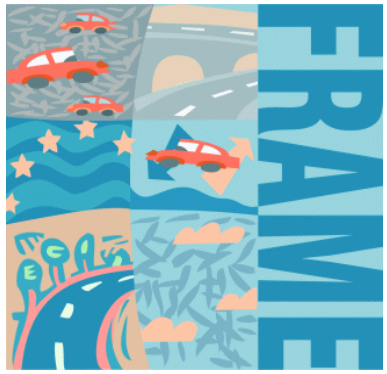


PLANNING A MODERN TRANSPORT SYSTEM

A GUIDE TO
INTELLIGENT TRANSPORT SYSTEM ARCHITECTURE

Why you need one and how to create it

Issue 2

Planning a Modern Transport System

A Guide to Intelligent Transport System Architecture

This Guide is for anyone wishing to have a better understanding of the benefits and implications of using ITS (Intelligent Transport Systems) in a modern transport system. In particular, it explains when and why an ITS Architecture is needed, what is involved in its creation, and the risks of not having one. It should be especially useful for executives who need to take decisions regarding the planning and development of transport systems, as well as those responsible for providing high-level advice in this field.

The Guide has been produced by the FRAME projects, as part of the Fifth Framework IST Programme of the European Commission.

Further information on the European ITS Framework Architecture, and the FRAME projects, can be found at the end of this Guide and on the website: **www.frame-online.net**

Contents

Introduction

Efficient and sustainable mobility

For a successful modern economy, the ability to guarantee the smooth and efficient transportation of people and goods is a fundamental requirement. Failure to achieve this represents a threat to competitiveness, and also reflects an unsustainable use of the transport infrastructure.

ITS applications have been shown to be a valid and cost-efficient way of supporting the management and operation of transport services. They can help to achieve:

- a major reduction in road casualties;
- an increase in effective road capacity without new construction (up to 20% demonstrated);
- travel time savings (an estimated total of one year over an average lifetime);
- significant reductions of vehicle pollutants, e.g. CO_2 emissions;

[source ERTICO 2000]

Growing numbers of ITS applications are now available across the different transport modes. It is estimated that by 2010 the European market for these applications will be as much as 20 billion euros.

To provide the maximum benefit, these applications must be compatible, which means that their implementation should be based on a strategic framework. The purpose of a System Architecture for ITS, or **ITS Architecture**, is to provide such a framework.

The best approach to ITS ?

This Guide explains:

- **the benefits of an ITS Architecture;**
- **the risks of not having an ITS Architecture;**
- **what is involved in creating an ITS Architecture;**
- **the rôle of the European ITS Framework Architecture.**

Intelligent Transport Systems

The benefits of ITS

The use of computers now extends into almost all fields of human endeavour - transport is no exception.

Intelligent Transport Systems (ITS), also called transport telematics, include a wide range of tools and services derived from information and communications technologies.

These systems have the potential to deliver significant benefits with respect to operational efficiency, service reliability, infrastructure management, as well as enhanced safety, reduced environmental impact, and valuable information services for transport users.

The range of systems include those for:

- automated traffic management;
- support for public transport operations;
- demand management;
- traveller information and trip planning services;
- freight and fleet management;
- incident management and support for emergency services;
- electronic payment services, and fee collection;
- advanced in-vehicle technologies.

Some examples are described later in this Guide (Pages 12-17), explaining the importance of their integration and interoperability.

Why an ITS Architecture is needed

Like other highly complex systems, integrated ITS applications need a strategic framework as a basis for choices concerning their design and deployment, as well as for investment decisions. Such a framework is generally called a System Architecture.

An **Intelligent Transport System Architecture** will need to cover technical aspects, plus the related organisational, legal and business issues.

ITS Architectures can be created at national, regional or city level, or relate to specific sectors or services. They help to ensure that the resulting ITS deployment:

- can be planned in a logical manner;
- integrates successfully with other systems;
- meets the desired performance levels;
- has the desired behaviour;
- is easy to manage;
- is easy to maintain;
- is easy to extend;
- satisfies the expectations of the users.

The ability to integrate systems greatly increases their potential. By complying with the European ITS Framework Architecture, not only will applications work together, but they can be made inter-operable at a European level, a feature of growing importance.

Inter-operability encompasses the technical, operational and organisational aspects, and implies the harmonious and complementary functioning of the overall system.

The benefits of integrated ITS – an example

There has been a serious accident on the city ring road. It is just after 8am and there is already congestion involving commuters coming into the city. The traffic control centre needs to be able to:

- identify the nature of the accident;
- ensure that the appropriate emergency services are alerted;
- give emergency vehicles priority at traffic signals;
- keep other traffic away from the accident;
- inform public transport operations about the incident;
- arrange diversions and advise drivers on all roads and motorways;
- inform pre-trip travellers, so they can adjust their plans.

To co-ordinate these tasks efficiently, there must be a *rapid and reliable flow of information* between all the systems involved. This flow can be speeded up significantly if the systems are integrated, i.e. if data is exchanged automatically between motorway and city control centres, if the information is available to public transport operators and users as well as to private car drivers, and can be sent to message panels, on-board vehicle systems, mobile phones, web-based transport information services, etc.

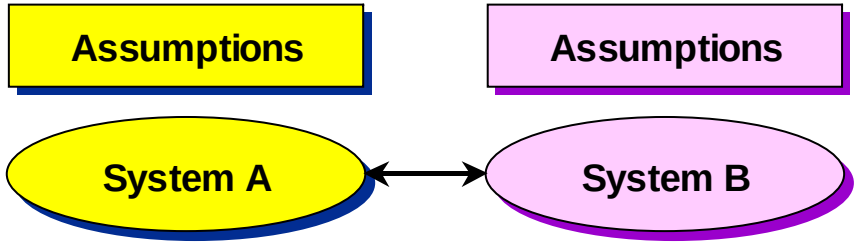
In this example, system integration can make it possible not only to minimise travel disruption, but also to save lives.

The benefits of an ITS Architecture

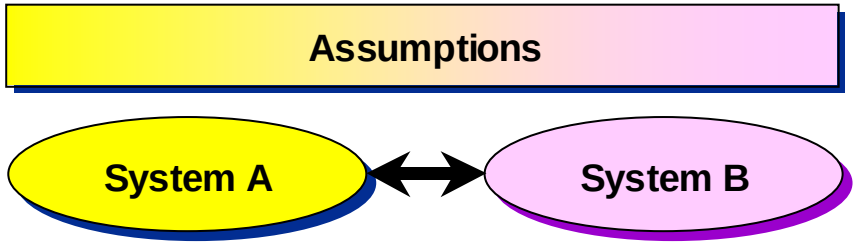
An ITS Architecture is important for a number of reasons:

- it ensures an *open market* for services and equipment, because there are "standard" interfaces between components;
- an open market permits *economies of scale* in production and distribution, thus reducing the price of products and services;
- it ensures *consistency of information* delivered to end-users;
- it *encourages investment* in ITS since compatibility is ensured;
- it ensures *inter-operability* between components, even when they are produced by different manufacturers, which is also good for SMEs (Small and Medium sized Enterprises);
- it permits an appropriate level of *technology independence* and allows new technologies to be incorporated easily;
- it provides the basis for a *common understanding* of the purpose and functions of the ITS, thus avoiding conflicting assumptions.

An ITS Architecture provides a systematic mechanism for capturing the objectives and requirements of all those involved – whether public authorities, transport operators, ITS producers, or final users. It therefore facilitates clear discussion between them and *gives valuable support to decision-makers*.



Result of piecemeal development with some communication



Result of harmonious development of an integrated system

See next page for an explanation

An example of the benefits

Piecemeal development with some communication

An urban area has an ITS deployment containing two systems, one for road traffic management, the other for the management of public transport. A traveller trip planning system is to be added.

The *road traffic management* system collects real-time data for the road network. It uses this to calculate congestion levels on each road link (none / medium / high) and traffic flow data (vehicles/ hour). The links are identified using an internal numbering system.

The *public transport management* system collects location data from public transport vehicles. The data is used to request priority for late running services and to calculate predicted arrival times, which are sent to the relevant stops. The system identifies the delay and arrival time by service number, and the number of the stop.

The *trip planning* system has been specified and purchased. However, it needs real-time journey times for private and public transport vehicles. The system requires this data for each road link using the geographic coordinates as a means of identification.

There is clear incompatibility between the data required by the trip planning system and that provided by the road traffic and public transport systems. To enable the systems to communicate properly they will all have to be modified. Since two systems are already in operation and the third is an off-the-shelf package, this will be expensive, may interrupt operations and have a high cost in terms of time.

Harmonious development of an integrated system

An ITS Architecture has already been produced, and covers the two existing systems. It identifies their areas of functionality, and highlights what data is currently available, its source, plus any communication links that exist between the areas of functionality.

This Architecture can be extended by adding the functionality needed for the *trip planning* facility. It will identify the data needed from existing systems, including any conversions required. The Architecture will also show if this conversion process requires additional data, e.g. digitised map data, public transport schedules.

There are several ways for the conversions to be carried out, e.g. within the new trip planning system, through separate systems, or by modifying the existing systems. The ITS deployment team will have to select the best way. Since the Architecture provides an overall perspective of the whole ITS deployment, they can do this through a meaningful dialogue with the prospective suppliers.

All of this can be done before any equipment or software has been procured. This means that the new functionality can be provided at a much lower cost than the ‘piecemeal’ development described opposite.

The risks you run with no ITS Architecture

Possible long term problems

It is possible that initially you will not be aware of any particular disadvantages, especially if there are only a few ITS deployments in your country, city or region.

However, as time passes, it will become evident that without an Architecture your ITS deployment risks being:

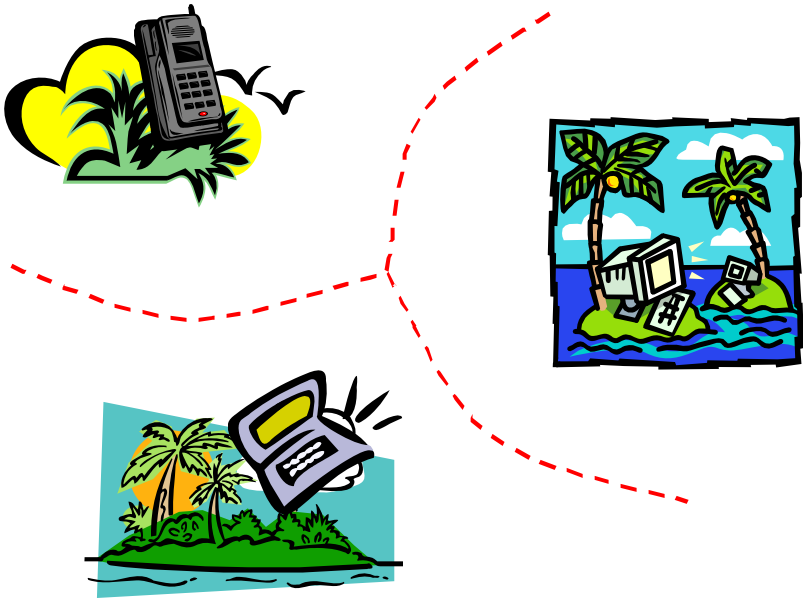
- unable to provide the expected services because the components, both publicly and privately owned, are not fully compatible;
- difficult to extend or modify as service requirements change;
- impossible to adapt when newer technologies emerge.

You will discover that this will result in:

- high costs for updates and the inclusion of newer technologies;
- limitations in service delivery due to lack of inter-operability;
- failure to develop the ITS deployment to its full potential.

At worst, you may discover a serious defect in the overall ITS deployment due to the failure to assess the full implications of component integration. Or you may find you have a deployment that is technically valid, but impossible to operate effectively for organisational reasons.

Lack of an ITS Architecture can result in the creation of "technology islands". Over time, when their boundaries meet – as a result of the need to expand or link these islands – incompatibilities will emerge.



Whether you are a national government, public administration or ITS provider, an ITS Architecture **helps you to achieve the best value for your investment and effort in the long term.**

What does an ITS Architecture consist of?

One of the main elements of an ITS Architecture is the list of **Stakeholder Aspirations**. These consist of the high-level objectives and requirements of all those involved in the ITS deployment, i.e. the users, operators, regulators and providers, who are usually referred to collectively as the "**ITS Stakeholders**".

These Aspirations are then converted into simple statements often called the **User Needs**, which are expressed in a form similar to those shown opposite. In addition, an ITS Architecture normally includes:

- an **Overview or (Conceptual Model)** – a top-level diagram that shows the whole system and explains how it works.
- a **Functional (or Logical) Architecture (or Viewpoint)** – a series of diagrams and specifications that show the functions or processes needed in order to satisfy the User Needs.
- a **Physical Architecture (or Viewpoint)** – a series of diagrams and specifications for the physical components and their locations for a particular deployment.
- a **Communications Architecture (or Viewpoint)** – an analysis of the communications requirements of the links needed between the locations shown in the Physical Architecture.

Other Viewpoints that might be included are an **Organisational or Enterprise Viewpoint**, which describes the business relationships between organisations, and an **Information Viewpoint** to provide models for key sets of data.

Stakeholder Aspiration – An Example for Public Transport

The delivery of more secure, comfortable and easily usable public transport services through the provision of accurate, reliable and timely service information at stops, stations, all types of interchange points and inside public transport vehicles.

User Needs – Some Examples *for Public Transport Travellers*

The system shall be able to inform travellers about public transport operations, e.g. travel times, delays, fares.

The system shall be able to provide information about public transport services to the travellers either on-board the public transport vehicle, or before the journey.

The system shall be able to provide an update of arrival/departure information in real-time and present it to travellers at public transport stops and/or on-board public transport vehicles.

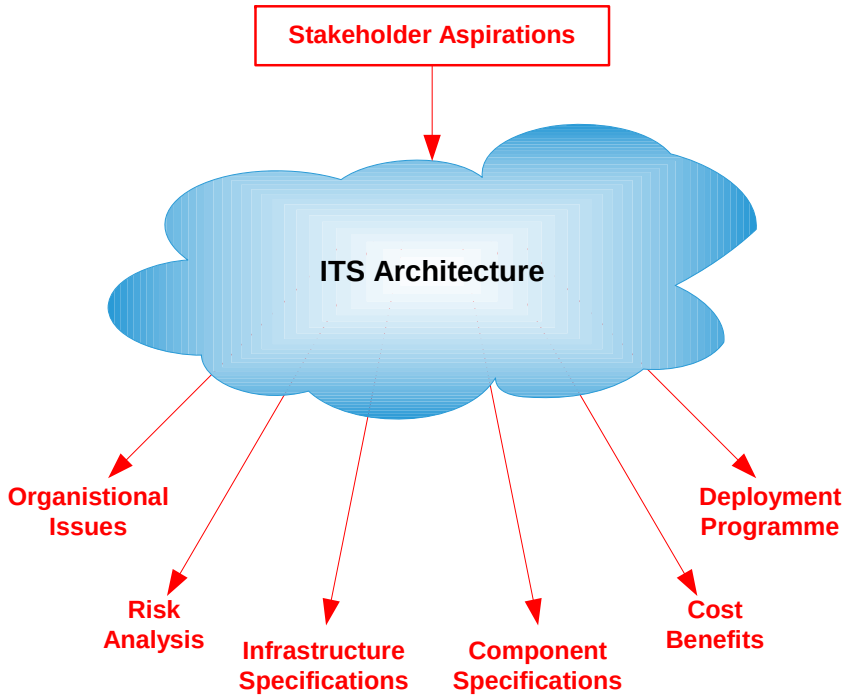
The system shall be able to provide general (dynamic) public transport information, personal safety information, as well as the arrival times of next vehicles, delays, etc. at mode interchanges, e.g. bus stops, in metro, railway or bus stations.

The system shall be able to provide information that is relevant to travellers with special needs, e.g. obstacles, manually operated doors, manual payment systems, restrictions for guide dogs and/or push chairs.

What will an ITS Architecture help you to do?

Once the ITS Architecture has been created, it can be used to provide:

- a preliminary analysis of *Costs & Benefits* identifying the sources of likely costs and benefits, e.g. savings from improved transport efficiency;
- a *Risk Analysis* examining potential problems, e.g. reliability of technologies, uncertainty about sources and volume of revenue, potential stakeholder conflicts;
- the starting point for producing the *Component Specifications* for the elements needed for the ITS deployment;
- a basis for the necessary *Infrastructure Specifications*, including standards for the communication links between components and also with external interfaces;
- the key milestones in the *Deployment Programme* in the short, medium and long term, specifying e.g. when existing component upgrades are needed, and when new components must be available;
- an *Organisational Issues* document, which highlights aspects affecting the organisation of the ITS deployment, e.g. relationships between the various stakeholders, revenue distribution, data ownership, procedures to ensure data privacy.



How is an ITS Architecture created?

When you have decided that an ITS Architecture is required, the first step is to identify the various people and institutions to be involved. These should include: the team responsible for creating the ITS Architecture, a review team, and all the ITS stakeholders. It is also helpful to have an **Architecture 'Champion'**. This should be an experienced and influential person with good communication skills.

The next task is to draw up the list of Stakeholder Aspirations, which involves establishing the objectives of each stakeholder (e.g. by holding a series of individual or group brainstorming sessions). These need to be agreed and endorsed by everyone, and can then be published. A survey of existing ITS applications may also be done at this stage.

During the ITS Architecture creation process it will be necessary to:

- turn the Stakeholder Aspirations into formal User Needs, for which functionality can be developed;
- split the functionality into components that can be produced;
- draw up the outline specifications of these components;
- submit these specifications to a review team;
- compare 'where you are' with 'where you want to be';
- draw up deployment plans.

The FRAME projects provide information, guidance, tools and practical support to help you with the development of your ITS Architecture (see also Page 11).

Brainstorming sessions with the ITS Architecture Team can help to clarify the stakeholders' aspirations

National ITS Architectures

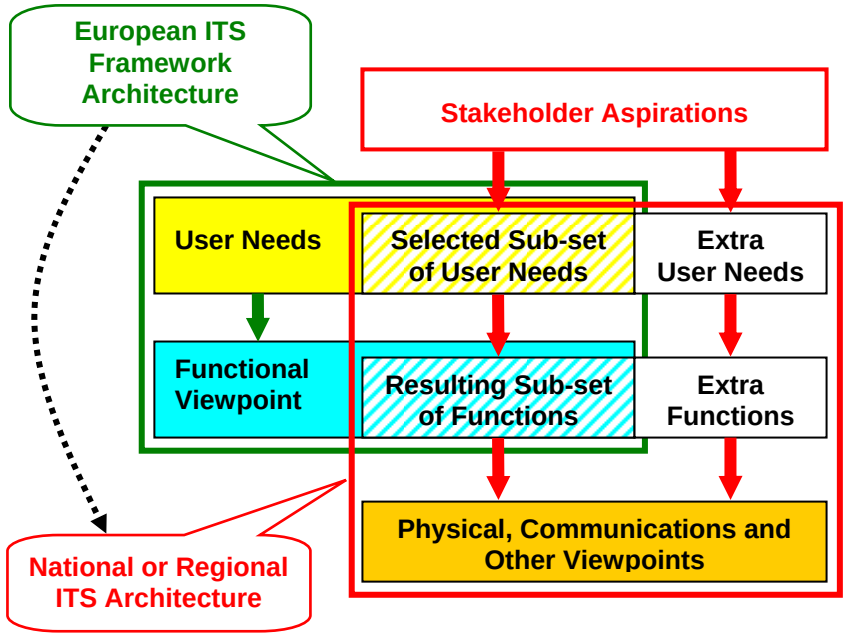
With the spread of ITS, more and more countries throughout the world are creating their own National or Regional ITS Architectures.

The first National ITS Architecture was created in the United States. It was funded by the US Department of Transportation and published in June 1996. All ITS deployments in the USA are now expected to conform to this Architecture.

Following high-level recommendations, the European Commission decided to fund the KAREN project, whose aim was to develop the **European ITS Framework Architecture**. The first version was published in 2000. It has since been updated and extended by the FRAME projects, and is being used by a growing number of countries as the basis for their National or Regional Architectures.

The European ITS Framework Architecture is designed to provide a flexible high level 'framework' that individual countries can tailor to their own requirements. National ITS Architecture projects based on the European ITS Framework Architecture, such as ACTIF (France), ARTIST (Italy), TTS-A (Austria) and TEAM (Czech Republic), therefore have a common approach and methodology, but each has been able to focus on the aspects of local importance and develop them in more detail.

Outside Europe, other nations, including Japan, China, Chile and Australia, have taken similar initiatives. Despite differences in the approaches adopted around the world there is a growing desire to exchange experience and explore the possibility of co-operation at a global level on key issues.



Frequently Asked Questions

How long does it take to create an ITS Architecture?

This will depend upon the scope of the Architecture and the range of services to be included. A Regional ITS Architecture can be created in 6-12 months, whilst a National ITS Architecture will probably take between 1 and 2 years to complete.

Fortunately, much of the work has already been done. The European ITS Framework Architecture provides a valuable basis for the task and its use can considerably reduce the time needed.

Is a large team of people needed?

It is more efficient if an ITS Architecture is produced by a small team. During the development of the Functional Viewpoint, in particular, it is easier to maintain a consistent approach if no more than two people are used to translate the agreed User Needs of all the stakeholders into the Functional Viewpoint. However, additional experts will be required at various times for consultation and to help produce the other documents.

It is also important that the resulting ITS Architecture is reviewed by a large team of stakeholders. This acts as a check on its acceptability with the users, its accuracy and suitability for deployment.

Where can specific technical information be found?

The FRAME website contains the current version of the User Needs and Functional Viewpoint documentation, a Browsing Tool for the Functional Viewpoint and a Selection Tool for creating architecture sub-sets. It also contains documents from the earlier KAREN, RAID and CONVERGE projects.

Is it too late to create an Architecture if we are already using ITS?

No. However, it will be necessary to draw up migration plans, which specify how to deal with existing or 'legacy' systems. It is important to recognise that 'migrate' does not necessarily mean 'replace'. The details of any actions required, and their sequence, will need to be set out in the *Deployment Programme*.

Nevertheless, it is always beneficial to create an ITS Architecture at an early a stage as possible.

Where can I get information about Cost/Benefit calculations?

Information about estimating the Costs and Benefits of ITS deployments can be obtained from the IBEC Group at:

www.ibec-its.org

Who can help with ITS Architecture creation?

Seminars, Training Workshops and practical assistance in the development of National ITS Architectures are provided free of charge by the FRAME technical team for the duration of this EC project (i.e. until October 2004). The team can be contacted at:

info@frame-online.net

Information on support and assistance available after October 2004 will be published on the FRAME website:

www.frame-online.net

Intelligent Transport Systems

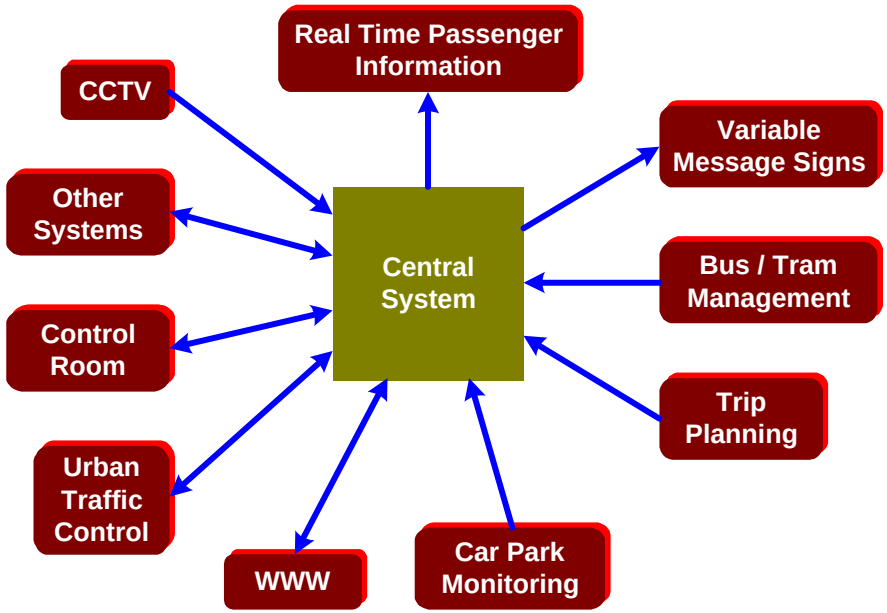
Transport authorities now accept that simply building more roads is rarely a solution to the almost universal problem of road traffic congestion. It is essential to find ways of managing traffic more efficiently on existing roads, and of increasing the use of other modes of transport by travellers and freight. ITS can make a valuable contribution to both of these objectives.

The first telematics systems, which appeared in the late 1960s, were computerised signal control systems designed to optimise urban traffic flows. Over the years, a growing number of increasingly sophisticated products and systems has been developed.

The range of systems now available is extensive, including support for commercial freight and public transport services as well as in-vehicle telematics and traveller information. They are spreading to all transport modes – not only road, but also rail, water and air.

To be able to exploit their maximum potential, it is important that these systems work in a co-ordinated way across the whole transport network, not only at national but also European level. This can be achieved if there is compliance with the European ITS Framework Architecture.

The following pages provide a brief description of some of the major transport services and applications that might be included in an ITS deployment for road-based transport.



This diagram shows the typical elements of an ITS implementation for urban traffic management and control. Such systems are likely to develop piecemeal over the years, as funds permit, and in response to changes in transport policy. The existence of an ITS Architecture gives a systematic basis for the gradual extension of the system and ensures that all of the applications are interoperable.

Traveller Information

This is one of the areas in which great strides are being taken. ITS service providers are able to offer information to travellers via many different channels before and during trips, e.g. on-board devices, web-based services, message panels, special kiosks, mobile phones, etc., giving support in the choice of the best mode and route, as well as information on journey costs.

ITS is moving towards the provision of a complete ‘travel service’: from trip planning and route guidance to the booking of tickets and parking places. Links with tourist services offer additional services, such as hotel bookings, information on places to visit etc.

Examples

- The automatic monitoring of traffic, weather and road conditions makes it possible to give travellers advice on whether to change route or mode. Drivers can, for instance, be warned of traffic congestion ahead and be advised of alternatives routes, or the use of Park and Ride.

- Public transport passengers can be advised of expected arrival times on-board the vehicles, at stops, by mobile phone or even on the Internet before they start their journey.

In these days of international travel, it is important to be able to plan and receive support for cross-border journeys. This means that information systems in different countries must be compatible and inter-operable.

ITS in towns and cities

Most major urban areas in Europe are already using various types of ITS in order to support the control and management of traffic and public transport operations, as well as for enforcement and access control.

A growing number of city transport departments are seeking to take advantage of the benefits to be gained by integrating such systems.

Examples

- The integration of traffic control systems, public transport management and traveller information makes it possible to:
  - regularise bus services by giving priority at traffic signals;
  - enable drivers to avoid congestion and rapidly reach a free parking space through automatic routing;
  - allow travellers to compare journey information for different modes before starting their trip;
  - provide information that enables travellers to change their journey plans when incidents and breakdowns occur.
- The inter-operability of electronic systems enables the control of access to urban areas through various forms of road user charging.

ITS on motorways

Congestion can be just as bad outside the towns and cities. There are many ITS applications designed to help manage traffic, and provide support for drivers on motorways and other roads.

Examples

- Automatic ramp metering to regulate access to congested motorways or ring roads.
- Provision of traffic information and advice to drivers via overhead message signs or on-board devices.
- Control of traffic speed on congested motorways to smooth out the total flow of vehicles (avoiding the 'concertina' effect).
- Incident detection systems that automatically send messages to traffic control centres and provide immediate warnings to drivers.
- Intelligent Speed Adaptation (ISA) systems to ensure that speed limits are maintained at all times – and even vary the limits dynamically according to road, traffic or weather conditions.

Given the increasing amount of long distance and cross border travel, international inter-operability is needed to ensure that on-board ITS devices can communicate with road-side equipment anywhere along the route and receive travel information in any country.

Freight and Fleet Operations

Numerous ITS applications are available to support drivers and fleet operators in the running of public transport services or commercial freight transport, covering both long distance freight haulage and urban goods deliveries. ITS applications can increase the efficiency of operations, encourage the use of different transport modes, and also improve the level of safety.

Examples

- Systems for the scheduling and 'matching' of vehicles, loads and drivers and the automatic compilation of trip reports.
- Optimal routing for both normal and 'abnormal' transport, such as oversized vehicles or hazardous goods.
- Monitoring of safety-related vehicle operations, with on-board data storage for response to roadside interrogations.
- Tracking and tracing of commercial vehicles, containers or loads throughout their journey, together with the monitoring of their physical status, e.g. for food or dangerous goods.
- Automation of the commercial and regulatory documentation that accompanies commercial vehicles and goods.
- Provision of an "office in the cab" for vehicle owner/drivers.

Supporting Services

There are a number of ITS applications designed to support the applications and services described on the previous pages. These include cash-free payment for services, the handling of incidents and support for law enforcement activities.

Examples

- A payment system, e.g. a single ‘smart card’, that enables a traveller to pay for parking, travel information, tolls, use of public transport systems, etc. This card can also store personal information and preferences, e.g. disabilities and hotel price ranges. With this system each service provider receives the correct payment due for the service that has been used.
- Automated tolling systems that enable vehicles to be charged the correct amount without needing to stop at pay booths.
- An on-board system can generate an automatic May Day call in the event of an accident. The call centre gives the emergency service(s) the precise location, and guides them to the scene with the support of a traffic management system.
- ITS can help in the management of exceptional road transport conditions, e.g. the passage of hazardous goods, and the management of bridges and tunnels.
- ITS can be used to detect traffic violations automatically, e.g. speeding, failure to obey traffic signals, together with the offending vehicle’s details. This facilitates follow-up action and frees personnel for other tasks.

The FRAME projects

The aim of the projects, FRAME-NET and FRAME-S, is to encourage and support the use of the European ITS Framework Architecture, and to maintain it as a living product. They organise international "Cluster" Meetings for the discussion of ITS Architecture issues, and the exchange of news and information. Seminars and workshops are also run for national or international groups or organisations on the benefits of using the Framework Architecture. If you wish to request a workshop, or become an associate member of the FRAME Network, please contact the FRAME Help Desk at:

info@frame-online.net

The FRAME projects are due to finish by October 2004. For information of the support and assistance that will be available after this time, please see the FRAME website:

www.frame-online.net

E-FRAME Project (5/2008 - 4/2011)

Advice and support for the European ITS Framework (FRAME) Architecture is now available from the EC funded project E-FRAME. This is also extending the Architecture to include Cooperative Systems. The FRAME Help Desk and website (see above) are still active.

E-FRAME Partners:

Peter Jesty Consulting Ltd (UK), Siemens plc (UK) ,AustriaTech (AT), Rijkswaterstaat (NL), Czech Technical University in Prague (CZ), CERTU (FR), MIZAR Automazione (IT)

Feb 2009

European Commission Contact Information

The FRAME projects are fully funded by the Information Society DG of the European Commission (EC) as part of the Information Society Technologies (IST) Programme. This is a major theme of research and technological development within the European Union's Fifth RTD Framework Programme (1998-2002). Further information about EC activities in this area can be found at the following websites.

IST Programme: www.cordis.lu/ist/home.html

Information Society DG: europa.eu.int/comm/dgs/information_society/index_en.htm

EC Research Information: www.cordis.lu/en/home.html

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