European ITS Framework Architecture

-

Deployment approach and scenarios

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Executive Summary

The target of KAREN is to produce a set of documents constituting the European ITS Framework Architecture that would ideally become the baseline that everyone can use to actually decide on and design ITS systems and services.

The deployment of the European ITS Framework Architecture can be done according different mechanisms:

- It is used by stakeholders as a basis to develop specific architectures.
- It is used as a reference by standardisation bodies to develop technical solutions allowing ITS to be “working” and “workable”.
- It is used as a reference by the European Commission to identify what new ITS related initiatives should be undertaken.
- Finally, deploying the European ITS Framework Architecture also means:
    - to create more awareness;
    - to train people on how to exploit the results;
    - to maintain those results.

It is therefore important for the KAREN project to “sell” its product, to convince the stakeholders about its value and to take into account any feedback to improve it. The follow-up of KAREN must also be prepared.

Beside addressing the aspects aforementioned, the present report also describes a methodology to develop specific architectures based on the European ITS Framework Architecture results, composed of four main stages:

- Identifying a System Architecture Champion.
- Planning the overall architecture development process.
- Technical Development of Architectures.
- Creating the right environment for Architecture deployment.

This last stage is critical, as the results that it produces must describe all issues that can impede on the deployment of the architecture and must recommend possible solutions to overcome them. Examples of such issues and solutions are given in the report, based on the European experience.

Finally, the report presents national initiatives related to national architecture development based or not on KAREN and taking place in Europe. This review lead to a series of recommendations that could be used by any new initiative addressing the development and deployment of system architecture.

1. Introduction

1.1 Outline

The KAREN project has produced the European ITS Framework Architecture. This document is part of the set of deliverables produced by the KAREN Project to describe its Framework Architecture and how it can be implemented. This particular document provides a description of a methodology, which is recommended for the development of specific architectures, based on this Framework Architecture. It describes issues and possible solutions to take into account when developing such architectures and deploying ITS. The report also describes national initiatives developing national architectures and proposes recommendations based on their experience.

1.2 Where the document fits in the Architecture Documentation

The document is one of documents produced by the KAREN Project to describe its complete Framework Architecture as part of the KAREN WP4.

1.3 Scope of the report

This document is intended to serve ITS professionals who are involved both in the development of national, regional, city or service and system specific Architectures based on the European ITS Framework Architecture proposed by KAREN and in the implementation of ITS based on an agreed architecture.

More specifically, it aims at:

- describing the relationships between the European ITS Framework Architecture and specific architectures building upon KAREN results;
- explaining how specific architectures can be derived from the European ITS Framework Architecture and identifying key players involved in the process;
- identifying potential issues that could impede on the development of these architectures and on the deployment of ITS systems;
- recommending actions that will encourage cost-effective implementation of ITS and that are compatible with the European ITS Framework Architecture.
- presenting examples of national architecture developments and provide recommendations based on their experiences.

1.4 Overview of the Document Structure

Chapters 2 and 3 of this report give an overview on the KAREN project and present an argumentation for using a common ITS Framework Architecture (FA). Chapter 4 describes how the European ITS Framework Architecture produced by KAREN can be deployed to develop specific architectures and discuss about the necessary elements to take into account to have a proper environment facilitating the deployment of ITS. Chapter 5 present different national initiatives developing specific architectures on the basis of the European ITS Framework Architecture produced by KAREN. Chapter 6 gives a set of recommendations.

1.5 List of Abbreviations

CASE	Computer Aided Software/Systems Engineering
CEN	Comité Européen de Normalisation
COTS	Commercial – Off-The-Shelf (of products and components)
EC	European Commission
EU	European Union
FA	Framework Architecture
ICT	Information Communication Technology
ISO	International Standardization Organisation
ITS	Intelligent Transport System
KAREN	Keystone Architecture Required for European Networks
MoU	Memorandum of Understanding
OSI	Open System Interconnect
RAID	Risk Analysis of Its Deployment
RDS-TMC	Radio Data System-Traffic Message Channel
TC	Technical Committee
TERN	Trans-European Road Network
TICS	Transport Information and Control System
UML	Unified Modelling Language
VDV	Verband Deutscher Verkehrsunternehmen

2. What is KAREN?

2.1 Introduction

The KAREN (Keystone Architecture Required for European Networks) Project intends to create a minimum stable framework necessary for the deployment of working and workable ITS within the European Union until at least 2010. It is the European ITS system architecture effort, requested by the High Level Group on Road Transport Telematics, approved by the European Council of Ministers and funded by DGXIII as part of the 4th Framework Programme. The project began on 1st April 1998, runs for two years, and aims to deliver an agreed, and promoted, Transport Telematics Framework Architecture which:

- defines the necessary elements for an open market of ITS products throughout Europe, and the rest of the world, for European ITS industry;
- is the basis for building consensus on issues that still prevent widespread deployment of ITS in Europe, and hence permit all categories of user to purchase cost effective ITS products that will work in the same way throughout Europe;
- is the basis for developing and deploying specific national, regional, local, service or system architectures;
- provides a bridge between the ITS community and those creating the current and future technologies that may be used by ITS;
- is a guide for investments on the basic infrastructure necessary for the deployment of the ITS services;
- supports the identification of areas where new research and demonstrations are needed.

The European ITS Framework Architecture, together with standards, will help national, regional and local authorities as well as service providers to plan and realise their goals with ITS in a way that is coherent, cost effective and extendible in area and over time. It also helps industry and service providers to produce and procure in a cost-effective way in markets of European scale. Those categories are the users of the European ITS Framework Architecture. Travellers and drivers will not directly use it, but may be involve in market research or hearings when parties define their specific ITS implementations and will experience the benefits of its results once implemented.

The European ITS Framework Architecture includes the following key outputs:

- a European set of User Needs;
- a Functional Architecture;
- a Physical Architecture;

- a Communication Architecture;
- a Costs/Benefits Study;
- a description of Deployment Issues and Scenarios;
- a Standardisation Framework;
- a set of Recommendations for the maintenance of European ITS Framework Architecture results and follow-up.

All of these may be found on the final CD-ROM issued by the KAREN Project (August 2000).

2.2 KAREN approach

The European ITS Framework Architecture produced by KAREN must accommodate national plans and support the various efforts in research, standardisation, deployment and investment. It must also provide a migration plan which incorporates and builds upon existing 'legacy' systems. (For a discussion as to what is meant by a Framework Architecture see 4.2). Therefore the European ITS Framework Architecture proposed by KAREN is building upon current European and International experience and is using a Permanent Consultation Group to review its results.

A common Framework, coupled with the development of specific architectures and standards, helps to achieve:

- compatibility of information delivered to end-users through different media;
- compatibility of equipment with infrastructures, thus enabling seamless travel across Europe;
- a basis for regional, national and European authorities to produce master plans and recommendations to facilitate ITS deployment;
- an open market for services and equipment where compatible sub-systems are offered (thus removing the need for ad-hoc solutions);
- economies of scale in equipment manufacture permitting competitive prices and less costly investment when compatibility is guaranteed;
- a known market place into which producers can supply products with reduced financial risk.

2.3 Relationship with other Architecture activities

2.3.1 International Activities

There are two other principal architecture activities from which information is readily available, namely the National Architecture for ITS for the USA and the work being done by ISO/TC204/WG1; though work is also going on elsewhere, e.g. Japan, Korea, and Australia. Both the American National Architecture and the ISO/TC204/WG1 Reference Architecture begin with a 'green field' and do not consider any existing systems or equipment. Although they were intended to be reasonably comprehensive, the American User Service Requirements are now recognised as being not totally applicable. The 32 Transport Information and Control System (TICS) Fundamental Services produced by ISO/TC204/WG1 have been based mainly on the American User Service Requirements and, as a result, they tend to be oriented towards US problems and desires.

The US National Architecture uses a Function Oriented (sometimes called Process Oriented) approach and contains Functional, (Information), Physical and Communications Architectures at varying levels of detail. ISO/TC204/WG1 have taken the American National Architecture and re-written it using an Object-Oriented approach with UML to produce a proposal for a Reference Architecture for TICS. During 1998 it was recognised by the US, European and Japanese representatives that the work needed to be improved with regard to its consistency and readability. These and other comments were submitted to WG1 in November 1998, the European ones being submitted through ISO/TC204/WG1/SG7 which is responsible for representing European interests in this area. The comments are now being worked on by WG1 to produce a revised and improved version. A new work item was also proposed, the "bridge building function", which would also describe the TICS architecture using a Function Oriented approach.

2.3.2 RAID

This is a study on system architecture performed as part the Telematics for Transport section of the 4th Framework Programme from January 1998 until March 1999 by a sub-set of the KAREN consortium. The objective of the RAID Project was to identify the obstacles that might prevent the successful deployment of ITS within the EU, and to recommend possible solutions for overcoming them.

The risks considered were those that may hinder, or prevent, the implementation of:

- The European ITS Framework Architecture in general;
- Any particular ITS.

All areas of ITS were considered, using the knowledge and expertise of both the members of the KAREN team, and the extensive group of external organisations established by the KAREN Project. Although not a specific objective, the output of the RAID project will serve as supplementary background information to the work of the KAREN project.

The final set of overall risks and their mitigation strategies can be found on the RAID CD-ROM. This can be obtained from the EC.

3. Added-value of the European ITS Framework Architecture

3.1 Benefits in using a European Framework Architecture.

The benefits of a European ITS Framework Architecture are fully described in the KAREN Cost Benefits Report [KAREN CB], but this section provides a brief résumé of those benefits.

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

1. Production of an accepted standard or result (such as the European ITS Framework Architecture).

2. Application of the standard/result by ITS implementers (in the development of specific architectures derived for instance from the European ITS Framework Architecture or in system deployment). This is a benefit to intermediate users.

3. Benefits resulting from this application, in terms of reduced costs and time for development and implementation. This is a benefit both to intermediate and final users.

The benefits can be clustered in terms of technical, social, legal/institutional and financial benefits and can take the following forms:

- common framework, concepts and terminology for ITS planners and implementers;
- reduced costs[1] for developing specific architectures from a common Framework (as they can use for instance the European ITS Framework Architecture as a base);
- reduced costs for developing ITS systems themselves;
- reduced costs 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 costs to users for services;
- reduced operating and maintenance costs (systems developed from a common architecture should be easier to maintain);
- 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);
- better knowledge of demand/transport patterns (due to greater service co-ordination);

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

- enhanced communication between actors at a local, national or international level (as a common architecture ensures that everyone is speaking the same ‘language’);
- improved management of research and development and standardisation at a national or international level (due to the fact that European standards exist as a guide/framework);
- interoperability of services, i.e. technical interoperability (compatibility between different systems) and legal and administrative interoperability (compatibility of procedures and approach between different operators or different countries);
- more seamless, co-ordinated and consistent services (due to interoperable systems and processes);
- improved quality of services (in terms of levels of information, seamless and continuous services, etc);
- increased multimodality (due to greater service co-ordination);
- increased competitiveness and market size (common basis for developing systems, therefore fewer entry barriers); and
- increased employment (in ITS and associated industries, as a result of faster expansion of services than would be the case without a common Framework Architecture);
- easier access to already established legal and organisational frameworks, MoU, model for contracts, etc.

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.

In addition, certain benefits (notably “increased multimodality” and “increased employment”) are of relatively low significance as they derive principally from ITS implementation and are only likely to 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.

3.2 Making the European ITS Framework Architecture alive

Public authorities which have responsibilities for traffic, transport, safety and environmental issues have to provide solutions. It is their job and the public will hold them accountable. They need to provide balanced solutions and ensure that they are implemented. As a result of different local circumstances, political objectives and available budgets, they may come to different conclusions.

One broadly accepted view at the present time is that it is less desirable to solve traffic problems simply by building more roads. Also traffic safety and environmental issues are more prominent now then they were a few decades ago. Those views, together with progressive R&D programmes during the last decade, have led to the conclusion that Transport Telematics, also called ITS, are cost-effective means to achieve traffic and transport goals in politically acceptable ways. Under the paradigm '**making better use of existing (road, rail) infrastructures**', ITS offers the opportunity and tools to realise goals for mobility, safety and the environment together. 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 this view.

In implementing ITS systems however, after the first system, complexity starts to grow. This poses threats to effectiveness, manageability, maintainability, extendibility and refurbishment 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 very much like them to co-operate, at least to a certain level and produce benefits of synergy, rather than to counteract or contradict each other. It is therefore evident that having 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.

Studies such as one by TRL in the UK also show that the use of common or shared infrastructure for ITS applications can be very cost-effective (see Figure 1)

Benefit/Cost Ratios (1)

UK Study by Transport Research Laboratory

Measure	**Benefit/Cost Ratio** Stand alone Application	**Benefit/Cost Ratio** With Common Infrastructure
Inter-urban		
Incident Detection	1.7	5.2
Speed Control	2.9	8.5
Lane Control	2.7	5.5
Ramp Control	3.6	7.1

Figure 1: Cost effectiveness of an integrated approach versus stand alone (interurban)

Projects such as 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 has been introduced in different sites and important results were demonstrated by means of extensive field trials and surveys [QUARTET 1].

	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

Table 1: Summary of results measured by QUARTET PLUS

The high level of integration demonstrated relevant benefit by sharing infrastructures, in the case of the 5T system it was calculated that by using a 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 reduced the service by one tram 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 [QUARTET 2]

The public would derive greater benefit (in terms of comfort, ease of use, safety and financial savings) from interoperable systems which enable them to experience continuous and consistent information and other services on their trips. In an international context, language independence and interoperable equipment (either in-vehicle or as personal digital assistants could be added.

Finally industries and private service providers look generally for European market scales and a clearer view of the market through known standards, and agreed infrastructures and interfaces which help to lower risks and barriers for investment, as well as costs. This will be particularly true for Small and Medium-sized Enterprises, which could provide solutions to be used at a European or global level.

Overcoming the above mentioned problems as well reaping the likely benefits requires the use of agreed **Architectures.**

Having explained the benefits of using Architectures, it was the High Level Group on Road Transport Telematics who recognised the need to have a **European ITS Framework Architecture** and made it one of the priorities of their short term action plan for the implementation of ITS in Europe. This conclusion has received the support of the European Council of Ministers of Transport.

The European ITS Framework Architecture will and can not be a strict prescription for one integrated ITS system in Europe. That would not be accepted and it would not work. It will be Framework, which is technology independent and policy independent, as technologies can change quickly and policies are made and chosen according to the rules and principles of democracy in the nations and regions of Europe. The European ITS Framework Architecture produced by KAREN should become the baseline that everyone can use to actually decide and design ITS systems and services to support their policies with the technologies of their choice. Together with standards, this will help realise the benefits mentioned earlier through, among others, more integrated implementation and use of systems and services within geographical or application areas and higher levels of interoperability and continuity of systems and services between areas.

To realise systems that can co-operate with each others, we need the following (see also 4.2):

1- The **European ITS Framework Architecture**,

which is technology independent and valid Europe-wide for a relatively long period of time;

2- an **Intermediate Architecture** (i.e. a National, Regional, Local or Service Architecture);

using ideally the European ITS Framework Architecture as starting point this intermediate architecture may already reflect <u>choices</u> which can not be made at the European level such as:

- typical roles of authorities, the private sector or organisations in that geographical area or for that particular service;
- reflect specific policies in that geographical area;
- give the scope of that areas’ interest, e.g. only a part of the Functional Areas of the European ITS Framework Architecture;

It also can give other advantages such as:

- being in the national language;
- promoting the awareness and expertise to address the national/regional/local plans.

3- Deployment Architectures, also called **System Architectures** from which groups of systems actually can be specified, designed and built.

In a deployment architecture the actual, specific choices are reflected which can be made by the owner (authority, consortium etc.) who can realise systems; the choices are more detailed now and can include technology choices.

4. Deployment of the European ITS Framework Architecture

4.1 Introduction

This section proposes a generic methodology which allows the benefits of the European ITS Framework Architecture to be used when defining a national/regional/city or service/system specific Architecture that is able to:

- include specific local constraints (e.g. legacy systems);
- describe the roles of relevant players;
- be used as communication tool between the different players involved in the process;
- describe all necessary elements to ensure that the Architecture can be implemented;
- tackle all necessary issues to ensure a successful deployment.

Before entering into the core of this report, the following definitions are provided:

- European ITS Framework Architecture: an architecture that is developed for the application of ITS within Europe. It is based on a set of User Needs for Europe produced by the KAREN Project. The Framework Architecture is currently available as part of the results (deliverables) of the KAREN Project.

- National Framework Architecture: an architecture that is developed to cover the application of ITS within a European Nation, or an autonomous State within a Nation. It can be based on the parts of the KAREN User Needs that are relevant to the Nation and be developed from the European ITS Framework Architecture proposed by KAREN. This Architecture will define the ITS applications that are to be provided within the Nation (or State) to serve the User Needs.

- Local Framework Architecture: an architecture that is developed to cover the application of ITS in a specific place or area like a region or a city within a State. It can be based on a sub-set of the KAREN User Needs used for the National (or State) Architecture, or if either of these do not exist, on those for the European Framework Architecture. The User Needs will be those that only define the services that the local area requires. This Architecture will therefore contain ITS applications that are specific to the locality where it will be used. The starting point for any Local Architecture will be either a National (or State) Architecture, or in the absence of either of these, the European ITS Framework Architecture itself.

- Service Architecture: an architecture that is developed for a specific ITS service independently of any geographical context. KAREN has identified a set of Fundamental Services [KAREN USER NEEDS]. [ISO TC204 WG1] has also proposed a set of 32 TICS Fundamental Services. For instance, an examples of service specific architecture can be defined for the Tolling or Route Guidance Service.

- System Architecture: a system structure that consists of system elements, interfaces, processes, constraints and behaviour. A System Architecture covers a particular part of a European, National, Local or Service Framework Architecture. It will show what is required to deploy a particular ITS application, e.g. Urban traffic Management, Electronic Fee Collection, Public Transport Management, etc. The contents will be at a level that provides the starting point for the generation of specifications that enable the purchase of the System.

For convenience, the term **Intermediate Architecture** will be used in the following sections and will mean either:

- a National or Local Framework Architecture or,
- a Service (specific) Architecture.

4.2 Reminder

It is important to distinguish between the three different roles of an “Architecture” in the European scenario. They can be defined as follows:

1. 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].

2. **Intermediate** level **Architectures** 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: inter-operability includes the technical, operational and organisational aspects.

   These architectures are also the 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.

3. The **European ITS Framework Architecture** 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 the other types of architecture. It will enable them 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 KAREN Project has the task of creating the key elements of the European ITS Framework Architecture, and whilst it must take account of what exists already, it must also look to the future and the desires expressed in the List of European User Needs, which may not be fully satisfied by existing systems. Thus, whilst the Framework Architecture will concentrate on the functionality and other features that are needed to satisfy the user needs, it will not "re-invent the wheel" if there is an existing solution.

Figure 2 provides an overview of how the various architectures will relate to each other once this work is completed. Initially, there will be two main categories of ITS system co-existing:

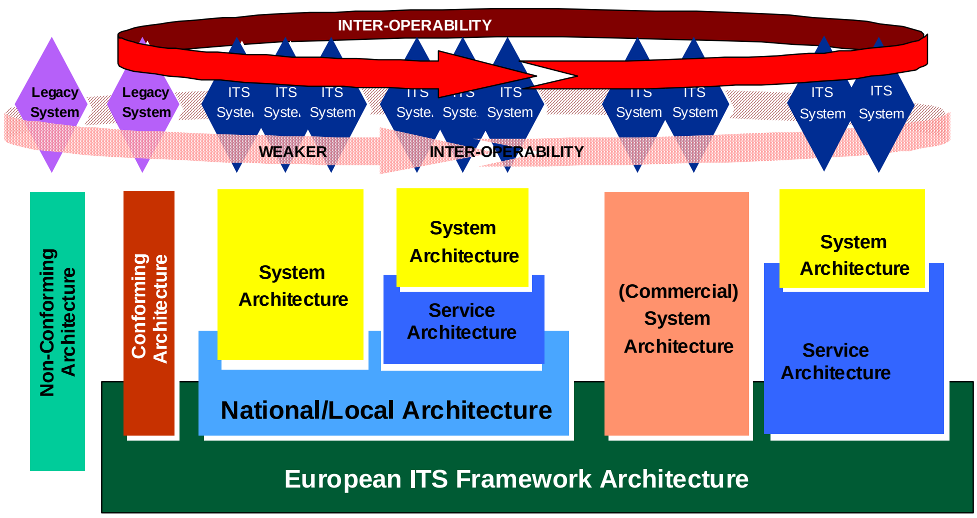

Figure 2: Overview of the Relationship between the Various Architectures

1) Those that will conform fully to the European ITS Framework Architecture. These will be made up of:

   a) new systems that have been designed to conform to the Framework Architecture: they will eventually be in the majority;

   b) legacy systems that do conform to the European Framework Architecture: some legacy systems will be in this category.

   These systems, by ensuring this conformance, will have completed the first major step towards providing inter-operability with each other.

2) Those legacy systems that do not conform completely to the European ITS Framework Architecture of other ITS. Whilst they may not be fully inter-operable with those systems that do conform, once can expect there to be a useful degree of mutual functionality especially for those systems that are not very old.

In order to make legacy systems fully inter-operable with other ITS, there will be a migration strategy to inform their owners on how they can become compliant with the European Framework Architecture. It should be noted that whilst 'migration' is often assumed to mean 'replace', in practice it can also mean 'enhance' or 'add to', which is usually less contentious and expensive!

The European ITS Framework Architecture will also have other roles, such as providing the bridge between the ITS community and those creating other current and future technologies (e.g. in the telecommunications or banking world). It may also be a catalyst for new research.

4.3 European ITS Framework Architecture Deployment

In this section, it is presented how the European ITS Framework Architecture proposed by KAREN can be used effectively to help the implementation of ITS. The overall deployment process of the European ITS Framework Architecture is depicted in Figure 3.

The deployment can be done according to the following mechanisms:

- It is used as a basis to develop **Intermediate Architectures** or specific ITS **System Architecture**. The European ITS Framework Architecture proposed by KAREN provides then a comprehensive terminology, set of User Needs and Architectures as well as a methodology to develop this type of architecture. We will describe in details this mechanism in section 4.4.

  We believe that the KAREN results can reduce significantly the kick off period of such developments as it defines many concepts which can be easily taken on board by any team developing a specific architecture. The main constraint is however the language as all KAREN material is in English. Another constraint could also be the methodology.

- It is used to make proposals or to give recommendations to bodies developing technical elements allowing ITS to be "working" and "workable". Such bodies include standardisation bodies (e.g. CEN/TC278), specific forums (e.g. DATEX Forum) or interest groups (e.g. motorway operator associations). First recommendations will be made by KAREN when proposing its Standardisation Framework. Some recommendations are also given in section 4.4 of this document.

- It is endorsed by stakeholders (mainly the European Commission) and becomes a de-facto reference. Those stakeholders can then promote the development of for example specific architectures based on KAREN results or make recommendations to the aforementioned bodies to work on specific items. KAREN results could also be used as a reference for deciding new R&D activities in the 5th Framework Programme of the European Union.

- Finally, deploying the European ITS Framework Architecture also means:
  - creating more awareness (by for instance presenting KAREN results to many city authorities) to ensure that all potential users of the European ITS Framework Architecture are familiar with it;
  - training people on how to exploit the European ITS Framework Architecture results, for instance by explaining how to use the results to develop specific architectures;
  - maintaining KAREN results based on on-going ITS developments and feedback provided by the architecture activities (see also [RAID]).

  A proposal addressing all these actions will be proposed to the European Commission as part of the 5th Framework Programme.

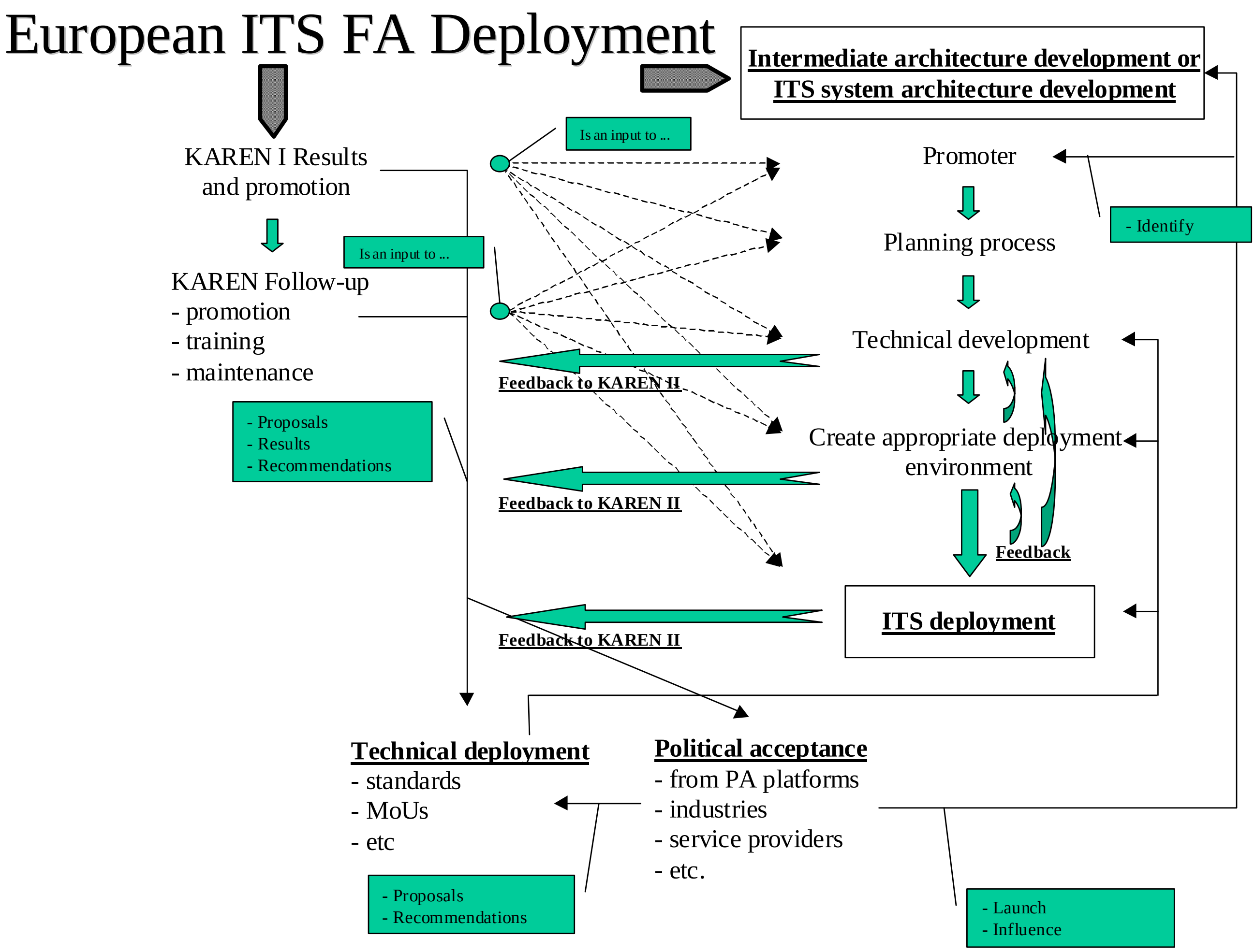

Figure 3: Overall deployment of the European ITS Framework Architecture

4.4 Intermediate and System Architecture Development

4.4.1 Introduction

Figure 3 presents the overall the European Framework Architecture deployment process. The development of Intermediate and ITS system Architectures is part of this process. As discussed in section 4.1, Intermediate Architecture can designate:

- a National or Local Architecture or,
- a Service (specific) Architecture.

The development of these Architectures should be based on the KAREN results and add more specific details related for instance to specific design considerations, local policies or legacy systems. It is indeed important to reiterate that achieving European inter-operability of systems and operating modes already starts at the architecture definition level. Therefore, the European Framework Architecture deployment process can be seen as a necessary starting point.

The following sections will present one methodology which could be applied to develop these Architectures. KAREN recommends that this process be based on its results, but the methodology is generic enough so that it can used by developers whether or not they choose to use the KAREN results.

The architecture development process summarised in Figure 3 in four steps is described with more details in Figure 4. The different steps are described in the following sections.

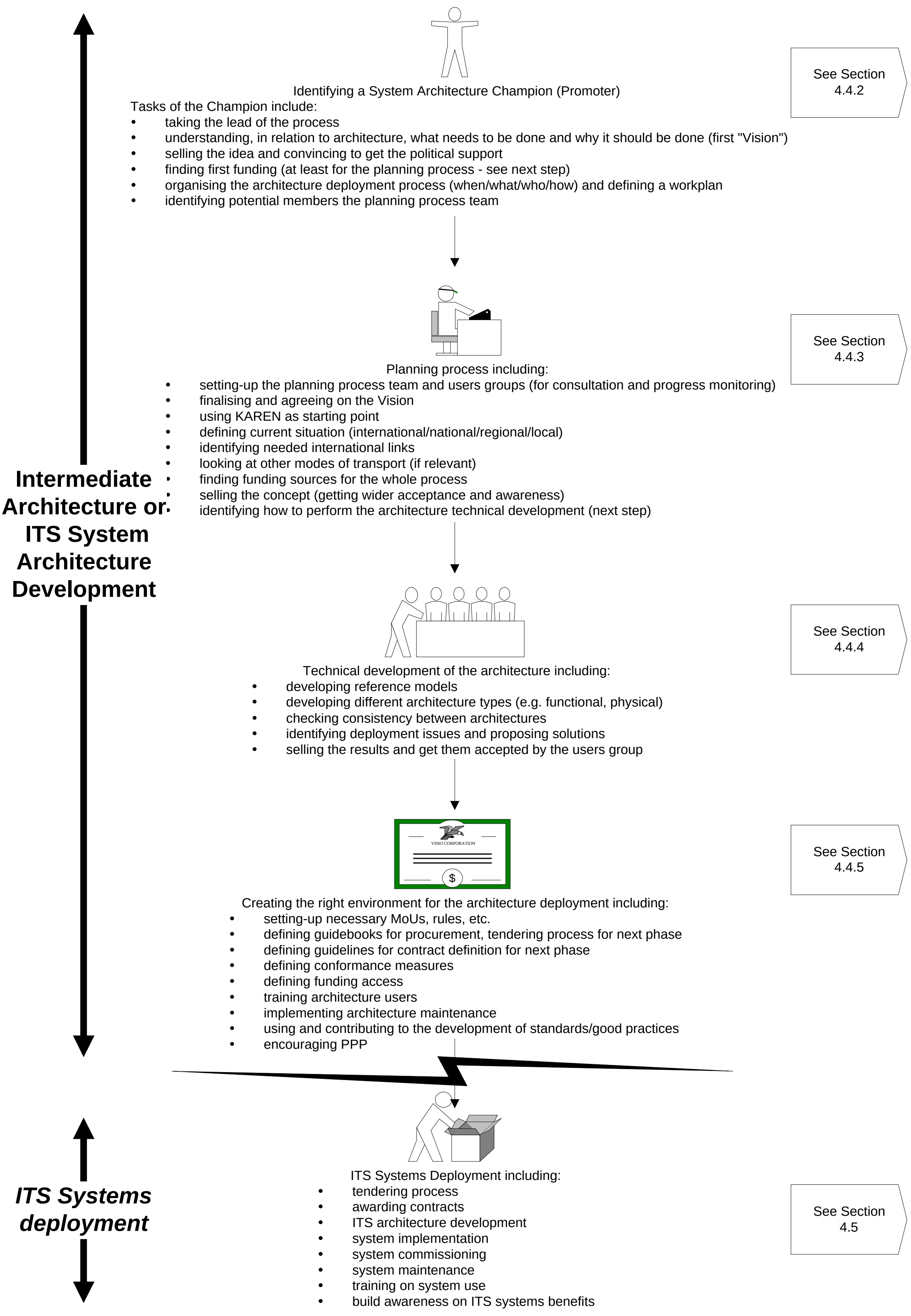

Figure 4: Intermediate and ITS System Architecture development process

4.4.2 Identifying a System Architecture Champion

To deploy the European ITS Framework Architecture for a specific country, region or city or for a specific service, a "problem owner" is needed. While it may be relatively easy for an authority or a company or consortium to design and build one ITS system, it is more difficult to implement and work from a (Framework) Architecture, not necessarily for primarily technical reasons, but for financial and organisational reasons. While a system may be owned and financed by a single party or consortium, architectures usually cover the combined interests of many parties. The question therefore arises as to who is going to take the initiative and who will pay for it.

As with ITS itself, the potential benefits of an ITS architecture are huge, amounting to tens of billions of euros a year in Europe for a single investment of the same magnitude. Although this appears to be a very profitable situation, the difficult part is that the potential benefits exist largely on a macro economic level, and they include investing in and sharing of infrastructure. The question therefore arises as to how business cases can be developed that create acceptable risks and an acceptable division of benefits between partners.

In many situations it will be national authorities, who are closest to macro-economic benefits and for that reason have a tradition of investing in and providing infrastructure. However if we look at regional or urban authorities, they often play a similar role within their own areas. Furthermore, multinational industries and service providers in some areas can be seen to act in a similar way (e.g. car industries, telecommunication providers, oil companies etc.).

For the deployment of the European Framework Architecture and the development of specific architectures in nations, regions, cities or for services and systems, a "Champion" will be needed. The role of this Champion is to initiate the process, to organise sufficient support and participation, to find finance and finally to obtain the commitment to carry it through to the architecture development stage and to use it for actual system designs and implementations.

The Champion may be one person, one organisation or both. The function of Champion has two major components: an intellectual one to convince, initiate and guide the process and an owner component, one which can provide or organise the substance, finance and commitment to carry it through.

For national architectures, national authorities seem best suited for the role of Champion, since they can best be identified with the ownership of the 'problem', can act as mediator between parties in their country, can be seen as being fairly impartial in maintenance of the architecture(s) and have the substance to implement it. They should not act on their own, but they are well suited to provide the Champion. Other possibilities however also exist. In a number of countries now ITS platforms or associations exist. They certainly could provide the Intellectual Champion. Depending on their financial situation and structure they may or may not be capable to play the ownership role too. They may have to team with, for instance, national authorities for that role.

For other architectures the regional, local authorities or service owners may play the role of Champion. Often, teaming with an ITS association can be an option here as well. National authorities can help stimulate, facilitate and possibly co-ordinate the work.

The roles of this (or these) Champion(s) include:

- Starting the whole process: understanding what needs to be done (by for instance organising early forums) and by whom, selling the idea, convincing, finding political support and initial funding (at least for the planning process), identifying the participants and organisations to be involved in the whole process both for the development and consultation process.

- Organising the architecture development process (when, what, who, how) and defining a workplan with a timescale.

- Identifying the participants in the detailed planning process.

4.4.3 Planning Process

4.4.3.1 Who should be involved in the architecture development process?

As the planning process requires co-ordination between different organisations, a key first task in this planning phase is to set up a team to carry out the architecture development. In order that a wide range of interests are represented, a consultation team should also be identified. These teams would be identified, for example, by the Architecture Champion and could include the following actors:

Public Authorities

Public authorities exist on six broad levels:

- city, borough or district councils;
- metropolitan area, county or departmental councils;
- regional councils;
- devolved/autonomous governments within nation states;
- national governments; and
- European institutions.

The bodies involved would of course depend on the area covered by the development activity. In the case of a single city, it is logical that the city council will take a leading role, but neighbouring authorities should also be involved if the proposed implementation affects them. For example, the introduction of road user charging or traffic management measures in a city will have an effect on travel patterns outside the city boundary in terms of trip timing, modal split, and origins/destinations, and therefore has the potential to either improve or worsen traffic, economic development, etc. in these neighbouring districts.

For a regional architecture, the process would include the regional authority or authorities, but should also include a selection of key authorities at a more local level. In countries without a regional structure, such as in the UK, transport measures are often implemented by a consortium of neighbouring authorities.

For a European architecture relating to a specific service, it could be the case that the lead will be taken by the European Commission, possibly with inputs from national governments. Examples of this include not only KAREN itself but also initiatives such as the DATEX Memorandum of Understanding for electronic traffic data exchange and the CARDME project, dealing with interoperable electronic fee collection.

Within each public authority, there are a number of departments, ministries, etc. that could conceivably be involved in architecture development. The most obvious is the department responsible for transport, but other relevant departments within an authority could include planning/land use, economic development, environmental protection, public relations/ information and finance. Where the deployment affects specific groups of people (children, the elderly, disabled, etc), local or national government departments responsible for areas such as health, social services and education may also become involved.

Operators

The generic term used here covers a potentially very wide range of actors. These can be:

- Infrastructure operators, which can be:
  - public authorities (e.g. national transport ministries, local highway authorities);
  - publicly owned agencies (national roads agencies, state-owned railway infrastructure, port or airport authorities, air traffic control, etc); or
  - private companies (private motorway, bridge or tunnel companies, port or airport authorities, railway infrastructure companies, privately run car parks, etc);
- Transport service operators, which may also be publicly, semi-publicly or privately owned and operated either as a social service, on a commercial basis, or a mixture (e.g. a commercial operation but with public subsidies to cover certain unprofitable but socially desirable services). These can be:
  - passenger rail operators;
  - local bus and urban transit operators;
  - coach operators;
  - taxi operators;
  - special passenger transport operators (school buses, hospital and social services transport, etc);
  - maritime and inland waterway passenger ferry, vehicle ferry and freight shipping operators;
  - airlines;
  - road freight operators (long distance, distribution, express deliveries and postal services);
  - rail freight operators (bulk loads, wagonload, containers, piggyback, etc).

The ITS industry

This category comprises the suppliers of ITS products and related IT equipment, and are important in terms of providing technical expertise for the planning process. It also includes software editors and system integrators.

Telecommunications companies

This includes suppliers of telecommunications equipment and services (including GSM, Internet service providers, etc).

Information Service Providers

This category includes different types of organisations able to provide specific ITS services either to the public as a whole or to members/subscribers. These organisations include radio broadcasters, television stations (including teletext operators), telecommunications companies, the print media, the electronic media and motoring organisations.

Their role is vital in any implementation involving traveller information provision and can include not only information reception from other organisations and dissemination to the public, but sometimes also an information flow in the reverse direction, e.g. through radio station listeners phoning in to report on traffic conditions, and through broadcasters collecting information by their own helicopter “eye in the sky” surveillance service.

Banks and financial institutions

In cases where payment systems are involved, such as road pricing, public transport ticketing or pay-for-use information services, it will often be the case that a bank or similar financial institution will become involved (e.g. with smart cards, clearing houses, management of individual accounts, etc), and there would thus be a need for the architecture to take account of issues relating to the financial sector (technology available, operational costs, organisational and legal constraints, etc).

In addition, banks or other investment organisations may require to be involved in the financing of the ITS deployment, although this would not directly concern the architecture development process.

Police/Emergency services

Developments such as traffic management would require the close co-operation of the police and consultation with other services such as fire and ambulance services. Emergency services should also be linked into any implementation covering traffic data exchange so that they are aware of any problems and can respond more quickly to incidents.

Research and development organisations and planning and engineering consultants

The core team would often comprise a consulting organisation with expertise in the appropriate field from either the private sector or from a university or institute.

End users

End users may be individuals, commercial users, or organisations representing these groups, such as motoring organisations, passenger transport user groups, special interest and pressure groups (environmental, safety, cycling and walking, etc), groups representing people with special needs (elderly, disabled, etc), associations representing a specific industry, chambers of commerce, trade unions and professional institutes.

Defining the role of end users is somewhat difficult. On the one hand, end users are major stakeholders in ITS systems, as such systems are implemented largely for their benefit, whilst on the other hand, direct consultation with individual users is not normally feasible as the concept of a system architecture is not widely understood. However, end users can be involved in the following ways:

- consultation with commercial users who are familiar with ITS and system architecture concepts regarding how an architecture can best be designed to fit their needs;
- consultation with organisations representing private and commercial users (motoring organisations, public transport user groups, logistics/ transport institutes, etc);
- user needs surveys or demonstrations of trial systems of using volunteers, which will increase knowledge of user needs and identify any technical, legal or organisational problems, thereby contributing to the development of a final architecture.

Standardisation groups

These could include national standards organisations (e.g. the British Standards Authority) and on a international level, the CEN and ISO. Such groups would normally be involved only in a consultative capacity. It could also include industrial consortia such as the WAP Forum.

The above actors can be ITS providers (e.g. the ITS industry), ITS users (e.g. individuals and commercial organisations), both (e.g. public authorities), or third parties who are neither direct providers nor users (e.g. standardisation groups). The roles to be played by these actors and whether they would be in the core planning team or play a consultative role depends on the applications to be covered by the architecture and on the level of the architecture involved.

The System Architecture Guidelines produced by the Converge project [CONVERGE 1998] distinguish between four levels of architecture for ITSs:

- Level 3: Multi-authority interoperability properties;
- Level 2: Single authority system properties;
- Level 1: Overall system structure;
- Level 0: System design.

The system architectures with which this report is concerned are essentially those at levels 2 and 3 although it also applies for level 1, and the planning process is thus likely to be led by a public authority, although this would depend on the architecture champion being a public body or an individual within one, or perhaps an external expert consultant acting on behalf of the authority. If the champion represented another organisation, such as a transport operator, ITS manufacturer or service provider, this organisation could lead the process provided that it was acceptable to all parties, which may not be the case in where there are competing operators, manufacturers, etc.

In a city architecture, the composition of the planning team is relatively simple as the number of possible actors is not too great. However, for, say, a national architecture, there is often a very large number of transport operators, telecom operators, ITS manufacturers, local authorities, etc, and care must be taken to include all relevant interests in the planning team without making it unwieldy.

To this end, efforts should be made by the architecture champion to develop a level of consensus across each industry, so that one or two operators or manufacturers can represent their industry as a whole. This can be difficult as players within each industry are often competitors and in some cases may be reluctant to co-operate. However, in many cases there are industry-wide associations which can fulfil this role.

Table 2 lists the potential actors and their possible roles/levels of involvement in the planning process.

Table 2: Actors in the Architecture Planning Process

Actor	Examples of application domains for which the actor should be involved in the planning process	Type of involvement
Operators (transport services and infrastructure), including public operators, e.g. national and local road authorities	Electronic road toll collection Electronic traffic data exchange Safety and security systems Pre- and on-trip driver and public transport information services Public transport ticketing/booking services Traffic monitoring and management Freight and fleet management	Key operators to play a major role in the core planning team. Other operators, e.g. those of modes not directly concerned with the application but which have an interface with them, to be involved in a consultative capacity.
Public authorities (local/ regional/national/European)	All	Would normally take a leading role in the core planning team. Also important for authorities to link ITS plans with other plans related to transport, environmental, social and economic objectives, so that they complement each other.
The ITS industry	All	Representatives in the core planning team, principally to provide technical expertise. This includes those working on open ITS-platforms.
Banks and financial institution	Electronic road toll collection Public transport ticketing/booking services Public transport fare collection	Would have a major involvement in the architecture of systems involving customer accounts and clearing house operations. Other applications, e.g. transport booking by credit card or the development of smart cards would require less involvement.

Actor	**Examples of application domains for which the actor should be involved in the planning process**	**Type of involvement**
Information service providers (e.g. the media)	Pre- and on-trip driver and public transport information services Freight and fleet management	Would normally be involved in a consultative capacity in order to ensure that the system provided a compatible interface with their service (e.g. in the case of simple traffic information broadcasts). However, in some cases, e.g. broadcasters of information by RDS-TMC, there may need for greater involvement in the planning process
Police/Emergency services	Electronic traffic data exchange Traffic management Safety and security systems	Would normally be involve in a consultative role in terms of their provision and use of data, their place in the architecture (i.e. links with other players and procedures to be followed in the event of an emergency) and the effect of traffic management measures upon them.
Standardisation groups	All	Would play a consultative role in advising on the conformity of the architecture to agreed norms.
End users	Pre- and on-trip driver and public transport information services Public transport ticketing/booking services Freight and fleet management	Would play a consultative role in terms of user groups (businesses and organisations representing individual users), user needs surveys (businesses and individuals) and pilot schemes (individual and corporate volunteers)

To summarise, all the potential actors described above should be considered in terms of their interest and relevance to the system being proposed, and the core planning team should be formulated accordingly, with an appropriate balance in skills and knowledge between the following areas:

- transport and strategic planning;
- traffic engineering and modelling;
- ITS service and implementation;
- information technology;
- communications; and
- economic and financial analysis.

4.4.3.2 Agreeing on a Vision

Before any detailed work can start, the players involved in the planning process need to agree on the overall goals and objectives of the architecture development process. This is done by creating a "Vision" that must be agreed by all participants.

Developing and implementing an architecture is a long term activity. A shared Vision allows the players to have a common target to achieve and a common set of steps to go through.

The Vision should contain, as a minimum, the following elements:

- overall goal;
- specific operational goals;
- expected end-results.

As information, the Vision agreed by the KAREN consortium was:

The Vision of what should be the KAREN end-result is **a minimum stable framework necessary for the deployment of working and workable ITS within the European Union until at least 2010;**

This framework will:

- define the necessary elements for an open market of ITS products throughout Europe, and the rest of the world, for European ITS industry;
- be the basis for building consensus on issues that still prevent wide-spread deployment of ITS in Europe, and hence permit all categories of user to purchase cost effective ITS products that will work in the same way throughout Europe;
- provide a bridge between the ITS community and those creating the current and future technologies that may be used by ITS;
- be a guide for public investments on basic infrastructure necessary for the deployment of the ITS services;
- support the identification of areas where new research and demonstrations are needed.

4.4.3.3 the European ITS Framework Architecture as starting point

The European ITS Framework Architecture proposed by KAREN, together with standards, will help national, regional and local authorities as well as service providers to plan and realise their goals with ITS in a way that is coherent, cost effective and extendible in area and over time. Moreover it will guarantee the coordination at the European level with other ITS initiatives. It also helps industry and service providers to produce and procure in a cost-effective way in markets of European scale. Those categories are the users of the European ITS Framework Architecture. Travellers and drivers will not directly use it, but may be involved in market research or hearings when parties define their specific ITS implementations and will experience the benefits of its results once implemented. For more information please refer to section 3.2.

4.4.3.4 Current situation

Another aspect of the planning process is the definition of current situation related to ITS. This should provide an overall picture of the current context, for example at the national/regional/local level and, where relevant, at an international level (for instance, it is important to know the current standards for data exchange and location referencing).

This activity is a review or fact-finding process rather than a decision making one. Items to be covered include:

- status of transport and communication networks;
- transport use;
- current transport policies and plans;
- other relevant objectives, policies, plans and current developments;
- identification of institutional issues and players in the field of transport (on local, regional, national and international levels, as appropriate) and their relationships with each other;
- the current ITS situation; and
- current constraints or problems linked to the use of ITS.

The review of the **status of the current transport and communication networks** is effectively an audit of the network, and in particular:

- the networks relevant to the proposed architecture (roads, bus routes, rail, etc);
- interfaces with other modes not directly concerned with the architecture;
- current and committed projects regarding the network and interfaces;
- positive and negative aspects of the network, e.g.:
  - bottlenecks and congestion points and times;
  - areas where spare capacity exists;
  - safety record/accident rates;

- environmental issues (visual intrusion, noise, pollution, severance, etc); and
- facility of access to the network (cost to use, information provision, physical access for people with a mobility impairment, etc);

The review of **transport use** should cover the use of the network by passengers and freight, including flows, trends in the use of the network, etc. This review should collect sufficient information to allow analysis of the effects of the various ITS deployments proposed (e.g. the effects on traffic on alternative routes or alternative modes were road tolls to be introduced). As with the network review, this should identify and analyse issues, possible solutions to problems, costs of these solutions and the costs of not pursuing these solutions (i.e. a do-nothing option).

The review of **current transport policies and plans** should define the objectives of the authority or authorities responsible, and in particular:

- identify needs;
- list current projects and plans in terms of their location, nature, costs, likely benefits, constraints, and stage of development;
- identify the extent to which ITS can complement current policies and plans;
- identify the extent to which ITS can provide an alternative solution to an existing plan (e.g. one which involves the implementation of physical measures to improve the network); and
- identify the extent to which current plans can be modified if necessary in order to incorporate ITS and conform to the relevant architecture;

Other objectives, policies, plans and current developments, where relevant to ITS architecture and deployment, would be reviewed in a similar way. This could include policies relating to development and land use, the environment, social issues, etc.

The **players in the field of transport** can be identified with reference to Section 4.4.3.1 (“Who should be involved in the architecture development process?”) Their roles, objectives, and relationships with each other should be identified, along with any current plans these organisations have which could affect ITS deployment. This includes **institutional issues** relating to the powers and responsibilities of the various players, the constraints with which they are faced.

An analysis of the **current ITS situation** and the **current constraints or problems linked to the use of ITS** is needed in order to:

- define what already exists;
- define its level of performance and identify reasons for and solutions to any weaknesses;
- identify the relationships between different ITS applications and the level of interoperability;
- determine to what extent existing systems follow a common architecture and whether that architecture is compatible with any national or European architecture standards; and

- to determine the extent to which existing systems can be integrated with new systems, or whether they need to be modified or even replaced, and if so, at what cost.

4.4.3.5 Need for international cooperation

It is recommended that any architecture initiative liaises with other European or non-European groups to learn from their experience. Those groups can provide input on best practice (e.g. methodology, results) in relation to the architecture development and deployment process. It is important for the planning process team to have a complete picture of ITS and to know what common solutions exist that need to be included in their development process.

Examples of groups to liaise with include standardisation bodies and national architecture development teams, such as in the US and Japan.

There are several interesting examples on how an international co-operation could be reached and supported not only by the developing team, but also by industry and national, regional or local authorities.

- The first organisations in the field of international co-operation which should be invited to share and to exchange experience are the Standardisation Organisations, ISO in the global and CEN in the European context. The field of system architecture, especially the one covering the Framework architecture has been stood aside in Europe, whereas the US Department of Transport had forced the development of the American National ITS Architecture to create a harmonised and homogenous architectural approach. Due to the fact that the political situation is very different in Europe it is absolutely clear that the US-approach is not feasible, but with a close co-operation to the standardisation organisations there is a possible chance to involve groups and initiatives interested in architectural issues.
- A lot of experience exists in the area of air-traffic. Due to the fact that international co-operation is an essential and survival issue a lot of effort has been made to harmonise the ATC's (Air Traffic Control) spread all over Europe and to create a centralised system called EUROCONTROL. It is imaginable that there is a lot of experience on strategies and methodologies which could be of interest for ITS.
- Another opportunity is the way applications like RDS-TMC or DATEX (in a special case in Austria, Germany and Switzerland) were developed. Especially RDS-TMC had a story very similar to the KAREN approach. Finally RDS-TMC led to a European standard in data collection, collation and broadcasting of traffic related data.
  - Firstly, thanks to EC-programs, there was a lot of work performed and the main concepts were defined.
  - Secondly, through an in-depth work, European aspects like the event list ALERT-C or DATEX-NET specifications were harmonised.
  - Thirdly, a Memorandum of Understanding was defined and agreed upon by a lot of partners.

- Fourthly, in a various number of EC-projects (e.g. Corvette, Viking, CENTRICO, SERTI) the RDS-TMC approach was used to implement new technologies and services in a harmonised way.

  This last example is interesting for KAREN due to the fact that national authorities have an important role in the exploitation and circulation of the results. It is also a good experience showing the time needed from development to implementation and acceptance and how this time can be reduced.

- Another example of common agreements is given from the field of telecommunication. The development of several standards in the field of data transmission technology was only able through a common understanding of postal departments all over Europe. The results were the standards for ATM (Asynchronous Transport Module), SDH (Synchronous Digital Hierarchy) and MAN (Metropolitan Area Network), which led into an IEEE-standard.
- On the level of governmental administration it is absolutely necessary to have a common understanding on the deployment and on the use of the Framework Architecture. Therefore they should take part to the international co-operation in a group such as the High Level Group in Europe.
- From the level of European R&D projects it is necessary to identify and to establish contacts to consortia, which are developing systems on a demonstrator basis based on KAREN outcome. It is a chance to establish a common understanding of the usefulness of the European ITS Framework Architecture.

4.4.3.6 Looking at all modes of transport

Modes of transport are strongly related, both for the transport of freight and people. The European ITS Framework Architecture proposed by KAREN has only addressed the road mode with description of some key interfaces to other modes of transport.

It is therefore important to know for actors involved in the road mode what is happening in other modes, to know who are the key actors and the important interfaces, both at the technical, organisational and legal levels. It is also important to identify key common areas of interest and to tackle them with representatives of other modes.

From a European point of view all modes of transport are key elements in the transport chain of goods or people. Therefore it is a necessity to identify interfaces between the different means of transport; it is also necessary to divide specific geographic areas due to the fact that some modes of transport (e.g. waterborne transport) are only of interest if an adequate landscape (e.g. rivers) is available.

Some issues related to this topic are described below.

- The transport of people by train faces the major problem, that it is more convenient to travel shorter distances by car than by train, because of the flexibility of the traveller. On the other hand the amount of time needed for long distance travels is several times higher when a traveller chooses the train and not aircraft transport. There are of course some exceptions (e.g. between the UK and Western Europe), but for the major part of Europe this is a valid statement.

For that reasons local regional and national rail transport providers are trying to make public transport more attractive. Especially in urban areas there are several successful stories of such initiatives. In most European countries the main train operators have still a monopolistic position and, due to this, a lack of flexibility can be identified.

Several projects funded by the EC are developing systems and demonstrators to increase attractivity for travellers and to convince them to use public transport instead of their own car. Door-to-door travel planers, based on Internet applications and using distributed databases in different European countries are the first step to make the use of public transport travellers more pleasant.

The condition of public transport in the urban area is another issue. The road traffic in most of the big European cities has reached a level which is so high (e.g. traffic jam, rush hour traffic, ...) that under the condition of a well improved public transport system, a major part of the population is changing their mobility behaviour and uses public transport. Definitions of human interfaces like information displays at bus and tram stops are developed to provide travellers with information about the status of their mean of transportation but this information must be continuous and reliable.

- The transport of goods is a very critical subject, because there is a strong demand for alternatives to road transport especially in all countries located in the middle of Europe, serving as transit routes for trucks (e.g. Germany, Austria). There are a lot of projects and initiatives to shift goods from road to rail, either as an full alternative or as a possibility to cover parts of the way with pick-up transport or with combined transport (e.g. containers). The success of these projects and especially the co-operation between the different transport modes is depending on the visibility of the benefit. The key question is always the same: Is a complete flow of data guaranteed, covering the whole route?

- Another challenge is to keep the goods moving by reducing delay when a transfer is made from one mode to another. If the movement of goods is stalled for any length of time during the transport, it is warehousing, not intermodality.

4.4.3.7 Funding the whole process

Funding is naturally a key issue in the deployment process and the successful deployment of the European ITS Framework Architecture is based on the assumption that funding is available for:

- turning the European ITS Framework Architecture into a specific architecture; and
- producing, implementing, operating and maintaining ITS systems.

However, it can be argued that costs for the second category will be shared with industry (if a reasonable return on investments can be expected) and with the final users (i.e. the general public) who will invest in equipment. It is therefore important to estimate what are the contributions of each category. Similarly, one could expect that the private sector could contribute to the first cost category. Indeed, public transport or motorway operators for instance could finance their participation in this exercise.

Financial resources can be found at different levels:

- On the top of this hierarchy are the European organisations, institutions and other groups, interested in funding European projects to improve and harmonise the development of ITS systems all over Europe. The main contact on the European level is the EC with the possibility to support projects working in the area of the Trans-European Networks. A possibility would be to make sure that an additional budget can be granted to a project if it follows the Framework guidelines.

  Another organisation of interest is the CEI (Central European Initiative) funding infrastructure projects in countries of the former East (Hungary, Poland, Czech Republic,..) together with to European Bank for Reconstruction and Development (EBRD). These organisations could be interesting partners, with the restriction, that projects will be funded only in a limited number of European countries.

- Between the European and national level relevant partners are the DoTs of Europe grouped either in the form of the High Level Group (they could propose funding guidelines) or in the form of Euro regional projects (e.g. CORVETTE), where several European countries are working together to develop specific systems. In these projects funding from DoTs operators (public transport, motorways, other operators involved etc.) is possible.

- On the national level the main actors are the DoTs. A key issue is to convince them about the necessity of an open, harmonised and compatible architecture. Due to the fact that road traffic is increasing and that classic solutions are failing in solving this additional burden, innovative and intelligent solutions have to be found. This is where the development of ITS systems and the deployment of the Framework Architecture should hook in. With specific budgets dedicated to research activities, funding could be made available. If there is additionally an expected return on investments, parts of the funding could be shared with partners from the industry.

- A lot of European countries are organised in regions, which means that these regions are partly or fully independent in making decisions concerning their structure in traffic organisation. These regions (e.g. Italy/Emilia-Romagna, Austria/Region of Upper Austria,...) are interested in minimising and accelerating the traffic crossing their territory to decrease the amount of pollution and stress for their population. Due to this fact they are interested in new technologies and systems, which they can fund. Other partners are regional public transport operators, limited to a certain area, but also interested in an efficient system which helps them to improve their performance (e.g. Verkehrsverbund Berlin, Wiener Linien, etc.).

- The lowest level where funding could be expected is the urban area and the responsible city authorities. Under the assumption that traffic management is a key issue of every major city it seems understandable that the production, implementation and operation of an ITS system with respect to the European ITS Framework Architecture has a good chance to be funded from the responsible authorities.

As a résumé it could be said, that the main sources for funding are public authorities, not mattering the level of competence they have in the shown hierarchy. It is also possible to involve other partners like motorway operators, public transport operators and industry, but the main point is to convince authorities of the usefulness of the European ITS Framework Architecture produced by KAREN to allocate funding.

4.4.3.8 Output of the planning process

The output of the planning process described in this section should consist of (non-exhaustive list):

- a vision;
- a management structure including the role and identity of each participant;
- a list of members for the consultation group;
- a funding plan;
- a description of the current situation relevant for the architecture development and deployment including an assessment of the KAREN results;
- the liaisons to be established with other bodies at the national and international levels including other modes of transport. The nature of the liaison must be specified;
- a detailed time plan for developing and deploying the architectures.

4.4.3.9 Selling the concept

Selling the concept of a common architecture to decision makers, planners, transport officials, politicians, operators, etc. is one of the most important starting up activities. This can be done at an early stage through the user groups (see section 4.4.3.1) but should also be extended to those organisations not involved in the consultation group which could have some relation at a certain time to the architecture.

The key topics of the selling exercise include:

- benefits of using ITS;
- benefits of using a common architecture to implement ITS;
- key issues to be solved;
- expected contributions from all actors.

4.4.4 Technical Development of Architectures

The development of specific architectures can be done according to the 9 steps described below. This methodology is a proposal which can be accommodated to take into account specific needs. Other methods can be looked at such as [IEEE P1471].

4.4.4.1 Definition of user needs

Defining user needs is a first step in the technical development of an architecture. Some 500 user needs have been defined in the KAREN User Needs deliverable [KAREN UN]. This describes user needs under the following ten groups:

1. General.
2. Management activities (e.g. transportation planning support and infrastructure maintenance management).
3. Policing/Enforcing (e.g. policing traffic regulations).
4. Financial transactions (e.g. electronic fee collection).
5. Emergency services (e.g. emergency notification and personal security, emergency vehicle management and hazardous materials & incident notification).
6. Travel information (e.g. pre-trip information, on-trip driver information, personal information services and route guidance and navigation).
7. Traffic management (e.g. traffic control, incident management, demand management, safety enhancements for vulnerable road users and intelligent junctions and links).
8. In-vehicle systems (e.g. vision enhancement, automated vehicle operation, longitudinal and lateral collision avoidance, safety readiness and pre-crash restraint deployment).
9. Freight and fleet operations (e.g. commercial vehicle pre-clearance, commercial vehicle administrative processes, automated road safety inspection, commercial vehicle on-board safety monitoring and commercial fleet management).
10. Public transport (e.g. public transport management, demand responsive public transport, shared transport management, on-trip public transport information and public travel security).

The KAREN list of user needs can be used by national architecture initiatives as the national reference list of user needs. However, some developers of architectures may wish to expand selected entries of the KAREN list in order to provide a more detailed inventory of user needs.

The planning team needs to prioritise user needs for the particular geographical area or ITS application concerned. It should be noted that some user needs can be catered for by more than one ITS function and, of course, a given ITS application normally addresses a number of user needs.

The relevant needs should be broken down into precise services to be supplied by analysing how the user wishes the need in question to be met (by what means public authorities wish to address the issue, in what way motorists wish to receive a service, etc). The next stage involves deciding how to supply the services, in terms of technological requirements (links between services, availability, reliability and cost of equipment, etc) and organisational issues (organisational links, barriers, who is responsible for what, etc).

4.4.4.2 Definition of reference models

Any high-level description that is able:

- to represent a certain system issue (e.g. what are the levels of system security?),
- to ease communication (e.g. global simple picture that helps people from different backgrounds to understand the same concept),
- to simplify the subject (e.g. simplification of the system communication procedure),
- to present relationships (e.g. who controls what in a given system?),
- to define certain constructs in the system (e.g. overall structure of a database),

can be called a conceptual model. Preferably, a conceptual model is easy to understand, unambiguous, uses a certain semantics (which must be explained somewhere) and is resistant to (future) changes in the system or its environment.

A conceptual model becomes a reference model if the model turns out to be a fundamental part of either the communication between the participants in the system realisation (either during the architecture or ITS systems deployment) or a basic construct during realisation of the system (again at the architecture or ITS systems deployment level).

Hence the main challenge for someone developing an architecture is to find such models and to see how they may help to define the architecture and the system. A reference model may even be promoted to the status of a de facto or official standard (e.g. OSI Reference Model) to be used in a much wider range of situations. This is based on a process of gradual perfection, increasing acceptance and formalisation.

Reference models are thus used to provide a high level of abstraction of a complex system or to communicate complex matters in a simple way. They can typically be used for:

- simplifying the representation of complex control procedures (as in traffic control) by providing a high-level of abstraction;
- simplifying the representation of complex functional descriptions by providing a high-level of abstraction;
- representing the role of different organisations (allocation of responsibilities) involved in a common process such as the management of a complex system;
- representing where various types of safety and security functions are allocated throughout the system.

Examples of Reference Models

- Three ITS reference models have been defined for use in Europe, one each for Urban and Inter-Urban Traffic Management and one for In-Vehicle systems [SATIN AC13-PT7].

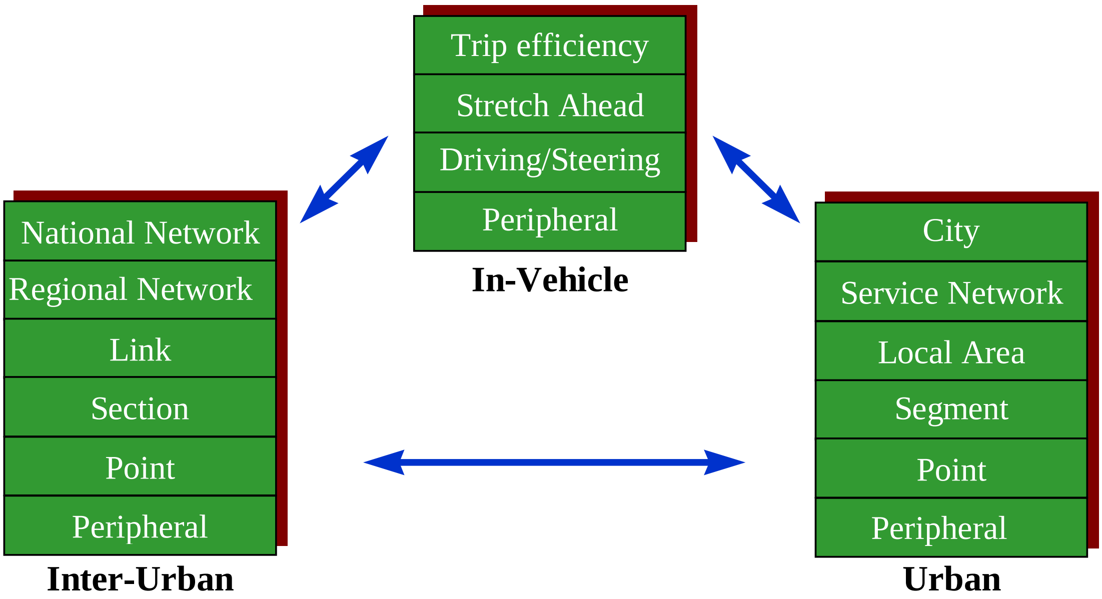

Figure 5: SATIN Reference Models.

- An Enterprise Model (sometimes also called Enterprise Architecture) represents the commercial and/or business relationships of the various enterprises or authorities within a system and the flow of resources between organisations, persons, services and/or functions. The responsibilities of each party are also defined. As such an Enterprise Model is a reference model.

4.4.4.3 Development of architectures

Once the players, the user requirements and the types of measures to be implemented have been defined, it is necessary to develop the appropriate architecture or architectures. These can include the following:

Functional Architecture - describes the structure and logical behaviour of the system, in terms of what functionality is needed in order to meet its requirements and the inter-relationships between the various functions. This architecture should be produced by disaggregating the system's functions to show the flow of data between functions sub-functions, and the required input data.

Control Architecture - describes the method of controlling the system. This is often incorporated in the functional architecture, although the creation of a separate Control Architecture can help to provide clarity, particularly where the control system is complex.

Information Architecture - this describes the data needed by the system by defining the structure of the data sets and showing the relationships between them. The Information Architecture is related to the functional architecture and, to some extent, the form of the one will depend on the form of the other. Some characteristics can also be influenced by the Physical and Communication architectures. The information architecture may be influenced by the requirements of the other architectures in terms of the availability of data, its accuracy, the way it is distributed around the system (i.e. ease of access), security of sensitive information and privacy of personal data.

Physical Architecture - this groups the functions into physical units (or “market packages”) and describes the communication lines between them. It may show the physical locations of the various elements of the system and associated links. It should normally be technology and/or manufacturer independent.

Communication Architecture - this architecture describes the characteristics of the various channels identified as being needed in the Physical Architecture, i.e. the way spatially separated subsystems communicate. This can include descriptions of the type of communication medium (wire, radio, infrared, visual, etc), the physical characteristics of data flow (regularity, volume, speed, encoding techniques, etc) and the logical characteristics of data flow (such as information composition).

Management Architecture - this covers the organisational structure of the system, in terms of who is responsible for what.

Safety Architecture – this describes the measures taken to ensure that the system or part of the system will never perform an action that will create a safety hazard. These measures are usually achieved directly by the addition of functional and integrity requirements that are translated in functions.

This is a non-exhaustive list of architectures commonly used. Other types of architecture include the information infrastructure architecture, the application architecture, the Information Communication Technology architecture, etc.

Remark:

[ISO 14813-5] proposes another terminology: the Functional, Control and Information Architectures are part of the Logical Architecture while the Physical and Communication Architectures are grouped together. This document is also recommended to the reader to complete his background.

Architecture development can follow two distinct processes: the Object Oriented approach and the Process Oriented approach.

The **Object Oriented approach** is based on objects, classes, abstraction, inheritance and encapsulation. It has emerged from the requirement by digital computers for discrete mathematics to model their workings, and this set theory leads naturally to the concept of objects. The ‘object’ is an instantiation of a class combining the data and behavioural properties of all the objects that might be in that class. By means of this encapsulation the detailed operations can be hidden, thus permitting the system designer to work at higher levels of abstraction, and closer to the application. This approach also offers other facilities such as polymorphism and inheritance, which lead to a greater possibility of re-use.

Object Oriented methodologies were originally targeted at information systems that depend only on the processing of data, and are thus intangible. They are particularly good at handling situations where similar processes needs to be performed on different types of data. The first use of an object oriented approach was in the late 1960s to simulate the behaviour of real world objects, e.g. cars and traffic lights in a road-system simulation. Since then its use has spread, in particular to applications that are centred around the use of (distributed) databases, graphics and user interfaces.

The **Process** (or Function) **Oriented approach** - is based on concepts such as data flow and functional decomposition. It was initially used by software engineers because it was already in use in all other fields of engineering. As this approach is more obvious and easier to understand, it is more commonly understood by engineers from a variety of disciplines, which is important when, as is generally the case for ITS, engineers with diverse backgrounds need to work together on a system.

Process based methodologies have been used for all types of system and in all stages of the life-cycle for many decades. They are well understood though they cannot guarantee the production of a working and workable system. In addition, all current safety standards, guidelines and techniques assume, or are based on, the use of a Process Oriented approach.

In summary, the key points regarding these two approaches are:

- an Object Oriented approach is more suited to those with an education in discrete mathematics, whereas a Process Oriented one is more natural for an engineer with a function analysis and calculus based background;

- most architecture users will only understand the Process Oriented approach, and are likely to be more interested in the processes than the data;

- the Object Oriented approach was originally targeted at information, or software only, systems (and is therefore often a more natural approach for some informatics applications), whereas ITSs also include direct and indirect safety-related control systems, for which the applicability of an Object Oriented approach is still being debated (safety-related systems normally need a Process Oriented approach to satisfy current standards and guidelines);

- it is not necessary to use the same methodology throughout the life-cycle;

- the lack of real rigour of the Object Oriented approach can make it difficult to understand fully;
- the hidden complexity of the Object Oriented approach can make it difficult to get systems working correctly;
- both approaches need care to be taken to ensure consistency during their structured decomposition; and

As a result of the above, the KAREN Functional Architecture deliverable [KAREN FA] recommended that the Process Oriented approach be used for the European ITS Framework Architecture proposed by KAREN. It also recommended that at some level in the decomposition, the Unified Modelling Language (UML) top-level Use Case diagram for each function should be drawn for those who wish to proceed later using an Object Oriented approach.

Many of the object-oriented methodologies are supported by CASE (Computer Aided Software/Systems Engineering) tools. The use of a CASE tool is recommended in the development of a Functional Architecture and to animate the Control Architecture to ensure completeness of this architecture, and consistency with the Functional Architecture. These tools can also ensure completeness of the Information Architecture, by helping to achieve consistency with the Functional Architecture.

Object Oriented methods have been used for instance to develop the architectures for Chicago, Los Angeles and the national architectures for Australia and Japan (see also ITS America Architecture URL http://www.itsa.org or http://www.vertis.org.jp).

4.4.4.4 Description of technology/design options

Once the architecture has been developed at an abstract level, the next step is to choose the specific design of the system(s) and the technology to be used. The adoption of a common architecture for ITS products will simplify this process as increased compatibility and interoperability will enable components from different manufacturers to be used in the same system.

The key factors to consider in the choice of the technology to be used are:

- functionality;
- level of performance;
- reliability;
- security and ease of use;
- ability to manage changes;
- development and installation costs;
- operating and maintenance costs;

- interoperability with any existing systems, including:
  - legacy systems;
  - systems operating in another application domain, but which will need to interact with the system to be deployed; and
  - systems operating in the same application domain but in a neighbouring area;
- interoperability with any other planned system.

Where there is a potential problem with lack of interoperability, a further consideration is the development of an appropriate interface between the two systems involved.

A key consideration in terms of interoperability is the case of planning a specific system is its relationship with systems in neighbouring areas. This is pertinent not only to services across national or regional borders, but also to the interrelationship between urban and interurban systems. The co-ordination of such systems is essential not only to allow the efficient deployment of infrastructure but also to enable the application of policies on a consistent basis. The same is true for applications covering different modes: the aim should be to maximise integration and coherency, thus facilitating greater intermodality.

Compatibility applies not only to the technical characteristics of systems, but also to organisational issues, whereby different public authorities and private operators may have different policies and priorities (see also section 4.4.5).

Examples of interoperability requirements between different systems are the links between a traffic control and a traffic information system, and between both of these applications and toll payment systems. For public transport, interfaces between urban local transport and inter-urban services are areas where there is frequently a lack of co-ordination at a physical, organisational and operation level. Technology covering pre-trip information and integrated payment systems is increasingly multimodal. To ensure that this becomes the norm rather than the exception, compatibility issues between systems such as electronic road pricing, car parking and public transport ticketing (e.g. by means of smart cards) is required, and should be considered in the architecture planning of individual systems. Interfaces between safety and data exchange systems and most other systems are particularly important as these applications are horizontal in nature.

4.4.4.5 Implementation strategies

Following the technical development of an architecture, the next question concerns how to implement it. Experience in this area can be drawn from the implementation of the National ITS Architecture in the United States. This architecture was developed by a consortium of US government and industry experts to provide a common structure for ITS design. The TEA 21 act (Transportation Equity Act for the 21st Century) was implemented following a study of the use of the US National ITS Architecture, and states that authorities may develop their own local architectures but that these must use standards based on the National Architecture in order to secure Federal funding.

In the operation of any system, common practices (or at least, practices which are compatible and have appropriate interfaces) are essential, otherwise the effort that has been invested in ensuring technical and organisational interoperability (as discussed in Section 4.4.4.4) will not produce results. Operational aspects to consider include:

- prioritisation of tasks, relative importance of events and actions;
- types of actions to be taken in response to specific conditions (e.g. traffic re-routeing);
- ways in which information is transmitted; and
- elimination of duplicated effort between different parties.

Areas in which different practices often exist, and in which special attention must therefore be focused, are interfaces between urban and interurban transport, e.g. local and inter-city public transport, urban and interurban traffic control and the interface between air traffic and other modes at airports. Those practices must be reconciled when implementation is taking place.

4.4.4.6 Cost/benefits assessment

In order to ensure public funds are wisely spent (both for private products and public infrastructure) it is essential to have a clear understanding of the benefits and costs involved. These issues are more fully discussed in the KAREN Cost-Benefit report [KAREN CBA] in relation to the European Framework Architecture, but a summary of the main cost and benefit issues is presented here as they are very similar to other types of architecture.

The costs of developing an architecture (whether national, local, system, domain-specific, etc) can be classified in terms of the type of cost and by whom the cost is incurred. The types of cost can be classified in terms of three broad groups and a number of sub-categories, as follows:

- **Architecture development**, e.g.:
  - identification of system architecture promoters;
  - undertaking the planning phase;
  - 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); and
  - results review (review by consensus groups and final acceptance).
- **Exploiting the "paper" results**, e.g.:
  - 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).

- **Implementation**, e.g.:
  - finding funding resources;
  - migration 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.

Benefits can be technical, social, legal/institutional or financial. Again, they can be benefits which are directly felt be the end user (e.g. cross-border continuity of service), or which are benefits to intermediate users (transport operators, public authorities, ITS service providers, etc), which may enable them to increase efficiency, reduce costs and/or improve their services to the end user.

The costs of architecture and system development can usually be quantified in financial terms (costs of research, equipment, training, depreciation, etc), however problems can persist in areas such as:

- the deployment of multiple ITS improvements which provide opportunities for equipment and cost sharing;
- it can be difficult to anticipate the life of new ITS equipment, both in terms of physical durability and technical obsolescence;
- funding sources, whereby investment from sources other than the promoting authority (e.g. the private sector, or funding from other public authorities) can increase the viability of a given deployment.

The benefits, however, can often be very difficult to quantify because:

- the effects of a particular system deployment on traffic levels, network efficiency, modal split, safety, pollution, congestion, operating costs and utility to the end user can only be estimated, as all of these variables are also affected by other factors and because there is rarely an equivalent “control” variable to measure what would have happened without the deployment or by using a different strategy;
- even if the benefits can be forecast with a reasonable degree of confidence, many of them cannot easily be quantified in financial terms;

- the extent to which a certain architecture can improve the performance of a certain application is not always evident; and
- benefits are spread across a very large number of beneficiaries, and while some of them will welcome the benefits, others will notice little difference (e.g. in the case of small time savings or reduced accident rates), will not take advantage of the benefits (e.g. in the case of improved pre-trip information), or will not consider the benefits to be worthwhile.

Deployment benefits therefore require to be modelled using a wide range of forecast data sources and the use of a variety of scenarios. These should include a “do nothing” and “do minimum” options, together with a selection of alternative solutions. In some cases, national guidelines exist for certain categories of costs and benefits.

4.4.4.7 Funding system operation and maintenance.

Maintenance and other questions regarding operations should be tackled early in the planning process **before** starting the deployment of ITS. These questions may not only lead to unplanned costs but may also affect the choice of system design and scale of implementation. Sufficient resources for ongoing maintenance as well as to ensure the availability of expert operational staff should be provided. Costs for items such as equipment depreciation and continued training of staff should also not be overlooked.

One consideration could be to tie maintenance in with system procurement by making the system suppliers responsible for the successful operation of the system over a period of time, thus reducing the risk to the deployment authority of high costs due to start-up problems or unreliable technology.

In some cases, ITS operation can be partially or wholly self-funding, by means of user charging. An obvious example of this is electronic road pricing, but others can include pay-for-use traffic and travel information, including route and itinerary planning. Other sources of funding include the selling of various non-sensitive data collected by ITS means, such as traffic flows or use of a public transport terminal, or the carrying of advertising on certain ITS media (e.g. travel information).

4.4.4.8 Timescale for system implementation

A timescale for system implementation should take into account all the steps outlined in this chapter, from the identification of an architecture “champion” to the actual implementation and testing of the systems themselves. This should be planned on a critical path basis, by identifying what activities need to be completed before others can start (e.g. political approval and funding needs to be decided before deployment can proceed) and which activities can run concurrently.

The planning should provide for adequate time for negotiations, agreements, MoUs, etc on a multilateral level (e.g. with politicians, providers, end user groups) as well as for the tendering/procurement process, the development and installation of the equipment, training and testing.

4.4.4.9 Training plan

Training requirements can differ according to the target groups, which can be defined based on the different architectures and systems described. These target groups can be categorised in four ways, as follows:

- Scope of the architecture (European, national and local): for training purposes, the European and national levels are most relevant.
- Type of architecture (framework architecture, system architecture and system design).
- Type of involvement (planning, development, deployment and user).
- Type of stakeholder (public authority, ITS platform, private company, end users, etc).

Using these categories, target groups can be defined, e.g:

- stakeholders who are users of architectures at a European level;
- an ITS forum at a national level dealing with the deployment of national architecture; or
- an education/awareness campaign for end-users of a specific deployment on a local level.

By defining groups in this way, they can be targeted with appropriate training guidelines and materials.

For all groups, both training and the involvement of staff in the design process of architectures or systems is very important in the process of ‘buying-in’ staff, i.e. in fostering positive acceptance of the new systems and allaying any fears or perceived threats. Training should also take into account existing management practices to ensure that conflicts do not exist.

Once the training target groups have been identified, the training needs of each group need to be defined, along with the training methodology (external courses, internal seminars, simulation, hands-on experience, production of guidebooks/instructions, etc) best suited to meeting these needs.

In addition to training architecture developers, user, etc at the outset, a rolling training and information programme should be implemented in order that stakeholders are kept up to date with developments and that new actors in the field rapidly develop the necessary knowledge and skills.

4.4.4.10 Expected output of the technical development of Architectures

At the end of this third step, the outputs to be made available should include the following (non-exhaustive list):

- a list of user needs including specific system and design requirements;
- a set of agreed reference models;

- a set of architectures including functional, information, physical and communication architectures. Others could be provided such as a safety or management architecture;
- a list of design options including the selection of appropriate standards to ensure the provision of compatible and interoperable systems and services;
- a description of how the systems work and interact with each other to provide services;
- an argumentation presenting the benefits provided by the services and an estimation of costs of the implementation. This should include both tangible and intangible costs as well as recurrent and non-recurrent costs;
- a description of the funding sources to implement and operate the systems describing what are the shares of the public and private sectors;
- a timescale for the implementation of the systems including the different phases of the implementation (infrastructure, services, staff, etc.);
- a training plan for the staff in charge of using the architecture. This should also describe the different staff categories that should be involved.

Remark:

- This list could be used as a checklist in a tender as list of output to be provided by the tendering parties.
- All output should be peer reviewed and approved by the consultation groups (see also section 4.4.3.1)

4.4.5 Creating the right environment for Architecture deployment

4.4.5.1 Introduction

Experience has shown that in order to deploy successfully an architecture, the technical references (e.g. functional, communications, physical architectures) have to accompanied by the necessary set of rules that creates an enabling environment. In other words, it is of fundamental importance to complete the architecture with suitable organisational architectures covering the organisational and the legal issues that defines the playground for the deployment.

This fact emerged in implementation experiences throughout Europe where large integrated systems with interoperability features were in some cases failing and in other cases succeeding (e.g. RDS-TMC) because of the approach used to create the operating environment. An example of a project that failed is the Crusader project in the city of Gothenburg in 1997. The reasons for this failure were investigated and it was found that they lay principally in a lack of attention to organisational issues, rather than in any shortcomings of technology [QUARTET 1].

Successful exploitation of the market for Telematics Applications requires the active participation of forces involved in the “market pull” and “market push” dynamics. In the case of transport, however, the “pull” and “push” forces which are normally found in the open market cannot be isolated; instead a closed loop exists linking industries, public authorities, service providers and the end users. The strength of the links needs to be based on clearly identifiable benefits to each user. Moreover, the Crusader project demonstrated that technology alone cannot provide cost-effective solutions, but that really meaningful achievements in the area of transport telematics can only be obtained when decision-makers and developers base their system on the right framework and adopt the right approach to integration.

In the medium term, the demand for ITS is satisfied only if a European market for interoperable systems and components is created. A structured approach based on ITS architecture plays a key role while, besides, a process is required in which all innovative components of pilot schemes are inventoried and implemented as local prototypes, *to give way to* the open market in which the authorities (and the end users) can decide on the best choice for their requirements by comparing different options on the basis of sound, agreed evaluations.

In addition to the results produced by the latest European research programmes, important indications and suggestions for ITS deployment were identified by the RAID project [RAID] (a project performed by the KAREN consortium that analysed the risks that might hinder the ITS deployment and proposed correspondent mitigation strategies) and by the work performed in KAREN for the physical and communication architecture. The content of this section reflects these findings and aims at providing a practical reference for those who have the task of defining and launching an architecture.

There is no specific set of documents to be produced or action to perform in order to guarantee an efficiently ruled environment for the architecture deployment, but there are a number of issues to be taken into account and to be solved according to the type of architecture, its mission, the existing infrastructure, the legal/political scenario, etc. The following text considers the most common issues, although on a case-by-case basis their relevance has to be considered as well as the need to deal with additional specific issues.

In the sake of clarity, the following pages have been organised in subsections related to different topics in the attempt to focus the attention of the readers on one limited scope at a time. In reality the issues there analysed overlap considerably and are sometime strongly dependent on each other, thus their actual separation has to be considered on a case by case basis.

4.4.5.2 Establishing the link with the European ITS Framework Architecture

It is very important that from the very beginning the organisation in charge of defining the architecture formally establishes a liaison structure to guarantee continuous contact with the European Framework Architecture. Ideally, the architecture has to be defined and maintained to work as a “translation” of the European ITS Framework Architecture into the terms and the constraints of the specific domain targeted by the architecture (see section 4.2). Depending on the evolution of KAREN, it is possible that in the future a formal means for adhering to the European ITS Framework Architecture liaison structure will be provided through specific forums, committees, etc.

The continuous liaison with the European ITS Framework Architecture is needed:

(i) to provide a reliable channel through which the European Framework Architecture receives the feedback generated by one of its specific practical use;

(ii) to ensure that the architecture is constantly updated and/or extended accordingly to the evolution of the European ITS Framework Architecture that will work as the reference point for the use of emerging technologies, R&D results, standards and harmonised solutions;

(iii) to assure the establishment of a focal point for the exchange of information and experiences with other architectures having similar characteristics or showing commonalities;

(iv) to favour the discussions and exchange of experience between actors having common interests although on different fields of ITS.

For some architectures, the liaison with the European ITS Framework Architecture may be established indirectly through a hierarchical structure of architectures (e.g. through the regional and national architectures), the relevance of the benefits will not depend on this providing all the elements of the structure are reliable and efficient.

4.4.5.3 Contractual framework for data exchange and data sharing

Data exchange between systems and organisations is an item that has been demonstrated to be very sensitive to the organisational solution. The efficient and extended exchange of data is normally the key factor for the success of integrated systems and for actually creating an open environment of expandable systems. One of the benefits of the integrated environments lies in the possibility of using the data collected by other systems to gain as wide and complete as possible a picture of the conditions on the transport network. On the other hand the involvement of different organisations and responsibilities create the problems of privacy, ownership, reliability etc. of the data exchanged and used.

Contractual frameworks should be established and used to manage the data exchange between different organisations operating on domains that either coincide, overlap or are reciprocally influenced. Due to the general definition of architecture a wide range of different scenarios may be affected by this issue although with different levels of complexity and criticality: systems and organisations exchanging cross-border traffic data, road operators responsible for sub-networks of the same transport network, systems and organisation operating in the same geographical domain but on different modes of transport, etc. In all cases the data exchanged must be of high quality and able to provide continuity of ITS services across different domains (e.g. regions or countries) for travellers using all modes of transport.

The architecture will have to provide a suitable environment (e.g. a “model for contract” or a “memorandum of understanding”) that provides the basic rules to which the members of the data exchange network need to agree. In order to be effective and to give confidence and trust to the members these tools have to be developed at the domain level, according to the characteristics of the service, and adapted to both the scenario in which it will operate and to the members that will adhere to it (e.g. a model contract needs to be compliant with local law, it should not present language barriers, etc.). At the same time care has to be taken to develop the contractual framework, consistent and compliant with upper level frameworks, that guarantees the compatibility of the solution with larger domains (e.g. if the objective is to provide rules for data exchange between TICs and TCCs at a regional level, compliance with the DATEX memorandum of understanding is an important requirement so that extension and interoperability at national and international level is also ensured). The KAREN Framework Architecture provides the necessary references and the liaison with the European Framework Architecture (see above) guarantees the access to current developments.

The contractual framework developed in an architecture has to define at least:

- a set of rules for the format of data;
- the quality criteria for the data exchanged and offered;
- the reference standards;
- the “data administrator” in charge of maintaining the description of the data formats;
- the responsibilities of actors;
- the roaming rules.

The “data administrator” covers an important role which has to be defined at all levels, with the tasks of:

(i) maintaining the basic data necessary for the data exchange (e.g. location coding database);

(ii) updating and upgrading the databases and specifications; and

(iii) providing support to new members; performing compliance check.

The same issues and solutions should also be considered with reference to vehicle communications.

4.4.5.4 Training and education programmes

The successful deployment of architectures is related to the associated training and education programme (see also section 4.4.4.9). These have to be organised in order to ensure that the organisations required to adhere to the architecture are aware of the details and of the benefits of using it.

A proper structure should be set up to organise regular open workshops and to issue updated documentation. The programmes should aim to achieve:

– awareness, among the potential actors, of benefits in using the architecture in terms of safety, efficiency, European dimension, etc.;

– creation of a reference point where technical questions on the practical use of the architecture can find expert answers;

– provision of information, training and support service adapted to needs and characteristics of the users of the service (language, use of terms, etc.);

– provision of the rules and details, possibly agreed and in use at a higher architecture level (e.g. at European framework architecture level, national architecture, etc.) adapted to needs and regulations applicable and in use in the considered domain;

– stimulate the demand for ITS systems and services compliant with the architecture.

In the domain addressed by the architecture the target of the education and training programme has to be twofold: on the one hand the professionals involved must be trained, informed and supported to make them able to work easily in their field after the introduction of the architecture; on the other hand the final users have to be informed and convinced of the existence, the meaning and the benefits of the architecture so that they will desire compliant systems and services, thus contributing in creating the environment for its deployment.

Potential communication channels to be used for dissemination are various, ranging from dedicated workshops and conferences to specific university courses.

In general it is important that a proper budget is put aside for these activities from the very early stages of the development of the architecture.

4.4.5.5 Public Private Partnership

One of the main objectives of an architecture is always to integrate different systems and actors to create a co-operative environment aimed at performing a set of ITS services. In general the actors involved include both public authorities and private companies.

Although it is expected that at the European level a code of practise for ITS services on traffic management and control issues will be drawn up including model agreements with service providers, a local (i.e. national, city or service) architecture has to provide the necessary models taking into account that in each European country, the role of public authorities and the private sector vary enormously.

The subject has to be dealt with as an important issue in the education and training programme (see above) in order to convince the actors involved of the mutual benefits. Solutions to obstacles, such us the change to consolidated operating procedures required, need to be discussed in concertation and agreed.

Models of contract clauses have to be decided and possibly included in formal documents to provide rule covering:

- independence of actors involved (i.e. all actors co-operate and share data, infrastructure, resources, etc. for mutual benefit);
- modularity of the solutions (i.e. the performance of systems benefits from integration but does not diminish normal performance if other systems are not present);
- quality criteria for actors, including data content and accuracy for the data exchanged;
- combined services and payments.

Lessons learnt in different implementations in Europe showed the importance of separating traffic management and control services, usually under the responsibility of the public sectors, and value added services (e.g. individual route guidance, personal information) which are the typical domain of the private sector.

4.4.5.6 Traveller privacy and data protection

Suitable legal protection for travellers with respect to their privacy and treatment of data need to be provided by referring to existing legislation and complementing it, if necessary, with additional measures aimed at protecting the traveller from cases of data misuse. As the user of the ITS systems and services, the traveller generates the demand for the ITS systems or services and his/her confidence in using them actually determines the success or the failure of the deployment.

First of all the idea that safeguarding the personal privacy of travellers using ITS is essential must be actively promoted amongst the involved actors. The measures that have to be made to ensure a maximum level of privacy for travellers must be clarified. In parallel with these activities, the social awareness and acceptance of the need to identify movements must be actively promoted amongst travellers.

The current European scenario has the potential to ease the handling of this issue. In fact, there is a EU directive in force since October 1998 concerning protection of private data. National legislation, where not already adapted, are likely to be so in the near future. Consequently, from the legal point of view, conditions exist (or will shortly exist) to allow the level of protection of privacy to be the same throughout the European Union.

4.4.5.7 Sharing ITS infrastructures

Models for contract, agreements, education programmes and all other mechanisms considered so far should, where applicable, also be aimed at favouring the sharing of ITS infrastructure between actors and systems.

Sharing infrastructure and particularly the communication channels allows sensible reductions of operating costs, reduction of the risk of investments, easier achievement of the critical mass necessary to justify the ITS services on technology mainly used for other purposes, etc.

Where possible the sharing of infrastructure should also consider services outside ITS, such as entertainment and general data communications.

The architecture should favour the access of ITS systems and services to incentivise and influence policy strategies supporting the approach.

4.4.5.8 Migration of systems

The role of the architecture should also force the adoption of solutions that are, as far as possible, technology independent and therefore able to be adapted or transferred to new technologies. This is indispensable to keep the ITS services constantly in line with rapidly evolving technologies and thus competitive and attractive in the market.

4.4.5.9 Architecture maintenance and conformance checking

So far the discussion has covered the creation of the right environment by means of the establishment of a series of suitable mechanisms aimed at providing rules for the:

- relations between actors;
- interface of the systems and services with environment in which they operate;
- liaison with upper level framework and schemes;
- correct interaction with travellers; and

– basic choice of the technical architecture solution.

In order for the architecture to be effectively and successfully used, activities have to be planned to make sure that on the one hand systems and services comply with it, and on the other hand that the architecture evolves rapidly enough to be able to keep showing the benefits of its use. In other words the adherence to a given architecture has to be seen by the actors involved as a reference point providing the facility to speed up implementations, reduce costs, improve performance, etc.; while it should never be felt as an imposed constraint actually limiting the development possibilities.

To make the compliance to an architecture compulsory is neither desired nor, usually, beneficial. Experience in all fields of IT is showing that “universal” adherence to architectural solutions (e.g. “de facto” standards such as TCP/IP) is sometimes spontaneous just because all actors realise that benefits are evident and time/costs can be saved.

A correct and focused approach can anticipate and influence the process for benefit on a larger scale than that imagined by the actors for single application, thus maximising the benefits for the final users and saving the interests of the single actors.

A solid organisation has to be set up to keep the architecture operational and maintain it in a similar way as the Framework Architecture is maintained at the European level. Key public and private actors, operating in the architecture domain, should be represented as well as the users of the ITS services which the architecture supports. The same key actors should also be the sponsors of such an organisation, this approach will reflect the actual commitment of the actors and will confirm their confidence in the initiative; if the actors are not willing to sponsor the architecture initiative in most cases there will be little chance of success.

The following basic tasks need to be undertaken during the whole lifetime of the architecture:

– Technical committee, providing the reference point for any technical issues and co-ordinating the evolution of the architecture.

– Technical support, providing the answer to implementation problems and adaptations and keeping the technical documentation upgraded and updated, issuing the reference software, etc.

– Discussion forum, providing a periodic exchange of experiences, ideas and new requirements among the actors operating the domain.

– Close monitoring, providing the careful observation point toward the external world and able to promptly seize the opportunities offered by new technologies and research results.

– Liaisons, establishing active links with the European Framework Architecture or upper level architecture as appropriate, with relevant ITS application committees, with user associations, etc.

– Inspection and checking, providing the approval of the adherence of applications to the architecture.

– Promotion, performing activities aimed at disseminating the results and benefits achieved as a result of compliance with the architecture.

– Training, providing the necessary training at all levels to ensure the correct preparation of the people involved in the domain.

4.4.5.10 Use of standards and procurement process

Authorities need to develop easily understood procedures for the procurement of ITS products and services. It may be the case that the current procurement process is more adapted to civil engineering aspects (e.g. concrete, asphalt, etc.) and not suitable for complex ITS systems using complex hardware, software and communications technologies.

The European Council of Ministers' decision 87/95/EEC refers to the use of standards. It makes it mandatory for public purchasers in Europe to refer to appropriate standards in their tendering process, to base procurement on European standards and in cases where suitable standards are not available, international standards should be referenced. See also section 4.5.2.2.

4.4.5.11 An example of successfully deployed architecture

The same problems and characteristics related to the deployment of the European ITS Framework Architecture are also applicable, in a smaller scale, to specific architecture (e.g. the national architecture initiatives or even to the architecture set up for specific services) which in the end might also be incorporated into the European Framework Architecture.

Examples and lessons can be taken from the European experiences in the field of real-time information services.

The approach adopted for the RDS-TMC service can be taken as an example. In this case the benefits and the importance of using a Framework for data exchange were experienced and the lessons learnt, although with the necessary adaptations, the framework architecture as a whole should also be considered and consequently also for national architectures or other service-specific architectures.

In the case of the RDS-TMC there were very specific needs: the objective was to be able to provide real-time and seamless traffic information to travellers while in vehicles. In other words travellers should be able to receive constant updates of traffic conditions relevant to their route, in their own language, regardless the country and the region in which they are travelling.

This objectives were defined based on two assumptions: (i) dynamic and reliable traffic information was available through proper traffic control and information centres for the major roads in the interested countries; (ii) a specific data transmission technology (i.e. the FM/RDS) was selected to be used to deliver the information on board vehicles.

Given the objectives, the data availability and the selected transmission technology the solution to the two classes of problems had to be agreed between the interested parties. From a technical point of view there was clearly the need to define the communication protocols to be used for both exchanging information between centres and for transmitting the service to vehicles, to define the suitable format and structure for messages, etc. The technical solutions at the level of system design were not sufficient to make the service actually operational and here the architectural issues became important. Besides the technical solutions there was the need to clearly define to the actors the separation of responsibilities, the rules for data exchange and to agree on the separation of functions, on the location reference to use, the coding for the events, etc.

The issues mentioned above are particularly evident if we consider the requirement to have a "seamless" service. Indeed this means that the information to drivers has to be:

- relevant at least to the entire TERN (Trans-European Road Network) so that European routes across different countries are covered;
- independent of location, meaning that neither the different road and location coding nor the languages used in different countries should affect the comprehensibility of the information presented to the driver on board;
- independent of the service providers, meaning that the same driver while crossing different areas or even countries keeps receiving the basic information service without interruption by "roaming" through transmission domains of different service providers.

The approach adopted in the implementation of the TMC service includes an open architecture for data exchange between European operators (both data and service providers). In this case the DATEX approach was used and complete specification of the solutions in terms of functional, information, communication, physical, organisational architectures etc. is provided. The important issue is that the chosen solution is as far as possible general purpose:

- the data exchange network is neither dependent on nor limited to the TMC service;
- the TMC service, although optimised for the RDS channel, can be almost directly transferred to other communication channels;
- the location referencing used is open to be extended to cover a larger road network and other modes of transport.

The most important lesson learnt from this example is that, starting from specific needs an "open" architecture approach has been chosen that may also facilitate the implementation of other services. All the rules (both technical and non technical) are explicit and documented so that any actor can join. Those organisations who wish to join the data exchange network are required to accept and sign a Memorandum of Understanding (MoU). The MoU defines a set of rules for the format of data and the quality criteria for the data exchanged and offered.

4.5 ITS systems deployment process

4.5.1 Introduction: From System architecture to system design and implementation

This section (together with Annex 1) presents an introduction to the domain of systems engineering. Systems engineering is of particular relevance to the KAREN project, especially when considering the implementation of a Framework Architecture in the real world.

It is difficult to give a precise definition of systems engineering, due to the many disparate ways that a system can be defined, e.g. should the system include communication exchanges that occur between elements at organisation or human level, in addition to purely technological communication?

A first set of definitions could be:

*A **system** is a connected structured set of elements that perform functions that serve an intended purpose.*

***Engineering** may be defined as the art and science associated with a process that leads to creation of cost-efficient technological solutions that fulfil human needs, and by extension to the creation of technological products and services.*

***Systems engineering** is the profession associated with the engineering of systems of all types and with consideration given to all of the relevant issues that affect the resulting product or service.*

Alternatively, systems engineering may be viewed as a process based effort that is comprised of a number of activities that:

- assist in the definition of a system that will be trustworthy, high quality and cost-effective in meeting user needs;
- transform the resulting set of requirements and specifications into a system through various development efforts; and
- provide for the deployment of the system in an operational environment.

In the efforts required to engineer a system, the engineering team performs two major roles with:

- a **process** oriented perspective in an effort to ensure that a product line is cost-effective and trustworthy;
- an **integration** perspective is taken in an effort to ensure that the needs of the customer, the systems engineering team and existing or legacy systems are considered in integration.

In all systems, the core subject should be product integration. The more efficient the integration of the elements, the more efficient the system.

4.5.2 Specific steps in the Deployment

4.5.2.1 Tendering Process

This section explains the main elements of a tendering process. The invitation to tender includes a number of points to be looked at carefully. Due to the fact that public invitations for tender are regulated by national legal aspects there are some points which have to be respected by all countries who are members of the European Union.

General guidelines indicate that the invitation must be public for companies of all over the area of the EU. There must not be any restrictions in the participation except in terms of disability to match the required standard of the system.

The following points are the main elements of a tender:

- Organisation who invites to tender

  A detailed description of the organisation, department or company is given. It includes responsibility, area and location.

- Description of the output

  An overall view of the piece of work, eventually of sub-modules and components is given.

- Structure of the tendering document

  The tendering document is normally divided in several parts:

  General terms

  The general terms are describing high level framework requirements, which must be met by the tenderer. This could be:

  - the demand for the last released software version;

  - the correct form of the offer;

  - the right of the initiator to ask for a relevant test-system;

  - the aspect of completeness of the whole system;

  Defined deadlines for delivery

  This sector includes the date of decision, date of a test-system, date of delivery and installation, date of testing and finally date of acceptance. These deadlines are normally binding for the tenderer.

Terms of payment

This sector includes all financial modalities, pre-payment, payment after each successful milestone, and the final payment of the orders amount.

4.5.2.2 Procurement

In the process of a system selection the tenderer as an organisation and the system as its product has to fulfil a number of criteria, which are also included in the invitation for tender. These are general standards or norms, which are essentially for the chance of the tenderer to win the contract with its offer.

In general terms, the requirement for the bidder could be a valid certification of ISO 9000 (ISO 14000) as a guarantee of his internal quality process.

Some examples of usual standards from the world of system design and implementation are given below:

- In the area of telecommunication the system has to have a data flow over an 802,6 or a SDH network. If the connection should be wireless, it must be GSM, infrared or another defined standard (e.g. microwave).

- In the area of the Internet several standards or protocols should be compatible to the system. This could be that the system has the possibility to understand XML, HTML or other languages. Furthermore, it could be the request for the understandability of the WAP format in the near future.

- An example of a specific standard for a specific area of ITS systems in a specific part of Europe is the VDV interface, used in nearly every public transport system in Austria, Germany and Switzerland. If a bidder is not able to offer a system with this interface, there is no chance for him to gather a contract.

Of course there are a lot of specific, national and partly regional standards which have to be taken into account when offering a system to ensure the success of the offer.

4.5.2.3 Awarding contracts

The process of awarding contracts follows clear guidelines.

- Collection of offers.

- Ensuring that offers are treated in confidentiality and anonymity. The content of the offer must be secret until the official date of opening.

- Opening of the offers, normally by a commission at a fixed place and time.

- Examination of the offers. The offers are examined in terms of price and high and low-level output. The invitation to tender includes defined output that have different grades of importance. Therefore reviewers examine if all output are included in the offer and judge them according to their grade.

- Elimination of offers. This includes offers, which are not in time, incomplete offers, bidders without an economical, financial or technical reliability or offers without a understandable context between output and price.

- Election of the offer (in most European countries this works under the rules of the best-offer principle)

- Order and contract. The order has to be in written form to become valid. Usually this have to be done within a certain period, otherwise the bidder has the right to retreat from his offer.

The process ends with either the signing of the contract through both parties or by the cancellation of the tender through defined reasons.

4.5.2.4 System Engineering and Implementation

This section explains the bridge between the classical V-model (see Annex 1) and the approach that was adopted for KAREN.

At current stage of the KAREN project, the reference architectures have been produced.

- The **reference architectures** were obtained by mapping the system onto logical groupings of activities that are to be performed. The reference architecture is said to have three principal characteristics. Functional Architecture decomposition represents the breakdown of each function of the system into component functions, each having specified inputs and outputs. The Physical Architecture describes the assignment of functions to systems and this identifies and characterises “example systems”. The Data Stores and Flows (equivalent to the information model) represent the entire collection of objects, relationships, and information units that are involved in interactions between subsystems.

Systems engineering provides a benefit for KAREN through the creation of an engineering architecture. In progressing from a reference architecture to an implementation architecture (see below), it is necessary to pass via an engineering architecture [Sage, 1998]:

- The **engineering architecture** is said to add detail to the principal elements of the reference architecture. It does this by mapping logical activity groupings onto available or instantiable subsystems. Furthermore, it identifies types of exchange mechanisms and subsystem interfaces. An engineering architecture is composed of the three principal elements. Firstly a subsystem model describes the real subsystems (as opposed to the “example systems” of the Physical Architecture) that will be considered as black boxes. It also describes the functions assigned to them. Secondly the interface model describes interactions between subsystems. It represents sets of input-output connections specified by the functional decomposition. Thirdly integrating mechanisms represent the exchanges that are used for each identified interface.

As already foreseen by the KAREN project, the last step of the system engineering approach is the production of an implementation architecture:

- The **implementation architecture** adds operational technical detail to the elements described in the reference and engineering architectures. This view describes components, languages and communication protocols. COTS products that perform functions and interactions identified by the engineering architecture are specified, and extra design details are provided to enable the creation of specific code. The implementation architecture is comprised of four principal elements. Firstly hardware, operating systems, and communication protocols are specified for use in the system implementation. Secondly a system model is used to identify the specific products that implement the subsystems, defined in the engineering architecture. Thirdly an interface model specifies exchange mechanisms for the subsystem interfaces and between the database management systems. Finally, the information model specifies the different data models.

The systems engineering to implementation phase ends when the implementation architecture is realised and the following entities are **integrated**:

- hardware, software, databases and operating systems;
- interface mechanisms;
- communications services.

The integrated system will have undergone testing at module, subsystem and system level. An integrated system still has to be approved by the User that ordered it (e.g. the public authority). This commissioning and acceptance phase is detailed in the next section.

For more information on system architectures, see the Guidelines for the Development and Assessment of ITS Architectures [CONVERGE 1998], which covers the issues found in this section in more depth.

4.5.2.5 System Commissioning and Acceptance

This section explains how the integrated system undergoes commissioning and subsequently acceptance by the User.

The aim of the commissioning process is to complete the system testing phase and be sure that the system is fault-free, i.e. to “make the system work”. The commissioning tests are normally described in a System Test Plan. After the commissioning phase is successfully completed, acceptance testing of whole system can begin. An Acceptance Test Plan would have been written during the phase when the User needs are defined.

The aim of the Acceptance Test Plan is to prove that the User needs are satisfied by the system. As such it is not written by system supplier, but normally by or on behalf of the User (e.g. the Public Authority that is responsible for procuring the system). Once the tests have been performed and the results recorded, an Acceptance Test Review is held in order to go through the results of the acceptance tests. If the conclusion of the review is that the system is accepted, then the system is fit for use and can become operational. It is at this stage that the System Maintenance phase begins.

4.5.2.6 System Maintenance

The system is normally delivered to the User with a guarantee. If there is a fault, either in a subsystem or at the system level, then the supplier in question must fix the fault (at his own expense) during the period of the guarantee. However, once the guarantee period is over (e.g. after 1 or 2 years), the User may take out a maintenance contract. Depending on the terms of the original contract to provide the system, the User may be free to take out a maintenance contract with the original supplier or with another system integrator.

During the maintenance period, any faults identified in the subsystem or system shall be fixed in order to restore the system to its fully-functional state. Due to the complex nature of deployed systems, the terms of the maintenance contract should normally be defined before system design starts, during the awarding of procurement phase. From an operational point of view, the maintenance contract is normally awarded to system supplier since they have the best knowledge of the system.

4.5.2.7 Training

The users of a deployed ITS perform several different roles. As such, their training requirements are each different. They are presented below.

General public

The general public uses ITS services for travelling or for getting his goods transported. His training should be as minimal as possible. ITS services need to be easy to use. Basic instructions should be sufficient to be able to use the services or systems.

Transport professional

The transport professional is involved in a transport process, which is directed at the actual transport of people or goods. He uses ITS services in his transport operations. This is for instance the bus driver, the transport planner or the operational manager of a distribution centre.

His training needs to be directed at the use of the ITS services in his transport work. He needs to understand the primary transport process that he is in (e.g. public transport), his responsibility in that process (fast, safe and comfortable transport of passengers by bus) and how the ITS service supports this responsibility (e.g. by giving buses priority at signalised junctions). For him the actual use of the ITS services also needs to be as simple as possible.

ITS service professional

The ITS service professional is involved in delivering ITS services to civilians or transport professionals (e.g. traffic control, providing travel information). Generally, several roles can be distinguished here:

ITS service operator

This operator actually delivers the service (e.g. the traffic control operator who executes traffic control measures), or he controls the delivery of the service (travel information operator in case of an automatic service). His training needs to be directed at the delivering of his service as a means to support the actual transport process.

This operator needs to understand the transport process that he is supporting (like traffic flow), the possible impact of the service he is providing (like the impact of different sorts of traffic control measures) and the way these services should be provided in order to contribute as much as possible to the actual transport process.

The operational delivery of the ITS service needs to be as simple as possible. The operator needs to have an intuitive interface to the system he uses to deliver the services.

ITS system operator

This operator is responsible for the correct operation of the system. He needs to understand the services that are supported by the system and he especially needs to be aware of the service levels required. He must be able to operate the system in accordance with those service levels (this concerns issues like availability, operational performance, etc.).

His understanding of the working of the system needs to be good enough to be able to operate the system and to be able to change operational conditions. He needs to know which disturbances can be handled by himself and when to call for system maintenance.

Other ITS professionals

Other roles include system development, system maintenance and system management. Of course these professionals have to understand the ITS business they are in, but apart from that their roles do not differ much from system development etc. in other domains so their training needs do not specifically have to be mentioned here.

4.5.2.8 Awareness and Promotion

Some awareness raising activities can be:

- Present the benefits achieved of the use of ITS at conferences, exhibitions and events.
- Establish a liaison to other national or local ITS organisations to provide assistance in using ITS.

- Provide background material and suggestions to facilitate national or local promotional activities.
- Promote the exchange of experiences and ideas among countries/regions/cities concerning ITS.
- Publish on a regular basis the results of further development and deployment of ITS.
- Create and maintain a WWW site as a reference in the field of ITS deployment.
- Publish a multimedia tutorial on ITS to provide the first level of introduction to the subject to new actors.

5. Example of architecture deployments

5.1 Context

5.1.1 approach

This section presents architecture initiatives that are taking place in different European countries at the national level. This level is the first one among the various levels of intermediate architectures (considered in 4.4) to be concerned with KAREN results. The situations will be described for countries participating to the KAREN project either directly (as partners) or indirectly (as consulting members). Countries covered include those:

- that are developing a national ITS architecture. This includes Finland, the Netherlands, France, Italy and Sweden.

- that are not developing a national ITS architecture. This includes Germany and U.K.

For the latter, it is interesting to explain why it was decided not to launch a national architecture programme.

5.1.2 Common template for national ITS architecture description

So as to facilitate reading and comparisons, the situations are described according a common template (at least for the countries having a national ITS architecture programme). The template is shown below. This template is intended to be used as a checklist of issues to address, not necessarily as a questionnaire, as content may evolve during discussions with stakeholders.

- project resume:
- *project name*
- *who initiated the work? who is funding? what is budget and duration?*
- *work-breakdown structure, outsourcing of contracts*
- *what are the main objectives? what is envisaged after the current project?*

- scope:
- *how high level issues (e.g. institutional and societal issues, general concepts about using IT in the transport sector...) are addressed?*
- *how low level issues (e.g. physical designs and technical solutions for particular systems, telecoms) are addressed*
- *which actors are involved? which modes of transport are covered? which services are addressed?*
- *who are the "clients" that are intended to use the architecture? for which usage?*

- links:
- *links with other national initiatives? with European level?*
- *links with standardisation activities?*
- *links with political (national or local) level?*

- approach:
- *importance of architectural models vs. informal discussions on ITS deployment and interoperability issues?*
- *which method? which design process? which tools?*

- dissemination:
- *how are communications media such as the web, users forums, workshops, brochures, intended to be used?*
- *education courses and awareness raising seminars*

5.2 Finland

The Finnish national ITS-FA project is called Telemark; Kristian Appel of Traficon Finland, member of Karen Permanent Consulting Group, contributed to this section.

5.2.1 Project resume

5.2.1.1 Project name

TelemArk – Finnish National Architecture for Transport Telematics

5.2.1.2 Executive summary

TelemArk is an architecture, which describes the actors involved and the information systems used in the field of transport telematics and even more importantly the relationship between the actors and the systems.

TelemArk describes roughly how the telematic services will look like in the next decade. The actors (travellers, road users, transport operators, authorities, service providers, etc.), major IT systems and the inter-relationships between them are shown by TelemArk. Moreover, TelemArk attempts to point out strategies and policy measures that will enable the telematic services to get rooted and flourish. Legislative, organisational and commercial obstacles are identified in the Deployment Strategy. Preventive and counteractive measures are recommended by the Strategy in order to overcome these obstacles.

TelemArk is considered as a unique effort with an exceptional breadth of scope. It covers all transport modes (road, rail, air, water).

5.2.1.3 Initiative

The TelemArk project was initiated within TETRA, The Finnish National Research and Development Programme on Transport Telematics Infrastructure, by the Finnish Ministry of Transport and Communications. More specifically, TelemArk in an essential part of TETRA project 8, which aims at promotion of the development of transport telematics systems and improving the preconditions of transport telematic services. The TETRA programme includes nine projects all of which consist of several subprojects.

5.2.1.4 Funding and general organisation

The project is funded by the Finnish Ministry of Transport and Communications.

The project preparations started in summer 1998. The actual consultant work began in February 1999 and was accomplished in December 1999. Follow-up measures will be carried out in the coming years, starting already in the year 2000.

5.2.1.5 Project structure

5.2.1.5.1 Committees and co-ordination

The project is co-ordinated by the steering committee, which consists of representatives from

- Ministry of Transport and Communications
- The Finnish National Road Administration
- Finnish Rail Administration
- Helsinki Metropolitan Area Council (YTV)
- Confederation of Finnish Industry and Employers (TT)
- Telecommunications Administration Centre (THK)
- Finnish Railways (VR)
- Matkahuolto Ltd (provides bus travel/freight services)
- The Finnish Taxi Association
- Cap Gemini Ltd
- The Technical Research Centre of Finland (VTT)
- Traficon Ltd.

5.2.1.5.2 Contractors

Cap Gemini Ltd, The Technical Research Centre of Finland (VTT) and Traficon Ltd form a consultant consortium contracted by the Ministry of Transport and Communications. Within the consortium Cap Gemini Ltd was responsible for the methodology and the description of the architecture while The Technical Research Centre of Finland and Traficon Ltd represent the knowledge of the transport sector and were responsible for preparation of the Deployment Strategy.

5.2.1.6 Objectives

The objective is to create prerequisites for the introduction of the different transport modes and common services by developing a common framework architecture for transport telematics. It will offer a description of the operating environment, within the limits of which the development and use of the different systems and services can take place. Furthermore a description of the relations of the actors involved is produced. An open common framework architecture creates prerequisites for data and functional interoperability, data exchange, the combination of services and systems as well as for the development of the standards associated with them. TelemArk provides a tool for the Ministry to direct the efforts of operators, sector authorities and service providers. These actors may use the architecture for service and business process development as well as in the development of actual ITS applications.

The advantages that are sought through developing a National Architecture for Transport Telematics are:

- interoperability/compatibility
- transparent basis for promoting PP-partnerships
- faster implementation of new systems
- reduction in need for support
- better reliability and flexibility
- uniform terminology
- less problems caused by complex systems, non-interoperable systems
- better traceability.

On a larger scale the project is aiming at securing competitiveness in the modern IT-based society through efficient usage of existing resources. This goal is pursued, for example, by defining the responsibilities of public and private services in the transport sector, which results in reduction in unnecessary and overlapping work done. In short, by employing ITS the traffic authorities and operators expect to contribute to the efficiency and growth of the whole economy.

5.2.1.7 Future

TelemArk work will be continued during the coming years. Technological evolution is rapid and the role of organisations might change. Therefore services and roles of different actors covered by TelemArk might change correspondingly. These changes require that TelemArk should be reviewed from time to time as well. The next big challenge for TelemArk is the marketing, education and implementation work which will start in the year 2000.

5.2.2 Scope

5.2.2.1 Project range overview

The main interest of the TelemArk-project lies on the system description and does not therefore include information on physical designs nor technical solutions for any particular system. At the other end, the scope ranges all the way to legislative processes and organisational structures in order to disclose the hindrances for creating a uniform telematic-utilising transport system.

The current project does not include functionality internal to a party. Nevertheless, future projects sequel to TelemArk will presumable explore deployment of systems and also technical issues.

5.2.2.2 Participating actors and users

The actors and users within the TelemArk-project are listed below. The ones in parenthesis took part in work shops in which the architecture was defined.

End users

- Commuters
- Business and leisure travellers
- Drivers

Commercial users and service providers

- Public transport providers (Helsinki City Transport, Koiviston Auto Oy, VR (Finnish Railways))
- Freight transport providers (Matkahuolto Ltd, VR)
- National transport sector associations (The Finnish Bus Association, The Finnish Taxi Association)
- Administrative (Central Administration of The Finnish National Road Administration)
- Information services (Karttakeskus Oy, Finnish Tourist Board)

Local authorities

- Communities (City of Helsinki, City of Tuusula)
- Provinces
- Regional Districts of The Finnish National Road Administration
- Regional bodies (Helsinki Metropolitan Area Council)
- Police
- Rescue forces

National authorities

- The Ministry of Transport and Communications, The Finnish National Road Administration, Finnish Rail Administration, Finnish Aviation Administration
- The Ministry of Interior, Police Department

Telematic system and hardware suppliers

- Integrators
- System suppliers

5.2.2.3 Modes of transport concerned

TelemArk covers all transport modes and thus is a unique project.

5.2.2.4 Areas of functionality

Areas of functionality and actual services included in the national framework architecture are:

1) Public transport information
    - Information on alternative transport possibilities
    - Passenger information, real-time and schedule based
    - Information on routes, travel and tourist services
2) Information to drivers
    - Information on level of service, incidents and road construction works
    - Information on weather and road conditions
    - Route guidance
    - Emergency services
3) Park & ride
    - Parking information, real-time
    - Information on alternative transport possibilities
4) Demand-responded public transport and public transport chains
    - Combining transport
5) Access control
6) Payments for transport
    - Road pricing and toll collection
    - Public transport payment
    - Integrated payment
7) Road traffic management
    - Intersection and road section signal control
    - Network signal control
    - Traffic signal priority
    - Local variable message signing
    - Speed control
    - Variable direction signing
    - Lane control

8) Hazardous goods
    - Public transport fleet management
    - Hazardous goods management
    - Maintenance operation and fleet management
    - Emergency vehicle management
9) Incident management, private transport
    - Incident detection
    - Incident management
10) Incident management, public transport
    - Public transport disturbance detection
    - Public transport disturbance management
11) Traffic enforcement
    - Speed enforcement
    - Enforcement of driving red light
    - Hazardous goods monitoring
    - Weighing in motion
    - Lane monitoring
    - Automated speed adaptation

5.2.3 Links

5.2.3.1 National level

The TelemArk project is currently the core of a project number 8 of TETRA, The Finnish National Research and Development Programme on Transport Telematics Infrastructure.

Of all nine TETRA-projects, TETRA 7 and 9 are closest related to TETRA 8 and therefore to TelemArk. Project 7 comprises a data exchange framework covering all transport modes whereas project 9 handles dissemination of information on national and international work on system architecture, harmonisation and standardisation of Transport Telematics. TETRA 9 will also make initiatives to the standardisation bodies if needs for further standardisation is identified.

5.2.3.2 European level

TelemArk interacts with international framework architecture projects, of which KAREN is the most important one. A member of the TelemArk steering committee is also a member of KAREN's Permanent Consultation Group. Furthermore the schedule of TelemArk is compiled considering the one of KAREN in order to utilise the interaction with KAREN as far as possible.

5.2.3.3 Standardisation

In the future work within TETRA 8, the TETRA 9 information channel to CEN, ISO, ETSI etc. will be used. If new standardisation needs are identified, initiatives will be made to the standardisation bodies through TETRA 9.

5.2.4 Approach

5.2.4.1 Design process

Based on a preliminary work plan the consultant consortium for the actual work was chosen through an open tendering process. As a base for the consultant work, a more detailed work plan was prepared, which then was approved by the steering committee. This included a list of actors involved, the functions to be covered and a description of the whole process of creating the architecture. In the next phase a plan for collection of information was prepared. The needed information was gathered in workshops with the actors and the results were reviewed also as the gathering proceeded. The information was divided in three groups: general, by actor and by function. The information was analysed and revised and an conceptual architecture model was compiled accordingly. The conceptual architecture was then approved by the steering committee.

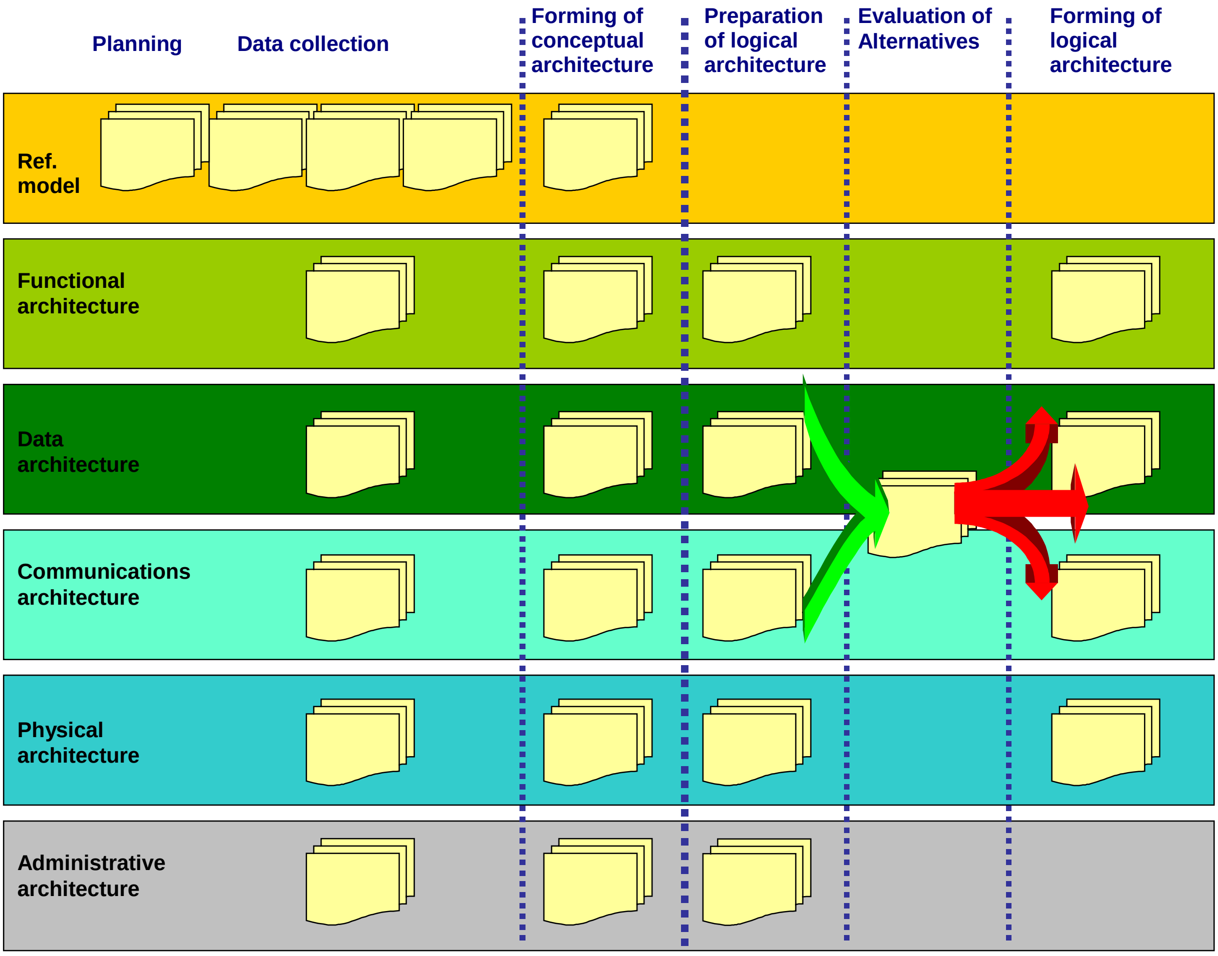

Figure 6: Phases of work

The next step was the forming of a logical architecture. The process started from the conceptual model. The project team provided the steering committee with multiple alternatives about the pursued state of the functions described by the architecture. After the analysis on the alternatives the chosen state of architecture was described thoroughly on both general and functional level. At this point a Deployment Strategy was prepared. The architecture was finally reviewed and approved by the steering committee in December 1999.

The describing processes utilised a methodology developed by the main consultant Cap Gemini Ltd. Main software tools used were Visio and Excel.

5.2.4.2 End results

The intensive work done in workshops turned into a conceptual and logical architecture. The content of these architectures are described in the following.

The conceptual architecture describes:

- Current systems: name, type, location, main processes, links, state, technology
- Actors: juridical or natural person / system / set of equipment
- Processes: operational functions of the components, data security, dependencies
- Information flows: direction and content of the flows between the components and the processes
- Process charts: components, actors, information flows, different classifications
- Demands of the architecture: based on the environment and the strategies of the actors

The logical architecture describes:

- Data exchange processes: data maintaining responsibilities, user interface
- Components of the data exchange processes
- Data set: data needed for a performing a process
- Process schemes: functions supporting the process components

Secondly, the work resulted in the Deployment Strategy. The plan defines how to

1. make sure that the National Architecture for Transport Telematics will be utilised
    - making the benefits and procedures known among the actors
2. support the development of transport telematics in Finland
    - listing the needs for developing and factors preventing the development
3. update and improve the architecture in the course of time.

5.2.5 Dissemination

5.2.5.1 Media

An Internet web site (http://www.mintc.fi/www/sivut/suomi/tetra9/, in Finnish) is open for the participants of the project and for public. Papers will be published in transport related publications and the architecture is introduced in different events in Finland as well as abroad. The TelemArk architecture will also be presented internationally via KAREN.

5.2.5.2 Other

At least two seminars are to be arranged; the first before involved actors make comments on the current architecture description and the second before the workshops on how the architecture should be used in different organisations are held.

5.3 Sweden

This section was brought by Christer Karlsson and Per Wenner, SNRA, project coordinator for Sweden’s national ITS Framework Architecture project and member of the KAREN Wise Men Group.

5.3.1 Project resume: launching the initiative

A National Delegation for Transport Telematics reported in 1996 their task of analysing, in context of transport policy, the use, consequences and introduction of transport informatics in the Swedish transport system. Their task included: information activities, analysis of users and transport informatics, cost-efficiency analysis of transport informatics, transport informatics as a strategic instrument for transport policy, road traffic management organisation, strategy for implementation of transport informatics, assessment of applications and a National program for transport informatics.

One of the items in the National programme was identification of the need for an investigation of the creation of a system architecture on a European level (KAREN). The Swedish Parliament accepted the report and decided to use it as a basis for the further developments in the transport informatics field.

SNRA (Swedish National Road Administration) has, as responsible authority for the road transport system, formulated a National plan for ITS in the road transport sector. One of the identified needs was a National System Architecture for ITS in the road transport system.

5.3.2 Scope and actors

A National System Architecture project started during 1998. However the project changed its scope and focus after realising the need for identification of actors and processes involved in the ITS area. The result of the revised project was a method for describing the processes in the ITS-area, called “Client Value Processing” (CVP).

Parts of the work with the National System Architecture will now be handled within a recently established project called GTIS. The main scope of this project is establishment of a stable and open structure to facilitate development and deployment of new traffic information services.

ITS Sweden, established in the end of 1999, is a competence centre which will be engaged in many types of work in the ITS area and can play an active role in formulating a National multi-modal system architecture for ITS.

5.3.3 Links with European level

Within the Euro-regional project VIKING there is an ongoing activity concentrating on system architecture issues. This activity is now focusing on following the developments within the KAREN project, adoption of its results, and harmonisation with the national system architecture projects in the VIKING area.

The Swedish representatives in the VIKING system architecture group made the following reflections after reading existing KAREN-documents (October 99) and presentations of what is expected:

- To some extent the descriptions, produced by the KAREN project, reflect the situation in the home-countries of the authors, but it is normal that the author’s experiences influence this type of work. The national system architectures have to take this into account when examining the results.

- The countries have different organisational structures, experiences and cultural heritage. National system architectures may highlight other parts of the work than what was addressed by the KAREN project. For example, the process developing the User Needs can be performed differently, analysing the actors involved in the service-chain at an early stage.

- When planning the involved activities in a National System Architecture the order of the activities may vary. For example, the infrastructure for information exchange can be described at an early stage to facilitate for early detection of new User Needs which may otherwise get lost.

- The European ITS Framework Architecture produced by KAREN contains all main components needed for a Systems Architecture and is therefore a good base for developing National System Architectures.

- Major parts of KAREN can be used in the National System Architecture work.

5.3.4 Approach

ITS is a relatively young and rapidly developing discipline. This makes architecture work more important. This also makes it imperative to follow the development closely and make the necessary changes to the architecture to be able to give valuable support to system designers and get the expected results of the System Architecture work.

It is important to get understanding of what a System Architecture is and why it is needed. Decision-makers must understand the basic components of an architecture and the effects of various approaches when initiating National System Architecture projects.

The methods used in the System Architecture work may vary in the different countries and also in different parts of the Architecture. E.g. process-oriented methods will be used as well as object-oriented methods. For some parts a combination of methods will be used.

It is beneficial to use an iterative approach to the System Architecture work. A step-wise approach makes it easier to go back and make the necessary corrections during the work.

5.3.5 Dissemination

KAREN is an excellent basis for the required training activities before the National System Architecture projects starts.

5.4 Italy

This section was contributed to by Gino Franco (Mizar).

5.4.1 Project Resume

5.4.1.1 Project Name

Provisional name: Italian ITS Architecture

5.4.1.2 Who initiated the Project?

A National Architecture working group nominated by the Ministry of Public Works set the basis for the definition of a national architecture compliant with the European ITS Framework Architecture produced by KAREN, the preliminary document was included in the "second national plan for transport telematics" issued in 1999.

5.4.1.3 Who is funding? Budget/duration?

A proposal was included in the financial law for the year 2000 (currently to be approved by the council of ministries) for setting a budget of 5MEuro to the National Architecture activities. The study will then be run under the responsibility of the two ministries of Transport and Public Works (actual allocated budget is not known to-date). Parallel studies/projects are envisaged with the sponsorship of the European Commission in the context of infrastructure funding programme (e.g. TEN-T programme).

The start of the project is expected by June 2000 for a duration of two years.

5.4.1.4 Work breakdown structure, outsourcing of contracts?

A call for tender will be published for the assignment of the development activities of the project to one company.

The project will be run by the two ministries of Public Works and of Transport who will nominate a team of independent expert for the technical supervision; this group will actually act as the project steering committee.

Consensus will be reached on intermediate results produced by involving relevant stakeholders in the ITS sector. This will happen mainly involving the TTS organisation (the national organisation for promoting and favouring the development of Telematics for Transport and Safety) which currently includes the following partners: ACI, AINE, AUTOSTRADE, TRAGA-SERVICE, FIAT, MIZAR, RAI, STA-ROMA, ST-MICROELECTRONICS, TELECOM-ITALIA, MINISTERO DEI TRASPORTI, MINISTERO DEI TRASPORTI, FERROVIE DELLO STATO, ANIE, PIRELLI, IVECO, VIASAT, TELESIS, FIAT-CRF, CSST, MAGNETI MARELLI, TELEATLAS, MINISTERO DELLE TELECOMUNICAZIONI, UNIVERSITA' DI BOLOGNA, FEDERTRASPORTI, SINELEC, AUTOSTRADE VENEZIA-PADOVA, ELSAG.

5.4.1.5 What are the main objectives?

The goal is to develop a national architecture for Intelligent Transport Systems in Italy that serve as the reference platform for the implementation of truly intermodal services nation-wide. The developed intermodal national architecture will

- Be compliant with the European Framework Architecture for ITS produced by KAREN 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 mode of transport (ground, air and water) and the necessary interfaces between them.

- 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.

5.4.2 Scope

The project activities will aim at the development of the national architecture for intermodal transport services. 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 telematics systems of all modes of transport and will conform to the European Framework Architecture for ITS. The main focus of the architecture relies on the organisational aspects (i.e. agreements, share of responsibility, architecture maintenance, etc.) necessary for the successful and effective implementation of truly intermodal transport services. This project will be performed involving national stakeholder representatives to form a 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 travellers.

- 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 inter-modal and multi-modal 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 intermodal services involving multiple actors.

- Definition of the national architecture for transport telematics systems including functional, physical and communication architecture and particularly focused on scenario-based organisational architecture.

- Set up of the structure for the continuous update and upgrade of the national architecture.

5.4.3 Links

Liaison links will be established with the European ITS Framework Architecture group that will be operating during the project period, with all relevant standardisation bodies and ITS application fora and committees.

5.4.4 Approach

The approach will be proposed by the companies participating to the call for tender. The call for tender will only pose the constraints in terms of objectives of the project and compliance with the European Framework Architecture.

The winner of the call for tender will propose the methodology, the process and the tools to be used for the development of the project. The proposed methodology will be discussed and finally approved by the steering committee.

The dissemination activities and the education programme have not yet been planned; this will be one of the roles of the TTS organisation.

5.5 Belgium / Flanders

This section was proposed by Rudy Tegenbos (Tritel)

5.5.1 Project Resume

5.5.1.1 Who initiated the Project?

The Flanders ITS functional specifications were designed before KAREN, with the Flemish ministry of infrastructure and traffic as a specific user. The Flemish ministry is road administrator of inter-urban and urban roads. The Flemish public transport company falls under the responsibility of the ministry.

5.5.1.2 What are the main objectives?

As a consequence, an integrated urban- interurban and public-private traffic management was expressed in the user requirements of the Flemish ministry.

5.5.2 Scope

- The Flemish ITS architecture encompasses the following functions: Regional multi-modal traffic information
- Emergency services
- Incident management
- Inter-urban traffic management
- Urban traffic management

5.5.3 Links with KAREN

The Flemish ITS functional specifications have been elaborated before KAREN results were available. If the KAREN functional specification would have been available before the drawing of the Flemish specification has started up, the latter would have been certainly designed as a subset of the KAREN specification. This subset would have been elaborated in much more detail then the KAREN specification. Even this could be done on a European level by combining the work of TELTEN with the work of KAREN taken into account some practical exercises as for instance the Flemish specification.

5.6 The Netherlands

Victor Avontuur (RWS/AVV) contributed to this section.

5.6.1 project resume

5.6.1.1 project name

"Koepelarchitectuur". (National ITS Framework Architecture for Inland Transport).

5.6.1.2 Who initiated the project?

ITS-Nederland (ITS-Netherlands), a public-private partnership to support the implementation of ITS in the Netherlands.

5.6.1.3 What is the funding level?

The framework architecture development is funded by VenW (Dutch Ministry of Transport). The budget is 200.000 Euros. The project duration is 1 year, from September 1999 till September 2000.

5.6.1.4 Work-breakdown structure and outsourcing of contracts

There is a steering-committee with representatives of partners involved. The actual work is outsourced to a consortium of ITS-Dutch partners.

5.6.1.4.1 Steering-committee

The chairman of this committee is the director of ITS-Nederland. The members: are representatives of the following partners: ITS-Nederland, VenW, TNO (knowledge institution), CMG (computer management company).

5.6.1.4.2 Consortium

The consortium is composed of TNO and CMG and is led by TNO.

5.6.1.5 Main objectives of the activity?

Main objective is to identify ITS-services and systems with most potential to be implemented successfully in the Netherlands. Therefore it is considered useful to develop a framework architecture, which encompasses all relevant parts of Inland ITS in the Netherlands.

The framework architecture is supposed:

- to show the coherence between ITS parts;
- to show the coherence with the European ITS Framework Architecture produced by KAREN;
- to serve as a base for further development of partial ITS architectures;
- to serve as a means to reach agreement within ITS-Nederland on the further implementation of ITS in the Netherlands.

5.6.1.6 What is envisaged after the current project?

The development of architectures for parts of ITS (or the continuation and “tuning” of architecture developments that have started already) will take place. These partial architectures will address urban/interurban traffic management, public transport, logistic chain management, etc.

These partial ITS architectures will be funded by ITS-Nederland. Budget: 2 million Euro.

5.6.2 Scope

5.6.2.1 How high level issues are addressed?

Institutional and societal issues are covered as well as general concepts about using IT in the transport sector.

To identify services and systems with highest potential to be implemented successfully, a "hype cycle model" is used, in which technology maturity, institutional readiness and user acceptance are investigated and combined. Institutional and societal issues are covered to assess "institutional readiness".

General concepts about using IT in the transport sector are addressed by describing the ITS-system in general. Special emphasis is given tot the assessment of ICT-infrastructural elements that can be used in several ITS-systems or both in ITS-systems and other civil service systems (like healthcare, education, etc.).

5.6.2.2 How low level issues are addressed?

In the framework architecture we describe ITS services and systems on a "conceptual" level. In following partial ITS architectures we may drill down to "functional/logical" levels.

In the description of ICT infrastructural elements the activity may identify (potentially) successful technical solutions like "UMTS", "WAP", "EDIFACT", etc. It will not describe technical solutions for specific ITS parts like traffic management, etc.

5.6.2.3 Who are the actors?

Partners in ITS-Nederland. Some of them are directly involved in the development of the framework architecture; these are represented in the steering committee. Other partners are involved in the review of intermediate and final results.

5.6.2.4 Which modes of transport are covered?

Covered transport modes are road-, rail- and inland water transport, and the interfaces to air- and sea transport.

5.6.2.5 Which ITS services are covered?

All related ITS-domains, like those mentioned in ISO and KAREN lists.

5.6.2.6 Who are the "clients "of the architecture? For which usage?

Clients are ITS-Nederland partners. They use the framework architecture for further development/refinement of partial ITS architectures in which they are specifically involved.

5.6.3 Links

5.6.3.1 Links with other national initiatives?

Via ITS-Nederland there are links with all major national initiatives, like smart card platforms, telecom platforms, logistic chain platforms, etc.

5.6.3.2 Links with European level?

VenW, TNO and CMG are also involved in KAREN (in the project group, the PCG or the Wisemen group), often via the same people.

5.6.3.3 Links with standardisation activities?

Not yet directly related tot the framework architecture development, although this activity participates in ISO and CEN at several levels.

5.6.3.4 Links with political (national or local) level ?

This is achieved mainly at the national and regional (provincial) level.

5.6.4 Approach

5.6.4.1 Importance of architectural models vs. informal discussions on ITS deployment and interoperability issues?

Both are important. Apart from architecture development there are several deployment initiatives related to ITS, like urban/interurban traffic management, the use of smart cards in public transport, etc. Within those domains interoperability issues are addressed, although restricted to the specific domain.

5.6.4.2 Which system engineering method is used?

No formal architecting or engineering methods are used. The activity uses things like the "hype cycle model". No formal design process and tools are used. The activity does not use "engineering-level" approaches, so there are no discussion on PO versus OO approach.

5.6.5 Dissemination

Results will be communicated via ITS-Nederland. Awareness raising seminars will be organised via ITS-Nederland. No education courses are planned at the moment.

5.7 France

This section was provided by Patrick Gendre (Certu).

5.7.1 Project summary

5.7.1.1 project name

"ACTIF" - French acronym for “Framework Architecture for Intelligent Transport in France”.

5.7.1.2 Who initiated the project?

The French ministry of Transport (initially the Road Traffic and Safety Directorate, but since mid 1999 the Steering Committee comprises all Directorates of the ministry); partnership with other actors (industries, local authorities, operators, users) is actively sought and will be represented via a High Level Group.

5.7.1.3 What is the funding level?

The project is funded by French Ministry of Transport (several Directorates) and by the EC. The Budget is 2 M Euros. The duration of the project is 2 years, from September 1999 till September 2001.

5.7.1.4 Work-breakdown structure and outsourcing of contracts

5.7.1.4.1 Committees

The steering-committee is made of representatives of the ministry of transport. A technical committee is mirroring the steering committee (with representatives and orientates the project at a more tactical level). The High Level Group is currently being created and should comprise representatives of ITS actors (industry, authorities, operators, users). Experts are consulted when necessary.

5.7.1.4.2 Coordination and Contractors

The project co-ordination has been outsourced to a private company (Algoé), and the project is led jointly with a small team of representatives of the ministry (CETE de Lyon, and also DSCR and CERTU).

The actual work will be outsourced via a call for tenders process and should start early 2000.

5.7.1.5 What are the main objectives?

The framework architecture works towards the following goals :

- better communication between actors and elaboration of prospective visions;
- a method and a tool to address ITS architecture issues;
- identification of technical points (interfaces) to standardise;
- elaboration of specific recommendations for specific application domains or technologies;
- description of likely mid-term deployment scenarios, so as to better anticipate any difficulties and risks;

The two first points should be answered by the framework architecture itself, while the three latter will be addressed by case studies, to be started and run "in parallel" with the framework elaboration.

5.7.1.6 What is envisaged after the current project?

The follow-on of the ACTIF project will depend on its success. A specific assessment study has been planned within the project work breakdown structure, so as to define what to do next. Of course, if everything goes well, the resulting architecture framework should be maintained. Also, this will depend of the follow-on of KAREN at the European level.

5.7.2 Scope

5.7.2.1 How high level issues are addressed?

The project does not address societal questions, and whether or not to implement a telematics system for a particular ITS application; such issues should have been addressed elsewhere (e.g. at the ITS France level). It is supposed that the "clients" of ACTIF know already what ITS is about (in particular because they operate or develop, or are in the process of doing so). However, it is been recognised that this conceptual and strategic level is essential to a successful ITS deployment.

5.7.2.2 How low level issues are addressed?

In the case studies, it is intended to address some deployment and technical issues, although the level of detail will depend on the particular domain, technology or project to be studied.

5.7.2.3 Who are the actors?

ACTIF will encompass all road ITS actors already covered in KAREN (authorities, suppliers, users, operators), plus the actors of other modes of transport which need to interface their systems with the road.

5.7.2.4 Which modes of transport are covered?

Covered transport modes are road-, rail- and inland water transport, and the interfaces to air- and sea transport.

5.7.2.5 Which ITS services are covered?

All related ITS-domains, like those mentioned in ISO and KAREN lists. Within these domains, some will be elected as ‘high priority’ by the steering / high level committee and will be studied in more details as case studies.

5.7.2.6 Who are the "clients" of the architecture? For which usage?

Basically they are the same than the actors, although maybe the national and local authorities and large companies will be more concerned than the others.

5.7.3 Links

5.7.3.1 Links with other national initiatives

ITS France should be created in early 2000; other professional associations will be involved, in particular with respect to the case studies.

5.7.3.2 Links at the European level

ACTIF will rely on KAREN’s results; the EC is a major funder of the project, so all links will be established. Documents will be translated in English.

5.7.3.3 Links with standardisation activities

Those links will be addressed, in particular for the case studies, via the national participants to CEN/ISO, or consortium standardisation bodies.

5.7.3.4 Links with political (national or local) level

Those links will be established through different groups, e.g. via the steering committee, the high level group and possibly ITS France.

5.7.4 Approach

5.7.4.1 Importance of architectural models vs. informal discussions on ITS deployment and interoperability issues?

The framework architecture will be based on a model, and should in the end produce a tool for the users, so that they can navigate through the model, possibly edit and adapt the model to their needs. Informal discussions are important as well, typically at the steering committee and high level group levels, as well as in the case studies where all problems cannot be "put" into a model. Communication is an essential part of the approach and should be made in plain French / English.

The model "content" will initially be that of KAREN (users' needs, functional and physical architecture), to be adapted to the French context. It will be updated later in the project, as the first case studies will be progressing.

5.7.4.2 Which system engineering method is used

The method, design process, and tools should be proposed by the architect to whom the work will be awarded. A good compatibility with KAREN results, and with standards such as the WWW and the UML will be sought. Simplicity and robustness are also key criteria.

5.7.5 Dissemination

A web site will be open in early 2000, with material both in French and English. The Web will also be used as an intranet. User forums are envisaged in liaison with the high level group and the case studies. Brochures and workshop are considered, but the communication strategy will be defined later in the project.

A specific study will be done within the project, so as to elaborate the programme of ITS-FA education courses (content and organisational feasibility).

5.8 Germany

5.8.1 General Strategy

In 1993 the German Federal Ministry of Transport worked out a strategy for the introduction of Transport Telematics, which defines the need for action and decision-making by all parties concerned . This strategy points out the potential effects of the use of telematics by all means of transport - rail, road, waterways, and air transport - and in both public and private transport. In detail it was expected that by introducing and using telematics systems and services on a broad basis a considerable contribution can be made to

- making **more efficient use of the existing transport infrastructure**, especially in respect of reducing and avoiding traffic congestion as well as empty journeys and traffic in search of its destination.

- making better use of the specific advantages of rail, waterway and air transport by inter linking them in an integrated **overall transport system**.

- enhancing **traffic safety**

- reducing transport related **pollution** by using new technological possibilities of transport organisation and management.

The detailed development of the strategy showed that the successful introduction of telematics depends highly from the engagement of the private sector in establishing telematics services.

The "Economic Forum on Transport Telematics" was created in 1995, under chairmanship of the Federal Minister of Transport. Senior representatives of transport policy from the federal government, the federal states and local governments, from the public transport sector, among others Deutsche Bahn AG, from the automobile, electrical and electronics industries as well as from the service sector came together to create this forum in order to speed up the large-scale introduction of telematics services on the market in Germany. The participation takes place on voluntary basis . It is open to any interested party and has attracted many actors from policy, transport operators, car and electronic industries and service providers.

The forum reached consensus that:

- the planning, organisation and operation of telematics services have to be carried out under **competitive conditions**

- regional and supra regional telematics services which strengthen the **overall transport system** rather than only some sectors have priority

- telematics services must be **interoperable** and meet common **European standards**.

- telematics systems and services must comply with current and **future European and national law**

The quintessence of the forum consensus can be summarised as follows: **Progress in telematics services is made by agreements between representatives from transport policy and industry.** These agreements determine a distribution of tasks according to which **the planning, organisation and operation of telematic services are to an essential degree the task of the private sector**, while **the public sector focuses on tasks concerning sovereign measures and involving legal obligations**.

5.8.2 System Architecture Approach

Under the background of the general strategy for ITS deployment in Germany there is currently no initiative ongoing with aiming at the development of an explicite “German national ITS architecture”. Integrated system architectures are developed within dedicated projects which interrelate different areas. The coordination of the development is carried out by the engineering work on requirements of practical interconnections. This “bottom-up approach” is accompanied by concertation mechanisms within the framework of national and international research programmes (most important current national programmes are : “Mobility and Transport in Intermodal Traffic” (MOTIV), “Mobility in Conurbation Areas”; international co-operation takes place in the EC research programmes, the TEN-Transport and TEN-Telecom lines and of course in the framework of standardisation bodies etc.). Thereby the development and application of standards is promoted. Example cases which show the strong engagement of the German industry and administration in the development of international standards for ITS are ALERT-C, DATEX, GATS, WAP, etc.

The federal government represented by the now Ministry of transport, building and housing (BMVBW) and by the Ministry of education and research (BMBF) supports ITS deployment by the elaboration of workable framework conditions. In detail this means

- Model road use contract for private telematics equipment on federal trunk roads.
- Model contract on the provision and sale of traffic data from federal traffic control centres.
- Model contract on the provision of traffic- relevant data between local authorities and private sector service providers.
- Agreement on Guidelines for the design and installation of information and communication systems in motor vehicles.
- Guidelines for co-operation between the public and private sectors in telematics services
- Act on Information and Communication Services
- Research projects as a basis for the introduction of telematics systems and services on the market

- Outline conditions at European level

  - Conditions on road transport telematics

  - Conditions on satellite navigation

5.8.3 Future Steps towards an European ITS Framework

Concerning the application of the KAREN results, the Federal Ministry of Transport will stimulate a critical survey by the responsible and interested parties on a broad basis. But up to now, there is no necessity recognised by the ministry to initiate a decision of applying the European ITS Framework Architecture produced by KAREN within the actual work. The application of KAREN results will mainly be left to the actors themselves as any directive on technical level aiming at a long term perspective is seen as a potential barrier for technological development.

The German authorities will continue to promote strongly the idea of creating suitable European Framework Conditions as essential prerequisite for operable European telematics services.

5.9 the UK

5.9.1 General situation

There is no national initiative existing to develop an overall national ITS architecture. But there are research activities like the UTMC (Urban Traffic Management and Control) Forum, which has been founded to help to address the problems arising from traffic in urban areas, the Department of the Environment, Transport and the Regions (DETR) has developed the UTMC concept. The aim of this five-year, £5 million initiative is to bring to the market open, modular systems that will support, in a cost-effective way, the management of transport into the 21st century in the UK and overseas.

5.9.2 UTMC background

Traffic congestion is a growing problem in most urban areas of the world. It threatens the economic well being of many towns and cities as well as affecting the quality of life of those who live and work there. Car ownership and use continues to grow strongly whilst public transport use continues to decline. Growing pressure on road space underlies increasing public concern about the environmental impact of road traffic, particularly in terms of air quality, but also noise and visual intrusion.

In response to these problems, transport policy is evolving to a ‘network management’ approach that makes best use of available road space and encompasses the management of all modes of transport and all travellers. Network management objectives can now include, in addition to minimising vehicle delays and stops:

- giving priority to public transport and other selected vehicles;
- improving conditions for pedestrians, the disabled, cyclists and other
- vulnerable road users;
- reducing the impact of traffic on air quality;
- improving safety;
- restraining traffic in sensitive areas;
- improved congestion and demand management.

To provide the tools to support efficient and effective network management and to facilitate competition in the supply of transport services, the Department of the Environment, Transport and the Regions (DETR) developed the UTMC concept.

UTMC systems have been specifically developed to:

- create modular systems which are capable of expansion and
- interoperation with other systems;
- build on and integrate existing systems;
- increase competition in system supply, expansion and operation;
- maximise the flexibility to meet evolving needs to and introduce new technology;
- provide quality information and the means to use this information,
- particularly to influence travellers;
- provide a means to move from existing systems to UTMC systems.

In short, the UTMC concept is the UK framework for the development and deployment of ITS (Intelligent Transport Systems) in urban areas. It does not define policy requirements but supports the chosen policy and provides the means to develop systems that can make best use of local opportunities.

6. Lessons learnt and recommendations for European scenarios

6.1 common findings and national peculiarities

The national ITS architectures are essentially still under development, however common trends can already be underlined:

- the national ministry of transport is usually the “Champion” (not e.g. the ministry of industry; interestingly, the countries considering architecture essentially as an industrial issue do not develop a national ITS framework: Germany, the UK);
- the national projects have connections with their respective ITS forum (as KAREN with ERTICO), and connections with KAREN as well;
- time horizon is generally around 10 years;
- a trend to widen the scope from road ITS towards truly intermodal ITS (especially in Finland).
- budgets vary, but are up to the order of magnitude of KAREN’s budget. We also note that European funding is a possibility (see e.g. France), notably via Euro-regional and Trans-European Network programmes.

There are also some differences worthwhile to note, as from country to country, focus is more on:

- case studies (France);
- a common framework and models for societal and technical issues (the Netherlands)
- organisational issues (Sweden, Italy);
- national deployment (the Netherlands, Finland);
- urban traffic management (the UK);
- regional integrated ITS (Flanders);
- public-private partnership and ITS market (Germany).

6.2 key issues and recommendations

6.2.1 deploying a national ITS architecture programme

Although most of national ITS architecture developments are only starting, some advices on how a national project could be managed can be given. First of all, the ministry of transport (the most “natural” and frequent Champion for such a project) should be assisted by a consulting organisation in management and procurement tasks, as it is really a full-time assignment. The project should be broken down into work-packages with concrete short term objectives, and should be designed from the beginning as having a follow-on, because it will be most fruitful if supported for several years.

Several issues should not be forgotten when designing the work-breakdown structure and budgeting the programme, including:

- involvement of actors and communication with the stakeholders;
- state of the art: bibliography, standards, actors, products and projects database;
- (if relevant) translation to/from English, liaison with other countries and the European level;
- training.

The first two tasks being more important when launching the project, the two last ones when completing it (or its first iteration: a successful project will have successive editions!).

Before starting the architecture, the scope of ITS systems involved should be clearly identified (what is outside: “terminators”, what is inside: “The System”) and a consensus should be reached by means of a proper involvement of all relevant actors. As already said in the first part of this document, national/regional architectures should benefit from the KAREN architecture models. Therefore, the focus should be:

- first on identifying which particular requirements were not taken account of in the European ITS Framework Architecture proposed by KAREN,
- then possibly adapt the functional architecture (but the effort could be reduced as KAREN has already developed a relatively comprehensive model), and
- then focus on the physical architecture: identify all actors, sub-systems, and flows, map to the relevant standards, consider various scenarios of applications, modalities of use, and allocation of functions to physical components; this should be a major tool for establishing discussions forums with the stakeholders.

An ITS national architecture should not be limited to the mere design of framework models, such as functional and physical architectures. It should include products such as:

- concrete recommendations for projects, technologies or applications of national interest
- concrete recommendations for follow-on actions
- a report for the European level
- information dissemination and exchange facilities (Web site)
- reference documents such as bibliography and projects/actors/products directories
- training material
- (possibly) ITS architecture design software tools

6.2.2 further developments

- Enhance links between national organisations and the EU level, as one cannot go very far without the other, and there is still a large effort before reaching the objectives. Links should be established on all aspects, including terminology, scope, methods, and tools.

- Ensure that national architectures take the TERN Euro-regional projects into account.

- Translate national/regional ITS architecture to English, so as to ease comparisons and links with the European ITS Framework Architecture.

- The major challenge is on deploying the national framework (or European framework, depending on the country) towards "real-world" projects. As KAREN has already developed a relatively comprehensive functional architecture, this may mean in particular that national architectures should focus on the physical architecture, where flows between sub-systems are identified and linked on the one hand to other connected systems, actors and users (terminators), as well as to communications standards and specifications between ITS sub-systems on the other hand.

- More communication is needed, at several levels, as confusion on scope is still prevalent and it is difficult if not impossible to address all issues within a single project. This documents is tentative to answer such kind of questions:

  - ✓ what is ITS? Which application domains are covered?
  - ✓ what is a framework architecture?
  - ✓ architecture-driven development: how do I plan, procure, design and deploy interoperable and dependable ITS systems?

- Very few convincing case studies show how an architectural approach has helped meeting requirements of all stakeholders over the whole lifecycle of an ITS system or application. Such case studies could be conducted at the European level.

- Today, relatively few ITS standards exist in Europe, and fewer if any include a certification procedure. A fortiori, conformance procedures to frameworks and architectures are still further away. A mid-term ITS standards programme should be elaborated, in conformance with the European ITS Framework Architecture.

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Annex 1 The System lifecycle

The following figure shows the development stages in the lifecycle of system. The different phases are subsequently explained.

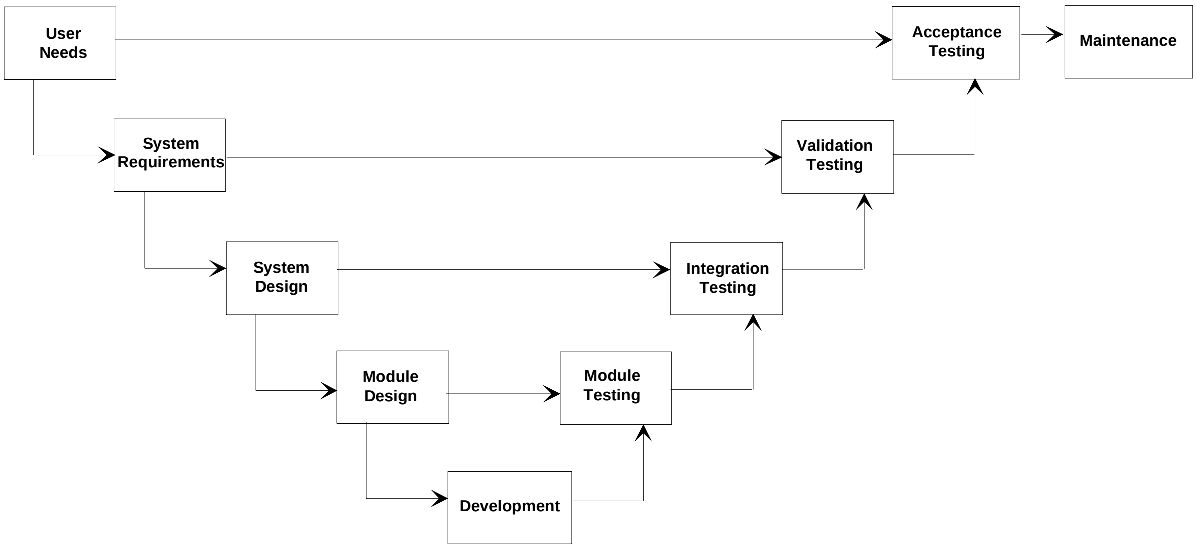

Figure 7: Generic System Engineering "V" Model

User Needs Phase

This is a preliminary step where the users of the system will define their needs in terms of requirements of the system, in a User Requirements Document (URD). The Acceptance Test Plan is issued, including a verification matrix towards the User Requirements Document. This was addressed by KAREN.

System Requirements Phase

This phase shall provide all the specifications of the system that satisfies the User Needs. They are brought together in the System Requirements Document (SRD). It shall also describe the external interfaces (hardware and software) to the system environment, in the form of Interface Control Documents (ICDs). This was partially addressed by KAREN.

System Design Phase

The objective of the System Design Phase is to define the ***system architecture*** that will satisfy the requirements of the SRD. The architecture is elaborated with a top-down approach, with the goal of maximum consistency and minimum coupling between subsystems in the architecture.

A System Design Document (SDD) is issued, including definition of the internal interfaces and a traceability matrix towards the SRD. An Integration Test Plan is issued, including a traceability matrix to the SDD. KAREN did not address the design aspect of this phase.

Module Design Phase

The aim of this phase is to define the detailed design of the hardware and software down to the module level and to describe the data structures. A Detailed Design Document (DDD) is issued. This is outside the scope of KAREN.

Development Phase

The aim of this phase is to produce the hardware and software code and to test it at the lowest level (i.e. the module). This is outside the scope of KAREN.

Module Testing Phase

The modules developed in the previous phase are tested in a stand-alone manner to ensure their correctness. This is outside the scope of KAREN.

Integration Testing Phase

The objective of the phase is to integrate the modules in order to achieve, through progressive integration, the complete system and to test at each level of integration. Integration tests are performed according to the Integration Test Plan. This is outside the scope of KAREN.

Validation Testing Phase

The validation tests are performed on the whole system. The purpose of this phase is to ensure that the system fulfils the requirements of the System Requirements Document.

The Validation Test Report includes a compliance matrix with respect to the SRD. This is outside the scope of KAREN.

Acceptance Testing Phase

The final aim of this phase is to demonstrate that the system fulfils the requirements laid down in the URD. The tests are executed in the operational environment at system level. For embedded software, the acceptance phase is preceded by a hardware and software integration activities and validation. The objective of these activities is to integrate validated software with validated hardware and then test the whole system.

The acceptance tests will be performed, according to the Acceptance Test Plan, on the integrated system (hardware + software) within an operational environment. The Acceptance phase shall end with the Acceptance Test Review. After the review, maintenance requirements are applicable. This is outside the scope of KAREN.

Warranty and Maintenance Phase

The purpose of the maintenance phase is to ensure that the product continues to meet the real needs of end users. The length of this phase, as well as responsibilities and roles during this phase, are to be defined in accordance with contractual requirements.

A Maintenance Plan is written as a general guideline for the maintenance phase. It should contain organisation, resources assigned to maintenance tasks, procedures for system modification and for documentation updating, maintenance operations description. This is outside the scope of KAREN.