeepney fleets, and to provide traffic engineers with a means of managing road assets and mitigating traffic congestion.

Sri Lanka

Overview

- The private bus sector in Sri Lanka consists of 19,000 vehicles, which are independently owned, mostly by single-vehicle Owners. There is a very low level of collective organizational or operational capacity.
- The National Transport Commission (NTC) regulates tariffs and service standards island-wide and regulates permits for inter-provincial bus routes. Raising standards and monitoring compliance are key functions.
- NTC has already successfully launched the implementation of Electronic Ticket Machines, currently deployed on over half the Sri Lankan bus fleet (see the Fare Collection Toolkit)
- NTC achieved this through a combination of mandating their use, preparing specifications, giving type approval to suitable suppliers, and allowing Operators to directly purchase approved models of their choice.
- NTC has launched an ITS pilot project on inter-provincial bus services, involving about 70 buses. The core application is automatic provision of location data to the NTC Control Centre using GPS and GPRS units.
- A similar approach to ETMs has been used whereby NTC prepared the technical specifications and invited suppliers to test compliant devices
- 7 suppliers have installed compliant systems. Many have exceeded the baseline requirement and installed additional functionality including fuel monitoring, driver alarms, speeding alerts, and in-vehicle image capture
- Subject to successful pilot phase, NTC intends to make ITS installation mandatory as part of the Permit conditions, and to make permanent their Control Centre for monitoring route and service quality compliance.

Glossary: Acronyms and Abbreviations

ADA	Americans with Disabilities Act
ALPR	Automatic License Plate Recognition
ANPR	Automatic Number Plate Recognition
APC	Automatic Passenger Counting
AVI	Automatic Vehicle Identification
app	Application (mobile phone usage)
AVL(S)	Automatic Vehicle Location (System)
AVM	Automatic Vehicle Monitoring
AWTCS	Area-wide Traffic Control System
BRT	Bus Rapid Transit
CAD	Computer Aided Dispatching (North American ITS usage)
	Computer Aided Design (common usage)
CAN	Controller Area Network
CEN	Comité Européen de Normalisation (European standards body)
CCTV	Closed Circuit Television
DRT	Demand Responsive Transit
DVR	Digital Video Recorder
ETM	Electronic Ticket (issuing) Machine
GIS	Geographic(al) Information System
GLONASS	Russian satellite navigational system, similar to GPS
GPRS	General Packet Radio Service (version of GSM)
GPS	Global Positioning System
GSM	Global System for Mobile communications
ICT	Information and Communications Technology
IP	Internet Protocol
ISO	International Organisation for Standardisation
	International Standards Organisation (common usage)
IT	Information Technology
ITS	Intelligent Transport Systems
kB	Kilobyte
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MB	Megabyte
MIS	Management Information System
MMS	Multimedia Messaging Service
NVR	Network Video Recorder
OCR	Optical Character Recognition
PC	Personal Computer
PDA	Personal Digital Assistant
PMR	Private Mobile Radio
PPIAF	Public-Private Infrastructure Advisory Facility

PTZ	Pan Tilt Zoom (CCTV usage)
RFID	Radio Frequency Identification
RTPI	Real-time Passenger Information
SAE	System d'Aide a l'Exploitation (equivalent to AVM; French usage)
SAM	Secure Application Module
SMS	Short Message Service (mobile phone application)
TC	Technical Committee (in context of CEN)
TCRP	Transit Co-operative Research Program
TCS	Traffic Control System
TETRA	Terrestrial Trunked Radio
TRB	Transportation Research Board
TSP	Traffic Signal Priority
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
USDOT	United States (of America) Department of Transportation
VCR	Video Cassette Recorder
WAN	Wide Area Network
WiFi	Wireless communication using IEEE 802.11 specification