European ITS Framework Architecture

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Introduction and Objectives

In order to effectively design and implement any type of framework architecture, it is essential that the costs and benefits involved are clearly understood. In this way, the architecture can be focused on areas where the best value for money can be obtained.

This document (European ITS Framework Architecture Deliverable D3.4) aims to address this need by presenting a Cost Benefit Study into the development and adoption of a framework architecture for Intelligent Transport Systems (ITS).

The objective of this task is to look at the benefits likely to be obtained from the deployment of the Framework Architecture (FA). In particular, it considers the results obtained from European Telematics projects where the integration of different applications in a common infrastructure has demonstrated benefits.

Cost-benefit aspects considered

The costs and benefits considered in this study are those which are additional to the costs and benefits which would occur in the case of ITS implementation without a common Framework Architecture.

This distinction is however difficult to clarify, since results from deployments where there has been a common architecture cannot be directly compared with those relating to deployments without a common architecture, as schemes are affected by so many other factors.

Actors

The actors involved in ITS architecture and deployment cover a wide spectrum, comprising:

- ITS system manufacturers;
- operators providing ITS services (infrastructure and public transport operators and other service providers, such as broadcasters, the electronic and print media, motoring organisations, etc);
- private users (individual members of the public);
- commercial users (businesses which stand to benefit from ITS);
- governments and other public authorities; and
- standardisation bodies.

Actors may be users or providers of ITS, or in some cases both. In the case of standardisation bodies, they are neither ITS users nor providers.

Costs

Regarding costs, the deployment of the Framework Architecture requires investment, such as:

- the investment that has already been dedicated to the European ITS Architecture (in the 4th Framework Programme European projects and in particular KAREN); and

- the investment that will be necessary at the national, or even at the regional level for establishing an EU compliant national or regional FA.

The costs of an ITS Framework Architecture can be classified in two ways:

- the types of costs; and
- by whom they are incurred (these are the actors detailed above).

The types of cost can be classified in terms of three broad groups as follows:

- Architecture development costs (identification of system architecture promoters, planning phase, tendering process, technical development and reviewing the results);
- Costs of exploiting the "paper" results (dissemination/awareness/promotion, training/ education, political acceptance; defining funding access and maintenance of paper results);
- Implementation costs (finding funding resources, migration of existing systems, procurement and tendering processes, building and maintaining ITS state-of-the-art, delivery and acceptance of systems, training on the use of new systems and maintenance of systems).

Benefits

The benefits of deploying a common framework architecture can be considered at different levels:

- benefits obtained through specific ITS applications/services that will use a common framework architecture. In general, these benefits will be obtained by a reduction in implementation costs;
- benefits obtained as a result of the Framework Architecture offering interoperable solutions between different services or different geographical areas;
- benefits obtained as a result of the ITS Framework Architecture facilitating ITS deployment in Europe. This will increase the number of ITS services and reduce implementation times, with each of these services bringing its own costs and benefits.

These benefits can take the following forms:

- reduced barriers to market entry for ITS manufacturers and service providers, leading to increased competition and reducing costs;
- reduced costs for developing national or local architectures (as they can use KAREN as a base);
- reduced costs for developing ITS systems themselves;
- reduced costs for purchasing the equipment;
- reduced operating and maintenance costs;
- reduced costs to users for services (where producers or operators pass on savings to users – although in this case, the financial benefits to operators and suppliers listed above will be reduced);
- reduced risk in developing and implementing systems;

- better knowledge of demand/transport patterns;
- enhanced communication between actors (at a national and international level);
- improved management of research and development and standardisation at a national level;
- interoperability of services (i.e. technical, functional and contractual interoperability);
- more seamless, co-ordinated and consistent services, leading to enhanced quality for the end user;
- increased multimodality; and
- increased market size resulting from lower costs and higher service standards, leading to increased employment.

These benefits are interrelated in that some of them are not final objectives as such, but are prerequisites for achieving other benefits, for example, interoperability leads to more co-ordinated, consistent and seamless services.

Benefits can also be clustered in terms of the following groups:

- technical benefits;
- social benefits;
- legal/institutional benefits;
- financial benefits.

The benefits emanating from a common Framework Architecture are indirect in that they are effectively the third stage of the following sequence:

1. Production of an accepted standard or result (such as the KAREN Architecture).

2. Application of the standard/result by ITS implementers (in the development of local architectures or in system deployment).

3. Benefits resulting from this application, in terms of reduced costs and time for development and implementation and reduced operation and maintenance costs.

Architecture deployment costs in selected EU Member States

National Framework Architecture projects are currently underway in a number of EU Member States. These can be summarised in the following table:

National Framework Architecture Projects in the EU

Country:	Finland	France	Italy	The Netherlands	Sweden
Name of project	TelemArk	ACTIF	ARTISTA	Koepelarchitectuur	OPTIS
Scope	Passenger transport telematics for all modes (road, rail, air, water).	Road, rail and inland waterway modes, plus their interfaces with air and sea transport.	All inland transport modes	Road, rail and inland waterway modes, plus their interfaces with air and sea transport.	Road
Aims/Approach	Adopts a bottom-up approach through workshops involving actors	To improve communication between actors, elaborate prospective visions and act as a tool to address ITS architecture issues. Approach involves case studies	Development of a national architecture for ITS that serves as a reference platform for the implementation of real intermodal services nation-wide. Involves the design of a national intermodal demonstrator	To demonstrate the coherence of various ITS elements, to demonstrate coherence with the European FA, to serve as a basis for further architecture development and to serve as a means to reach agreement on further ITS implementation	Focuses on services and aims to deliver dynamic information
Cost (euros)	0.6m (1998-2000)	2m (1999-2001)	3m (2000-2001)	0.2m for Koepelarchitectuur (1999-2000) plus 2m for sub-architectures	0.1m

Examples of "success stories" from European ITS projects and deployment programmes

The **QUARTET** and **QUARTET Plus** EU demonstration projects involved local authorities, transport operators and the others (including vehicle manufacturers, providers of telecommunications, IT and ITS systems, broadcasters and research organisations) in four cities, expanding to six in the case of QUARTET Plus.

The aim of the QUARTET project was to demonstrate a pilot implementation of integrated ITS applications. The project demonstrated that integration of advanced transport telematics on a large scale is both technically feasible and socially desirable.

QUARTET Plus had the objective of demonstrating a European platform for launching transport informatics in urban areas on an open market by means of comparative evaluations and by operating an information infrastructure, multimodal information and public transport management. A key part of the project with relevance to framework architectures is the workpackage dedicated to the demonstration of IRTE strategies, architectures and tools.

QUARTET and QUARTET Plus implemented a communication and physical architecture which shows a relatively high level of integration in the data exchange facilities between “systems” operating in urban area. A co-operative control scheme was introduced in different sites and key results were demonstrated by means of extensive field trials and surveys.

The high level of integration demonstrated relevant benefits by sharing infrastructure. For example, it is estimated that the costs of purchasing and installing roadside outstations in the Turin application (the 5T system) were recovered by savings on transmission charges over a payback period of one year. Cost benefit analyses also showed relevant benefit for the operators, e.g. efficiency savings have allowed the Turin public transport operator to remove one tram from the service as a result of improved regularity and efficiency.

The **ROMANSE** project in Southampton aimed to realise a vision of an information-rich society based on integrated ITS and to improve travelling conditions in the city by reducing uncertainties and providing the information required for travellers to make more informed travel choices. The project involved the implementation and testing of a range of telematic applications.

The architecture employed involved the linking of these applications to a strategic information system which is a fully integrated and locationally referenced database and can be viewed in real time on a map-based display.

The cost-benefit analysis of the applications was based on the average amount of time that each user would have to save in order to justify the investment. Examples of the time savings necessary to justify the implementations are between half a minute and one minute for the parking guidance system and half a minute to two minutes for the “STOPWATCH” real-time bus information display at bus stops. These benefits did not include benefits to operators (e.g. increased patronage for the bus company). Before and after surveys have also shown a significant increase in the proportion of users rating traffic information in the city as good,

Whilst the monitoring and evaluation has proved to be difficult, awareness of the systems was found to be very high amongst the travelling public and the levels of time savings required to justify the investment and operation are relatively small. Furthermore, the performance of the system as a whole has been analysed as being better than that of any individual product.

The **ENTERPRICE** project had the aim of improving multimodal traffic information. Its core activity was the establishment of Mobility and Traffic Information Centres (“MOTICs”) using an open standard architecture in the Rhine Delta area, Switzerland and Hessen.

Whilst the demonstrations at these sites had different priorities, the basic functionalities of the MOTICs were the same, in terms of collecting and processing traffic data. The architecture of the system was designed in order to fulfil the requirements of the various conditions in each European country.

The research costs for MOTIC within ENTERPRICE were in the order of 200 000 euro and the benefits included services to travellers and fleet operators, a contribution to the sustainable and safe mobility of passengers and goods over a wide area, services to improve multi-modal travel, improved information, a basis for higher safety and comfort at lower cost, and a basis for the development of new products and new markets.

In the case of TIC Nederland, the Dutch national traffic information centre which was established in 1998 as a result of activities within ENTERPRICE, the adoption of architecture standards have had the effects of making it easier for commercial service providers to enter the marketplace and of promoting competition, which has led to improved services to the end user. It has also allowed data exchange between other TICs (in particular, the North Rhine Westphalia TIC in Cologne) by means of Datex.

Electronic data exchange on an international level using the **Datex** format is currently being implemented in traffic centres around Europe and provides these traffic centres with language-independent information from neighbouring regions and countries.

In effect, the Datex architecture is defined as a number of interoperable client and supplier systems. The Datex Memorandum of Understanding (MoU) comprises the latest agreed version of the Datex specifications and the Datex documentation is currently being considered for standardisation by the CEN (European Standards Committee).

The benefits of adopting a communication standard at the Datex level include having a common understanding of the information to be exchanged and its structure, including language independence, and achieving interoperability at functional and technical levels. A further key benefit is a reduction in development costs compared to the situation where centres apply their own ‘standards’ on a bilateral basis.

The implementation of **RDS-TMC** in Europe is another area where a common communication architecture exists. The EU has focused on the deployment of RDS-TMC services as part of the TEN-T implementation programme and its implementation on an international level with a choice of broadcast languages is being planned. The aim is for a continuous, compatible and interoperable service with a key benefit being that the user can use the same certified receiver in any country in Europe to receive a standard quality in the language of his/her choice.

Implementation costs over the past three years have been around 10 million euro, and costs to users of RDS-TMC include the requirement to buy a terminal (or to purchase a car fitted with one).

Electronic Fee Collection (EFC) on motorways is an area where common architectures are being developed. A key requirement of such systems is interoperability, both between different motorway operators within a country and also between countries, to remove the need for motorists to have more than one tag fitted to their vehicle. Currently, interoperability exists on an national basis, such as in France (TIS - Télépéage Inter-Société) and Italy (Telepass). However, current EFC systems are not interoperable between Member States.

The CARDME (Concerted Action for Research on Demand Management in Europe) project involved the development of a non-technical framework architecture for EFC. Its report into the migration of existing systems looked at the costs and benefits related to the introduction of two new tolling services for users: a stop & pay service and an interoperable EFC service. For both services, the main cost is on the set-up of the back office procedures between the different operators for the transfer of claims and settlements between the participating operators. The other main costs are related to information provision to users about the existence of the new service, i.e. signing, brochures and contracts.

The user benefits will be in the time saving by accessing a common level of service across Europe, but will require the purchase and fitting of an electronic tag.

Although operators will face the principal costs at the time of development and introduction of new interoperable EFC services, they will gain longer term benefits such as a reduced need to invest in added capacity at toll plazas to accommodate international traffic, because of the increased capacity of toll plazas. Also, if EFC becomes more interoperability, it also becomes more attractive to users, thereby reducing the number of manual staffed barriers required.

Operators are also providing a value-added service to the motorist in implementing interoperable EFC, especially for international motorists, who will find the motorway both easier to use and will save time queuing, dealing with foreign money or making credit card transactions. Operators could recuperate their costs through modest increases in the toll rate.

Examples of “success stories” from outside the ITS world

GSM (Global System for Mobile communications) is a standard service architecture in the mobile phone sector. It is an architecture which has led to major benefits, in that it allows interoperability of mobile phones on a Europe-wide basis and beyond.

Although there are experiences to be learned from the development of this architecture, direct comparison to the ITS industry is difficult as GSM developed in a specific context where financial issues were predominant. In addition, the mobile phone market is far larger than that for ITS equipment.

The development of a GSM standard has however made a significant contribution to the growth in mobile phone use and competition in this sector is now intense, with prices falling. Service providers now offer a wide range of tariff structures and value-added services to differentiate their products.

The costs of this work are difficult to estimate, and comprise largely of inter-operator co-operation work. Operators do however consider the costs to be worthwhile in terms of the benefits, notably the 200 million GSM users (out of a total of 436 million mobile phones world-wide). Furthermore, growth in GSM ownership has been twice as fast as predicted, with over 40% of the European population owning a mobile phone in 1999 figure, compared to 14% two years previously. This level of success would not have been possible without the standardisation work.

Key benefits transferable to ITS include price pressure due to multi-vendor compatibility at a system level and the fact that customers are more willing to invest as they know that they can develop and realise their investment without being locked into a single supplier.

The **Internet** is another example of a standard architecture outside the ITS domain. This widespread information infrastructure was principally developed in the USA and had a lead time of some 20 years, although its use has exploded in the past two to three years (since the late 1990s).

Its framework architecture is therefore now a World-wide standard, connecting computers made by a variety of different manufacturers and supporting services such as e-mail and the

World Wide Web, which have their own sub-architectures. These applications are Internet protocols and use the Internet as a platform.

The Internet is one of the most successful examples of the benefits of sustained investment and commitment to research and development of information infrastructure. Costs were borne initially by the academic world and boosted by a ten year $200 million investment by the US National Science Foundation, but in more recent years, the growth in Internet users has been such that costs can generally be covered commercially.

In ITS, architecture development has been less based in the academic world and more in the industrial and public sectors although, like the Internet, commercial players are coming increasingly to the fore. The other difference is that the formative years of the Internet took place in a non-commercial environment in the USA, where public funding was conditional upon the system being used only for government and research uses. When the service opened up to commercial use, the same basic architecture was used, and was exported from the US world-wide. Although the Internet is now hugely successful, it attracted little interest during its formative years and was effectively producer-led. ITS, on the other hand, is more consumer led and commercially oriented. However, public funding is still necessary in order to develop the architecture as the large number of private players in a competitive environment make this an unfeasible proposition within the commercial sector.

The second major difference is the rate of growth. The benefits of the Internet are clear to most people, whilst those of ITS are less so, and are more of interest to public authorities and road operators than the general public, most of whom are unfamiliar with the concept. So while ITS services are undoubtedly on the increase and their value is being recognised, comparisons with the exponential growth of the use of Internet applications are impossible.

Approaches to ITS Architecture Outside Europe

The **US National Architecture project** for the Federal Department of Transportation represented the first large scale effort in the United States to document the costs and benefits of equipment associated with ITS deployment, and included the following three elements:

- Cost Analysis - this develops a high level cost estimate of implementation expenditures and acts as a costing tool for implementers.

- Performance and Benefits Study - this assesses the technical performance of the US National Architecture on a number of system-level and operational-level criteria. The analysis separates two types of benefits: the benefits of the architecture as a whole and the benefits of particular ITS products

- ITS Programme Assessment/Evaluation - this aims to ensure that the US National ITS Program is effective in meeting the DoT’s transportation goals, with emphasis being placed on tracking both programme outputs and programme outcomes. Programme outputs are results-oriented measures that track the progress of a programme for which the benefits are easily understood by the end-user.

In **Japan**, five government bodies jointly finalised the System Architecture for ITS in Japan in 1999. A cost-benefit study of the architecture is being conducted and results are expected at the end of 2000.

Conclusions

This report outlines the costs and benefits of developing, maintaining and implementing an ITS framework architecture. Costs and benefits in this report have been assessed and discussed in a qualitative way rather than a quantitative one, as the lack of experience in an ITS framework architecture means that concrete figures are simply not available at the present time.

Furthermore, these benefits are difficult to measure (due to the lack of an effective “do nothing” or “control” scenario as a benchmark with which to measure the results of implementations), they cannot often quantified in financial terms, they are spread across a very large number of beneficiaries, and it is also difficult to ascertain to what extent the benefits of ITS implementations are enhanced by the adoption of a common architecture or integrated system.

The purpose of this report has therefore been to provide an analysis of the issues and to provide ITS implementers and funders at European, national and regional/local levels with suitable reasons for adopting an approach based on a standard framework. These have been supported by a number of examples on a smaller scale where a common architecture or the integration of separate systems have brought benefits.

Therefore, while the benefits of the KAREN Framework Architecture cannot be quantified (or at least at the present time, when national architecture projects based on KAREN are still underway), KAREN can provide (and indeed is currently providing) benefits to the developers of national, regional and service-oriented architectures by providing a foundation for this architecture, thus speeding implementation and reducing costs.

These architectures will then provide the bulk of the benefits to the end user, whether private or commercial. In addition, the KAREN FA can provide some benefits to the end user in terms of creating a framework in which different applications and different services in Europe can inter-operate. This interoperability not only improves services to the end user but also helps to drive down costs in the longer term for users, operators, manufacturers, implementers and funders alike. Another benefit of the KAREN FA is that the common framework can reduce entry barriers to the market, including barriers between markets in EU Member States, thus contributing to the European Single Market and increasing the competitiveness of the European ITS industry.

1. Introduction

1.1 Background

Public authorities which have responsibilities for traffic, transport, safety and environmental issues are accountable to the public in terms of being responsible for providing solutions to traffic and transport problems. As a result of different local circumstances, political objectives and available budgets, they may come to different conclusions. However, there is a wide consensus that transport telematics, or ITS (Intelligent Transport Systems) can play a key role in achieving traffic and transport goals in politically acceptable ways, reducing the need for new infrastructure construction, promoting safety and promoting an environmentally friendly, fair and socially inclusive transport system.

At the European level, resolutions of the European Council of Ministers of Transport, white papers and communications of the European Commission and recommendations of the High Level Groups on Road Transport Telematics and on Safety strongly support the view that ITS is a key tool in making better use of existing transport infrastructure.

In the implementation of ITS however, the after the first system, the complexity of interrelationships between different applications and systems grows rapidly, posing a threat to the effectiveness, manageability, maintainability, extendibility and refurbishment of systems over time, and to overall costs. For instance, if a city wishes to implement ITS systems for public transport management, parking management, traffic management and traveller information, they would wish them to co-operate, at least to a certain level, and to produce benefits from this synergy, rather than to counteract or contradict each other.

It is therefore evident that a framework architecture providing a certain level of integration and interoperability would produce significant benefits in terms of consistency, maintenance and overall cost. Refurbishment with newly emerging technologies over time and extension with new systems and services would also be easier, more effective and less expensive.

1.2 Purpose of this document

In order to effectively design and implement any type of framework architecture, it is essential that the costs and benefits involved are clearly understood. In this way, the architecture can be focused on areas where the best value for money can be obtained.

This document (European ITS Framework Architecture Deliverable D3.4) aims to address this need by providing the sources, methodology and results of a Cost Benefit Study that has been undertaken by the KAREN Project Team.

The background to the development of the Framework Architecture is provided in the European ITS Framework Architecture Overview document (D3.6).

1.3 Where the document fits in the Architecture Documentation

The document is one of a set of seven documents produced by the KAREN Project as part of Workpackage 3 (Framework Architecture Development) to describe the complete KAREN Framework Architecture. The other documents in the set are as follows:

D3.1 European ITS Framework Architecture - Functional Architecture
D3.2 European ITS Framework Architecture - Physical Architecture
D3.3 European ITS Framework Architecture - Communications Architecture
D3.4 European ITS Framework Architecture - Cost Benefits Report (this document)
D3.5 European ITS Framework Architecture - Deployment Study Report (internal report, providing a base for D4.2: Deployment Approach and Scenarios)
D3.6 European ITS Framework Architecture - Framework Architecture Overview

1.4 Document structure

Following this introduction, Chapter 2 describes the general objectives of the cost-benefit analysis of the Framework Architecture and provides a brief overview of the architecture itself.

Chapter 3 provides the basis for the cost-benefit study in terms of identifying the key actors who pay for and/or benefit from a Framework Architecture and identifying the costs and benefits themselves.

The elements identified in Chapter 3 are expanded upon in Chapter 4, which provides a discussion of the costs and benefits as they affect each actor.

Chapter 5 goes on to provide examples of expected and actual costs and benefits involved in architecture deployment. This comprises:

- An overview of the plans already prepared at national level in some EU Member States for the deployment of framework architectures, including real examples of deployment costs where available.
- Examples of “success stories” from a selection of European ITS projects and deployment programmes (although these concern actual ITS deployment as opposed to architecture development, they cover situations where deployment has occurred in different geographical areas or across different applications using a global architecture, and thus the benefits gained are partly as a result of this common architecture).
- Examples of architectures “success stories” from the IT and telecommunications worlds.

Chapter 6 provides an overview of ITS architecture cost-benefit research outside Europe, and the conclusions of the study are set out in Chapter 7.

1.5 List of acronyms and abbreviations

ACTIF	Architecture Cadre pour Transport Intelligent en France (French national framework architecture project)

CARDME	Concerted Action for Research on Demand Management in Europe
CEN	Comité Européen de Normalisation (European Standards Committee)
DSRC	Direct Short-Range Communications
EC	European Commission
EFC	Electronic Fee Collection
ENTERPRICE	Enhanced Network for Traffic Services and Information Provided by Regional Information Centres in Europe (EC 4th Framework Programme Transport Telematics Project)
EU	European Union
FA	Framework Architecture
GSM	Global System for Mobile telecommunications
HANNIBAL	High Altitude Network for the Needs of Integrated Border-crossing Applications and Links (EC 4th Framework Programme Transport Telematics Project, concerned with implementation of interoperable data exchange)
HGV	Heavy Goods Vehicle
IRTE	Integrated Road Transport Environment
ITS	Intelligent Transport Systems
KAREN	Keystone Architecture Required for European Networks
MOTIC	Mobility and Traffic Information Centre (developed as part of the ENTERPRICE project)
MoU	Memorandum of Understanding
OPTIS	Optimised Traffic in Sweden (Swedish national framework architecture project)
PPP	Public-Private Partnership
QUARTET	Quadrilateral Advanced Research on Telematics for Environment and Transport (QUARTET: EC DRIVE II project; QUARTET Plus: EC 4th Framework Programme Transport Telematics project)
RAID	Risk Analysis of ITS Deployment
RDS-TMC	Radio Data System - Traffic Message Channel
ROMANSE	Road Management System for Europe

TEN-T	Trans-European Network for Transport
TIC	Traffic Information Centre
VMS	Variable Message Sign

2. Objectives of the Cost-Benefit Analysis of the Framework Architecture

2.1 Introduction

The objective of the Cost-Benefit Analysis task is to look at the benefits likely to be obtained from the deployment of the Framework Architecture. In particular, it considers the results obtained from European Telematics Projects where integration of different applications in a common infrastructure has demonstrated the benefits obtained. This task is also related to the "Deployment Plan" task, which addresses issues such as migration from existing systems, standard development, institutional aspects and the development of supporting infrastructure.

2.2 Cost-benefit aspects to be considered

The benefits of the deployment of a common Framework Architecture (FA) can be considered at different levels:

- Benefits obtained through specific ITS applications/services that will use a common framework architecture. In general, these benefits will be obtained by a reduction in implementation costs.
- Benefits obtained as a result of the Framework Architecture offering interoperable solutions between different services or different geographical areas.
- Benefits obtained as a result of the ITS Framework Architecture facilitating ITS deployment in Europe. This will increase the number of ITS services, each of them bringing its own costs and benefits, and will also reduce implementation time.

The costs and benefits considered are additional to those which would occur in the case of ITS implementation without a common FA. In some cases it is difficult to separate costs and benefits due to ITS implementation in general and those resulting from a common framework architecture, and where such doubts exist, this is made clear.

This distinction is however difficult to clarify, since results from deployments where there has been a common architecture cannot be directly compared with those relating to deployments without a common architecture, as schemes are affected by so many other factors.

Benefits are given in terms of overall benefits, plus examples from projects and national architectures both within the EU and in other key countries.

2.3 The KAREN Framework Architecture

The KAREN Framework Architecture is a **European Framework Architecture** in that it is at a "level" such that it can be used as a reference by all ITS architects in EU member states. It is intended to be the foundation for building other types of architecture and will enable these architectures to guarantee compliance at the interfaces of other systems, so that seamless services can be provided to cross-border travellers and an open European market of compatible components can be established.

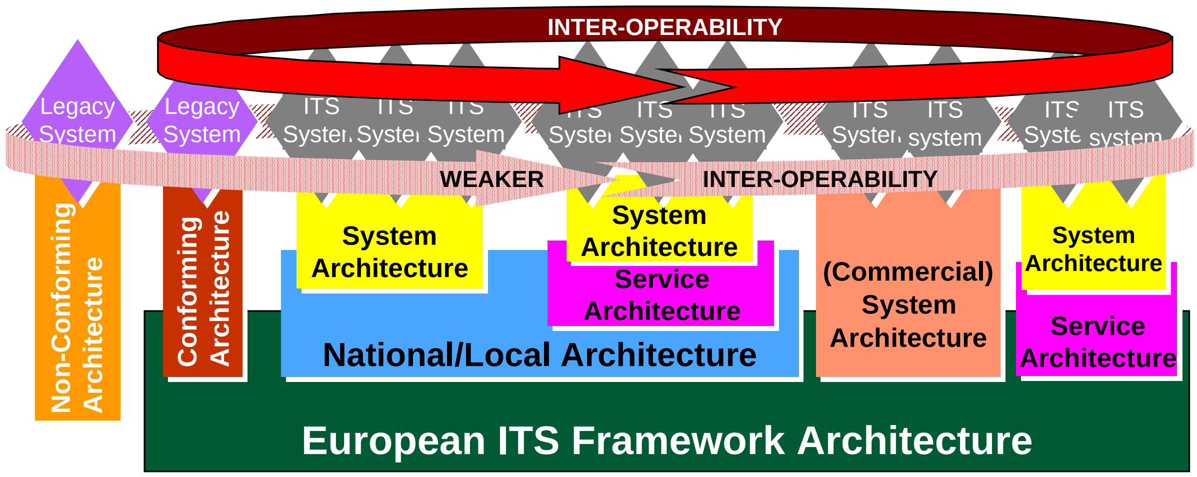
The two broad levels of architecture below the KAREN FA are as follows:

- Intermediate level architectures, which are being defined for EU Member States, regions or cities or for a specific service to create the conditions for a market of compatible and modular solutions, and for establishing the implementation of nation, region or city-wide inter-operable solutions and services. Two or more systems are inter-operable if they can pass data between each other to their mutual benefit, i.e. to provide harmonious and/or complementary functionality: interoperability includes the technical, operational and organisational aspects.
- At the level nearest the design there is the System Architecture which is of fundamental importance when systems are created by integrating two or more sub-systems. The system architecture provides the structure around which a class of systems may be developed. It is the level at which the basis for "Working and Workable Systems" is set up [CONVERGE 1998 - ref. (j)].

In addition, these architectures are a tool for guiding national research initiatives and for providing the reference document for standards and rules to be used for their applications. They also provide the common terminology for specifying systems, and possibly recommend the standards and the interfaces to be used to achieve compatibility at the European and national level.

Figure 1 below provides an overview of the interrelationships between these various architectures.

Figure 1: Overview of the relationship between architectures



The key features of the KAREN Framework Architecture are that:

- it is open - anyone can join;
- it is multi-modal, i.e. for all forms of road transport, not just for the private car, and with interfaces to other modes of transport; and
- it is technology independent.

The KAREN FA is not a system or component design or a system specification, but it can be a starting point for high level system specification development.

Clearly, the deployment of the FA requires investment, such as:

- the investment that has already been dedicated to the European ITS Architecture (in the 4th Framework Programme European projects and in particular KAREN); and
- the investment that will be necessary at the national, or even at the regional level for establishing an EU compliant national or regional FA.

3. Identification of actors, costs and benefits to consider

3.1 Actors

The actors involved in ITS architecture and deployment cover a wide spectrum, from ITS system manufacturers and operators to individual members of the public, from businesses which stand to benefit from ITS to governments and other public authorities. In brief, actors may be users or providers of ITS, or in some cases both.

Table 1 describes the various actors and explains where they fit into the wider ITS picture. It should be noted that within the "Public authorities" category in this table, actors can have two distinct roles: that of policy making/funding and operation of the network. There are close parallels between the latter and the "Companies providing/using ITS services", as a national roads agency or a local highway authority is essentially an operator in the same way as a private motorway operator – they are both concerned with providing similar services to the road user.

A further category of actors, not listed in Table 1, is that of standardisation bodies. This group is not listed in the table as it neither provides nor uses ITS services, but provides a support role to architecture and system developers through the development of standards.

The KAREN User Needs Document (Deliverable D2.02) describes more fully the requirements of these users and providers, in terms of ten user need groups, containing 510 individual user needs.

Table 1: ITS actors (users and providers)

Actor	Clarification/ Examples	Role as an ITS user	Role as an ITS provider
Private users	Individuals	Motorist or public transport passenger	Limited to voluntary transmission of data by automatic means (e.g. floating car) and human means (e.g. reporting of incidents/traffic conditions by mobile phone)
Commercial users	Hauliers/distribution companies Commercial drivers (HGV, bus, taxi, etc) Individuals travelling on business and their employers	Motorist (for business) or commercial driver Logistics or public transport scheduling/ management	As above
Companies providing/using ITS services	Private road infrastructure operators (motorways, tunnels, etc) Public transport operators[1]	Use information supplied by other actors via ITS ITS equipment user	Provide pre- and on-trip information to road users Provide other ITS services to increase road safety and efficiency

Actor	Clarification/ Examples	Role as an ITS user	Role as an ITS provider
Value-added ITS service providers	Broadcasters Internet service providers GSM service providers	Use information supplied by other actors via ITS (particularly by infrastructure operators)	Provide pre- and on-trip information to road users and additional services (e.g. rescue services)
The ITS industry	System manufacturers and suppliers	Use location data bases provided by authorities;	Provide equipment and maintenance support
Public authorities[2]	European institutions High level ministries (national governments & devolved/autonomous governments within nation states) Regional authorities Local authorities (cities, counties, etc) National/Regional road and traffic agencies Police	Use information supplied by other actors via ITS ITS equipment user	Provide policies contributing to the development and organisation of ITS Provide pre- and on-trip information to road users Provide other ITS services to increase road safety and efficiency

1 Although KAREN does not cover ITS architecture for public transport operations, PT operators can be relevant actors insofar as the interface with road transport is concerned (park-&-ride, ferry ports, etc).

2 This comprises the KAREN classifications of European authorities, national authorities and local authorities.

3.2 Costs

The costs of an ITS Framework Architecture can be classified in two ways:

- the types of costs; and
- by whom they are incurred (these are the actors detailed above).

The types of cost can be classified in terms of three broad groups and a number of sub-categories, as follows:

a) Architecture development costs:

- general management;
- identification of system architecture promoters (who will lead the process, sell the idea to politicians, industry and others, identify initial funding sources, define a workplan and identify other potential team members);
- planning phase (by the initiator of the process, including identifying the vision, reviewing the current situation and identifying how to perform and finance the process of technical development);
- tendering process (selection of developers);

- technical development of the architecture (reference, functional and physical architecture at global or local level and defining a deployment plan;
- review of results (including review by consensus groups and final acceptance).

b) Costs of exploiting the “paper” results:

- general management;
- dissemination/awareness (and possible review by other consensus groups);
- political acceptance;
- defining funding access and encouraging public-private partnerships;
- education (e.g. development of guidelines and guidebooks for procurement, tendering process, contract definition, etc);
- training architecture users;
- maintenance of paper results (e.g. implementing and contributing to best practice);
- communication costs (promotion).

c) Implementation costs:

- general management;
- finding funding resources;
- migration/upgrading of existing systems;
- setting up of a procurement process;
- tendering process for contracting implementation of architecture elements;
- build and maintain ITS state-of-the-art (including maintenance of standards/protocols and location referencing);
- delivery and acceptance of systems;
- training on use of new systems;
- maintenance of systems.

Table 2 shows the ways in which these costs are incurred by the various actors involved.

Table 2: Costs of a Framework Architecture

Actor:		Private users	Commercial users	Companies providing/using ITS services	Value-added ITS service providers	The ITS industry	Public authorities
Development phase	***Cost***						
All	***General management costs***	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	Costs by European institutions and national governments in co-ordinating research at a European and national level (e.g. cross-fertilisation activities). Management of national research. Co-ordination of overall policy.
Architecture development costs	***Identification of system architecture champions (promoters)***	No direct costs[1]	No direct costs[1]	Possibly, if industry takes a proactive role in architecture development.	No direct costs[1]	Possibly, if the industry take a proactive role in architecture development.	This would normally be a public authority role: costs would be incurred at a national, regional or local level depending on the level of the architecture (national, city, etc).

[1] "No direct costs" means that the actor is liable to pay only through general taxation

Actor:		Private users	Commercial users	Companies providing/using ITS services	Value-added ITS service providers	The ITS industry	Public authorities
Development phase	***Cost***						
Architecture development costs *(continued)*	***Planning phase***	No direct costs[1]	No direct costs[1]	Identifying functional requirements and user needs.	Identifying user needs.	Identifying user and operator needs.	Development of policy, identification of best practice, identification of financing issues.
	Tendering process for architecture development	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	This cost would normally fall on public authorities at all levels.
	Architecture development	No direct costs[1]	No direct costs[1]	Informing decision makers (including the ITS industry) of the advantages and disadvantages of current systems/ making recommendations on development.			Costs to European institutions and national governments of research programmes (e.g. KAREN). Costs to national, regional and local government for actual development of national/local architectures.

Actor:		Private users	Commercial users	Companies providing/using ITS services	Value-added ITS service providers	The ITS industry	Public authorities
Development phase	***Cost***						
Architecture development costs *(continued)*	***Review of results***	No direct costs[1]	No direct costs[1]	Possibly - depends on whether the architecture is developed by authorities only or with industry.	Possible role.	Manufacturers would need to review the results in terms of how the architecture affects their current and planned products.	Cost to all authorities which participate in architecture development.
Costs of exploiting the "paper" results	***Dissemination/ awareness***	No direct costs[1]	No direct costs[1]	Yes - making staff and customers aware of changes, new benefits, etc.			Updating/further development of architecture research and development (e.g. possible follow-on activities to KAREN). Costs to national/ regional/local government in disseminating information to the general public and user groups (the fact that ITS services are or are not based on a common architecture should be transparent for the final user).

	Actor:	**Private users**	**Commercial users**	**Companies providing/using ITS services**	**Value-added ITS service providers**	**The ITS industry**	**Public authorities**
Development phase	***Cost***						
Costs of exploiting the "paper" results *(continued)*	***Political acceptance***	No direct costs[1]	No direct costs[1]	Costs of providing feedback on results.			Costs to public authorities at all levels.
	Training (of architecture users)	No direct costs[1]	No direct costs[1]	Costs of training system developers.			Costs to authorities at national, regional and local level in training staff on their own architectures
	Promotion	No direct costs[1]	No direct costs[1]	Provision of feedback on results.	Could possibly have a role in architecture promotion.		Costs at a European and national level for promoting KAREN and national architectures.
	Maintenance of paper results	No direct costs[1]	No direct costs[1]	Provision of feedback based on experience with the architecture and new developments which may have implications on the architecture.			Costs to all architecture developers.
Implementation costs	***Finding funding resources***	No direct costs[1]	No direct costs[1]	Start-up costs for new equipment/ services/ procedures.	Start-up costs for new services.	Start-up costs for new develop-ments/equipment/ processes. Possible contribu-tion to public infrastructure funding through a PPP.	Funding requirements for new/revised systems which are compatible with the framework.

Actor:		Private users	Commercial users	Companies providing/using ITS services	Value-added ITS service providers	The ITS industry	Public authorities
Development phase	***Cost***						
Implementation costs (continued)	***Migration/ Upgrading of existing systems***	Requirement for compatible equipment: possible replacement or upgrading costs.				Costs involved in changing the nature of the products manufactured.	Costs to national/regional/local government where new compatible equipment is required. Costs to national government in updating/modifying national standards.
	Setting up of procurement process	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	Costs incurred by all levels of public authority (including the European Commission, e.g. through TEN-T budget line funding).
	Tendering process for contracting implementation of architecture elements	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	No direct costs[1]	Co-ordination of standardisation activities at European and national levels. Participation in standardisation activities and location referencing at a national and local level.

Actor:		Private users	Commercial users	Companies providing/using ITS services	Value-added ITS service providers	The ITS industry	Public authorities
Development phase	***Cost***						
Implementation costs (continued)	***Build and maintain ITS state-of-the-art***	No direct costs[1]	No direct costs[1]	Costs of maintaining state-of-the-art by following relevant trends in the field.			Project co-ordination costs
	Delivery and acceptance of systems	Costs incurred if new compatible equipment needed.		Costs of trialling new systems.	Costs of trialling services on the new equipment.	Responsible in case of new equipment being unsuitable or having problems. However, in the longer term, as use becomes more widespread and technology is proven, these costs should fall.	Costs of trialling new systems.
	Training on use of new systems	No direct costs[1]	Need to train/familiarise staff in case of new systems (although training for a system following a common architecture should be no more costly than that for a non-standard system).			May have a role in training provision.	Costs incurred where the authority is the operator of an ITS system.
	Maintenance of systems	No direct costs[1]	No direct costs[1]	Costs are unlikely to be higher than for systems without a common architecture.	No direct costs[1]	Responsible for maintenance, but costs should fall in future with improved technology.	Costs are unlikely to be higher (and will normally be lower) than for systems without a common architecture.

3.3 Benefits

3.3.1 List of benefits

This section outlines the benefits of a European ITS Framework Architecture. Clearly, many of the benefits are interrelated and many are not final objectives in themselves but pre-requisites for other beneficial results, e.g. interoperability is not desired for its own sake, but to facilitate improved co-ordination, consistent and seamless services, better quality and choice, reduced costs, etc.

The benefits of a European ITS Framework Architecture can take the following forms:

- increased competitiveness (common basis for developing systems, therefore fewer entry barriers);
- reduced costs[1] for developing national or local architectures (as they can use KAREN as a base);
- reduced costs[1] for developing ITS systems themselves;
- reduced costs[1] for purchasing the equipment (both in terms of the costs of the physical equipment itself and procurement costs, as common system specifications avoid the need for a lengthy decision making process to choose between very different sets of standards);
- reduced operating and maintenance costs[1] (systems developed from a common architecture should be easier to maintain);
- reduced costs to users for services (where suppliers and operators pass on cost savings to users[2]);
- reduced risk in developing and implementing systems (if a common architecture has been endorsed, this implies that it has a sound basis, thus reducing uncertainty);
- enhanced communication between actors (at a national and international level) - international co-operation will be strengthened if everybody agrees to use a common framework architecture, leading to faster decision-making at a European level;
- better knowledge of demand/transport patterns (due to the improved communications, interoperability and inter-authority co-operation brought about by the common architecture);
- improved management of research and development and standardisation at a national level;

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[1] These references to reduced costs also include reduced time (benefits such as faster implementation, etc), as time is a cost.

[2] Note that if all cost savings are passed on to users, the cost benefits to operators will be cancelled out – care must be taken not to count the same benefit twice. However, suppliers and operators may still benefit from passing all cost savings on to users due to the increased demand these lower prices will create, leading to more business.

- interoperability of services, i.e. technical interoperability (compatibility between different systems), functional and contractual interoperability (compatibility of procedures and approach between different operators or different countries);
- more co-ordinated and consistent services, leading to improved quality for the end user;
- increased multimodality;
- increased market size (due to competition, lower costs, improved quality, etc), leading to increased employment in ITS and associated industries, as services will expand more rapidly relative to a scenario without a common framework architecture.

Certain of the above benefits (notably "increased multimodality" and "increased employment") are of lesser significance as they derive principally from ITS implementation and would probably only be increased marginally by the adoption of a common framework architecture. Conversely, other benefits (such as "more seamless services") would be negligible or non-existent in the event of uncoordinated implementation of ITS, and are therefore important benefits of a common framework architecture.

However, regarding benefits which accrue principally from the ITS applications themselves rather than from a common architecture, it is important to note that these benefits would normally be available sooner and more widely available as a result of the FA, as it acts as a motor to drive forward the co-ordinated deployment of integrated systems.

Table 3 lists the benefits of a Framework Architecture as they accrue to the various ITS actors.

Table 3: Benefits of a Framework Architecture

Actor: / **Benefit**	**Private users**	**Commercial users**	**Companies providing/ using ITS services**	**Value-added ITS service providers**	**The ITS industry**	**Public authorities**
Market benefits	Increased choice of services and lower costs due to a more competitive market.		More competitive market reduces procurement costs and increased the range and quality of ITS infrastructure available.	More open standards reduce entry barriers to the market. Reduced entry barriers, lower costs and increased (and fairer) competition increase the overall market size.		A wider and more competitive market can allow commercial operators to have a greater role in providing services, reducing the need for service provision and funding at a public level.
Cost and time savings	Bigger and more competitive market can reduce costs.	Bigger and more competitive market can reduce costs. Standard solutions available to business users, reducing procurement time and costs. Reduced costs for companies operating in several regions/ countries as common interoperable equipment can be used.	Bigger and more competitive market can reduce costs. Standard solutions available to ITS system operators, reducing procurement time and costs. Greater standardisation of equipment reduces operating and maintenance costs.	Technical standardisation reduces uncertainty and reduces the time, costs and risk involved in research, development and manufacturing.		Reduced development costs and faster implementation time for public infra-structure.
Communication benefits		Common framework ensures that ITS infrastructure and service suppliers and companies/authorities purchasing ITS systems are speaking a "common language".				

Actor: / **Benefit**	**Private users**	**Commercial users**	**Companies providing/ using ITS services**	**Value-added ITS service providers**	**The ITS industry**	**Public authorities**
Institutional benefits						Increased integration of services leads to increased knowledge of travel patterns, allowing more effective planning of services. Easier implementation of transport policy (which could favour intermodality). Contributes to policies on regional/ European cohesion, competition and sustainable mobility. Improved overall image for the public authority.

Actor: **Benefit**	**Private users**	**Commercial users**	**Companies providing/ using ITS services**	**Value-added ITS service providers**	**The ITS industry**	**Public authorities**
Quality of service	Services provided are improved by the integration of different systems, e.g. the use of the same personal device or fixed equipment for more than one service. Same equipment may be used in different geographical areas, thus increasing cross-border continuity of service. Consistent support from different service providers is a possible benefit (particularly to commercial users with multinational operations), and a consistent look and feel to devices/ equipment is also important to users.		Increased inter-operability between different companies, allowing overall quality to be improved.	Service providers can provide standard services to users with a range of equipment types (e.g. to users in different countries). Easier access to multiple information sources, allowing provision of more comprehensive services.	Allows producers to market standard products throughout the EU, with less need for bespoke/ad-hoc solutions.	Increased inter-operability of services across municipal, regional and national boundaries means services can be co-ordinated or shared between different authorities or service providers (either in neighbouring areas or between authorities with different responsibilities within a single area). This increases the quality of service that can be provided to citizens.
Social benefits	More rapid, comprehensive and co-ordinated deployment of ITS services, leading to improved safety, information provision (favouring multimodality) both to travellers and to the freight business, increased reliability and reduced journey times.		Common standards help to ensure a level playing field, promoting fair competition.			Can increase multi-modality and efficiency of use of the transport system, increasing social cohesion and safety and reducing negative effects on the environment. Wider market leads to increased employment and prosperity.

3.3.2 Benefit clusters

Benefits can be considered in terms of technical, social, legal/institutional and financial benefits.

However, there is not a direct relationship between the various types of benefit and these four groups, as individual benefits can often fall into two or more groups, for example, interoperability of services can occur due to the removal of technical barriers and/or legal/ institutional barriers, and the benefits gained can be of a technical, institutional, social or financial nature.

Figure 2 illustrates some key examples of the interrelationships between the various benefits and benefit clusters.

3.3.3 Stages of benefits

The benefits emanating from a common Framework Architecture are indirect in that they are effectively the third stage of the following sequence:

1. Production of an accepted standard or result (such as the KAREN Architecture).

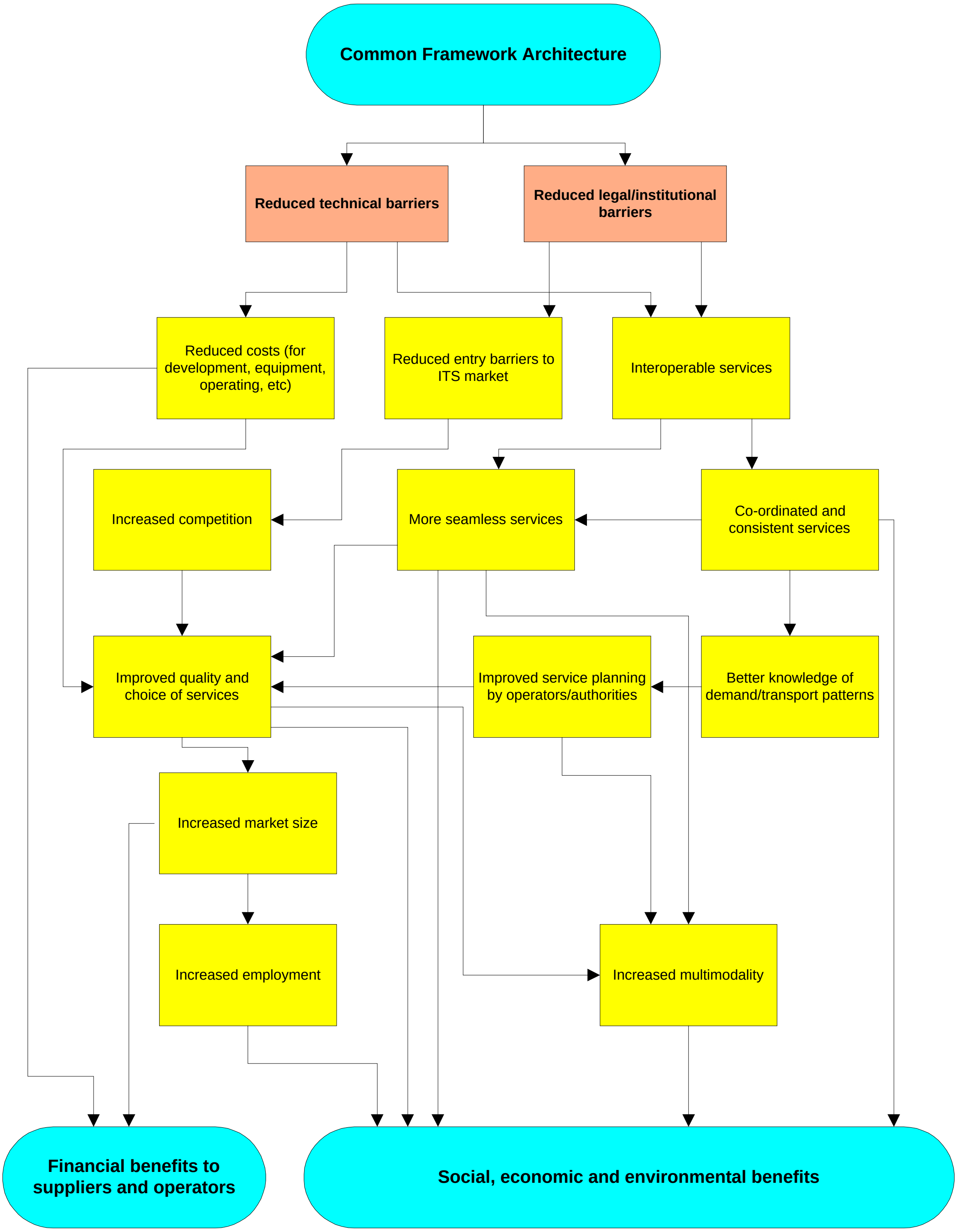
2. Application of the standard/result by ITS implementers (in the development of local architectures or in system deployment).

3. Benefits resulting from this application, in terms of reduced costs and time for development and implementation, and reduced operation and maintenance costs.

There is of course a time lag between when costs are incurred and when benefits begin to be realised. The duration of this delay depends on the specific benefit obtained, for example interoperable services can be obtained relatively quickly (normally immediately after the deployment of architecture-compliant systems), whereas increased market size and increased multimodality are more long term benefits.

Because of this relatively long payback period from the time of architecture development to the point at which the ITS infrastructure and services are actually up and running and reaping benefits, many commercial companies would be reluctant to invest in framework architectures, although they will of course need to develop system architectures for their specific products and services. As a result, this long term framework architecture investment generally falls on the public sector, i.e. the European Commission for the KAREN architecture and the governments of the EU Member States for their national architectures.

Figure 2: Examples of the key interrelationships between the main benefits of a Framework Architecture (indicative flowchart)



Note: The arrows show the sequence of benefits, i.e. which benefits lead to other benefits. In some cases, "reverse links" are possible (although not shown to aid clarity), e.g. increased market size can lead to increased competition, thus creating a circle.

4. Costs and Benefits to each Actor

4.1 Introduction

This chapter expands on the lists of actors, costs and benefits provided in Chapter 3 by discussing the costs and benefits (and, where appropriate, disbenefits) of a Framework Architecture as they affect each actor.

4.2 Private users

Private users (i.e. individual motorists and users of public transport) would face few, if any, direct costs as a result of the implementation of a framework architecture. On the other hand, they would of course pay for architecture development and implementation through their taxes, as many of the costs will be faced by governments and other public authorities.

Any direct costs would normally be due to the need to purchase new compatible equipment (e.g. in car systems or personal devices) or to upgrade existing equipment where the architecture has rendered such equipment non-compatible or obsolete.

However a framework architecture would normally be open in nature so as to accept the majority of legacy systems, therefore this cost is unlikely to fall on many users.

In addition, the current rate of development in ITS technology is such that many private users would replace their equipment on a periodic basis in any case, just as owners of cars, mobile phones, televisions, etc often do. Such users would not therefore incur additional costs in replacing non-compliant equipment with new architecture-compliant equipment.

In terms of technical benefits, a common architecture may permit the use of a single personal device or piece of in-vehicle equipment to be used for more than one service. Examples are the use of Wireless Application Protocol (WAP) to access the Internet by cellular phone, or the use of a single on-board electronic tag for electronic toll collection systems in different countries. The other significant technical benefit (for which the interoperable electronic toll tag also serves as an example) is that of seamless cross-border services. Such services could also include RDS-TMC and in-vehicle navigation systems, as well as the possibility of a consistent level of support from different service provides (or the same service provide in different countries).

On the other hand, many commercial operators, even if their product/service conforms to a common architecture, will wish to differentiate it from the competition in such a way as to commit users to their brand, either by introducing technical features to reduce interoperability or by using their pricing structure to encourage brand loyalty, e.g. through contracts rather than a one-off payment, customer reward schemes, or even “disloyalty charges” or loss of certain benefits to customers who use the services of a competitor.

Although such practices can reduce or even cancel out the benefits of interoperability, they are not necessarily a disadvantage of a common architecture, as they could equally occur in a situation without such an architecture – in all spheres of commercial service provision companies use a wide range of tactics to encourage customer loyalty. Nevertheless, if a supplier or service provider has a captive market due to technical reasons and a common architecture removes these technical constraints, the company may attempt to stem a possible loss of business by locking customers into their product by financial or contractual means.

Reduced barriers for entry into the market as a result of a common standard are likely to lead to increased competition, which will bring about a greater range of equipment and services (both in terms of technical specifications and other forms of product differentiation, e.g. a range of inclusive tariffs/contract rates reflecting different levels of usage) and at a lower price.

A further benefit for private users (and for commercial users) is the use of certain user interface standards, providing a consistent look and feel, which is important for users in terms of familiarity and ease of use. A comparison can be made with products such as mobile phones, video recorders, or for that matter, cars, where despite a wide range of competing manufacturers and different individual specifications, the look and feel of the user interface is fairly standard. In this way, someone who, say, drives a make of car to which they are not accustomed, does not need to take further driving lessons in order to be able to drive it.

The increase in seamless and interoperable services resulting from a framework architecture can lead to enhanced mobility, particularly on a cross-border level, and can also encourage multimodality through the provision of information on alternative transport options.

4.3 Commercial users

The costs faced by commercial users of ITS (professional divers and businesses using, but not involved in the provision of, ITS or associated services) would be broadly similar to those described above for private users, i.e. the costs of possibly upgrading or replacing equipment and contributions towards the architecture development costs of public authorities by way of corporate taxation.

However, regarding upgrading/replacement costs, businesses often tend to renew their equipment more regularly than the average individual, so many businesses will move towards framework architecture compliant systems in the course of their equipment replacement programme.

A further cost to business would be possible training needs for staff using the new equipment (e.g. for logistics companies using freight and fleet management systems). However, these training costs should be considered in the context of the long term benefits that these new systems could bring, and it should also be remembered that training is often necessary for new equipment and applications whether they comply with a framework architecture or not.

Technical benefits would also be broadly similar to those reaped by individual users in terms of the ability to use the same device or equipment for more than one service and to benefit from seamless services across geographical areas.

Of course, for commercial companies with high transport use (e.g. freight or passenger vehicle fleet operators), these benefits would be significant as they would be multiplies several times. Similarly, such companies would benefit disproportionately from the greater choice of equipment and service providers, and the greater degree of interoperability between different products. This open market means that their purchasing power would result in lower costs and increased efficiency (as has been the case in countries where utilities such as gas, electricity and telecommunications have been deregulated). This however implies that large companies will benefit proportionately more than small businesses and public investment in architecture development and deployment could therefore be construed as a public subsidy to big business.

Benefits to commercial users can have two principal follow-on benefits in the social sphere, these being the benefits reaped by employees of these commercial users (increased support in certain tasks they perform) and those reaped by their customers (improved quality of service, lower prices, etc).

4.4 Companies providing/using ITS services

It is possible that these organisations could have a role in architecture development, particularly in the case of major system operators or associations of ITS service operators. They may therefore incur costs such as identifying functional requirements and user needs, and in some cases taking part in the actual development of the framework architecture and reviewing the results.

However, these activities would normally be led by a public authority and ITS service users/providers would be included essentially to provide specialist input and to ‘democratise’ the process by ensuring that their specific needs are taken into account. In other words, the costs they would incur in this participation would only be a small proportion of the total architecture development costs.

Once the architecture is developed, these companies will incur some internal costs in terms of applying it to their systems and services. These include making staff (and possibly suppliers and clients) aware of the architecture and its implications, and providing further feedback to architecture developers where necessary. There will also be costs for implementation, which will vary according to the size of the company’s operation and their existing architecture and equipment. Replacement or upgrading of equipment may be necessary, although the design of the architecture should be open enough to accept most legacy systems. As with commercial users, companies providing/using ITS services will also have a rolling upgrading/ replacement policy for their systems, so compliance with a framework architecture could in many cases be incorporated into this at little additional cost.

The adoption of a framework architecture can bring substantial benefits to companies providing and using ITS services, such as a greater choice of equipment providers and technical specifications (due to a greater degree of competition), lower equipment costs and increased interoperability through equipment with standard interfaces. This will improve efficiency for service providers and allow them to improve their services to transport users. Employees of ITS providers will also benefit form the improved technology.

Examples of benefits for this group of actors include interoperable payment systems for different toll road operators, thus increasing the attractiveness of an electronic tag to motorists (as they can use it on more than one network) and reducing the time and costs involved in manually collecting tolls for all operators following the architecture.

As discussed under section 4.2, the possibility exists of equipment providers creating barriers to interoperability in order to protect their own markets from intrusion by competitors. However, this should be less of a problem for ITS service providers than for individual users as the former are relatively large purchasers and can therefore specify levels of interoperability and other bespoke requirements in tender documents. Individuals, on the other hand, are normally compelled to buy products off the shelf and, although this group is important in terms of its size and the fact that individuals are really the end users, private users do not normally have a strong collective voice which is backed up by a uniform purchasing strategy.

4.5 Value-added ITS service providers

A major effect of a framework architecture on value-added service providers is the removal of many of the technical and administrative barriers to market entry, thereby leading to increased competition. This is already being seen in the ITS world with the growth of providers of services such as traffic information, both public providers and commercial fee-based information services.

It is possible that some of these service providers could contribute to architecture development and implementation costs in terms of identifying user needs, informing decision makers of the requirements of the value-added service industry and reviewing results. However, the increasing number of value-added service providers coming onto the market, and the further increase in competition that a common architecture will undoubtedly bring, means that such service providers can (and indeed do) enter the market and compete successfully without having taken part in the architecture development process. This therefore seems to remove any incentive for other value-added service providers to carry any of the architecture development costs.

ITS service providers will of course have start-up costs for new services, although these will most likely be lower than in a case where there is no framework architecture, so can generally be considered as a benefit. Development time and risks would also be reduced, due to increased technical standardisation.

Other benefits include the potential to develop different services using the same supports (e.g. services using a common communication network) and easier access to multiple information sources, allowing the provision of better and more comprehensive services to clients. This improved access to information could however limit the scope for competition as it may be difficult for a large number of, say, commercial traffic information providers, to provide sufficient product differentiation from their competitors. As in many other industries (e.g. telecommunications) signs of consolidation are already showing, with smaller firms being taken over by larger ones.

Moreover, where “value-added” services are provided for free by the public sector, commercial operators cannot really compete unless they can offer substantial additional benefits. For this reason, commercial operators are increasingly teaming up with vehicle manufacturers to provide in-vehicle systems, rather than opting for traditional broadcasting.

The overall benefits to value-added service providers therefore appears to rest more on the actions of data providers, pubic authorities, “standard” ITS service providers and vehicle manufacturers than on the adoption or otherwise of a framework architecture.

4.6 The ITS industry

The effects of a framework architecture on the ITS industry would be similar to those described above for value-added service providers. One way in which these two industries differ, however, is that while value-added service providers normally operate on a regional, national or, increasingly, a European level, the ITS industry is more globally oriented. This is because businesses in the former category are more concerned with information (which is area-specific and often language-specific) while the latter are concerned with producing and supplying equipment, where requirements are broadly similar across the world.

The effects on the ITS industry of a common European framework architecture therefore depend to a large extent upon the similarities of this architecture to framework architectures in other major countries, particularly in the USA but also in Japan, South East Asian countries and Australia, as the greater the similarities, the greater the opportunities for the European ITS industry to market outside Europe and for non-European producers to penetrate the European market. In any case, market entry barriers will be reduced and conditions for increased competition will be created.

A common European architecture will undoubtedly be beneficial to the European ITS industry in terms of breaking down barriers between Member States and allowing producers to market standard products throughout the EU, with less need for bespoke/ad-hoc solutions, although this will also make it simpler for non-European manufacturers to develop products tailored to the European market.

However, there is a risk that such an architecture could constrain the growth of certain new technologies which require a different architecture. As in many other fields (computer operating systems, videos, etc) it is possible that an architecture could develop because it is used by the largest and most powerful manufacturer in the business, rather than because it is the best.

Costs borne by the ITS industry on the architecture development stage are again broadly similar to those that could be borne by value-added service providers, i.e. identifying their needs and helping to identify those of their clients (i.e. public and private infrastructure operators, vehicle manufacturers, transport operators, etc), making recommendations and reviewing results. These costs are unlikely to be significant.

In later stages, however, there will be greater costs as a result of complying with the architecture, such as training system developers, development start-up costs, migration of existing processes where required and responsibilities for the performance of new equipment delivered to clients. However, these costs will be short term and are likely to pay off in the medium term once the architecture is up and running. For example, recruiting and training staff from elsewhere in the ITS industry will become simpler as the architecture will achieve a certain level of common skills and knowledge across the industry. Increased technical standardisation will also reduce the time, costs and uncertainty involved in system development, as well as costs incurred in maintaining systems.

4.7 Public authorities

Public authorities, whether at a European, national, regional or local level, will undoubtedly bear the lions share of architecture development costs. There are three simple reasons for this:

- framework architecture development is a relatively long term process without an immediate and obvious financial payback;
- it requires a level of co-operation and co-ordination between many players, and therefore needs to be developed in a democratic way which will benefit all (rather than oriented towards a single company, as would normally be the case were a commercial enterprise to take the lead); and
- the benefits of a framework architecture take many forms, are often intangible and are spread over a wide range of users and other actors, many of whom will be difficult, impossible, or socially undesirable to charge in order to share in these benefits.

Costs to public authorities have already included the investment of the European Commission in the RAID and KAREN projects, and national governments are currently funding their own national architectures based on the KAREN results. In time, regional and local authorities will develop new or revised architectures resulting from national plans and policies.

The European Commission and national and regional authorities have also funded trans-national implementation and cross-fertilisation projects, such as those concerning Datex and RDS-TMC, as well as developing and co-ordinating national and European transport policy relating to ITS.

Dissemination costs such as promoting KAREN to national governments and the dissemination by governments of their own ITS framework architectures to actors at a regional and local level, together with training and architecture maintenance costs are further costs which must be borne by the public sector.

There will also be costs to public authorities responsible for road operation (national, regional and local highway authorities), which will be the same as those pertaining to private road infrastructure operators (described in section 4.4).

In terms of benefits, these are largely economic or social and will be reaped principally by final users and ITS providers (the ITS industry, service providers, etc) rather than directly by the public authority itself. Of course, economic and social benefits to the city, region or country concerned also benefit the responsible public authorities as they improve its image, and increased economic activity also raises tax revenue. Other specific benefits to the public authorities investing in ITS architecture include more efficient traffic and transport management, as the architecture provides a basis for measures to reduce congestion, increase traffic safety and to promote multimodality.

A common architecture also promotes interoperability and co-operation on an inter-regional and international level. This can be particularly beneficial to public authorities close to the border of another EU Member State in that the reduction of technical barriers at a European level will facilitate improved co-ordination of traffic and transport services with the corresponding authorities in the neighbouring country.

At a European level, a framework architecture contributes to EU policies on European cohesion (e.g. through the cross-border co-operation mentioned above), competitiveness (through reducing barriers to market entry) and safe and sustainable mobility (through the faster implementation of more comprehensive ITS services aimed at multimodality, safety, etc).

Integrated and interoperable ITS services do not just provide information in one direction (i.e. to the road user), but also provides vital information regarding traffic, transport use, user behaviour, pollution, etc back to the public authorities, facilitating improved evaluation, development and implementation of policies and measures to improve transport.

In summary, the benefits to public authorities can be summarised as increased efficiency, improved services to citizens and a better image, which can help to promote increased inward investment. Benefits to public authorities in respect to road network operation are as described for companies providing/using ITS services (section 4.4).

5. Case Studies of Costs and Benefits

5.1 Introduction

This chapter explores some of the expected and actual costs and benefits involved in architecture development and deployment with reference to national plans, “success stories” from a selection of European ITS projects and deployment programmes, other ITS studies/ experience and examples from outside the ITS world (i.e. from the IT and telecommunications domains).

5.2 Architecture deployment costs in selected EU Member States

5.2.1 Finland

The Finnish National Architecture project “TelemArk” was launched in Summer 1998 and covers passenger transport telematics for all modes (road, rail, air and water).

The work was started by drafting a preliminary plan for producing conceptual and logical architecture descriptions as well as a proactive plan to enhance the emergence of new ITS services and service providing entrepreneurs. From the beginning of this year (2000), the actual information gathering for the architecture has taken place. Also the first versions of the architecture drafts and the proactive plan to enhance ITS services have been produced.

Architecture input data gathering consisted of two phases: first, the actors within the transport sector were invited to actor-workshops and their state-of-the-art systems and services were charted. This phase was completed by May 1999. Then, the actors were invited to function-workshops, where each ITS function was reviewed by the actors and the processes producing different services were drafted. Both of the workshops were carried out using two time horizons: present day and the likely situation after 10 years. In short, TelemArk adopts a bottom-up approach in its architecture design.

Direct consultancy costs for the period 1998-2000 were approximately 0.4 million euro, covering the feasibility study, architecture design and preliminary information dissemination. In addition, internal costs to administrations and organisations for the same period amount to 0.2 million euro, covering labour, workshops, meetings and project management.

These costs would of course be multiplied several-fold if future architecture implementation costs were included.

5.2.2 France

The French framework architecture for ITS, known as ACTIF, was initiated by the French Ministry of Transport (Ministère de l’Equipement - DSCR) and is a two year project (September 1999 - September 2001) with a budget of 2 million euro. The project is being led by the DSCR and its representatives and the actual work is being put out to tender to consultants.

The aims of the architecture are:

- to improve communication between actors;
- to elaborate prospective visions; and
- to act as a tool to address ITS architecture issues.

Case studies to run in parallel with the framework architecture elaboration have the further aims of:

- identifying technical points (interfaces) to standardise; and
- forming specific recommendations for specific application domains or technologies; and
- describing likely mid-term deployment scenarios so as to better anticipate any difficulties or risks.

The ACTIF architecture covers road, rail and inland waterway modes, plus their interfaces with air and sea transport.

Of the 2 million euro budget, 15% will go on the development of the framework architecture itself. 30% will be spent on project and domain case studies. Other major items include the development of a Web repository of actor, project and product descriptions (11% of budget), dissemination and Web site (11%) and project management (15%).

5.2.3 Germany

There are no plans as yet in Germany to produce a national architecture comparable to KAREN. However, German authorities have implemented several R&D activities relating to ITS applications.

5.2.4 Italy

Defining the national architecture for Intelligent Transportation services has been an objective in Italy for some time. Policies aimed at this were included in the First and Second National Plans for Road Transport Telematics (1995 and 1999) and are part of the Guidelines for the National Master Plan for Transportation (1999). Moreover, the procedure for obtaining the architecture was defined within the scope of the above-mentioned Master Plan (Quaderni del PGT, “Architettura di Sistema”, 1999).

The preliminary work has been undertaken: drafts for the basic elements of the architecture are already available, and the overall work plan has been established, in agreement with the European progress.

Finally, an association was established (TTS Italia), which sees the participation of both public authorities (Min. Trasporti and Min. Lavori Pubblici as promoters) and private stakeholders. The association will be the main actor for consensus formation and for dissemination.

The two Ministries have now evaluated the costs and made a plan for the actual development of the Italian National architecture. The work will proceed in two main phases:

- in phase 1 the national architecture will be developed, together with the design of the first national demonstrator;
- in phase 2 a structure for inter-modal systems and services, compliant with the national architecture will be deployed, in an intermodal corridor of national interest.

In April 2000, a project proposal is under negotiation between the two ministries and the European Commission for the support of the first phase of the project under the context of the TEN-T budget. The project, named ARTISTA, is planned to start in April 2000 with the definition of the call for tender to select the team performing the work and is aimed at delivering the Italian national architecture by the end of Year 2001. The total estimated cost is 3 million euro.

The goal of the first phase of the Italian architecture project is to develop a national architecture for Intelligent Transport Systems in Italy that serves as the reference platform for the implementation of real intermodal services nation-wide. The intermodal national architecture will:

- be compliant with the European framework architecture for ITS and current and emerging communication standards, so that it can guarantee interoperability of systems and continuity of services throughout Europe;
- be suitable for intermodality, as it will include issues related to all modes of transport (road, railway and maritime, with interfaces to air transport) and the necessary interfaces between them; and
- include both the technical aspects and mostly the organisational architectures necessary to rule the interaction between different actors and to make feasible intermodal services actually operating.

The first phase will also include the feasibility study for the design of a large scale demonstrator along an intermodal corridor, which will include road, railway and maritime transport for freight and passengers.

The national architecture will provide the reference platform for the development of an integrated environment where compatible systems can interact and co-operate. The national architecture will include the peculiarities of the telematic systems and services of all modes of transport and will conform to the European Framework Architecture for ITS. Considerable attention is given to the organisational aspects (i.e. agreements, share of responsibility, architecture maintenance, etc.) necessary for the successful and effective implementation of true intermodal transport services. This project will be performed involving national stakeholder representatives to form the consensus on the results produced by the following activities:

- identification of national services and requirements (both functional and not functional) for the national transport on ground, air and water of goods and passengers;
- review of existing transport systems and services in Italy;

- review of existing and emerging European results in the field of system architecture and communication and data exchange standards for the different modes of transport;
- definition of intermodal and multimodal transport services to be especially supported by the national architecture;
- identification of solutions to envisaged organisational and legal issues that may hamper the actual implementation of intermodal services involving multiple actors;
- definition of the national architecture for transport telematic systems including functional, physical and communication architecture and particularly focused on scenario-based organisational architecture;
- set-up of the structure for the continuous updating and upgrading of the national architecture; and
- definition of the structures needed for providing continuous formation of both public and private sector representatives on the practical issues related to the architecture.

Furthermore, a large scale corridor will be chosen, to form the basis for a follow-up phase aimed at the design and development of a prototype set of systems and services, compliant with the National Architecture. The choice of the corridor will be based on i) the relevance for the national transport network, ii) the existence of a large set of “modal” systems and services, iii) the need to incorporate these legacy systems in a coherent, intermodal architecture. Thanks to previous efforts, corridors having these characteristics already exist in Italy and can provide a convenient basis for the demonstrator.

5.2.5 The Netherlands

The national ITS framework architecture for inland transport, known as Koepelarchitectuur (Dome Architecture), was initiated by ITS-Nederland and is funded by the Dutch Ministry of Transport. The project has a duration of one year (September 1999 to September 2000) and a budget of 200 000 euro. A further 2 million euro has been budgeted for the development of ‘partial’ ITS architectures from the Koepelarchitectuur, such as urban/interurban traffic management, public transport and logistic chains.

The main objective is to identify ITS services and systems which could most feasibly and beneficially be implemented in the Netherlands. The framework architecture is being developed for all relevant inland transport (road, rail and inland waterways), together with and interfaces with air and sea transport, in order to:

- demonstrate the coherence of various ITS elements;
- demonstrate coherence with the European Framework Architecture;
- serve as a base for further architecture development; and
- serve as a means to reach agreement on further ITS implementation in the Netherlands.

5.2.6 Sweden

In Sweden, the OPTIS architecture (Optimised Traffic in Sweden) is a project involving several industrial players such as Ericsson, Volvo and Saab. OPTIS focuses on services and aims to deliver dynamic information. The Swedish National Road Administration's part will be described in line with KAREN.

This work has a budget of 100 000 euro.

5.2.7 Conclusions

It is difficult to generalise in terms of costs for national framework architectures, as the projects in the five countries mentioned (Finland, France, Italy, the Netherlands and Sweden) differ in terms of their breadth (i.e. modes covered), depth and timescale.

However, these development costs are not high, with the highest cost (Italy: 3 million euro) equating to only 52 euro per 1000 people in that country whereas the French "ACTIF" architecture costs are 34 euro per 1000 population. In Finland, however, the total costs of TelemArk (0.6m euro) represent 118 euro per 1000 population.

5.3 Examples of "success stories" from European ITS projects and deployment programmes

5.3.1 QUARTET and QUARTET Plus

QUARTET (Quadrilateral Advanced Research on Telematics for Environment and Transport) was a demonstration project within the European Commission's DRIVE II programme. It was a joint venture between local authorities, transport operators and the others (including vehicle manufacturers, providers of telecommunications, IT and ITS systems, broadcasters and research organisations) in the cities of Athens, Birmingham, Stuttgart and Turin.

The aim of the project was to demonstrate a pilot implementation of integrated ITS applications, including modules on:

- a target IRTE (Integrated Road Transport Environment) architecture;
- environmental traffic control;
- dual mode route guidance;
- public transport management and information systems; and
- emergency call.

The project demonstrated that integration of advanced transport telematics on a large scale is both technically feasible and socially desirable.

Insofar as the IRTE architecture was concerned the main applications in each city were as follows:

- Athens: verification of pollution levels, traffic flow monitoring, meteorological forecasts and central control of ITS systems;

- Birmingham: exchange of travel information within a multi-centre context;
- Stuttgart: dynamic updating of an autonomous route guidance system through centrally processed information;
- Turin: integration of traffic management and control systems and a demonstration of the transferability of integrated target architectures.

QUARTET Plus (an EC DG-Information Society project within the 4th Framework Programme for Transport Telematics) is a follow-on project from QUARTET and includes two additional cities: Gothenburg and Toulouse, as well as a broadening of the Birmingham site to cover the West Midlands and Leicestershire.

Its objective was to demonstrate a European platform for launching transport informatics in urban areas on an open market by means of comparative evaluations and by operating an information infrastructure, multimodal information and public transport management. A key part of the project with relevance to framework architectures is the workpackage dedicated to the demonstration of IRTE strategies, architectures and tools.

The IRTEs implemented in the six sites provide an optimal framework for the introduction of ITS in a structured and cost-effective way and leads to the following benefits:

- reduced journey times;
- reduced fuel consumption;
- more control over pollution levels;
- a more informed society;
- improved information;
- more efficient use of the transport network; and
- a robust, well tested, open system architecture that will provide a platform for multi-vendor applications and effective services.

QUARTET and QUARTET Plus implemented a communication and physical architecture which shows a relatively high level of integration in the data exchange facilities between “systems” operating in urban area. A co-operative control scheme was introduced in different sites and key results were demonstrated by means of extensive field trials and surveys.

Table 4: Summary of results measured by QUARTET Plus

	Dynamic Control	**Dynamic Control + Information**	**Dynamic Control + Information + Demand Management**
Travel Time Benefit for Private Traffic	as high as 17%	as high as 20% (21.6% on total trip duration)	> 20% > 21.6%
Travel Time Benefit for Public Transport	as high as 15%	as high as 19%	> 20% > 21.6%
Reduction of Pollutant Emissions	as high as 5-6% locally	as high as 18% locally as high as 8% globally	as high as 21% locally as high as 11% globally

The high level of integration demonstrated relevant benefits by sharing infrastructure, in the case of the 5T system in Turin it was calculated that by using multifunctional outstations (performing intersection control and message dispatcher for other road-side devices such us VMS, information displays, etc.), the number of communication links needed was reduced to less than 20% of those that would be required by the alternative solution of connecting single function outstations to the centres. In terms of the costs for purchasing and installing the outstations at the roadside, it is estimated that they are recovered by savings on transmission charges over a payback period of one year.

Cost benefit analyses also showed relevant benefit for the operators. As an example the public transport operator of Turin has already managed to make cost savings through implementation of the system: they have been able to remove one tram from the service as a result of improved regularity and efficiency (the equivalent to a pay-back period just over 2.5 years, or just a few months if the time saving for passengers is considered). The Toulouse partners have calculated that similar savings could be made in their city by the extension of the Integrated Environment.

5.3.2 ROMANSE

ROMANSE (Road Management System for Europe) is a project sponsored by the EC, Hampshire County Council and Southampton City Council. ROMANSE I began in 1992 and the three year project cost a total of £8.25 million (approx. 13 million euro). In 1996, ROMANSE II became the UK activity within the EC 4th Framework EUROSCOPE project.

The overall aim of the project was to realise a vision of an information-rich society based on integrated ITS and to improve travelling conditions in the city of Southampton by reducing uncertainties and providing the information required for travellers to make more informed travel choices. The ROMANSE approach forms an integral part of the long term strategic transport policies for Hampshire and Southampton.

The project involved the implementation and testing of a range of telematic applications in the city of Southampton. These products are:

- STOPWATCH real time bus information displays at 42 stops, coupled with the fitting of automatic vehicle location transponders to 114 buses;
- Enhanced existing media (radio traffic news transmitted from the ROMANSE Traffic and Travel Information Centre);
- City centre outbound variable message signs (VMSs) at three sites, and five mobile VMSs;
- Parking guidance system, giving real time information on car parking space availability for 13 car parks;
- TRIPlanner touch-screen journey planning terminals located at key points in the city.

The architecture employed involved the linking of these applications to a strategic information system. This system, which is a fully integrated and locationally referenced database, can be viewed in real time on a map-based display, with information displayed in any combination of the available themes (VMSs, public transport information, parking availability, etc). This information system is used by the operator to make decisions, including advice/warning messages on VMS, radio, etc.

The project involved a before and after study [reference (u)] in which the impacts of these implementations were measured against a "do nothing" scenario, taking into account underlying socio-economic, demographic, transport and land use changes.

The benefits measured fell into the following categories:

- Provision and use of ITS (technical performance, extent of use, level of awareness, perceived quality, etc);
- Individual behavioural changes (changes in mode used, trip frequency, trip time, route choice, destination choice, etc);
- Aggregated effects by time of day (bus patronage, car park patronage and link flows);
- Public transport impacts (bus load factors, passenger bus stop waiting times, bus journey times, variability in journey times, punctuality, etc);
- Road network inputs (link and junction capacity/flow ratios and car journey times);
- Car park inputs (queuing time, search time, capacity utilisation, etc);
- Modal split.

The data used comprised both secondary data (e.g. automatic traffic count data) plus data from a series of specific surveys (including interviews and focus groups) and the evaluation comprised both a traditional cost-benefit analysis using monetary values, and a wider multi-criteria analysis incorporating such non-monetary elements as usage rates of the facilities provided.

The cost-benefit analysis of the applications was based on the average amount of time that each user would have to save in order to justify the investment. This was taken by using standard UK values of time and dividing it by the number of drivers/passengers who see the information over the course of a year and are likely to benefit from it (determining which users are likely to benefit from a certain type of information requires data on origin-destination, journey purpose etc).

Examples of the time savings necessary to justify the implementations (the first figure applying a 5% discount rate and excluding R&D costs and the second applying an 8% discount rate and including R&D costs) are as follows:

- 23 sec to 1 minute for the parking guidance system;
- 3 to 9 minutes for TRIPlanner (a relatively high figure due to the relatively low number of accesses);
- 36 sec to 2 minutes for STOPWATCH; and
- annual savings of 4 minutes per listener for Radio Solent Traffic News.

However, these analyses only considered the products in isolation and do not include benefits to traffic operators resulting from the integrated information platform provided by ROMANSE. It is also difficult to tell whether these time savings are actually being achieved.

Before and after surveys have also shown a significant increase in the proportion of users rating traffic information in the city as good, e.g. parking information was considered as good by 36% of motorists in 1994, 52% a year later and 70% in 1996. Also, in 1996, 81% of respondents stated that they experienced no delays due to finding a parking space and 92% found a space in 5 minutes or less.

In summary, ROMANSE has successfully developed and installed a number of ITS applications and has also applied an integrated architectural approach to their management and operation. Whilst the monitoring and evaluation has proved to be difficult, awareness of the systems was found to be very high amongst the travelling public and the levels of time savings required to justify the investment and operation are relatively small. Furthermore, the performance of the system as a whole is better than that of any individual product, particularly as the integrated nature of the system brings benefits not only to end users, but also to the traffic authorities and public transport operators.

5.3.3 ENTERPRICE

The ENTERPRICE project (EU 4th Framework Programme) was carried out by partners in Spain, the Netherlands, Denmark, Germany, Switzerland, Italy and Greece with the aim of improving multimodal traffic information.

The core activity was the establishment of a Mobility and Traffic Information Centre (“MOTIC”) using an open standard architecture. These were established in the Rhine Delta area (the Netherlands), Switzerland and Hessen (Germany).

Whilst the demonstrations at these sites had different priorities (e.g. traffic management in the Rhine Delta and HGV road pricing in Switzerland), the basic functionalities of the MOTICs were the same, in terms of collecting and processing traffic data. The architecture of the system was designed in order to fulfil the requirements of the various conditions in each European country. In this way, ENTERPRICE has contributed to European standards.

The research costs for MOTIC within ENTERPRICE were in the order of 200 000 euro and the benefits include:

- services to travellers and fleet operators;
- contribution to sustainable and safe mobility of persons and goods within a wide area;
- a wide range of services to improve multi-modal travel;
- opportunities for better information;
- a basis for higher safety and comfort at lower cost;
- a basis for the development of new products and new markets.

TIC-Nederland - the Dutch National Traffic Information Centre

Several ENTERPRICE research and development activities have contributed to the establishment of TIC Nederland in January 1998. This Traffic Information Centre collects and produces high quality actual traffic information and provides this information via service providers to end users.

During 1997 a prototype TIC system was tested at the EuroDelta test site which led the foundation for TIC Nederland. The overall architecture and specifications of the TIC platform have been analysed and the functioning of the TIC in its international context has been investigated, with agreement having been reached on the cross border data exchange between TICs.

Finally a system module for cross border information exchange between TIC Nederland and TIC Nordrhein Westfalen (North Rhine Westphalia, Germany) was built and tested in the ENTERPRICE project.

TIC Nederland provides high quality actual traffic information to its connected service providers, including information on queues, roadworks, incidents, forecasts, weather, public transport, parking, route advice and driving recommendations. The output of the TIC system is provided on-line to service providers in the form of traffic messages coded in Datex/TRAVIN.

Developments in the near future of TIC Nederland include placing more emphasis on automated input via the highway monitoring system, the production of travel time and speed data related to road segments (Datex/TRAILS), and the exchange of information with neighbouring TICs.

In The Netherlands there is a strict policy that the TIC-Nederland does not distribute traffic information directly to end-users (e.g. by an Internet site or telephone service). It is believed that providing information to the end-users is first and foremost a task for commercial service operators who have a much better knowledge of what the end-users wants. Moreover, providing free traffic information to end-users by the TIC will destroy the commercial market for service operators, such that no operator will start this service.

Service providers obtain information from TIC Nederland for a limited fee. They may fine-tune the information, make it specific for the travellers' individual needs, or combine it with other information with the objective to give it added value as a service for the end user.

This approach has proved to be very effective. During the last year more than 15 service providers have started a commercial service based on information provided by the TIC. The quality of basic traffic information has been improved by the establishment of TIC Nederland but it leaves an open marketplace for commercial service providers to carry out a commercial business. Many more end-users are now using the traffic information than would have been the case if the TIC had provided it.

To enable potential clients to get hands-on experience with TIC information and to consider a connection to TIC Nederland an information receiving PC station called TIC-Connect has been developed which can be rented for a maximum period of 6 months. This initiative has invoked activities for commercially available products by system developers in the private sector.

In summary, the adoption of architecture standards for TIC Nederland have had the effects of making it easier for commercial service providers to enter the marketplace and of promoting competition, which has led to improved services to the end user. It has also allowed data exchange between other TICs (in particular, the North Rhine Westphalia TIC in Cologne) by means of Datex (see section 4.4).

Operational costs for TIC Nederland for 1998 were estimated at approximately 3 million euro. Both partners in TIC Nederland (Rijkswaterstaat and KLPD - the National Police) bear the cost for TIC operations. Revenues are a minor percentage of the costs, since service providers pay a limited contribution to get connected to TIC Nederland and to cover some of the research and development costs. The TIC information itself is currently offered for free.

Lessons learned from ENTERPRICE (Dutch application)

The activities in the ENTERPRICE project have led to a large number of lessons learned for the Dutch partners in the Dutch situation. Those which are relevant to system architecture are as follows:

- *The modular approach*

ENTERPRICE has shown that different approaches are possible in different countries for the set up and use of MOTICs, while using the same base concepts.

The base concept of the MOTIC, i.e. to combine information from different sources, to check them and to provide them to different services, is the same in The Netherlands as in the Hessian and Swiss sites. In Hessen, however, the approach is to fully integrate in *one* system both urban and non-urban information, road as well as public transport information, and information collection as well as provision as a service provider. In the view of the Netherlands this has led to a highly integrated, but also to a highly complex system.

The Netherlands has chosen for a strict modular approach, where there are different systems and different organisations responsible for different parts. Integration is here ensured by a good co-operation and a full and open exchange of information between the different organisations. Each organisation in the Netherlands (the national TIC which deals only with road traffic on motorways, regional TIC's, the public transport information centre and commercial service providers) has its own clear goal and objectives, and they therefore develop their own high quality systems at their own rates, without development or implementation being slowed down by others.

It is the opinion of the Netherlands that this approach of independent (but properly coupled) modules is an effective and powerful one, with this architecture having led to success in terms of the TIC-Nederland and many other services being operational for over a year.

- *Public-Private Partnerships (PPPs)*

PPPs can bring important benefits in terms of making ITS implementation more market-oriented and in spreading costs and risks. However, one lesson learned by the Dutch experience in ENTERPRICE is that the parties involved should have similar, or at least compatible, objectives. The intention was for TIC-Nederland to be set up by three organisations: the Rijkswaterstaat (Dutch MoT), the National Police (KLPD) and the ANWB (Dutch touring club). However, the ANWB withdrew from the TIC organisation, with one of the reasons for this being that the ANWB has a different goal as the other two organisations. In effect, the Rijkswaterstaat and the KLPD had an objective to provide traffic information for the general interest, while the ANWB had a much more commercial interest.

- *Service Providers*

It has been shown that a service provider cannot start a service easily. They have to be convinced about the possibilities and other input was needed. TIC-Nederland spent considerable effort in explaining to potential service providers what is possible and helping them with expertise.

One should not expect that when a TIC becomes operational service providers will be there at the same time. In the Netherlands it has shown that it takes one to two years before several service providers start their activities. They first need to build up enough confidence before they start to invest.

5.3.4 European implementation of Datex

On a Europe-wide level, two ITS applications are currently being implemented using a common Framework Architecture, these being Datex traffic data exchange and the RDS-TMC (Radio Data System - Traffic Message Channel) service.

These two applications are communication standards and as such are service architectures which are part of a Europe-wide communication architecture.

Electronic data exchange on an international level using the Datex format is currently being implemented in traffic centres around Europe and provides these traffic centres with language-independent information from neighbouring regions and countries. An active Datex community has been established, consisting of a Steering Committee (an executive body, supporting the harmonisation of European Datex implementation) and a Management Committee (concerned with providing technical, operational and organisational solutions).

In effect, the Datex architecture is defined as a number of interoperable client and supplier systems. The Datex Memorandum of Understanding (MoU), agreed by the Datex Steering Committee, comprises the latest agreed version of the Datex specifications and the Datex documentation is currently being considered for standardisation by the CEN (European Standards Committee).

Datex has been implemented in several countries under the auspices of the five Euro-Regional TEN-T projects and in other projects and programmes, such as the HANNIBAL project (EU 4th Framework Telematics Programme) which demonstrated cross-border data exchange between two different but interoperability systems in France and Italy. In the HANNIBAL demonstration, the benefits of cross-border operation of Datex were found to outweigh the costs, such that this operation is continuing beyond the end of the project.

The benefits of adopting a communication standard at the Datex or RDS-TMC level are in principle two-fold:

- to have a common understanding of the information to be exchanged and its structure, including language independence;
- to achieve interoperability at functional and technical levels.

A key benefit of Datex is a reduction in development costs compared to the situation where centres apply their own ‘standards’ on a bilateral basis. When two centres A and B each implement Datex and communicate with each other, then a third centre C should be able to attach to A or B at no (or very little) additional cost.

As for many open standards, this is only partly true in practice, since Datex leaves open many options still to be defined, i.e. agreed amongst partners. In the absence of such an agreement, industry will make its own choices and interpretation of the Datex standard, resulting in non-interoperable Datex-nodes.

When dealing with one vendor who is responsible for setting up a Datex network, this is not a problem but in the case of a multi-vendor environment one can expect significant additional costs in terms of harmonisation, tailoring and testing). Datex is therefore definitely not a ‘plug-and-play’ concept.

Whether this is an acceptable situation or not is as yet unclear, since there is no experience so far in large scale Datex deployment in a multi-vendor environment. Note that this multi-vendor issue in particular applies to the area covered by the CENTRICO Euro-Regional project (Benelux, western parts of Germany and northern France) area where the Datex systems of least four different vendors will have to inter-operate.

In order to establish an operational Datex link between two different organisations, it is the CENTRICO experience that both parties must work according to a commonly agreed project plan. In other words, setting up a Datex link should be treated as a regular IT project with planning of activities, allocation of activities, responsibilities etc., The quality of *permanent operational* links (as opposed to temporary Datex R&D links) must be agreed upon, in terms of reliability, continuity, etc. For the link between the Netherlands and North-Rhine Westphalia this quality is defined in a Service Level Agreement in addition to the regular Interchange Agreement.

Cross-border data exchange: Dutch experience and TIC2TIC (Netherlands-Germany)

The experience of the Dutch national TIC (TIC-Nederland) with Datex was that considerable effort was needed during mid-1997 to fill in missing areas in the Datex specifications, which are still far from complete. These specifications were considered unnecessarily complex and with large overheads, leading to high investment costs by TIC-Nederland and the service providers. However, the fact that a single specification was available and accepted on a Europe-wide basis was important too.

The TIC2TIC project was a bilateral co-operation between the Netherlands and North Rhine Westphalia. This has shown to be a very effective and successful approach.

It was decided not to wait for a European standard on Datex, but to recognise each other’s situation regarding the use of the different Datex versions and to build converters for the interfacing. Without this a cross-border exchange of information would be very far away.

The project also showed that the conversion between the different Datex versions is relatively simple. One should also recognise that these activities will give input to the further standardisation of Datex.

During the evaluation of TIC2TIC it was shown that about 10% of all messages (either in NL or D) are of interest for the neighbouring country. This is much more than expected and shows the need for cross-border exchange.

Datex: Conclusions

It is difficult to assess the costs and benefits of Datex deployment. In general, traffic centres value being informed about the current cross-border traffic situation, and many centres are willing to invest in Datex. However, in many cases they are doing so with the financial support of the European Commission, while the Datex organisation itself (e.g. the Management Committee and the helpdesk) is also funded by the Commission. What would happen without this support is difficult to assess.

It seems that further harmonisation of Datex is needed to make it attractive in a commercial environment e.g. between traffic centres and service providers. At the Management Committee level, the need for harmonisation and refinement is recognised. The general feeling is that so called implementation-profiles must be defined which prescribe Datex communication in a clear and unambiguous way. The adoptions of such profiles at the Euro-Regional or Europe-wide level would further reduce costs when anticipating a dense network of Datex nodes in a multi-vendor environment.

5.3.5 European implementation of RDS-TMC

The implementation of RDS-TMC in Europe is another area where a common communication architecture exists. The EU has focused on the deployment of RDS-TMC services as part of the TEN-T implementation programme and its implementation on an international level with a choice of broadcast languages is being planned. The aim is for a continuous, compatible and interoperable service with a key benefit being that the user can use the same certified receiver in any country in Europe to receive a standard quality in the language of his/her choice. At present, several regional and national services exist and others will start broadcasting shortly.

The RDS-TMC service architecture forms the minimum common denominator for this service. This universal link, known as ALERT functionality, is covered by a European MoU for RDS-TMC services.

Implementation costs over the past three years have been around 10 million euro, which covered service provision by the Nikita consortium, conversion of Datex-Alert-C (TMC protocol) and the provision of 1000 terminals to motorists.

Areas in which costs are incurred in the development and implementation of this architecture include location coding, message management (by information providers and broadcasters) and co-ordination activities (often EU funded) such as development of MoUs, workplans, etc. In particular, European co-ordination has been identified as being required in the following six areas:

- **overall coherence** (MoU management, RDS-TMC documentation centre, consistency of national location databases, cross-border continuity, links between countries, contacts outside Europe, control and statistics, etc);

- **communication** (international information, RDS-TMC newsletter, directory of RDS-TMC actors, etc);
- **technical matters** (standards, service evolution, levels of services, education and training, R&D, etc);
- **marketing and commercial services** (consumer contracts, advertising, surveys, etc);
- **legal matters** (European framework, arbitration, coherence of agreements between actors, etc);
- **financial matters** (budget evaluation and financial services).

Costs to users of RDS-TMC include the requirement to buy a terminal (or to purchase a car fitted with one) and the updating of location databases which require the user either to regularly purchase a new bearer or at least to download one. Then there is the possibility of a subscription for use of the service, depending on the provider.

Alternative ways of financing the system could include contributions from actors such as motoring organisations, equipment (e.g. receiver) manufacturers or vehicle manufacturers. Such sponsorship of the service could be recompensed by publicity or by compensatory rebates. Alternatively, some of the costs could be met by national or regional government on the basis of improved communication, energy saving, congestion avoidance, etc.

However, at present industry in many areas has not been as proactive in the development of RDS-TMC as in other areas of ITS, and the services in some countries (e.g. Germany and the Netherlands) are publicly operated.

5.3.6 Interoperable Electronic Fee Collection (EFC) on Motorways

Toll motorways exist in nine European countries, forming a 17 000 km network. In some countries (including Italy, France, Norway and Spain), motorists have the option to make electronic payments by means of EFC. This option is taken up by some 10% of users, where it is available, totalling some two million subscribers in Europe.

A key requirement of such systems is interoperability, both between different motorway operators within a country and also between countries, to remove the need for motorists to have more than one tag fitted to their vehicle. Currently, interoperability exists on an national basis, such as in France, where the TIS (Télépéage Inter-Société) system is being introduced by all toll operators as an additional EFC system alongside existing non-interoperable systems. In Italy, a common technical solution, Telepass, is used. However, current EFC systems are not interoperable between Member States.

The CARDME (Concerted Action for Research on Demand Management in Europe) project developed a strategy to achieve convergence towards interoperability of new and existing EFC systems in Europe, with a technical, economic and legal scope. This in effect meant the development of a non-technical framework architecture.

The CARDME report into the migration of existing systems [ref. (r)] looked at the costs and benefits related to the introduction of two new tolling services for users: a stop & pay service and an interoperable EFC service. For both services, the main cost is on the set-up of the back office procedures between the different operators for the transfer of claims and settlements between the participating operators. The other main costs are related to information provision to users about the existence of the new service, i.e. signing, brochures and contracts.

The user benefits will be in the time saving by accessing a common level of service across Europe, but will require the purchase and fitting of an electronic tag.

Although operators will face the principal costs at the time of development and introduction of new interoperable EFC services, they will gain longer term benefits such as a reduced need to invest in added capacity at toll plazas to accommodate international traffic, because of the increased capacity of toll plazas. Also, if EFC becomes more interoperability, it also becomes more attractive to users, thereby reducing the number of manual staffed barriers required.

Operators are also providing a value-added service to the motorist in implementing interoperable EFC, especially for international motorists, who will find the motorway both easier to use and will save time queuing, dealing with foreign money or making credit card transactions. Operators could recuperate their costs through modest increases in the toll rate.

It is interesting to note that countries in the process of developing electronic tolling on currently free motorways, such as the UK, the Netherlands, Germany and Scandinavia, have European interoperability as one of their major goals. For countries with existing traditional toll infrastructure (e.g. France, Italy and Spain), although they are also working towards interoperability, there are fewer benefits for them in terms of an interoperable EFC system, as the widespread acceptance of international credit and payment cards and the long distances between toll plazas on an international trip mean that the system is already interoperable in a way, even though it may not follow a European framework architecture.

5.4 Other studies and examples of the benefits of integrated ITS

5.4.1 Review of the potential benefits of road transport telematics

A study conducted by TRL (Transport Research Laboratory) in 1996 looked at the costs and benefits of shared infrastructure for ITS applications. The costs and benefits given were, however, presumptive, rather than based on hard evidence. Nevertheless, as an indication only, Table 5 illustrates some of the benefit/cost ratios which could be possible through ITS integration.

Table 5: Cost effectiveness of an integrated approach to ITS deployment compared with stand-alone applications (indicative estimates)

Application	Benefit/Cost ratio	
	Stand-alone application	With common infrastructure
Inter-urban measures		
Incident detection	1.7	5.2
Speed control	2.9	8.5
Lane control	2.7	5.5
Slip road (ramp) control	3.6	7.1
Urban measures		
Intersection control	34	34
Area traffic control	7.6	7.6
Parking management	1.7	7.1

Source: TRL [see ref (d)]

5.5 Examples of "success stories" from outside the ITS world

5.5.1 GSM Telecommunications Architecture

GSM (Global System for Mobile communications) is a standard service architecture in the mobile phone sector. It is an architecture which has led to major benefits, in that it allows interoperability of mobile phones on a Europe-wide basis and beyond. The GSM Association comprises 373 members in 143 countries, 40% of the members being in Europe.

Although there are experiences to be learned from the development of this architecture, direct comparison to the ITS industry is difficult as GSM developed in a specific context where financial issues were predominant. In addition, the mobile phone market is far larger than that for ITS equipment.

The development of a GSM standard has however made a significant contribution to the growth in mobile phone use and competition in this sector is now intense, with prices falling. Service providers now offer a wide range of tariff structures and value-added services to differentiate their products. These include call waiting, call hold, call forwarding, calling line identify, SMS (short messaging service) and data services.

GSM is a "roaming" standard, giving the ability to use the same personal mobile phone number in another GSM network, thus allowing mobile phone interoperability in over 100 countries thanks to the roaming agreements between the network operators concerned.

In terms of costs, this is difficult to quantify due to the large number of organisations involved and the ongoing nature of the work. As an indication, for 2000 there are 162 meetings scheduled for all the 3GPP groups (dealing with UTMS - Universal Mobile

Telecommunications Systems) and while some operators would participate in 30 to 50 meetings per year, others would send 1 to 2 delegates to most meetings. Including back-office work, preparation, etc, each meeting may require up to 40 hours of work per delegate. As a very rough estimate, the more active operators could therefore spend between 300 000 and 700 000 euro per annum on standardisation work.

Suppliers spend significantly more, sending five or more delegates to important meetings, in addition to considerable back office work.

The costs of this work are considered worthwhile - the difficulty often lies in finding people with the required competence who are prepared to participate in standardisation.

In terms of benefits, some 200 million users have a GSM phone, out of a total of 436 million mobile phones world-wide. Some 125 million of the GSM users are in Europe. This growth has been twice as fast as predicted, with over 40% of the European population owning a mobile phone (1999 figure), compared to 24% in 1998, 14% in 1997 and only 2% in 1992. This phenomenal level of success would not be possible without the standardisation work.

Key benefits also include price pressure due to multi-vendor compatibility at a system level and the fact that customers are more willing to invest as they know that they can develop and realise their investment without being locked into a single supplier. These benefits are equally applicable to a framework architecture for ITS.

5.5.2 Internet

The Internet is another example of a standard architecture outside the ITS domain. This widespread information infrastructure was principally developed in the USA and had a lead time of some 20 years, although its use has exploded in the past two to three years (since the late 1990s). Whether it is an actual architecture is however debatable, as there are many members of the Internet community who would argue that Internet Protocol is a tradition rather than an architecture.

The development of the Internet started in the 1960s by individual researchers who saw the potential value in allowing computers to share information on research and development in scientific and military fields. The first global network of computers was proposed in 1962 and a Massachusetts computer was connected to one in California computer via dial-up telephone lines in 1965. The Internet proper, then known as ARPANET, was brought online in 1969 under a contract let by the renamed Advanced Research Projects Agency (ARPA) which initially connected four major computers at universities in the South Western USA.

The Internet matured in the 1970s as a result of the TCP/IP architecture and was adopted by the US Defense Department in 1980 replacing the earlier Network Control Protocol and universally adopted by 1983. In 1986, the National Science Foundation in the US funded a cross country backbone for the Internet, known as NSFNet. They maintained their sponsorship for nearly a decade, setting rules for its non-commercial government and research uses. Because of this public funding, commercial uses of the Internet were prohibited unless they directly served the goals of research and education. This policy continued until the early 90's, when independent commercial networks began to grow. It then became possible to route traffic across the country from one commercial site to another without passing through the government funded NSFNet Internet backbone.

The first national commercial service to offer subscriber access to the Internet (including e-mail) was Delphi in 1992. This was followed by access to its subscribers. It opened up an email connection in July 1992 and AOL, CompuServe and Prodigy. By 1995 there was widespread commercial usage of the Internet and NSF funding, together with the limitations on commercial use, came to an end. This funding amounted to $200 million from 1986 to 1995, during which time the Internet grew to over 50 000 networks on all seven continents and in space, with approximately 29 000 of these networks being in the USA.

The transition from a government funded, research-based Internet to a commercial one was sealed when Microsoft became an Internet Service Provider, and Microsoft’s browser is now integrated into its Windows 98 operating system, which has itself become not only a standard system architecture but also a virtual monopoly product.

In addition to funding, another key element in the success of the Internet was co-operation and interoperability. In 1985 a workshop was organised so that vendors could learn about how Internet Protocol worked, what it could do, and perhaps more importantly, where its weaknesses lay. This laid the basis of a cross-fertilisation process between inventors and vendors, with discussion being two-way (e.g. the inventors could learn about new problems discovered by vendors in the field). Furthermore, in 1988, 50 companies took part in the first the first Interop trade show, in which they strove to ensure that their products inter-operated with everyone else’s, including their competitors. This trade show is now so successful it is held in seven locations around the world each year, where an audience of over 250 000 people can see their products working together in a seamless manner.

The Internet framework architecture is therefore now a worldwide standard, connecting computers made by a variety of different manufacturers and supporting services such as e-mail and the World Wide Web, which have their own sub-architectures. These applications are Internet protocols and use the Internet as a platform. They have also revolutionised information provision and exchange in recent years. This can be illustrated by the exponential growth in the number of Web sites - in June 1993 there 130 Web sites, a year later this had increased to 2738. By June 1999 there were 6.18 million and just six months later, in December 1999, there were 9.56 million.

The key concept embodied in the Internet is that of open architecture networking, in which the choice of any individual network technology is not dictated by a particular network but can be selected freely by a provider and made to interwork with the other networks through a high-level “Internetworking” architecture. In this open-architecture network, the individual networks may be separately designed and developed and each may have its own unique interface.

Costs and Benefits

The Internet is one of the most successful examples of the benefits of sustained investment and commitment to research and development of information infrastructure. Costs were borne initially by the academic world but the concept was significantly boosted by the ten year $200 million investment by the US National Science Foundation.

In more recent years, the growth in Internet users has been such that costs can generally be covered commercially. For example a large part of the information on Web sites is commercial/advertising related and service providers are now providing products such as free e-mail which carries advertising. It is currently evolving to permit more sophisticated forms of pricing and cost recovery.

The key benefits of the Internet can be summarised as follows:

- geographic Distribution (reaches around the world);
- robust architecture (the net adapts to damage and error);
- speed (data travels at 2/3 the speed of light);
- universal access (the Internet provides the same functionality to everyone and the Web provides universal access to the same information from anywhere);
- the fastest growing technology ever;
- promotes freedom of speech;
- as the net is digital, it can correct errors;
- ease of use of the Web, including its search capabilities;
- e-mail benefits: e-mail communication can be from one person to many at once, it is asynchronous (i.e. unlike a letter, it is instant, but it unlike a phone call, you do not need to be available at the same time as the sender in order to receive it - it waits for you), and it is almost free.

Comparison with ITS framework architecture

The architecture of the Internet has been driven by a core group of designers, but the form of that group has changed as the number of interested parties has grown. With the success of the Internet has come a proliferation of stakeholders - stakeholders now with an economic as well as an intellectual investment in the network.

In ITS, architecture development has been less based in the academic world and more in the industrial and public sectors although, like the Internet, commercial players are coming increasingly to the fore. The other difference is that the formative years of the Internet took place in a non-commercial environment in the USA, where public funding was conditional upon the system being used only for government and research uses. When the service opened up to commercial use, the same basic architecture was used, and was exported from the US world-wide. Although the Internet is now hugely successful, nobody was interested in it during the formative years apart from limited parts of the academic world - it was effectively producer-led. ITS, on the other hand, is more consumer led, as there is a wide market keen to see ITS solutions developed to help solve traffic and transport problems.

ITS development, on the contrary, is taking place in many countries and is commercially oriented. Indeed, one of the aims of a framework architecture is to reduce market entry barriers and promote free and fair competition. On the other hand, public funding is still necessary in order to develop the architecture as the large number of private players in a competitive environment make this an unfeasible proposition within the commercial sector (the Internet having been developed by a smaller number of players, within the same country, and in a non-competitive research environment).

The second major difference is the rate of growth. The benefits of the Internet are clear to most people, whilst those of ITS are less so, and are more of interest to public authorities and road operators than the general public, most of whom are unfamiliar with the concept. So while ITS services are undoubtedly on the increase and their value is being recognised, comparisons with the exponential growth of the use of Internet applications are impossible.

However, a useful parallel can be drawn from the co-operation between players in the IT world through workshops, training and exhibitions to demonstrate interoperability and seamless services, showcase new developments and highlight areas where more research is required. That this produces benefits to all, and that commercial companies are keen to demonstrate that their products can inter-operate with those of their competitors indicates that a framework architecture is highly valued by the commercial sector as well as by end-users and policy makers. Such showcases could work equally successfully in the ITS world and the TITOS open architecture demonstration during the Turin ITS conference in November 2000, where a real life plug-and-play environment will be available for ITS applications, will be the first major chance in Europe to demonstrate the benefits of an ITS framework architecture.

6. Approaches to ITS Architecture and its Costs and Benefits outside Europe

6.1 United States

6.1.1 ITS America

The US National Architecture project for the Federal Department of Transportation began in 1993, with Version 1 of the National Architecture being completed in 1996 and Version 2 in 1998. This represented the first large scale effort in the United States to document the costs and benefits of equipment associated with ITS deployment, and included the following three elements:

- Cost Analysis;
- Performance and Benefits Study; and
- ITS Programme Assessment/Evaluation.

6.1.2 Cost Analysis

The Cost Analysis document has two purposes. This document develops a high level cost estimate of the expenditures that are associated with implementing ITS components. Secondly, it is a costing tool for implementers, providing unit prices and systems costs of ITS subsystems.

This is essentially related to deployment scenarios in rural, urban and inter-urban contexts and it includes all the financial details. Its level of detail is beyond the scope of KAREN, but it is recommended to readers requiring more information on the subject.

6.1.3 Performance and Benefits Study

The Performance and Benefits Study assesses the technical performance of the US National Architecture on a number of system-level and operational-level criteria. This is related to the work of CONVERGE on evaluation and is beyond the scope of KAREN.

In brief, the analysis separates two types of benefits: the benefits of the architecture as a whole and the benefits of particular ITS products.

The key benefits identified for the National Architecture were as follows:

- helps to foster a market for ITS;
- provides a common platform for systems integration (at architecture and deployment level);
- contributes to developing consensus standards (e.g. for interfaces and data exchange);
- propagates the integration of transport functions, technologies and information flows.

The follow-on benefits resulting from the above include expanded markets, increased competition, lower costs, compatibility of ITS applications (including interoperability and portability) and promotion of development of technology (by providing standards upon which innovative applications can be based). However, the adoption of standards in ITS could also impede certain innovative technology which may require the use of a new and different standard.

Benefits from the integration of transport flows include more effective system planning and management through the sharing of data (e.g. multimodal co-ordination) and the integration of different applications to provide a better service to the user.

Advantages of this integration of services include:

- *Data/information sharing for system management and planning* – the architecture identifies how organisations can share data and information, which is often necessary to provide particular user services, and can lead to more effective use of transport resources and better system-wide planning.
- *Common functions and functional integration* – by sharing certain functions between market packages, cost savings and operational efficiencies may be realised by the end users of these packages, and integrating particular market packages allows higher benefits to be achieved. For example, route guidance can be connected with regional traffic control, allowing an ISP to provide better routing advice, and allowing traffic managers to know how vehicles will be routed, so that they can better time their traffic signals to accommodate it;
- *Common technology* – data flows and functions specified in the architecture may be combined, in a specific system design, to leverage common communications and other technology, e.g. dedicated short-range communications devices can be used both for roadside toll collection, HGV check/clearance, and vehicle probe surveillance data.

The Performance and Benefits Study carried out a technical appraisal of the National Architecture in terms of system performance (principally in qualitative terms) and operational performance (in qualitative and quantitative terms). The criteria by which this analysis was undertaken were as follows:

Evaluation criteria for analysing the technical performance of the system:

- Support of ITS services;
- System flexibility and expandability;
- Performance of variously equipped vehicles;
- Multiple levels of system functionality; and
- Evolutionary deployment.

Evaluation criteria for analysing the technical performance of operations:

- Accuracy of traffic prediction models;
- Efficiency of traffic monitoring and control;
- Accuracy of position location;
- Effectiveness of information delivery;

- Adequacy of communication system;
- Capacity in relation to expected demand;
- Security safeguards;
- Map update;
- System maintainability; and
- System robustness.

6.1.4 ITS Programme Assessment/Evaluation

The US National ITS Program has undertaken assessment activities to help ensure that the program is effective in meeting the DoT's transportation goals, with emphasis being placed on tracking both programme outputs and programme outcomes.

Programme outputs are results-oriented measures that track the progress of a programme (e.g., the number of toll plazas equipped with EFC capability) and for which the benefits are easily understood by the end-user (e.g., a decrease in waiting time to pay tolls). Another type of ITS Programme Assessment/Evaluation activity is Programme Assessment Analyses. In these activities, in-depth studies are conducted and include modelling and simulation of the impact of ITS deployments, estimating the costs and benefits of ITS technologies, determining user acceptance of ITS products and services, and investigating institutional and policy issues related to ITS.

Program outcomes are measured according to four goals and 11 key measures of programme effectiveness: i.e.

	Goal Area	*Measure*
-	Safety	Reduction in the overall rate of crashes
		Reduction in the rate of crashes resulting in fatalities
		Reduction in the rate of crashes resulting in injuries
-	Mobility	Reduction in travel time delay
		Reduction in travel time variability
		Improvement in customer satisfaction
-	Efficiency	Increases in freeway and arterial throughput
		Productivity
		Cost savings
-	Energy and Environment	Decrease in emission levels
		Decrease in energy consumption

6.2 Japan

6.2.1 Introduction

In November 1999, five Japanese government bodies (the National Police Agency, the Ministry of International Trade and Industry, the Ministry of Transport, the Ministry of Post and Telecommunications and the Ministry of Construction) jointly finalised the System Architecture for ITS in Japan.

A cost-benefit study of the architecture is being conducted, but results are not expected until the end of 2000.

6.2.2 Economic effects of ITS deployment in Japan

A study into the economic effects of deploying ITS in Japan was conducted[1] in which the validity of the scale and costs of the ITS systems and the services provided were evaluated. However, this study concerned the costs and benefits of actual deployment rather than those of a common architecture.

The three cost categories covered were the ITS infrastructure, ITS on-board equipment for vehicles and the costs of software and service development. The study established deployment scenarios by introducing the concept of "Implemental Deployment Packages", each of which comprised:

- a service (e.g. driver route guidance, advanced safe driving, non-stop use of toll roads, etc) which could be analysed in terms of utilisation effects and risk; and

- a number of subsystems required for that service (e.g. traffic management centre, traffic sensors, beacons, DSRC on-board equipment, etc) which could be analysed in terms of risk, cost and communication load.

The study then developed a multi-sector general equilibrium model based on hypothetical ITS deployment scenarios to quantitatively measure the effects of each scenario. It was recognised that one subsystem could be used for several services, in which case the costs involved for each Implemental Deployment Package are reduced, thus recognising the added benefits of an overall framework architecture.

[1] Economic Effects of ITS Deployment (Keio Economic Observatory and the Public Works Research Institute of the Ministry of Communication)

7. Conclusions

This report has outlined the costs and benefits of developing, maintaining and implementing an ITS framework architecture. Evaluations and analyses of costs and benefits are critical to ensuring progress toward the vision of integrated ITS and achieving deployment goals as decision makers need to be able to justify their investment based on sound experience both from elsewhere and from previous comparable deployments in the same city or region.

Costs and benefits in this report have been assessed and discussed in a qualitative way rather than a quantitative one, as the lack of experience in an ITS framework architecture means that concrete figures are simply not available. In particular:

- the effects of individual ITS deployments are often difficult to measure, partially as a result of the uncertainty of background changes, which can make it difficult to determine whether an effect is a result of the ITS implementation or of other factors, and partially because the reactions of the travelling public to ITS applications (e.g. user information) vary considerably and are often not well understood;
- the assessment of an ITS architecture in concrete terms is yet more difficult, as the final benefits to users are provided by the ITS applications themselves, not the framework architecture, and there is no clear way of ascertaining how many of these benefits would have occurred without the framework architecture;

Even when benefits can be identified with a reasonable degree of confidence, there remain two further difficulties:

- these benefits cannot often quantified in financial terms; and
- they are spread across a very large number of beneficiaries, many of whom will welcome the benefits (although not all would be prepared to pay to receive them), while others will notice few differences (e.g. in the case of small time savings or reduced accident rates, which are not normally noticed by individuals).

The purpose of this report has therefore been to make the reader aware of the issues and it provides ITS implementers and funders at European, national and regional/local levels with suitable reasons in favour of adopting an approach based on a standard framework. These have been supported by a number of examples on a smaller scale where a common architecture or the integration of separate systems have brought benefits.

Therefore, while the benefits of the KAREN Framework Architecture cannot be quantified (or at least at the present time, when national architecture projects based on KAREN are still underway), KAREN can provide (and indeed is currently providing) benefits to the developers of national, regional and service-oriented architectures by providing a foundation for this architecture, thus speeding implementation and reducing costs. These architectures will then provide the bulk of the benefits to the end user, whether private or commercial. In addition, the KAREN FA can provide some benefits to the end user in terms of creating a framework in which different applications and different services in Europe can inter-operate. This not only improves services to the end user but also helps to drive down costs in the longer term for users, operators, manufacturers, implementers and funders alike.

In addition, the KAREN FA contributes to the European Single Market by providing a common framework upon which manufacturers and service operators can develop their products, thus reducing entry barriers to the market and promoting free trade across the EU by providing an interoperable platform. This will help the European ITS industry to grow and compete more effectively with the American and Asian players on a global scale.

For the benefits of KAREN to be fully realised, however, there is a need for education and dissemination of the architecture and its benefits to public authorities and the ITS industry across the EU, and also for the architecture to be maintained at European and national levels to ensure that future technological, market, administrative or legal developments that can affect ITS are taken into consideration.

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