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Executive Summary

The term "Cooperative Systems" is used, in general, to refer to those ITS which require V2V and V2I communications to provide applications and services. Especially the term considers those services, which contribute to the safety and efficiency of individuals and the road network as a whole.

Even though a reasonable number of projects and initiatives to develop such systems and analyse their impetus have been carried out, their real world deployment is literally in the fledgling stages.

One of the constraints to deployment is undoubtedly the fact that Cooperative Systems, by definition, involve players from many different sectors: the automotive industry, road operators and telecommunications operators, as well as road-based service and equipment providers. Real world deployment will require the definition of new relationships between these players as well as the solution of technical, organisational and business issues.

Further unsolved issues cover communication technologies and protocols, safety issues, security and privacy issues, and liability and legal issues.

The FRAME Architecture provides a tool and a methodological approach which can be used to help plan the deployment of integrated ITS for a nation, region, city or project. By creating various viewpoints – functional, physical, communications – a foundation can be produced to analyse and help solve the issues.

As stated above, Cooperative Systems involve a large number of players, but none of the stakeholders will be able to realise the systems by themselves alone. Cooperative system concepts must be defined and accepted across industries, operators, authorities and user sectors. However, the future rollout of Cooperative Systems will be facilitated if one type of organisation takes up the core responsibility and collaborates with the other entities involved. The leading entity will, according to their main area of interest, also have an impact on the principal scope of the scenario: road safety, efficiency or value-added services for the final users. The main scenarios identified therefore are: The industry driven scenario; the regulation driven scenario and the common European Mobility Scenario.

1 Introduction

1.1 Aim of the report

The primary objective of the E-FRAME project (2008-2011) has been to extend the European ITS Framework Architecture, often now called the "FRAME Architecture", to include the User Needs and functionality that correspond to the various Cooperative Systems developed throughout the EU since 2006, in particular by the Integrated Projects COOPERS, CVIS and SAFESPOT.

This report has been produced by Work Package (WP) 500 whose aim has been to examine the organisational and deployment aspects of cooperative systems and to suggest how the extended FRAME Architecture could be used to provide guidance in this area. This document is the final deliverable of Work Package 500 and brings together the results of the two earlier Deliverables, D5 and D6. It updates their conclusions and takes into account the developments which have occurred in this area in the meantime.

1.2 Background on Cooperative Systems

What are Cooperative Systems?

The term "Cooperative Systems" is used, in general, to refer to those ITS which require V2V and V2I communications to provide applications and services. There has, however, been a tendency to apply it to an ever increasing number of services and applications.

A feature of many Cooperative Systems is that they deliver data directly to a road user, usually the driver of a vehicle. This feature, however, has led some people to class *all* services that might be delivered to a driver as Cooperative Systems, even though some of them (e.g. the sale of insurance) have no direct relevance to the current driving task. This document will therefore primarily consider those Cooperative Systems that provide:

- Services and applications that deliver, to the driver of a vehicle, information which relates to the current driving task,:
  - o This information may, or may not, be personalised for each driver;
  - o Any information that takes account of the current, or anticipated future, traffic conditions must be delivered with the authority of the relevant local road authority or road operator.

Such Cooperative Systems will contribute to the safety and efficiency of the road network as a whole.

Current status of Cooperative Systems

Why is it so crucial to clarify the organisation and deployment issues facing Cooperative Systems? The answer lies in the nature of these systems and in their present status.

In Europe, a strong impetus to the development of Cooperative Mobility Systems was given by the European Commission in the period 2005-2010 through funding for pre-competitive research. A number of projects were supported and, as a result, numerous prototypes were developed and tested. This provided a 'proof of concept' of the cooperative mobility concept but it is generally agreed that they are still some way from commercial deployment. Many players are interested in exploiting the potential of such systems, but the complexity of implementing them, both technically and organisationally, mean that it not possible for one company of country to 'go it alone'. Although the projects did explore some of the organisational aspects and also put forward some potential business models, these were generally conceptual explorations.

One of the constraints to deployment is undoubtedly the fact that Cooperative Systems, by definition, involve players from many different sectors: the automotive industry, road operators and telecommunications operators, as well as road-based service and equipment providers. Real world deployment will require the definition of new relationships between these players as well as the solution of technical, organisational and business issues. A further constraint is the fact that the greatest benefits can be gained only if sufficiently high levels of penetration are reached. Achieving large scale deployment raises further issues relating to interoperability.

There are at present numerous groups and interests who are discussing: 'What happens next?' The main dilemma is: 'Who starts first?' In other words, who is prepared to invest in basic technologies and components? There is also much discussion on: 'Which are the basic areas requiring agreement and possibly standardisation?'

The main concern of the European Commission is to ensure that the Cooperative Systems of the future are compatible and interoperable across the whole of Europe. This was the same problem faced by transport telematics in the mid-1990s and the motivation behind the creation of the Framework Architecture. It is for this reason that FRAME is well suited to providing independent and neutral guidance on these issues and a systematic framework within which they can be analysed.

1.3 Background to FRAME

The FRAME Architecture provides a tool and a methodological approach which can be used to help plan the deployment of integrated ITS for a nation, region, city or project (see Figure 1). Thus the primary user of the FRAME Architecture is expected to be a local/regional authority or road operator.
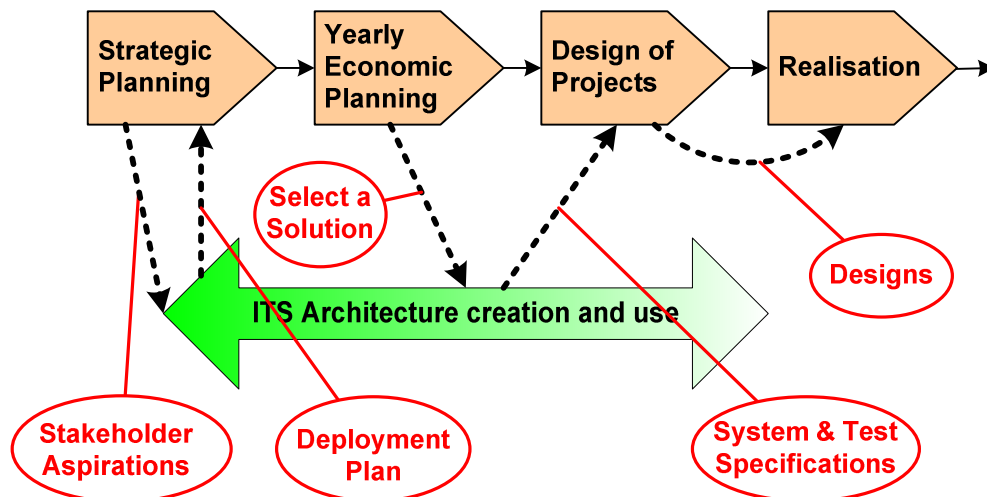
Figure 1: Deployment of Integrated ITS

The basis for a national, regional or project plan is a sub-set of the FRAME Architecture that contains models of the integrated ITS applications and services that will help to provide the road transport features and experiences, or aspirations, desired by its various stakeholders. The models that make up the sub-set ITS architecture will comprise, typically, a set of functions that describe what will be done (Functional Viewpoint), a Physical Viewpoint that shows where these functions are to be located (e.g. in-vehicle, in a roadside unit, a hand-held (mobile) device, at a Traffic Management Centre), and a high level analysis of the communications requirements necessary to pass data between those locations (Communications Viewpoint). These viewpoints can then form the basis of various analyses, as shown in Figure 2. Of particular interest for this document are the outputs labelled "Organisational Issues", "Deployment Programme" and "Risk Analysis", and how they relate to current (August 2011) knowledge of Cooperative Systems.
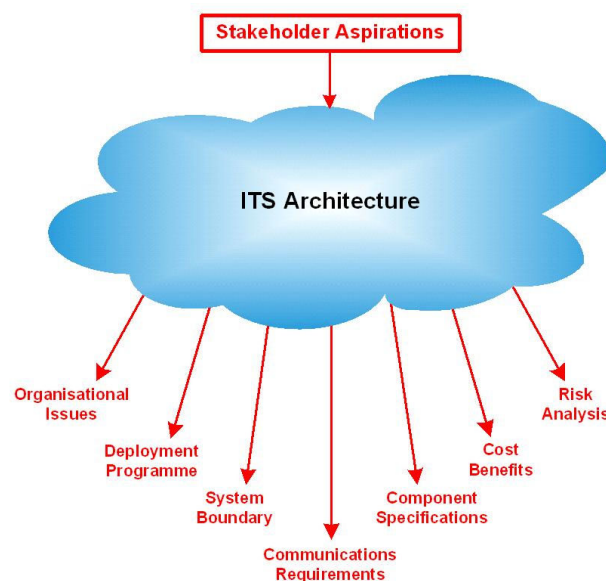
Figure 2: Some outputs from analysing an ITS architecture

For further information on FRAME and the E-FRAME project please visit the FRAME website at: www.frame-online.net.

1.4   Scope of the deliverable

The document is primarily targeted at local/regional authorities and road operators, but also other stakeholders such as service providers, groups from automotive sector or telecom who need to, or wish to, give some consideration to supporting Cooperative Systems as part of their integrated ITS applications and services may also find this report helpful. Since other reports produced by this project, e.g. Deliverable D7/8, provide examples of ITS architectures for Cooperative Systems, this document discusses some of the other issues that need to be considered for the deployment and integration of Cooperative Systems. These include, but are not exclusive to, topics such as who will own and manage the various components that make up Cooperative Systems (Organisational Issues); how will they justify their costs/investments (Business Cases); what is needed to ensure that they work properly (Deployment Issues); and what are the various liabilities surrounding the use of Cooperative Systems (Risk Analysis).

"There is a long way to go before the cooperative vision becomes a reality, but {CVIS, COOPERS and SAFESPOT} have brought us closer to seeing cooperative safety and efficiency applications on European roads" [TTI 2010]. This document will therefore derive its contents from the lessons that have been learned so far from these, and subsequent projects. It is too early to provide many definitive solutions, but it possible to describe many of the issues/problems that have already been identified, and to discuss their possible solutions and consequences.

The FRAME Architecture provides a common model that is independent of any commercial stakeholder, and this document will show how it is able to support many of the analyses and studies that are required to progress towards the full deployment of Cooperative Systems.

1.5   Overview of the document structure

Chapter 2 deals with the deployment of ITS in general including various pre-requisites. It also describes the role of an ITS Architecture in deployment.

Chapter 3 gives an overview of the motivation behind the research activities carried out in Europe in the field of Cooperative Systems over the period 2005 - 2010 and describes the main achievements. It focuses principally on the three large EC Integrated Projects, SAFESPOT, CVIS and COOPERS.

Chapter 4 deals with one of most urgent questions: what are the first steps needed and who will make the necessary investment in the deployment of Cooperative Systems? In

particular, it examines some of the potential deployment scenarios and the business and regulatory framework which is necessary to enable their real world deployment.

Chapter 5 analyses the main constraints for the deployment of Cooperative Systems, since Cooperative Systems, by definition, involve players from many different sectors, this are to a large part organisational ones. In addition, the chapter deals with issues related to communication technologies and protocols, safety issues, security and privacy issues, and liability and legal issues.

Chapter 6 outlines the potential of FRAME to contribute to the deployment of Cooperative Systems. Therefore it explains the methodology to create an ITS Architecture, including the various viewpoint, such as the functional or physical ones and how they can be used.

Chapter 7 provides conclusions and summarises recommendations for a successful roll out of Cooperative Systems.

2 The deployment of Intelligent Transport Systems

2.1 From R&D to implementation

Since the mid-1980s, when the first ITS programmes were launched in Western Europe, Japan and US, great progress has been made in the development of ITS services. All major cities and regions in these regions now use a range of ITS to make transport more efficient and safer, and to provide information services for travellers. Nevertheless, the wide scale implementation of these services has always lagged a long way behind the development of the technologies themselves. One of the lessons learned during this process is that ITS R&D is much easier than ITS deployment! In fact a recurring theme of discussions with ITS experts around the world, and a question frequently posed in congresses in this field is: "Why is it so difficult to deploy ITS?"

One of the answers lies, ironically, in the fundamental strength of ITS. The basic insight of ITS is that the infrastructure and the vehicles that run on it form a system. Information and communication technologies make it possible to connect together previously independent elements: the vehicles, the infrastructure-based components and the users of the transport system. Through this linkage (by means of the exchange of data), it has been shown that substantial safety and efficiency improvements, and a reduction in congestion, can accrue. It has also been demonstrated that when several ITS services are connected within a single integrated system, the benefits are even greater. It is however this systemic nature of ITS which is the most significant barrier to its deployment.

2.2 The need for organisational and technical harmonisation

In order to deploy an ITS service, it is necessary to resolve problems of both a technical and an organisational nature.

ITS implementation frequently involves both public and private organisations, including local authorities, public transport operators, equipment manufacturers, service providers. Before a service can be deployed successfully, their relative roles and responsibilities (financial and organisational) must be clearly established. This process is not always easy, especially where innovative services are concerned. New forms of collaboration for both public and private sector organizations are needed. Since they have previously focused on their own specific aspects, without the need to worry how they would operate as part of an integrated system, this kind of institutional change is difficult to achieve.

From a technical point of view, the systemic nature of ITS leads to other challenges. The need to make connections between the various elements of the system means that standardised interfaces and protocols for data exchange must be set up. Without such agreements, the deployment may be severely constrained (e.g. by operating in only limited conditions or geographical areas). Services with an international reach require

harmonisation between countries, and without such harmonisation, market viability is likely to be compromised.

2.3 Pre-requisites for ITS deployment

A useful statement of the basic conditions which need to underlie the implementation of ITS is made in the EC Directive: 'Framework for the deployment of Intelligent Transport Systems'. This document declares that "the selection and deployment of ITS applications and services shall be based upon an evaluation of needs, and shall respect the following principles":

- Effectiveness – the ability to make a tangible contribution towards solving the key challenges affecting road transportation in Europe (e.g. reducing congestion, lowering of emissions, improving energy efficiency, attaining higher levels of safety and security);

- Cost-efficiency – the ratio of costs in relation to output with regard to meeting objectives;

- Geographical continuity – the ability to ensure seamless services across the Community, in particular on the trans-European transport network;

- Interoperability – the ability of systems to exchange data and to enable information and knowledge to be shared;

- Degree of maturity – the level of development.

Only once an ITS service, or set of services, has shown that it meets the above conditions, and has a valid business case, can the second stage of deployment begin. This stage includes the following activities:

- Component development and procurement

- Infrastructure development and procurement

- Implementation and commissioning

- Set-up of the management structure

- Training of users

- Set up of maintenance & support activities

- Building user awareness of new services

The successful procurement of Intelligent Transportation Systems (ITS) is a challenging task for national, regional and local transportation agencies. The procurement process must

be flexible to accommodate the uncertainties of complex system acquisitions, while at the same time structured enough to ensure that the responsibilities of the participants are fully defined and their interests protected. It should also ensure that the most qualified organizations are selected for the system implementation.

2.4 The new 'Cooperative' mobility services

The above considerations become even more crucial where Cooperative Systems are concerned (please refer to Appendix A for a full definition of Cooperative Systems). They involve far more complex interconnections than conventional ITS and, as a result require new forms of collaboration between many different types of stakeholder and new standards and protocols for the interfaces and communications.

Figure 3 provides an illustration of the complexity of the interactions between the elements of a Cooperative Mobility service.
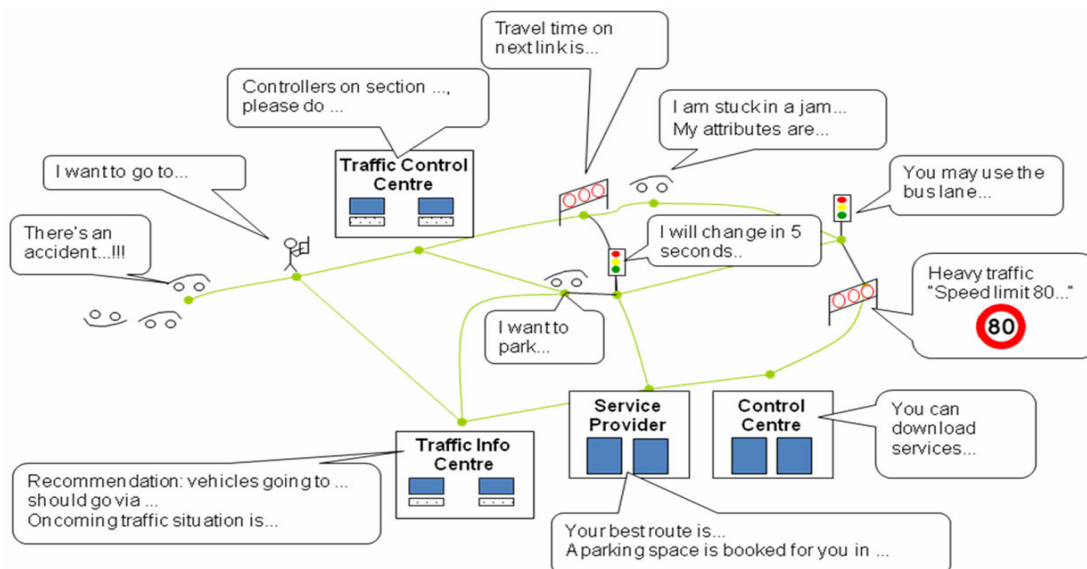
Figure 3: The systemic nature of Cooperative Systems (© CVIS)

Many prototype Cooperative Systems have been developed in recent years in European research projects such as CVIS, SAFESPOT and COOPERS (see chapter 3), and their technical feasibility demonstrated. Further follow-on projects (see chapter 3.6) are currently investigating the potential impact of the systems in real world conditions and providing more detailed specifications. Some work is also underway on standardisation. There are, however, in most cases, no immediate prospects for large scale deployment and realistic business models are still lacking.

It is therefore crucial at this stage to identify ways in which deployment can be facilitated and the constraints removed.

2.5 The role of the FRAME Architecture

An ITS Architecture is not an end in itself; it is a means to an end and thus can be considered to be a tool. In particular, it provides the basis on which the planning, including the creation of the business case, and deployment of ITS can take place. Thus an ITS Architecture provides a mechanism whereby ITS services can be understood at the 'application' level, and the principal components needed to provide them can be identified. The FRAME Architecture provides a common approach and, now that it has been extended to include Cooperative Systems as part of the E-FRAME project, it can be used by all stakeholders as a "language" to plan Cooperative System applications and services, in particular their integration with each other, and with the remainder of ITS. This is done by creating a logically consistent sub-set of the FRAME Architecture that contains all the ITS applications and services under consideration.

As well as being able to identify the order in which development and installations need to take place, much of the technical content of a Call for Tender (Request for Quotation – RFQ) can also be provided from the contents of the sub-set of the FRAME Architecture. ITS deployment, however, is also influenced heavily by a variety of organisational issues, in particular the relationship between the public and private sectors, and the business relationships between service providers. The sub-set ITS Architecture can also be used to examine such issues, since the various components and flows of data/information will be clearly identified.

For detailed information how the FRAME Architecture can help to foster the deployment of Cooperative Systems please refer to chapter 6.

3 Cooperative Systems: Initial research

The aim of this chapter is to give an overview of the motivation behind the research activities carried out in Europe in the field of Cooperative Systems over the period 2005-2010 and to describe the main achievements. It focuses principally on the three large EC Integrated Projects, SAFESPOT, CVIS and COOPERS.

3.1 Motivation behind Cooperative Systems research

The following excerpt from the eSafety Forum explains the background and identifies the principal reasons for the substantial investment by the European Commission in the development of cooperative systems [ESAFETY 2004]:

"Under the European Framework Research and Development Programmes projects have been funded which have developed and demonstrated traffic telematics systems aimed at making transport safer, more efficient and effective, and more environmentally friendly. Many of these systems were aimed at improving the transport infrastructure, while others were based in the vehicles themselves.

Mostly, the systems developed by these projects have operated as autonomous or stand-alone. They hold the great potential to improve road safety and efficiency. Nevertheless there are limitations to what can be achieved by systems based solely on the road, or solely in the vehicle, e.g. dealing with far distant threats or anticipating road difficulties with time margins compatible to the driver response time.

This requires another class of systems whose intelligence is distributed between vehicles and roads. As the capacity and flexibility of information technology and communications increases, and costs decrease, it becomes feasible to develop Cooperative Systems in which the vehicles communicate with each other and the infrastructure. In this way co-operative systems will greatly increase the quality and reliability of information, support and protection available to road users, and the cost-effectiveness of applications."

The text underlines that the main foreseen benefits of Cooperative Systems relate to the *quality and reliability* of the information generated, and that this information can be produced in a cost-efficient way, and provide useful services and increased safety for road users. In conclusion, the expert group stated that:

"Road operators, infrastructure, vehicles, their drivers and other road users will co-operate to deliver the most efficient, safe, secure and comfortable journeys. The vehicle-vehicle and vehicle-infrastructure co-operative systems will contribute to these objectives beyond the improvements achievable with stand-alone systems." [ESAFETY 2004]

The impulse for this research therefore originated from the desire to supersede the limits of autonomous vehicle based and infrastructure based applications by exploring the potential of V2V and I2V data exchange.

3.2 The major European research projects

A major impetus to the development of Cooperative Systems was given by the European Commission through the co-funding of a number of research projects, as part of the 6th Framework Programme. Among these were three large scale Integrated Projects (IPs), CVIS, SAFESPOT and COOPERS as well as several smaller initiatives.
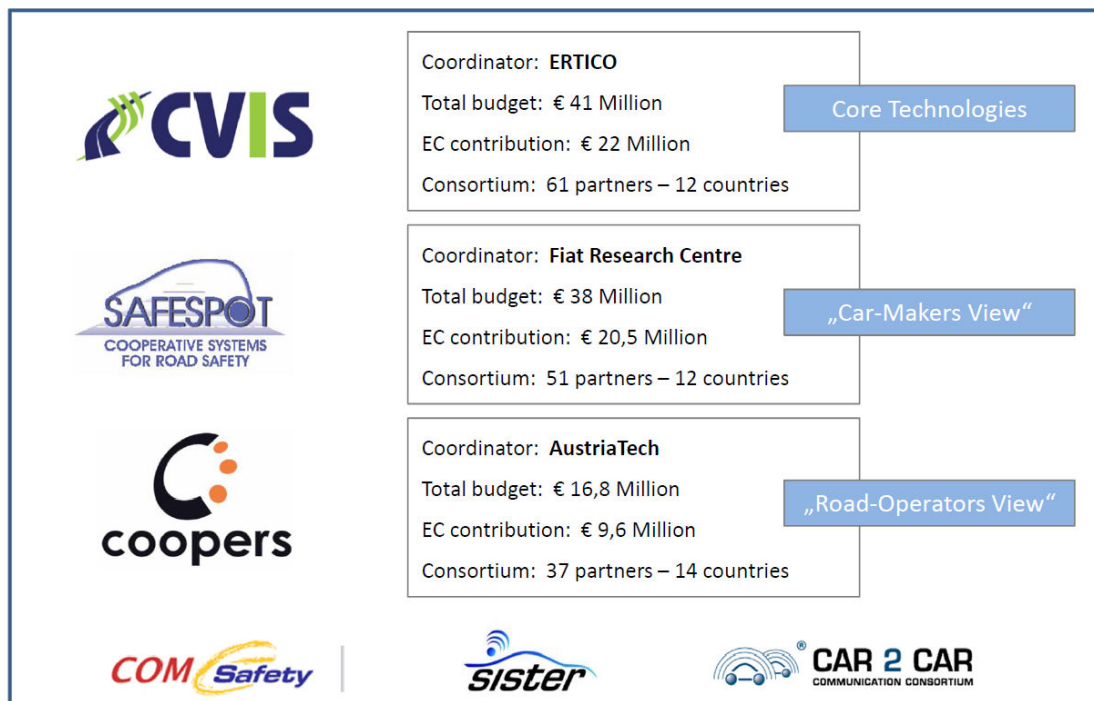
Figure 4: Major European projects regarding Cooperative Systems

As indicated above, CVIS, SAFESPOT and COOPERS alone accounted for over 50 million euros. Although the projects had a considerable amount of common ground in terms of their general aims, each one had a specific focus:

- CVIS concentrated on the development of the core technologies;

- SAFESPOT focused on developing cooperative applications for highly safety-critical tasks and was more vehicle-oriented;

- COOPERS explored cooperative systems from the road operator side and developed a range of systems using V2I communications only.

The following sections describe these three projects in greater detail.

3.3 CVIS

The goal of CVIS was to prove that the concept of cooperative systems was feasible and to demonstrate their potential to improve safety, efficiency and driver comfort. It also aimed to

create a wireless network between and amongst vehicles and the infrastructure, and to create an open platform for V2V and V2I cooperative services.

The technology sub-projects developed extended positioning components with real time lane-level map-matching. CVIS adapted the Local Dynamic Map (LDM), developed within the SAFESPOT project. CVIS algorithms were implemented in the LDM to calculate the traffic state through the fusion of sensor information from infrastructure-based equipment (e.g. stationary loop detectors) or vehicle-based sensors, and incident information.

This data was made available not only to other vehicles and the infrastructure but also to the cooperative monitoring (COMO) service centre to calculate the global traffic state.

The CVIS high-level architecture consisted of a peer-to-peer network with no particular hierarchy, which enables maximum flexibility for deployment: and any entity could communicate with any other entity. Vehicles could at one moment be service providers for a data centre and at the next moment be the client for a traffic information service.
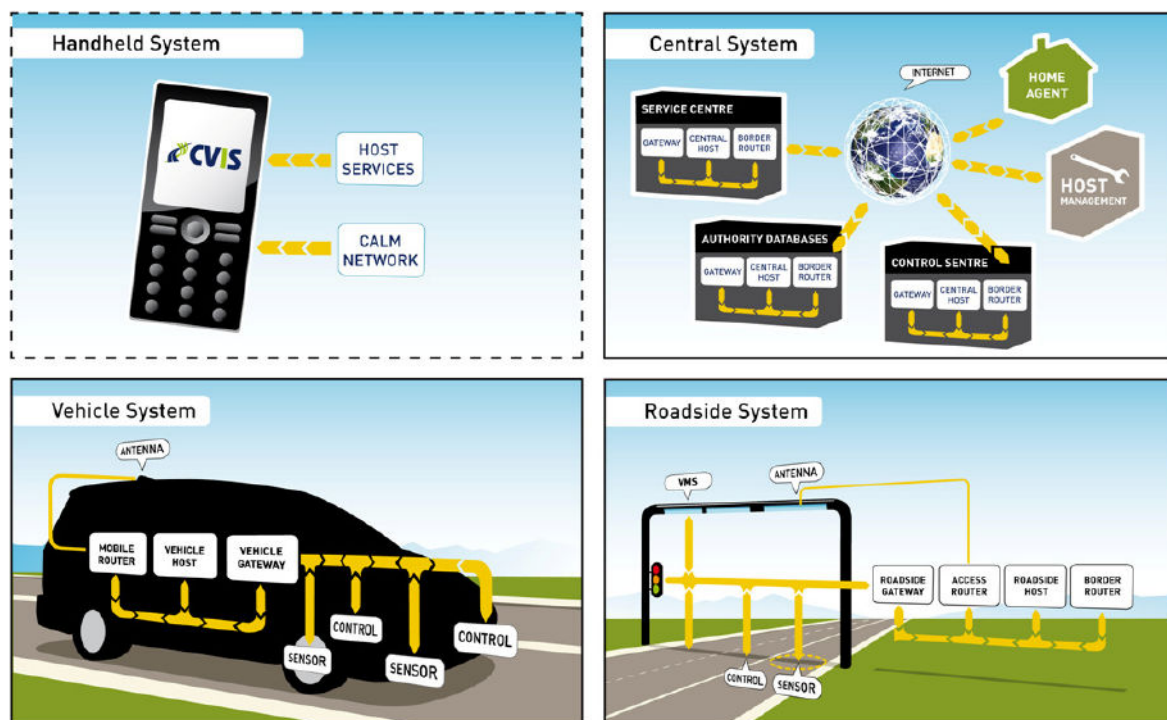
Figure 5: CVIS High Level Architecture [CVIS]

CVIS Applications are grouped into three groups – urban, inter-urban and freight & fleet, but it also demonstrated combined 'packages'.

Cooperative Urban Applications (CURB) involved individual on-trip information and re-routing based on accurate area-wide travel time information derived from floating vehicle data. These allow road operators to improve their traffic management strategies by communicating directly with road users. Applications include giving priority to emergency vehicles at intersections, speed advice for ensuring 'green' at intersections and bus-lane sharing by other vehicles to increase road capacity.

Cooperative Inter-urban Applications (CIN) improved drivers' awareness of conditions on the road through warnings about road incidents, bad weather and traffic conditions, speed regulations and the detection of ghost drivers (whose vehicles are travelling the wrong way along a road or carriageway).

Cooperative Freight and Fleet Applications (CF&F) offered the possibility for professional drivers and fleet managers to book rest area parking and (un)loading spaces. The latter in order to achieve shorter delivery times, less fuel consumption and an overall improved traffic flow. CVIS also developed systems for dangerous goods transport monitoring and access control to restricted areas.

Reference: http://www.cvisproject.org

3.4 SAFESPOT

The objective of the SAFESPOT cooperative mobility services (or 'applications') was to warn drivers of safety-critical situations on the road network, i.e. to implement the 'Safety Margin Assistant' concept. The detection of such situations is based on data from vehicle-based sensors and roadside sensing systems. Warning messages are communicated to the drivers of approaching vehicles via the HMI of equipped vehicles or via roadside devices (warning lights or VMS).

All SAFESPOT applications involved two common elements: the Local Dynamic Map (LDM) and the VANET (Vehicle Ad Hoc Network) communications system, which used the 802.11p protocol. The LDM is a geo-referenced database which stores information from the sensing systems.

The applications developed by SAFESPOT project fall into two major categories: vehicle-based and infrastructure-based. This distinction relates as to where the 'intelligence' of the system is located, i.e. where the main data processing takes place and the warning message is generated.

The vehicle-based applications can be grouped into four clusters:

Table 1: Clusters and Applications developed in the SCOVA subproject

CLUSTER	APPLICATION
Lateral Collision - LATC	Road Intersection Safety
	Lane Change Manoeuvre
	Safe Overtaking
Longitudinal Collision - LONC	Head On Collision Warning
	Rear End Collision
	Speed Limitation and Safety Distance
	Frontal Collision Warning

CLUSTER	APPLICATION
Road Departure - RODP	Road Condition Status – Slippery Road
	Curve Warning
Vulnerable Road Users - VURU	Vulnerable Road User Detection and Accident Avoidance

The infrastructure-based applications can be grouped into five clusters:

Table 2: Clusters and Applications developed in SP5 – CoSSIB

CLUSTER	APPLICATION
Speed Alert	Legal Speed Warning
	Critical Speed Warning (dynamic)
	Excessive Speed Alert
Hazard & Incident Warning	Obstacle on the road
	Wrong Way (Ghost) Driver
	Hazardous driving conditions: low friction/ low visibility
Intelligent Cooperative Interactive Safety – IRIS	Basic application at an urban intersection
	Emergency vehicle support
Road Departure Prevention	Road Departure Prevention - Alpha
	Road Departure Prevention - Beta
Safety Margin for Emergency and Assistance vehicles	Safety Assistance Vehicle: signalling at events
	Safety Margin for Emergency Vehicle crossing an intersection

The SAFESPOT project demonstrated and tested these applications and use cases in six different test sites, some of which were shared with the CVIS project.

Figure 3: SAFESPOT Test site locations

Among the main achievements of this project were:

- Demonstration of the ability to communicate messages between equipped vehicles, and between a roadside unit and passing vehicles over a distance of around 500m (over greater distances using the multi-hop mode). Vehicles constantly beaconed a basic message set consisting of speed, ID, position, timestamp and heading);

- The successful use of the Local Dynamic Map (dynamic database);

- The compilation of a large library of data formats covering all foreseen types of data.

Since they all involved safety-critical situations, most tests were carried out on Test Tracks or in controlled conditions and not for extended periods of time.

Reference: http://www.safespot-eu.org/

3.5 COOPERS

COOPERS dealt with the application of real time data communication between the infrastructure and the vehicle to exchange safety-related information (e.g. speed, road conditions, local traffic information, etc.) with respect to the actual conditions of a certain road segment. The services defined in COOPERS include:

Table 3: List of COOPERS services

Primary services	Secondary services
S1: incident management	S7: ISA (Intelligent Speed Adaption) with infrastructure link
S2: road/weather condition warning	S8: international service handover
S3: roadwork information	S9: road charging to influence demand
S4: lane utilisation information	S10: route navigation – estimated journey time
S5: in-vehicle variable speed limit information	S11: route navigation – recommended next link
S6: traffic congestion warning	S12: route navigation – map information update
	S13: floating car data (FCD)

The COOPERS system was tested under real road conditions on heavily-used sections of European motorways in four different test sites.

Figure 6: Overview of COOPERS test sites (French site split into several sections)

During the field tests, the motorway operators gained important insights regarding the development, installation, and use of Cooperative systems. Those experiences are also vital with the outlook on future deployment of Cooperative Systems and are summarised below.

- The installation requirements for the R&D prototypes of the COOPERS system were very demanding, as they had to be integrated into a complex highway infrastructure during operation, and were required to withstand daily operation in a challenging environment.

- The coding of traffic information using TPEG worked well on all sites and with all communication technologies. The COOPERS system was hardware independent; and its compatibility with CALM-IR, DAB, and GPRS demonstrated during technical tests (also presuming an easy porting to WiMax).

From the organizational/operational point of view (regarding the co-operation of motorway operators), it was concluded that:

- The definition of a common agreed set of services (that can be employed at a European level) and the resulting specifications of the common software extensions in the TCCs and CSC were an important first step towards harmonization of the service quality of traffic information services on motorways, and an important contribution towards a pan-European co-operative traffic information and management system.

- The tests permitted an initial estimate of the costs of installation and operation of such systems, and also identified missing elements in the TCC functionality which will remain research topics (e.g. the detection of irregular traffic conditions via sensor fusion).

- The long demonstration phase made it possible to compare the new equipment with already installed systems, and compare their performance and operational stability.

- The successful demonstration of the COOPERS systems in four test sites with different features suggest that it can be ported to almost any highway in Europe.

- The communication exchange between neighbouring TCCs demonstrated at Site 1 and the international transmission of services (at the Cooperative Mobility Showcase in Amsterdam), improved the cooperation of highway operators involved in the field tests.

The previous sections show that numerous applications have already been developed with the aim of improving safety, increasing traffic efficiency, reducing congestion or providing value-added services for drivers.

Also various validation tests have been undertaken to demonstrate functionalities; they successfully provided evidence of the ability to communicate dynamic geo-referenced databases and other content.

But despite some discussions of hypothetical future business plans it was clear, that Cooperative Systems are still some way from deployment when the three IPs closed in 2010. For CS to become reality many issues have to be resolved first, which are analysed in more detail in chapter 5.

3.6 Follow-up projects and initiatives

Since the closure of IPs in 2010 there have been numerous follow up initiatives all of which in some way are attempting to bring CS closer to deployment in Europe. A summary of those can be found in the following sections, for more detailed information please refer to Appendix B.

3.6.1 EC funded projects

After the first round of large development projects, the EC funded a series of more 'deployment oriented' projects as, for example, field operational tests and CIP (pilot) projects.

Field operational test funded by the EC FP7 program are, for example, Drive C2X, TeleFOT or FOTsis (European Field Operational Test on Safe, Intelligent and Sustainable Road Operation), which is a large-scale field testing of the road infrastructure management systems needed for the operation of close-to-market cooperative I2V, V2I & I2I technologies.

Overall an amount of approximately 50 M€ is being invested by the EC for such field operational tests. In addition, a variety of additional both larger and smaller tests have been performed, are in progress or are planned.

Further to these field operational tests, so called pilot projects have been set up which implement traffic information services in the real world environment of various test areas.

The Co-Cities project, for example, is setting up a mobile reference platform in cities and urban areas in order to introduce and validate cooperative mobility services.

COSMO, also an EC funded pilot, makes detailed measurements of the performance of a number of cooperative systems with regard to their ability to reduce CO_2 emissions and improve energy efficiency in comparison with conventional systems.

Also pushing the deployment of Cooperative Systems are EasyWay and the SMART studies 063 and 065. EasyWay is a deployment project of almost all European road operators with its duration extending only to 2013. It has its own task force which is dealing with Cooperative Systems. As a result, this task forces has proposed so called first priority cooperative services as being:

- Hazardous location notification
- Traffic jam ahead warning
- Road works warning
- Decentralised floating car data
- Traffic information and recommended itinerary
- In-vehicle signage (incl. speed management)

- Automatic access control / parking management (incl. Intelligent Truck Parking)

A similar proposal; including more details (e.g. a cost benefit analysis) is being done by the SMART063 study.

Taking all together, quite a large amount of money is being invested by the EC to start various projects which should help to foster the deployment of Cooperative Systems.

3.6.2 Standardisation activities

Due to the recent developments in Cooperative Systems, which have been described above, the EC has focused efforts on harmonisation needs. Such harmonisation can, next to others, be steered by timely standardisation. The main activities that have taken place in this field are:

- The EC mandated M453 coordination and allocation of responsibilities of two European SDOs on the creation of standards in ITS, namely in Cooperative Systems. With regard to this mandate there was also an ETSI workshop on Cooperative Systems,

- The establishment of joint Cooperative Systems working group in CEN and in ISO, as a result of Cooperative Systems projects (e.g. COOPERS, SAFESPOT, CVIS), so that standards developed in Europe will have their mirror image in world standards and

- The EU-US Task Force with a primary goal to harmonize R&D projects and implementation activities between EU and US

Figure 7 provides an overview of the standardisation bodies engaged in ITS and their relationship. For further information on standardisation activities please refer to Appendix C and the E-FRAME Deliverable D16 available from the website www.frame-online.net.
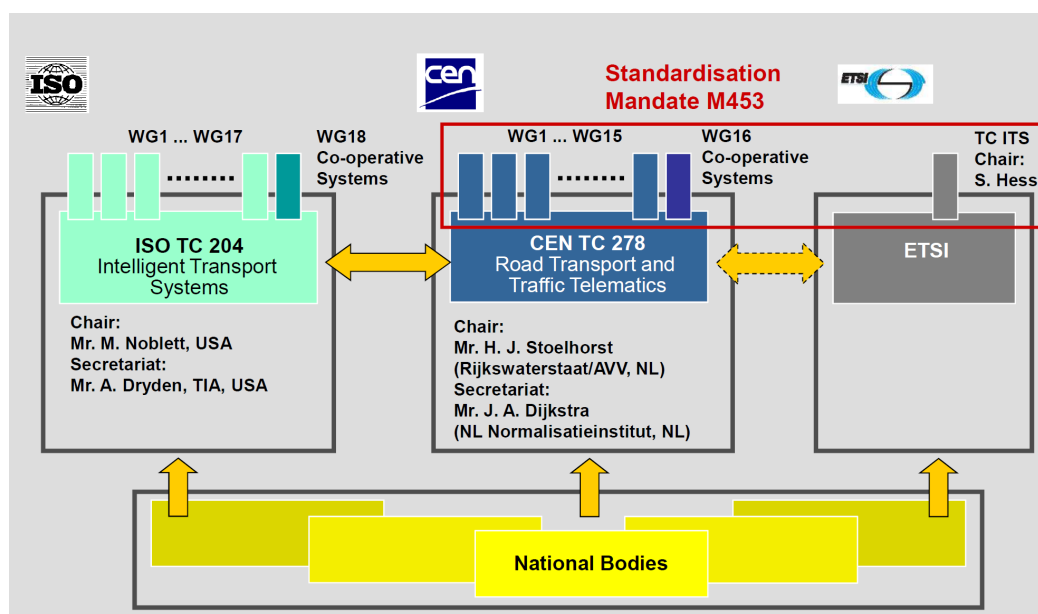

Figure 7: Standardisation bodies involved and M453 [SCHADE 2011]

3.6.3 Other groups and initiatives

IN addition to the aforementioned EC initiatives and organisation bodies, various other groups are working for a deployment of Cooperative Systems.

ERTICO - ITS Europe for example was founded at the initiative of leading members of the European Commission, Ministries of Transport and the European Industry. It is a multi-sector, public / private partnership organisation pursuing the development and deployment of Intelligent Transport Systems and Services (ITS).

Further, individual industries, e.g. the automotive sector, telecoms, road operators, service providers etc., are making their own studies of potential business opportunities. One of the main organisations representing the industry in this regard is the Car2Car Communication Consortium, which was initiated by European vehicle manufacturers supported by equipment suppliers, research organisations and other partners. Its main objectives are, for example, the development and release of an open European standard for cooperative ITS, specifications and contributions to the standardisation organisations including, in particular, ETSI TC ITS in order to achieve common European standards for ITS, and the development of realistic deployment strategies and business models to speed-up the market penetration.

Another initiative to be mentioned with regard to the deployment efforts of Cooperative Systems is COMeSafety (Communications for eSafety). COMeSafety is a Specific Support Action (SSA) of the European Commission within the Sixth Framework Programme. In FP6, three major Integrated Projects, COOPERS, CVIS and Safespot, and several STREPS have developed Cooperative Systems to improve road safety and traffic efficiency in support of the European Commission's eSafety Forum and Intelligent Car Initiative. The COMeSafety Support Action had complemented this research, working towards interoperable solutions. COMeSafety set the ground for compatible systems by defining a common European ITS communications architecture and successfully pushing for the allocation of a common European frequency for ITS road safety applications in the 5,9GHz band. See the website www.comesafety.org for more information.

3.7 Conclusions

At the time of writing, and just over one year since the closure of the major Cooperative Systems IPs, there are numerous activities in progress and a large amount of discussion on the subject of CS. It is useful therefore to review the current situation in the light of the five criteria presented in section 2.3 as pre-requisites of ITS deployment:

- Effectiveness (impacts in relation to reducing congestion, emissions, etc.)
- Cost-effectiveness (business opportunities)
- Geographical continuity
- Interoperability
- Degree of maturity

With regard to the ***effectiveness and maturity*** of CS applications, reliable and detailed data is still required on the impact of cooperative systems on traffic efficiency, safety and the environment in real world conditions, before public authorities, road operators and automobile manufacturers are prepared to invest in CS. There also needs to be evidence of greater maturity of the systems, e.g. in connection with their reliability, accuracy and continuity of service. Providing this kind of information and experience is the objective of the FOTS and CIP projects, which are implementing some of the most promising systems and making measurements of their impacts. One of their aims is to produce specifications and quantified results which will help to raise awareness and provide convincing evidence of the benefits of CS applications.

In relation to the ***cost-efficiency*** of CS, many individual industries and sectors interested in exploiting the business opportunities of CS are analysing the prospects. These are inevitably seen from the industry's own point of view and are based on some interesting hypotheses about the 'readiness to pay' on the part of the final user. The main difficulty is that since CS, by definition, involve numerous players from very different industry sectors, it is difficult, if not impossible, for a single industry to produce a convincing business model in isolation from the other sectors. The big question which remains open is; who will start off the process? In other words, who is prepared to make the initial investment? This question applies equally to the installation of the necessary roadside equipment, the setting up of the telecommunications networks and also on-board equipment.

The ***geographical continuity and interoperability*** of CS is one of the main concerns of the European Commission, who wish to ensure that seamless pan-European deployment is achieved and that incompatible 'technology islands' are avoided. It is also in the interest of the industrial players if the required level of penetration is to be achieved. Important work is in progress in the area of standardisation (discussed in greater detail in Deliverable D16). In this area it is especially crucial that there should be a neutral 'overview' representing the high level European interests, able to bring together all the individual industries.

4 Deployment scenarios for Cooperative Systems and possible 'roadmaps'

4.1 Introduction

In the previous chapter, the development and demonstration activities of some Cooperative Systems projects have been presented with a review of the current state-of-the-art. This chapter deals more specifically with two of the most urgent questions: what are the first steps needed, and who will make the necessary investment? In particular, it examines some of the potential deployment scenarios and the business and regulatory frameworks which are necessary to enable their real world deployment. For this development to happen, a number of issues need to be addressed, among them are:

- Which are the most likely deployment scenarios?

- What roles should be played by the stakeholders, in particular operators of roads and highways?

- How will the investment and expenditure from public sources be justified?

- Which practicalities have to be solved before the deployment can go ahead?

- What about the technical questions (standardisation etc.)?

Above all, this chapter discusses how FRAME can help to identify the answers to these questions which will be in the best interest of final users as well as of European industry.

In order to investigate these questions, the following sections provide a review of the scenarios that have already been identified by the projects which have finished, and present the most promising ones in further detail.

4.2 Deployment Scenarios

4.2.1 CVIS-identified scenarios

In order to investigate future pathways towards the implementation of Cooperative Systems, the CVIS-project considered three different scenarios [ROSENQUIST 2010], starting from three different angles of approach: (1) public, (2) commercial and (3) personal. Figure 8 shows these scenarios in relation to government involvement and market demand.

In the first scenario the public sector considers the implementation of cooperative systems to be an important means to contribute to policy goals regarding mobility, traffic efficiency, safety and environmental impacts [VERWEIJ 2010]. The public sector would take the initiative for deployment by providing public funding and promoting clear standards. "Road operators and vehicle manufacturers would join in the effort of building new communication and cooperative capabilities in cars, trucks and buses. With public policy favouring cooperative ITS in place and the promotion of a European harmonised technology platform

including IPv6, service providers would grasp the opportunity to deliver services and content through these new channels."
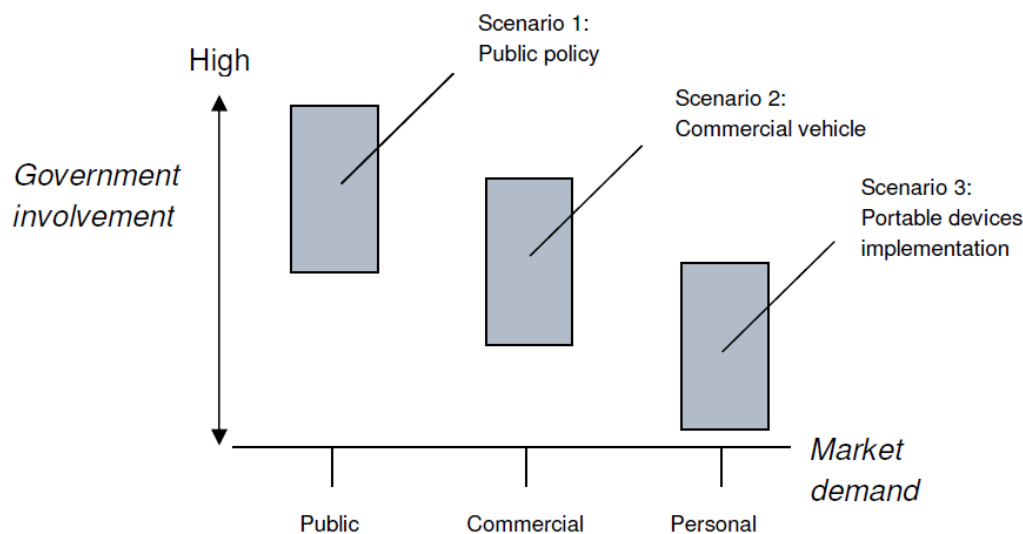
Figure 8: Deployment scenarios studied in the CVIS-project [ROSENQUIST 2010]

In this first scenario "public transport might be amongst the first to reap the benefits as cooperative traffic management began to reduce congestion "hot-spots" in urban areas and buses and trams began to benefit from priority throughout the road network. Safety would improve, with fewer fatalities and severe accidents thanks to the eCall service, hazard and road obstacle warnings, speed advice and ghost driver detection applications. Average traffic speeds would increase due to a better traffic flow management, and public confidence in public transport would improve, leading to greater use of collective transport." [ROSENQUIST 2010]

The second scenario focuses on commercial freight and fleet services. EU financial support for clean goods vehicles and for the cooperative structure stimulates the introduction of cooperative ITS services in the commercial transport. "Access control for heavy goods vehicles is introduced in cities and truck tolling is implemented on highways. Trucks can load and unload at specially equipped transhipment and rest areas. eCall is mandatory in all trucks and passenger vehicles."[ROSENQUIST 2010]

In the third scenario, the cooperative ITS system will be a "consumer-driven service business. Consumer acceptance will rely heavily on the industry's ability to tailor services to meet individual needs. The consumer's constant desire for the newest and easiest technology may make handheld systems more successful than built-in systems." "In a scenario led by on-board infotainment services, example applications include internet information, e-mail messages, but also parking spot reservation confirmation and other logistics based confirmation/information services. The driver when connected to his cooperative ITS system will enter a destination in the navigation system that also provides entertainment and information for the driver and passengers as well as wireless internet

connectivity. The driver can phone, listen to music while passengers watch videos. Driver and passengers can check e-mail, the news, the weather forecast, and can search for and reserve facilities like fuel, parking, restaurants, hotels, maintenance facilities, shops, campsites etc. The driver can also book and pay automatically for a parking spot near his destination. If the driver is held up, his booking can be automatically amended and offered to other users, maximising the use of parking facilities while keeping the personal benefits for users." [BOOIMAN 2010]

Table 4 shows a summary of the three scenarios considered by the CVIS project. These scenarios were also input for a cost-benefit analysis. For both the commercial scenario and the personal scenario this analysis shows that benefits do not cover the projected costs. Only the public scenario shows a positive result, mainly because of road safety impacts of applications reducing speed. However, it has to be stressed that these results are based on a large number of assumptions, which appeared to have great influence on the final results.

Table 4: Summary of scenarios considered in the CVIS-project

Scenario	Public	Commercial	Personal
Driving forces	Demand for sustainable mobility services	Reductions of costs in logistics, increase of reliability and profitability	Consumer demands regarding real-time traffic info, etc.
Applications	Public transport priority, car sharing, eco-driving, access management, real time route planning/rerouting	Access control, loading zone and parking booking, electronic tolling	Real-time traffic and road status, incident info, congestion avoidance, route recommendation
On-board equipment	At low cost (subsidised)	Pressure to develop "one-box for all"	Cellular connected handheld/portable systems
Road-side equipment	Pressure on authorities to create "intelligent infrastructure"	Pressure on authorities to create "intelligent infrastructure"	Only cellular network needed at the start
Main actors	Road operators, authorities	Fleet operators, local authorities, telecom providers, navigation providers, commercial vehicle manufacturers and suppliers	Traffic info service provider, navigation/route advice service providers, telecom operators
Deployment	High penetration, once implementation programme agreed and finance available	In the short term co-existence of several systems and low penetration	High potential for services as smart phone apps; limited potential as embedded services linked to single provider

4.2.2 SAFESPOT-identified scenarios

In order to develop scenarios the SAFESPOT-project first identified factors influencing the deployment of cooperative safety systems [FABER 2010]. Based on the most influential and most uncertain deployment factors it defined three scenario dimensions: (1) the

technical configuration (V2V versus V2I), (2) the lead organisations (public versus private) and (3) the functional scope (safety versus multi service). The three dimensions lead to eight scenarios, of which three scenarios were considered in detail (see Figure 9).
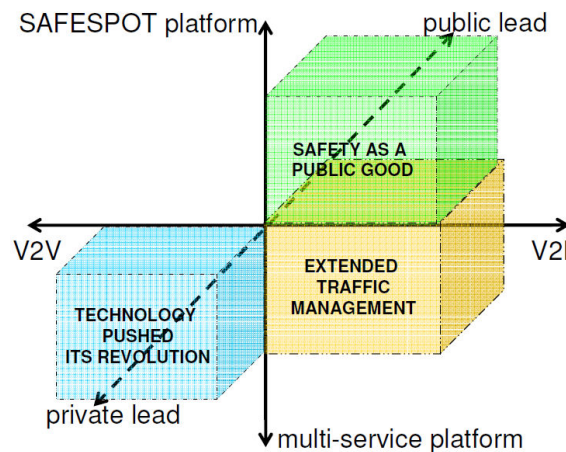

Figure 9: Scenarios considered in the SAFESPOT-project (source: [FABER 2010])

In the privately led "Technology pushed ITS revolution"-scenario V2V communication standards are agreed within the industries. Car manufacturers, suppliers and nomadic service providers will combine their strengths and realise systems integrated in the car. This will allow a wide range of safety warning applications and comfort applications. The system will be financed completely by the end-user. The industries will offer the system with a pricing policy that aims for a fast market introduction in all vehicle price segments in order to reduce the pay-back period. The road operator's role is limited, as well as the role of the (other) authorities. Authorities do not actively stimulate the deployment, but they may set system requirements (test and certification procedures) and allocate required frequencies.

In the "Safety as a public good"-scenario national governments subsidise the realisation of the necessary equipment for cooperative systems. Road safety is seen as a political priority. Authorities install road side equipment on those places with the highest societal benefit and subsidise the in-car equipment. Car manufacturers provide information about dangerous situations based on the vehicles' sensors. Legal interventions may be required to enhance penetration levels and to ensure minimum levels of service (e.g. equipment mandatory for all new vehicles).

In the "Extended traffic management"-scenario road authorities invest in intelligent roadside systems to meet their traffic management responsibilities. Authorities aim at optimising the societal benefits in terms of traffic flows and road safety. They will also implement road pricing. To compensate for this politically unpopular measure, they will add other applications onto the road pricing platform. This platform will be generic, to which existing equipment from private providers (e.g. traffic signals) can also be connected.

4.2.3 Pre-DRIVE C2X business cases

The pre-DRIVE C2X project did not describe scenarios for deployment. However, it developed two business cases [RAPPOLD 2010], one with the main focus on the role of authorities when implementing cooperative systems, and one with the main focus on comfort for end users and data useful for businesses. In the first business case revenues are: a reduction of casualties, congestion, CO_2 emissions, etc. Because these societal benefits were not valued financially, it is not clear whether these revenues outweigh the direct costs for investments (road side units), operation (service providers) and maintenance. The second business case includes services like media download, local electronic commerce, parking assistance, etc. In this case almost all the revenues come from the sales of on board units (150 EUR/unit), while no road side units are installed. Assuming that the on board units will be sufficiently attractive and the number will increase (2024: 50%; 2030: almost all cars), pre-DRIVE C2X shows that this can lead to a profitable business case.

4.3 Examination of three key deployment scenarios

Whilst a number of different deployment scenarios were put forward by the research projects, this document will now examine three of these in the context of their impact and consequences for the future of the European ITS Framework Architecture. The illustrations used as examples will form the starting point for the discussion and further necessary work. These three scenarios are:

- Industry driven scenario

- Regulation driven scenario

- Common European Mobility Scenario

The scenarios follow the principle that the future rollout of Cooperative Systems will be facilitated if one type of organisation takes up the core responsibility and collaborates with the other entities involved. The leading entity will, according to their main area of interest, also have an impact on the principal scope of the scenario: road safety, efficiency or value-added services for the final users.

4.3.1 Industry driven scenario

A group of industry partners agree to support the market introduction of Cooperative Systems and collaborate in making the steps required for market introduction following the confirmed feasibility and effectiveness of the systems. The group agrees on the common basic road safety-related functionality necessary for cooperation between the leading suppliers. Further, the group invites other companies and suppliers, research institutes and public organisations at an early phase of the project definition and extends its portfolio into additional service sectors.

In this scenario, the basic system design and the ITS Architecture is agreed within the core group and proposed as the technical basis for work in standardisation committees. From the first technical feasibility the validation and testing is extended to wider groups and lead customers and those application areas which are interesting target customers for system introduction. The next steps are system extension in the efficiency and convenience areas, awareness building and communication, agreement on the introduction road map, and at the same time preparation of an attractive product portfolio for the customers.

The main challenges faced in this scenario are: achieving agreement on the common service functionality supported by all members of the industry group and the timing of the introduction. Both need to be consistent in the ramp up of the market introduction in order to reach an acceptable level of market penetration rapidly. The relationship with public authorities and other stakeholders in the transport domain need special attention because otherwise the roadside (infrastructure-based) elements of Cooperative Systems, necessary for traffic management, will not be deployed. The consequence would be that not all the positive impacts would be evident for travellers, especially if they are 'early adopters'.

4.3.2 Regulation driven scenario

As progress related to road safety and efficiency is a key benefit of the introduction of Cooperative Systems in Europe, and the overall numbers of accidents and fatalities is still unacceptably high, one possibility is that public authorities take the initiative to introduce cooperative systems via European regulation in a Directive which is then followed up at the member state level.

In this case, basic system functionality related to road safety functions for road side elements and in-vehicle equipment, as well as related parts of the ITS system architecture, are defined between the main players in the wider transport domain, and standardised. Their introduction would be mandatory for new equipment purchased from a certain point in time and made an obligatory part of public procurement tenders. Because there would be mandatory and certified equipment on the road and in vehicles the liability for industry and service providers would be limited and controlled. The initial limitations of low penetration rates would be overcome from the introduction point on and be similar for all market players.

The challenges of this scenario would be the decision-taking between the member states in the European Union and the resulting processes, including the critical starting point of system introduction into the market. Related industries in transport and vehicle manufacturing would have a clear timeline for the preparation of market introduction but the development of the full product and service portfolio would be difficult to achieve. This includes the risk that the full benefits of Cooperative Systems would be difficult to communicate to consumers and end customers.

In this scenario the ITS system architecture would be used to identify the common mandatory functionalities, the input to standardisation of them, and the respective testing and validation processes for the introduction at EU level at a later stage.

4.3.3 Common European Mobility Scenario

The starting point of this scenario is that public authorities and industry sectors agree on the introduction of Cooperative Systems in Europe and identify basic responsibilities for the respective organisations, technical functionalities, a road map for system introduction and the process to clarify further topics in common. The scenario would need to cover not only basic safety topics but also efficiency and comfort topics and applications of Cooperative Systems, and therefore be attractive for public authorities, industry, service providers and consumers. The ITS Architecture would be used as the tool to clarify the realisation of user aspirations/ requirements through the full development and deployment cycle of the systems involved, with special focus on interoperability between the various regions and scalability of the selected solutions. As the full options of possible mobility related services are addressed, the impact on market introduction would be high through a large number of market players and service providers involved.

The challenges of the Common European Mobility Scenario are the initial steps to reach an agreement on the respective roles and responsibilities between organisations and groups that do not normally work together, such as the public authorities responsible for the transport system, the industries and suppliers, as well as the service providers. From this starting point a step by step approach should exist, with a consultation process for common decisions of the next steps that are necessary, but it needs to be defined in detail.

From the pros and cons of these three scenarios for the future deployment of Cooperative Systems it can be seen that a common methodology and process for the generation of the ITS system architecture is needed, but not always to the same extent and with the same group of actors involved in the process. In the first scenario the ITS Architecture Framework will be used to define the common minimum elements for interoperability in the safety domain, with support for additional functionality. In the second case the introduction of the common mandatory systems, the main functionalities and characteristics need to be "safeguarded" through certification and legacy systems and will include many interfaces to external actors and systems.

By far the most complex but consistent use of the ITS Architecture Framework is necessary in relation to the third scenario because here, not only do the single technical viewpoints need to be elaborated, but also additional ones covering the organisation, setup and operation of the installed systems and their interactions.

4.3.4 Example for an industry driven deployment

One scenario would be a self-commitment of the C2C-CC OEM to equip new cars with C2X technology. Obviously, the first customers who purchase a car equipped with the new cooperative system won't have a high added value.
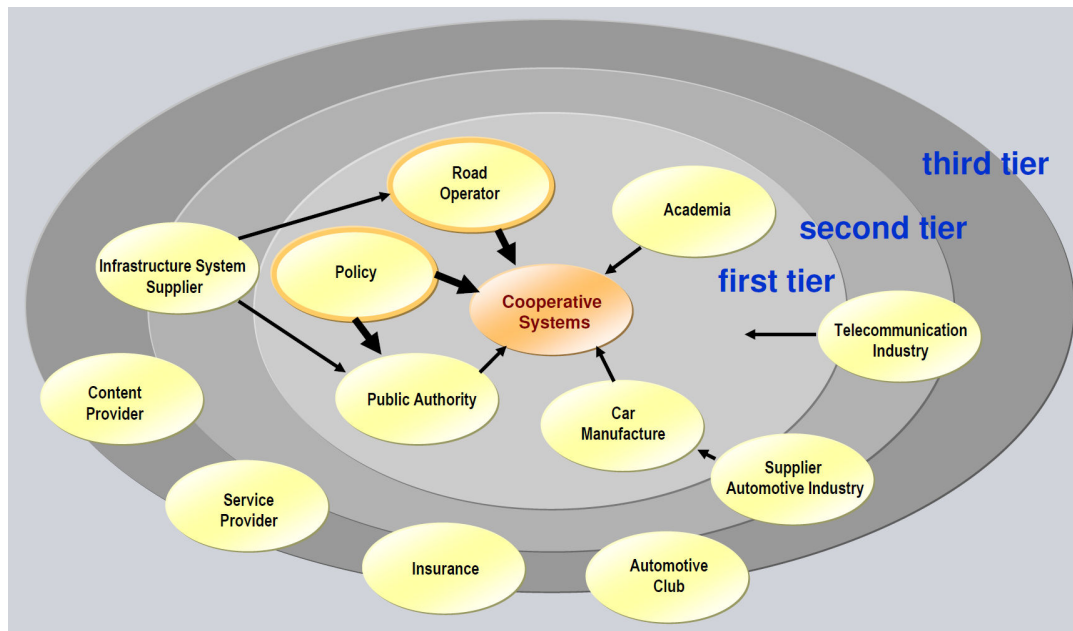
Figure 10: Different impact on deployment by stakeholders [SCHADE 2007]

The impact on the deployment of Cooperative Systems can be seen in Figure 10 Here the car manufacturers (or the consortium) have a direct influence and hence a big impact. Other important stakeholders in the first tier are public authorities and road operators.

The latter has the task of the deployment of RSUs on the primary and secondary road network (interurban, urban) and the deployment of C2X-control/management centres.

However, some prerequisites for a widespread deployment can be stated. One important component is the right policy. Policy leaders have the task of creating a public understanding. They have to communicate the benefits (e.g. an improvement of the road safety, the efficiency and the economic performance) of the system to the public and show engagement and leadership.

- Core technologies are fully validated and have achieved large-scale integration, so that an affordable integrated module for in-vehicle use would cost a few tens of Euros, and for roadside use a few hundreds of Euros;

- All vehicle makers agree to adopt a common technology based on European and global standards;

- Traffic system suppliers adopt the technology and offer both "upgrade kits" for existing equipment, new products incorporating the systems core technologies and on vehicle-infrastructure cooperation models;

- All drivers find the system an attractive product when buying their new vehicle, and perceive as good value a subscription to the services offered by road operators and service providers, in particular they consent to the collection of anonymous data from their vehicle for cooperative monitoring;

- Road operators, traffic managers, service providers, public authorities, mobile network operators and other parties needed for the full service chain succeed in forming workable consortia to deliver end-to-end services;

- The risks of potential faults in the system and/or its operation and use are clarified so that responsibilities for putting them right are made clear in advance. This will include mapping legal exposures so that there will be sufficient and sustainable insurance and/or other financial support for relevant exposures and costs;

- The system is an accepted, even favoured, tool of public policy at local, national and European level, and recognised for its benefits for traffic safety, road network capacity and efficiency, for personal mobility, for air quality and for commerce and industry.

Successful deployment is intimately linked to organisational issues. The policy framework for the deployment is the EU ITS action plan [COM/2008/886/FINAL] which was adopted on 30.03.2009.

4.4 The need for a 'migration strategy'

An analysis of the prospects of cooperative systems in relation to wide-scale deployment was made in a paper presented to the International Road Foundation in 2010. The principal conclusions were, firstly, that the critical constraint, i.e. the lack of standardisation on the communications technologies and protocols, needs to be rapidly resolved. Secondly, in order to arrive at the scenario of the 'fully connected vehicle' (in which vehicles travelling on the road network are able to continually exchange data with other vehicles), it is necessary to define a gradual 'migration strategy'. We focus here on this second aspect.

With regard to commercial installation of cooperative systems on Europe's road network, the authors express the view that, although many cooperative applications have been subjected to technical trials, it is unrealistic to imagine a fully cooperative road environment being implemented in the immediate future. It is suggested that the introduction of cooperative systems will inevitably proceed step by step and hence require a 'migratory plan'. One of the reasons is that it will certainly be many years before the minimum threshold of vehicles is equipped.

One key assumption is that – at least in the initial stages – support of the road infrastructure will continue to be important. With relatively inexpensive and simple adaptations, road operators would be able to upgrade their networks and make it possible for a first generation of cooperative mobility services to become operational. This would result in improved safety and traffic efficiency, and enhance the value of existing investment in the road infrastructure.

The stages are described below:

Stage 1: In this stage, roadside units could simply transmit the information contained in existing road signs and overhead panels to passing vehicles so that it is visualised on the

on-board displays. The focus would be on improved information services (rather than active safety applications which are far more complex and demanding). This would permit warnings, such as speed limits, sharp bends, narrow bridges, etc. missed by drivers due to bad visibility or sight lines blocked by large trucks, to reach drivers directly. It would require the devices to be upgraded with a wireless component so they can "beacon" messages to vehicles, as shown in Figure 11. Existing hardware elements could for instance be equipped with WAVE 'hot spots' for the radio transmission of signal stages and radio repetition of VMS messages and other information (both static and dynamic).
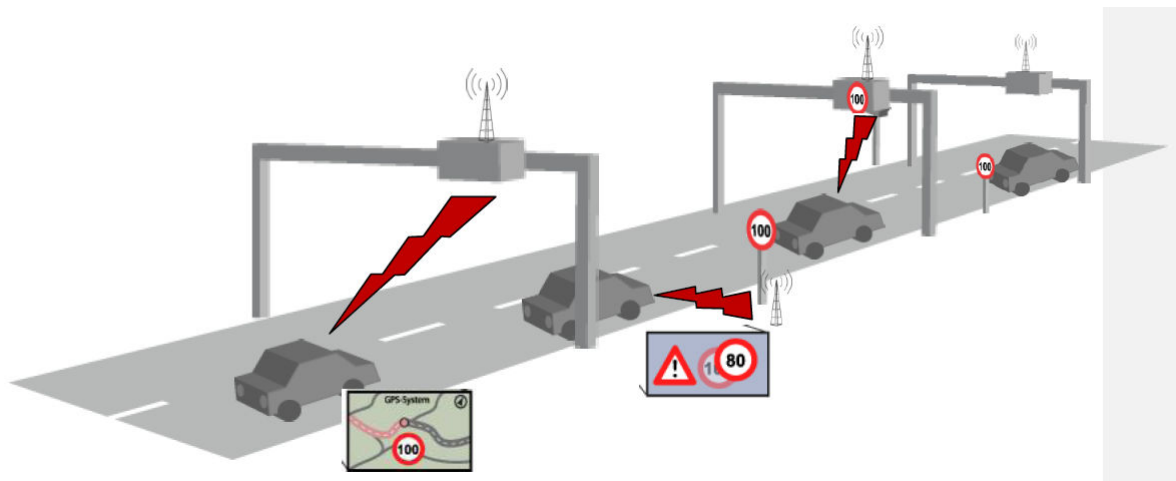
Figure 11: Beaconing of data from the infrastructure to vehicles

Stage 2: The parts of the road network known to be potentially dangerous, i.e. 'black spots', could be similarly equipped and beacon warnings to drivers when there is an increased risk due, for example, to adverse weather conditions, an accident ahead.

Stage 3: In this phase, vehicles would also gradually be equipped to allow cooperative communication. This would probably begin with the aftermarket installation of "listening" radio devices to enable vehicles to pick up the messages sent by the infrastructure. Automotive manufacturers (OEMs) would then begin to equip new cars with devices permitting them to beacon data continuously - and anonymously – so the messages can be 'picked up' by nearby vehicles and roadside devices. This scenario is illustrated in Figure 12. Initially, the beaconed message could consist of an anonymous basic data set, including vehicle type (car/van/truck). This could then be supplemented by the vehicle's position, speed and direction, as long and security and privacy issues are satisfactorily resolved.

Figure 12: Beaconing of data between vehicles and to the infrastructure

Stage 4: At a later stage, the basic data set provided by vehicles would be complemented with data from on-board systems such as ABS, ESC (e.g. on road conditions) or more sophisticated sensors, including laser scanners, radar and infrared systems.

Finally, some suppositions are made in relation to the market prospects

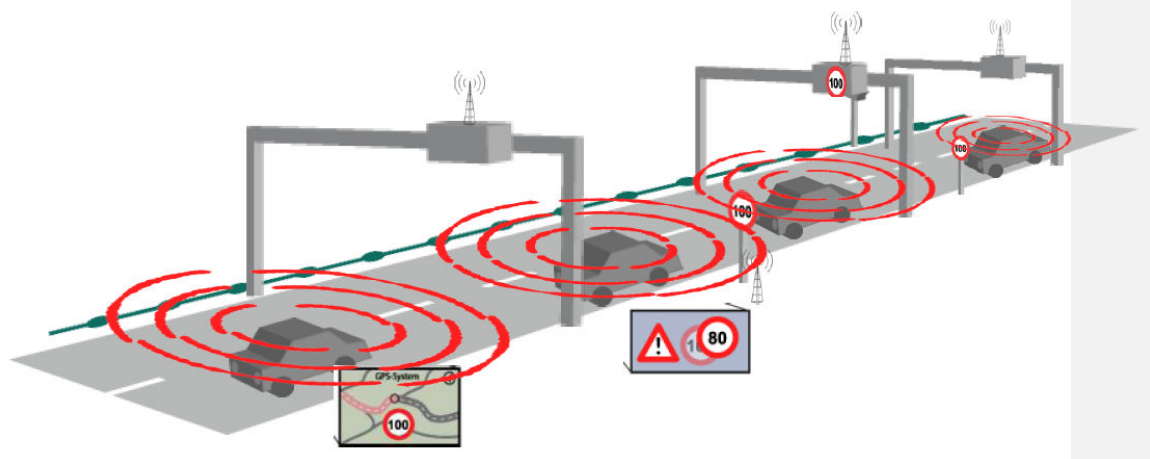How could the market for cooperative applications work in practice? It is suggested that the most appropriate architecture is likely to involve an 'application store' approach. This would allow drivers to choose the type of equipment they prefer (installed in the vehicle or a mobile device) as well as the type of application. For instance, if vehicles were equipped with the minimum hardware for beaconing, incoming information could be made available to the user through a personal smart phone. Car owners would then subscribe to their preferred Service Provider in order to have access to the applications they desire.

In order to 'get the process started', infrastructure operators could send drivers accurate real-time data, free of charge, in exchange for very basic data (e.g. class, speed, journey time information).

To permit the above scenarios to become reality, several key issues need to be resolved. The first concerning the interoperability of services and hence the question of international standards and harmonisation, necessary to ensure:

a) the interoperability of the principal components (e.g. roadside units, interfaces of the on-board displays, message format),

b) roaming agreements to permit geographical continuity.

In the highly competitive automotive environment, it will certainly not be easy to establish the necessary standards and protocols, although the fact that the basic research was carried out collaboratively is a positive sign.

c) solution of the privacy, security and safety issues. This is essential, as data will be broadcast from individual vehicles, and especially critical in the case of safety-related applications.

A fully guaranteed and secure system of user authentication and network management will need to be established before users are willing to trust such systems. Mechanisms also have yet to be defined for the payment and billing for the services. A further complication is that different vehicle categories (cars, vans, trucks, coaches, etc.) would require different types of application having different data needs.

Finally, for the above to come about, it is crucial for the major players in the market to be prepared to make an active commitment. This in turn requires convincing evidence of the benefits of cooperative systems (in terms of performance, data quality and reliability) and, as a result, the existence of a market.

4.5 Conclusion

Based on the scenarios and cost-benefit analyses it is possible to identify significant factors and pre-requisites for deployment. A clear conclusion regarding the platform is that deployment is unlikely to start with sole implementation applications based on V2V communication. The barriers to realise pure vehicle to vehicle infrastructure platforms are huge. It would take a very long time before substantial penetration would be achieved. The SAFESPOT-project [FABER 2010] mentions two ways to deal with the low penetration rate at the start of deployment. One way is to make use of the existing penetration of nomadic devices and the existing GSM/UMTS infrastructure. Several services can be provided through this existing platform, either by updating the software of existing nomadic on-board units or by new nomadic on-board units. Another way is to use an infrastructure-based architecture, ensuring that on a limited number of roads/intersections high quality of service is available even with a low penetration of equipped vehicles. A limited number of roads could be the start for full geographical coverage. Also related to the infrastructure-based architecture is the key role of applications that are of main interest to the public sector (national or European). If the public sector decides to implement applications such as road charging or environmental access then the platform would be made available for wider use, and this may give deployment a boost.

The scenarios also show that cooperation among the main stakeholders is a pre-requisite for the deployment of cooperative systems. None of the stakeholders is able to realise the systems only by themselves. Cooperative system concepts must be defined and accepted across industries, operators, authorities and user sectors. Organisational models are necessary to ensure clearly defined roles and responsibilities, bringing together actors who might not be used to collaborating with each other. Clear evidence of the benefits of cooperative systems should be gathered and disseminated to all relevant actors. In all phases of deployment there should be a positive business case for all stakeholders. The cost-benefit analysis in CVIS [BOOIMAN 2010] indicates that private and commercial benefits could be achieved, but only when costs are shared between the private and the public sector. This makes public private partnerships (PPP) a pre-requisite for a successful deployment.

Discussion of these organisational and related aspects is continued in the next chapter.

5 Main issues in Cooperative Systems deployment

5.1 Organisational and management issues

Who is responsible for carrying out which functions? Who is liable for the accuracy of data and the correct working of the systems? Which parties are needed, and how are they working together? These and many other questions concerning management and organisational roles have to be solved in order to overcome one of the main constraints to the large scale deployment of Cooperative Systems. The questions are hard to solve for various reasons. Political and financial interests need to be satisfied in the first instance and, since there are a lot of parties involved, those interests do not always go in the same direction.

As a first approach to solve some of these questions, organisational analyses have been undertaken by the major Cooperative Systems projects. These include the Value Chain analyses performed in the COOPERS and SAFESPOT project, and the Value Network defined by CVIS. There is also a description of the analyses of organisational relationships carried out as part of the COOPERS and SAFESPOT projects. The latter was based on the methodology developed in the Organisational Architecture of ARTIST.

Comparing these organisational analyses, some similarities can be seen but also some contrasts. A common value chain can be drawn up to fit all of the three project approaches (see Figure 13).
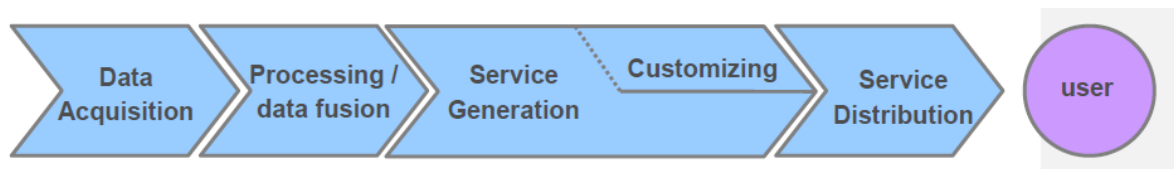
Figure 13: A value chain approach for cooperative systems

First of all, data has to be acquired. Whereas in COOPERS this step is called 'Data Acquisition', and in SAFESPOT it is called 'Detection', in both cases this first step involves the collection of raw data, e.g. data from detection loops, FCD or vehicle dynamics from on-board sensors as well as pre-processed data or information (e.g. detailed weather forecast, map data).

In the next step this non-homogenous data is combined and processed in order to obtain a single, homogenous pattern representing the current traffic situation as well as a prediction model.

The third step involves the important process of generating the service itself. In some cases these services are customized and provided to specific types of user.

The last step in the value chain considers the distribution of the service via a designated distribution channel.

Example of organisational relationships in the Austria COOPERS Test Site

In order to provide a practical example, an analysis was made of the relationships between the actors involved in the Test Site in Austria.

The Austrian Test Site was a corridor consisting of the A12 Inntal Motorway (78 km) and the A13 Brenner Motorway (36 km) from the Austrian/German border Kiefersfelden/Kufstein via Innsbruck to the Austrian/Italian border, at the Brenner pass. A Traffic Management System including traffic and weather sensors, VMS, information panels and Traveller information services was in operation along the whole corridor.

Figure 14: The Austrian test Site of COOPERS

The main actors or stakeholders involved in the Cooperative Services developed in the COOPERS project are shown in Table 5.

Table 5: Main stakeholders in COOPERS (I2V)

Data Acquisition	Processing / data fusion	Service Generation	Customizing	Service Distribution
Map provider Road operator / FCD provider	Service provider	Service provider	Emergency service provider Freight service provider	Network operator
TCC operator	TCC operator	TCC operator		TCC operator

In the case of the Austrian Test Site, the network operator was the Austrian Infrastructure operator, ASFINAG, which is a publicly owned body. In a commercial scenario, ASFINAG would no doubt take a leading role in the provision of safety-related co-operative services.

With its Traffic Control Centre in the Inzersdorf, ASFINAG would be able – together with other actors such as AustroControl providing weather data and the Austrian Broadcasting Cooperation (Ö3) which has a FCD fleet – play the role of the Content Provider. It could also use data content collected on the infrastructure itself, such as weather information and traffic data. This data would be aggregated and processed in the ASFINAG's TCC. ASFINAG could, in addition, adopt the role of data clearance, as it is a public operator and is entitled to do so.

Value Added Services would be produced in the TCC and the segment-specific information distributed via the COOPERS road side unit to single end users on Austrian motorways. Data could also be distributed via alternative channels, such as DVB-T or DVB-H. Telecom Operators could also distribute the information, via GPRS for example. Third party sponsors, such as motorway service area providers, would also be able to distribute the information in the service stations.

In this model, providers of on-board units, such as TomTom or Garmin, could supply the necessary hardware. The on-board unit would be the direct interface to the customer and the provider would benefit from the possibility of selling high quality value-added data as an 'extra' to their hardware. The end user would buy the on-board unit and, as part of the price, a lifelong service charge for value added traffic information could already be included. This would mean that the end user would have no further payments, e.g. monthly bills.

The on-board unit provider would require permission from the TCC to distribute the value-added traffic information provided by ASFINAG. This could be compensated for via financial or other benefits for ASFINAG.

Basically, the result of the Cooperatives Systems projects was a 'proof of concept' of many of the basic technologies and applications but until now there are very few 'real-world' deployments. Although the projects did explore some organisational aspects, these were in the nature of conceptual explorations and mostly not directly related to 'real-world' deployments, as the institutions involved were working collaboratively as partners in pre-competitive research.

However, if the systems are to be become commercially viable solutions, a full investigation of the organisational aspects will be fundamental. This is especially important because Cooperative Systems, by definition, involve actors from both the vehicle and infrastructure worlds in technical and business relationships which are not yet well established. By creating a model of the proposed Cooperative Systems with a sub-set of the FRAME Architecture the technical and business issues can be analysed, and the separate components and the flows of data/information between them will be clearly visible.

5.2 Communication technologies and protocols

One of the main constraints to achieve large scale deployment is the unsolved issue of the standardisation of communication technology and protocols. Currently there is a wide range of technologies used in the various projects. For research and development projects and even for FOTs this is not a problem, however, if services want to be deployed on a large scale and cross border, consensus will have to be found.

The variety of communication technologies used is huge and includes the following:

- IR-MR

- CEN DSRC

- CALM IR

- Bluetooth

- GSM/GPRS

- UMTS

- DAB/DMB

- Wireless LAN

- WiMAX

Each of those technologies can be described by a number of parameters which state their advantages and disadvantages depending on the point of view. Some can be used only for short range communication others are broadcast technologies. Some have a high bandwidth; others can reach a large number of people. Some are costly for the provider, others for the user etc.

Combination of technologies

One main conclusion of the COOPERS project was, that a combination of technologies might be useful to fulfil the requirements of ITS services. By using a combination the advantages of different technologies are available. The coverage of GSM/GPRS is very high in all European countries, but the data rate is low compared to the other technologies. Thus, e.g. IR-MR or CALM IR could be used when short range high data rates are required, and another technology (e.g. GSM/GPRS) could be used for all requirements which need an area-wide coverage but only low data rates.

For more details on communication technology and the respective standards please refer to the E-FRAME deliverable D16 available from the FRAME website www.frame-online.net.

5.3 Safety issues

A more detailed discussion of this topic can be found in Appendix D.

All ITS applications and services should be considered as being safety-related until they have been shown not to be.   This is done using a process called Preliminary Safety Analysis (PSA), which has three main tasks:

- Identify all the top-level safety hazards associated with the system;

- Classify the risk(s) associated with each hazard;

- Allocate safety requirements that will reduce each risk to an acceptable level.

During the DRIVE I and DRIVE II programmes the DRIVE Safely Task Force showed that the safe use of ITS had three principal components:

- (Functional) System Safety – e.g. relating to design faults or system malfunctions;

- Human-Machine Interaction (HMI) – relating to usability, e.g. perception, overload, under load;

- Traffic Safety – all components of the traffic system working together.

Guidance on each component was produced by separate projects, and this has been brought together in a "Framework for the Development and Assessment of Safety-Related (Inter-)Urban Traffic Management Systems" [UTMC22 1999].

With regard to functional system safety ITS is outside the scope of ISO/FDIS 26262 "Road Vehicles – Functional Safety", and so the generic standard IEC 61508 "Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems" should apply. One of the techniques for PSA recommended by IEC 61508 was developed by the DRIVE II project PASSPORT [PASSPORT 1995]; which was trialled on other projects, including a cooperative system (TESCO), and has since been used successfully on a number of commercial systems.

All safety-related systems need to be developed with additional stages in the lifecycle, including PSA of the concept, Detailed Safety Analysis of the design, and Safety Assessment of the product. A particular concern for Safety Assessment relates to software, which is too complex to be proved sufficiently correct in all conditions by testing alone, and so attention is also given to the manner of its development. All safety-related systems need to be validated by a Safety Assessor who is independent of the development team.

HMI safety is of particular concern for Cooperative Systems, since it is their intention to bring much more information inside the vehicle than currently occurs. A key question is how much information can be presented to a driver before it stops being a help and starts to be a distraction. Ownership of the problem is also an issue since, whilst integral displays are the concern of the vehicle manufacturer, the use of mobile devices is less easy to regulate/control.

Considerable traffic safety advantages are being predicted for the use of Cooperative Systems, but the "law of unintended consequences" would indicate that one should be

careful in what is being foreseen. Some ITS, e.g. GPS navigation systems, have already been shown to have unintended consequences, sometimes due to their misuse, and their total effect on the traffic situation needs to be understood. A set of hypotheses that should be considered can be found in [CODE 1997].

A model of the ITS in question, based on a sub-set of the FRAME Architecture provides a model of the components, their functionality and their interconnections, and is thus a suitable basis for peforming a Preliminary Safety Analysis of all three safety topics.

5.4 Security and Privacy issues

Security Issues

Security is ensured by implementing countermeasures to any threats which may exploit vulnerabilities of an ITS system. Users and owners of ITS systems must have confidence that those countermeasures will minimise any security risk. The threat agents may be actual or perceived. Security abuse commonly includes, but is not limited to, unauthorised disclosure of information (loss of confidentiality), unauthorised modification of data (loss of integrity), and unauthorised deprivation of access to the asset (loss of availability). Security issues relating specifically to Cooperative Systems were studied by the project SEVECOM [SEVECOM 2008].

Many ITS systems are likely to have to deal with both security and safety issues. One of the most vulnerable aspects of cooperative systems lies in the 'cooperative' element itself, i.e. the vehicle-to-vehicle or vehicle-to-infrastructure communication. If interfered with in any way, this could lead to very serious risks to security and safety. Since it does not make sense for engineers to have to follow two entirely different development processes in order to receive third-party assessment for them, a unified approach to safety and security has been proposed in [JESTY 2007].

Privacy

Although related to security, the impact of privacy on cooperative systems needs to be considered as a separate topic. A particular issue is that just making the identity of a vehicle "anonymous" is not always sufficient to ensure privacy in the long run since, by looking at the routes taken by anonymous vehicles over time, the pattern of these routes will sometimes reveal the identity of the vehicles taking them. The topic has been studied by the FP7 project PRECIOSA, which has produced a set of guidelines for privacy aware cooperative applications [PRECIOSA 2011].

5.5 Liability and Legal issues

Liability usually arises in a situation in which something has "gone wrong" and it is necessary to go through a legal process to find out "who" is responsible and remedial action taken. The "who" can be a person, or it can be an organisation. The thing that has "gone wrong" can range from a system malfunction to a breach of data protection laws that

govern the way that peoples' personal data is recorded and used. In most instances when something "goes wrong" it is highly likely that a law will have been broken.

It is therefore important to establish which organisation has ownership (or more specifically legal liability) for the correct functioning of each element of an ITS application as this makes it possible to clarify the responsibilities for safety and security (see above). Since many of the Cooperative Systems services include safety-related functions, these topics are extremely relevant to this field.

In the case of integrated ITS applications, it is likely that separate systems or modules will share data or information with other systems for their mutual benefit. The end user is unlikely to be aware that the service being provided is the product of a number of distinct systems each owned and managed by different organisations. Indeed, the user will often be benefiting from the 'emergent properties' created by the integration process in addition to the properties of the individual systems.

While everything works properly there is no problem. However, if something goes wrong with the system, it is necessary to identify who is responsible for putting it right. In the case of a failure with serious consequences, it is also necessary to identify who is liable for accident-related damages. It should perhaps be noted that the potential complexity of engineering systems is sometimes in advance of the liability laws. [ELLIOTT 2006].

6 Contribution of FRAME to Cooperative System Deployment

6.1 Background

The European ITS Framework Architecture, was a response to the situation which had arisen in the mid-1990s in relation to Intelligent Transport Systems (ITS). There had been a large amount of RTD activity and a growing number of applications were being developed, but deployment was slow and there was concern about the risk of incompatibility between the different systems. There was also a general uncertainty about the most effective investment strategy for ITS.

The European High Level Group on road transport telematics recommended the creation of a European ITS Framework Architecture, and this was subsequently supported by a resolution of the Council of Ministers. The vision statement for the KAREN project was "to create a minimum stable Framework necessary for the deployment of working and workable ITS within the European Union until at least 2010".

The work needed to create a European ITS Framework Architecture was carried out by the project KAREN that was funded by DG-INFSO. The first version of the Architecture was published in 2000. Support for its continued maintenance and enhancement was provided by the follow-up FP5 projects FRAME-S and FRAME-NET (2001-04) which provided the short name of the "FRAME Architecture". The FRAME-S project developed a methodology and computer-assisted Tools for creating self-consistent sub-sets of the FRAME Architecture. By the end of those projects the FRAME Architecture covered most road-based ITS at the time, with links to other modes when required. It comprises four principal projects as follows:

- a List of User Needs – descriptions of the systems that provide the various ITS applications and services;

- a Functional Viewpoint – data flow diagrams, with descriptions of each element, that satisfy the User Needs;

- a Browsing Tool (to permit navigation through the FRAME Architecture)

- a Selection Tool (to assist the creation of logically consistent ITS architectures subsets).

It is important to point out that, since the FRAME Architecture is intended for use within the European Union, it conforms to the precepts of subsidiarity, and does not mandate any specific physical architecture or organisational structure. In other words, while it provides a Functional Viewpoint, which sets out what needs to be provided to ensure that an ITS application can be successfully deployed, it does not specify how this should be done (e.g. what kind of hardware or technology should be used, or where the functions take place). The FRAME Architecture was thus created to provide a common approach, or "language",

for use throughout the European Union so that the implementation of integrated and inter-operable ITS can be planned.

One of the objectives of the E-FRAME project (2008-11) has been to enhance the FRAME Architecture to include Cooperative Systems, in particular those studied by the COOPERS, CVIS and SAFESPOT Integrated Projects.

There are significant similarities between the difficulties of deployment facing ITS in Europe in the mid-1990s and the current situation facing Cooperative Systems. These include the need to ensure the compatibility of systems (e.g. between infrastructure-based and automobile-based components, across OEMs, and across national borders). There is also a need to facilitate communication and agreement between the stakeholders. In the case of Cooperative Systems this is likely to be even more complex than for conventional ITS.

The FRAME Architecture was designed to provide constructive support in resolving such issues, and has been successfully used in numerous contexts of ITS deployment (urban, regional, national and project), and it is well suited to do the same in the present context. This Chapter looks in more detail at the kind of support that can be offered.

6.2   The System Engineering Lifecycle

In order to fully understand and appreciate the use of the FRAME Architecture it is necessary to see how it fits into the overall system engineering lifecycle, whose "V" model is shown in Figure 15 .
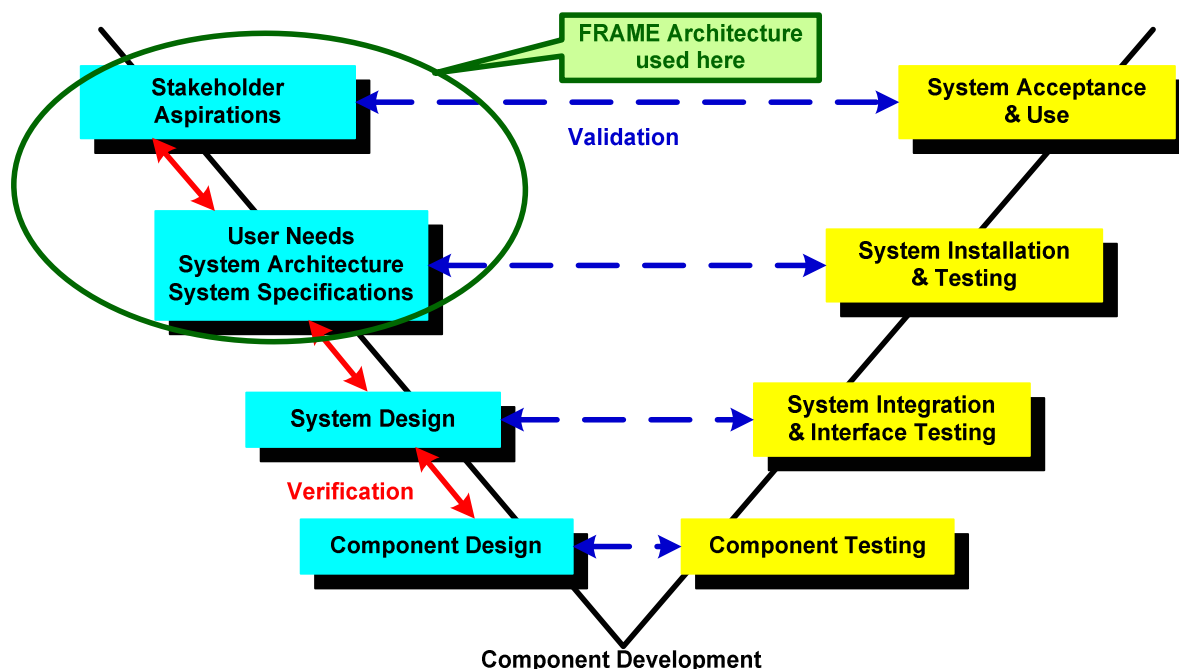

Figure 15: The use of ITS architectures in the System Engineering lifecycle

System architectures are used to describe various properties of the whole system at a number of different levels of abstraction, and the manner in which they have been used for ITS Architectures was examined in 1998 by the EC funded CONVERGE project. The two

most common levels that are used for ITS are those that describe the system structure, (Level 1) and those that describe the system design (Level 0).

6.2.1 System Structure – Level 1

System structure ITS architectures are used to provide a description of the functionality and communications needed to provide the services expected by stakeholders and comprise a number of different viewpoints. There are three principal viewpoints, the Functional Viewpoint (sometimes known as the Logical Viewpoint) which shows how the system works; the Physical Viewpoint which shows where the functions are located, and the Communications Viewpoint which describes the characteristics of the communications paths between the physical units that pass data between the functions within them.

A distinctive feature of a Level 1 system architecture is that it should be written in a technology independent manner, i.e. stating what should happen and not how it should be done. In this manner the specifications that come from a Level 1 ITS architecture give suppliers the freedom to employ the most appropriate technical solution when tendering. It thus describes a class of systems for which there may be many different designs.

This type of ITS architecture is created by (or for) organisations such as national and regional governments, research projects, etc. Apart from the FRAME Architecture, the most widely used example of a Level 1 ITS Architecture is the US National ITS Architecture.

6.2.2 System Design – Level 0

System design architectures are used to describe the relationships between the principal components and the communications needed for ITS implementations. These architectures are created as part of the design activity that commences once procurement has been agreed and use the Level 1 specifications as their starting points. The component may be realised using either hardware, software, or a combination of the two, and the use of particular technologies and communications standards will almost always form a part of the Level 0 descriptions.

6.2.3 Relationship between Level 1 and Level 0 ITS Architectures

The relationship between Level 1 and Level 0 ITS Architectures is shown in Figure 16. The 'bridge' between the two is provided by the component specifications and communications specifications used in the procurement process.

It should be noted that even Level 1 is not the actual starting point for the full process, for there needs to be a set of "requirements" for the Level 1 architecture. For most ITS architectures these "requirements" take the form of Stakeholder Aspirations, which are statements of what the stakeholders (e.g. senior traffic engineers, politicians) want the ITS to provide.
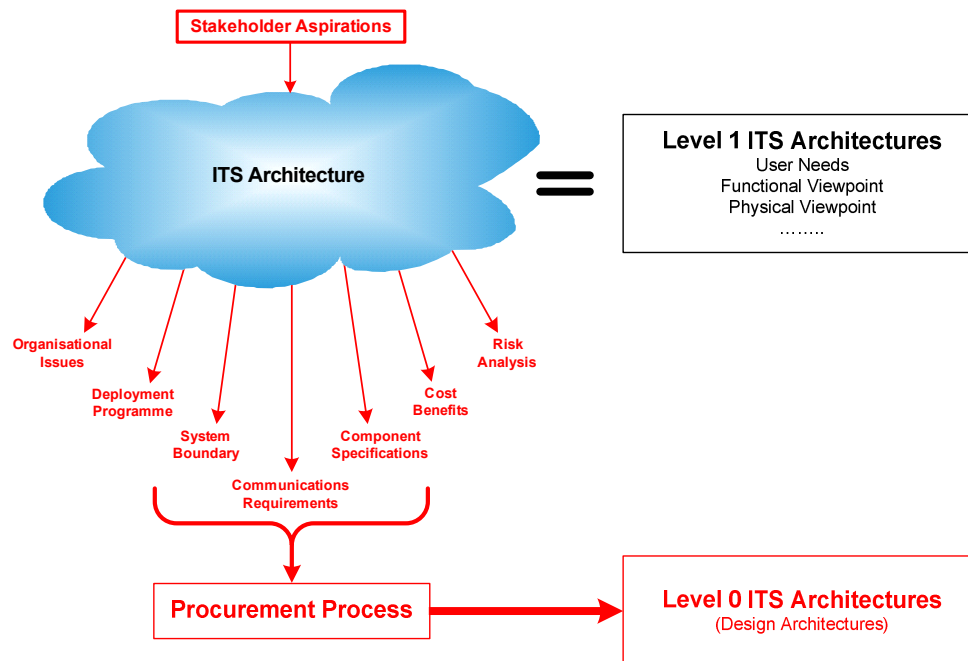
Figure 16: Relationship between ITS Architecture Levels

6.3   Using the FRAME Architecture for Cooperative Systems

Although the European projects carrying out research into cooperative systems all created ITS architectures to support their work, each project used its own methodology. This was sometimes at Level 1 and sometimes at Level 0 (or somewhere between the two). The E-FRAME project has therefore produced its own set of User Needs to describe the various Cooperative Systems, written in a manner that is consistent with the existing set of User Needs. In addition the Functional Viewpoint has been extended to fit into the existing framework.

The original methodology for creating ITS Architectures from the FRAME Architecture developed by the FRAME-S project did not provide any advice on the Communications Viewpoint beyond performing a high-level analysis of the requirements. For Cooperative Systems, however, there has been considerable work done on their communications requirements both within the three IPs themselves and by the projects COMeSafety and Pre-DRIVE C2X. Their results come together with the FRAME Architecture as shown in Figure 17.
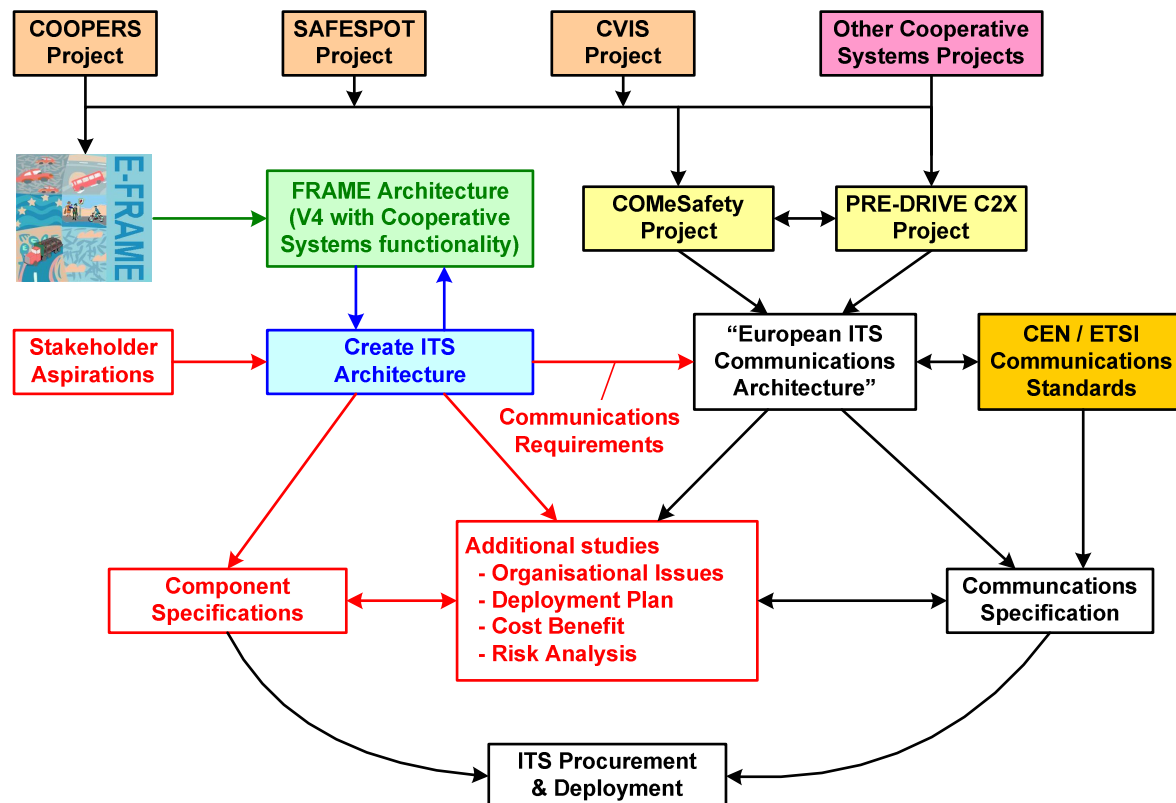
Figure 17: Relationships between Cooperative Systems ITS architecture activities

The process of creating an ITS Architecture for Cooperative Systems is therefore as follows. Starting from the Stakeholder Aspirations (see Section 6.2.3), a Level 1 ITS Architecture is created from the FRAME Architecture in the usual manner. This will result in a Function Viewpoint sub-set of the FRAME Architecture, and a Physical Viewpoint which shows the locations of the functions and data stores in the Functional Viewpoint. The next stage in the process is to examine the communications requirements between the physical components with a view to identifying the mechanisms or standards that can be used in the design. For those communications paths that relate to Cooperative Systems it will be necessary to consult the European ITS Communications Architecture created by the COMeSafety and PRE-DRIVE C2X projects and/or the standards being created by CEN and ETSI.

Although Figure 17 shows the end result of the process to be an ITS deployment, it is more likely at the moment that the resultant ITS Architecture will provide a model on which additional studies can be made. These studies can include:

- Organisational Issues – see section 5.1

- Deployment plan – see chapter 4

- Cost Benefit studies

- Risk Analysis, including Liability Issues – see section 5.5

An advantage of using the FRAME Architecture is that models will always need to be created to undertake this work, and its use avoids a great deal of re-work (an estimated 80%) and it provides a common "language" across the models.

6.4   The Organisational Viewpoint

Any ITS deployment can be considered from two distinct perspectives, the technical one and the organisational/business one. While the technical perspective is concerned with the technologies and processes involved, the organisational perspective is concerned with who owns what, who manages and maintains what, and the business/contractual relationships between the various parties involved. A clear idea or 'map' of these roles and relationships is an essential basis for a successful deployment. The aim of an 'Organisational Viewpoint' or Architecture is to provide such a map.

The Organisational Viewpoint is usually a derivative of the Physical Viewpoint. It is used to show the organisations that will own, and/or operate, and/or maintain the Sub-systems and Modules in the Physical Viewpoint. This is very useful for highlighting the relationships between different organisations and any conflicts that may arise. It can also be used to look at how data will have to be, or could be, shared between organisations.

An Organisational Viewpoint usually considers the following specific issues:

- Each service that can be provided by the functionality in an ITS architecture will be *used* by somebody or an organisation.

- Each sub-system and module within the Physical Viewpoint must be *owned* and/or *managed* by an organisation.

- The relationship between organisations can take one of the following forms:

  o **Directional** – one (or part of an) organisation has the power to direct, or manage, what another (or other part of an) organisation does and, possibly how it is done, e.g. the organisation managing the road network manages how public transport uses the road network.

  o **Long Term Contractual** – one organisation is required to perform a defined service for, or on behalf of, another organisation, e.g. a communications provider will provide a service that enables data or information to be communicated from one part of the system to another;

  o **Short Term Contractual** – one organisation, or individual, pays another organisation for a well-defined service, e.g. the Traveller pays to use Public Transport

Some sub-systems and modules will provide data for others and this can raise organisational issues if the data that is provided is incorrect and/or incomplete. When such a failure occurs, it is important to be able to identify who is responsible for its occurrence, for rectifying it and for preventing it happening again. This may not be obvious if the failure is in an emergent property of a service provided by sub-systems owned by more than one organisation, each supplying part of the total service (see Figure 18).
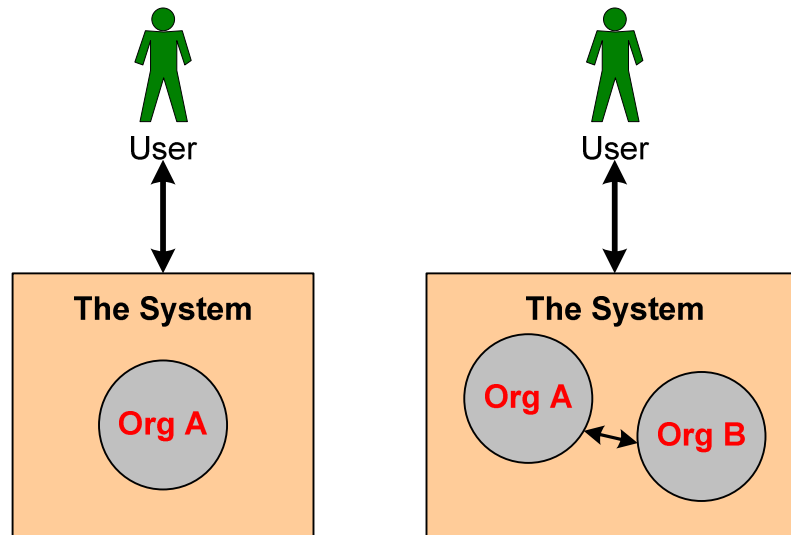
Figure 18 – Who owns "The System"?

6.4.1 High-level Models

On occasions there is a need, or a wish, to impose a particular type of model on the Organisational Viewpoint, sometimes known as a Level 2 Reference Model. This has been done, for example, as part of the Italian ITS Architecture called ARTIST, which uses the concept of a "Value Chain".

The process consists of four main steps:

1. Definition of the macro-processes (Value Chain): representation of the principle (high level) processes or functions required for the delivery of an ITS service in the form of a flow diagram;

2. Definition of the processes or sub-processes: this involves breaking down the above into the constituent processes/sub-processes which are in fact the functions of the so-called Logical Architecture of ARTIST (Functional Viewpoint).

3. Definition of the roles and responsibilities: the above are then expressed in terms of activities and the entity responsible for each activity identified. This makes it possible to define the roles of each entity, and also the levers required for ensuring that the activities are effective.

4. Mapping of roles and activities: the result of this step is the creation of a Service Flow Diagram, which clarifies all of the steps involved in delivering the service.

One of the main aims of an Organisational Viewpoint, for ARTIST, is to highlight and analyse the organizational and business aspects of an ITS service in order to clarify the responsibilities for all the activities involved, analyse the value chain, and ensure that there is a valid business case for its deployment.

6.4.2 Summary

Most integrated ITS implementations have components and communications links that are owned and managed by more than one organisation, who have to work together in an harmonious manner if the deployment is to be successful. Issues such as command and control, ownership of equipment and data, and priority in the use of communications links therefore need to be identified and resolved as early as possible before installation takes place. Since an ITS Architecture shows the technical relationship between components, it is valuable as a basis for discussion and agreement about the organisational issues.

An Organisational Viewpoint can help to define clearly many important characteristics of an ITS service, as follows:

- Define the responsibilities for purchase, management and maintenance of all the elements of an ITS service

- Establishing data ownership

- Setting up the contractual relationships

- Defining the legal implications (see also section 5.5)

- Drawing up business models

- Defining service levels and responsibilities

- Clarification of the safety and security responsibilities (see also sections 5.3 and 5.4).

7 Conclusions and Recommendations

This document has demonstrated just how difficult it will be deploy fully integrated Cooperative Systems throughout the EU. The various R&D projects have demonstrated that Cooperative Systems can be implemented from a technical point of view, but the existing organisational structure surrounding road transport means that a number of different organisations and companies will have to work together in different ways if integrated cooperative systems applications and services are to be fully realised.

The motivation for participating in the deployment of Cooperative Systems will vary depending on the stakeholder. The public sector will tend to concentrate on aspects of safety and (green) efficiency; companies will need to make a profit, whilst the user will only want to purchase equipment that provides services that he/she will find beneficial. Fully functioning and fully integrated Cooperative Systems cannot be deployed over a wide geographic area quickly or cheaply, and it is therefore necessary to identify a phased deployment that will not only work technically, but that will enable all the stakeholders to receive their desired benefits for each phase. Three scenarios have been identified that will achieve these aims, but in different ways. They are the industry driven scenario, the regulation driven scenario and common European mobility scenario.

The fact that this document describes alternatives and their consequences, rather than a single solution, is indicative of how complex is the world of integrated ITS in general and of Cooperative Systems in particular. The technology has been shown to work, but there is no obvious multi-stakeholder business plan for its deployment.

This situation is similar to the one facing the deployment of integrated ITS in Europe in the mid-1990's, and for which the FRAME Architecture was created. It has now been extended by the E-FRAME project to include Cooperative Systems, and so it can be used as a "common language" by all those who wish to deploy them. It enables models of Cooperative Systems to be created such that alternative deployment and organisational scenarios can be investigated. As well as creating a structure that is suitable for the required business plan, models created from the FRAME Architecture are suitable for the analysis of safety, security and privacy and their resultant legal liability issues.

In addition, being part of a larger composition, these models can be extended to show how Cooperative Systems fit with the other parts of ITS. There will not be single plan for the initial deployment of Cooperative Systems, different applications and services will be deployed separately. However, provided each one is modelled using the FRAME Architecture their commonalities will become apparent, so that when their functionalities do start to overlap, they can be merged into a single coherent whole with each one supporting the other.

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[1] The reference to 'Urban Traffic Management and Control' in the title was the name of the programme that funded its production, the document in fact relates to all ITS, including cooperative systems.

Appendix A   Definition of Cooperative Systems

Due to the variety of possible applications, the term "Cooperative Systems" is often understood in different ways. To be in-line with the European understanding this report uses the definition produced by the eSafety Forum. The following excerpt points out the motivation behind the development and deployment of cooperative systems.

"Under the European Framework Research and Development Programmes projects have been funded which have developed and demonstrated traffic telematics systems aimed at making transport safer, more efficient and effective, and more environmentally friendly. Many of these systems were aimed at improving the transport infra-structure, while others were based in the vehicles themselves.

Mostly, the systems developed by these projects have operated as autonomous or stand-alone. They hold the great potential to improve road safety and efficiency. Nevertheless there are limitations, to what can be achieved by systems based solely on the road, or solely in the vehicle, e.g. dealing with far distance threats or anticipating road difficulties with time margins compatible to the driver response time.

This requires another class of systems whose intelligence is distributed between vehicles and roads. As the capacity and flexibility of information technology and communications increases, and costs decrease, it becomes feasible to develop co-operative systems in which the vehicles communicate with each other and the infrastructure. In this way co-operative systems will greatly increase the quality and reliability of in-formation, support and protection available to road users, and the cost-effectiveness of applications."

The following definition of Co-operative Systems was agreed during the expert meetings:

"Road operators, infrastructure, vehicles, their drivers and other road users will co-operate to deliver the most efficient, safe, secure and comfortable journeys. The vehicle-vehicle and vehicle-infrastructure co-operative systems will contribute to these objectives beyond the improvements achievable with stand-alone systems." [ESAFETY 2004]

The existence of the variety of applications mentioned previously means that many different kinds of implementations exist. The common element is that different, physically separated telematics systems cooperate with each other via means of wireless data communication to accomplish a common goal, such as increased safety, efficiency and sustainability.

The various cooperative system implementations can be categorised according to their different communicating entities: infrastructure, vehicle, vulnerable road user (pedestrians or cyclists with communication device).

Appendix B Follow up projects

Field Operational Tests (FOTs)

After a the first round of integrated project dealing with Cooperative Systems, the EC called to convert the knowledge gained into large scale field operational tests.

Field operational test funded by the EC FP7 program with a total overall amount of approximately 50 M€ are:

Drive C2X

Duration: 36 month. Start, January 1st, 2011
Total cost: EUR 18.92 million, (Community funding EUR 12.4 million)
Programme: FP7-ICT-2009.6.2

The objective of the DRIVE C2X Integrated Project is to carry out comprehensive assessment of cooperative systems through Field Operational Tests in various places in Europe in order to verify their benefits and to pave the way for market implementation.

TeleFOT

Duration: 48 months. Start: June 1st, 2008
Total cost: EUR 14.5 million, (Community funding EUR 9.7 million)
Programme: FP7-ICT-2007-2

TeleFOT is a Large Scale Collaborative Project under the Seventh Framework Programme, co-funded by the European Commission DG Information Society and Media within the strategic objective "ICT for Cooperative Systems".

The project aims to test the impacts of driver support functions on the driving task with large fleets of test drivers in real-life driving conditions. It assesses the impacts of functions provided by aftermarket and nomadic devices, including future interactive traffic services that will become part of driving environment systems within the next five years.

euroFOT

Duration: 40 months. Start: May 1st, 2008
Total cost: EUR 21.57 million, (Community funding EUR 13.9 million)
Programme: FP7-ICT-2007.6.2 ICT for cooperative systems

euroFOT has brought together a comprehensive array of different organisations to test intelligent vehicle systems across Europe. Car manufacturers, suppliers, universities, research institutes and others stakeholders– in all some 28 separate organisations are involved with the aim to make road transport safer, more efficient and more pleasant.

The field testing focused in particular on 8 distinct functions that assist the driver in detecting hazards, preventing accidents and that make driving more efficient. Over the

course of one year, more than 1000 cars and trucks equipped with a range of different intelligent technologies were being tested on European roads across France, Germany, Italy and Sweden.

FOT-Net

In order to learn about and apply this methodology on Field Testing, the European Commission DG Information society and Media launched the Specific Support Action FOT-NET.

FOT-NET is conceived as the first Field Operational Networking Platform, aimed to gather together European and International Stakeholders to present results from Field Operational Tests, identify and discuss common working items and promote a common approach for FOTs.

National, European an International Field Operational Test organizers are now gathered in the strategic networking platform FOT-NET.

FOTsis

Duration: 42 months. Start: April 1st, 2011
Total cost: EUR 13.83 million, (Community funding EUR 7.85 million)
Programme: FP7-ICT-2009.6.2 ICT for cooperative systems

FOTsis (European Field Operational Test on Safe, Intelligent and Sustainable Road Operation) is a large-scale field testing of the road infrastructure management systems needed for the operation of seven close-to-market cooperative I2V, V2I & I2I technologies (the FOTsis Services), in order to assess in detail both 1) their effectiveness and 2) their potential for a full-scale deployment in European roads.

In addition to these Field Operational Tests, a variety of additional larger and smaller tests have been performed, are in progress or are planned. Taken all together, European, American, Asian initiatives, quite a large amount of money is being invested to foster the deployment of Cooperative Systems.

CIPs

Co-Cities

Co-Cities is a Pilot project setting up a mobile reference platform in cities and urban areas in order to introduce and validate cooperative mobility services. It will develop a dynamic "feedback loop" from mobile users and travellers to the cities' traffic management centres, and add elements of cooperative mobility to traffic information services. These software extensions are based on the In-Time Commonly Agreed Interface (CAI) and the pilots will run in the cities of Bilbao (ES), Florence (IT), Munich (DE), Prague (CZ), Reading (UK), and Vienna (AT).

COSMO

COSMO is an EC funded project belonging to the Commission's Policy Support Programme (PSP) and is part of the Competitiveness and Innovation Framework programme (CIP). One of the principal objectives is make detailed measurements of the performance of a number of cooperative systems with regard to their ability to reduce CO_2 emissions and improve energy efficiency in comparison with conventional systems. The project began in November 2010 and will conclude in June 2013.

The underlying aim of the project is to bring the tested systems a step closer to deployment by producing a set of 'specifications' based on accurate and reliable evidence of their environmental impact as well as detailed information on their installation, maintenance and potential business cases.

In order to provide the necessary information, a range of cooperative traffic management systems is being installed in three Pilot Sites where they can be tested in real-life, or close to real-life, traffic conditions over an extended period (between six months and one year). The sites include both urban and inter-urban road environments and are located in three countries: Austria (the Vienna Ring Road), Italy (the inner road network of a large university campus in Salerno) and Sweden (in the City of Gothenburg). The applications being tested include:

- Environmentally sensitive traffic control strategies

- Eco-driving for private vehicle and for public transport

- Multimodal real-time information systems designed to maximise energy efficiency

- Advanced energy efficient technologies integrated in roadside equipment

- Dynamic City Access Management strategy

- Advanced Real-Time Congestion Management System

It should be pointed out that the project does not involve development or research work, but only the necessary installation and integration required to permit the testing of prototypes already available. These involve components and communications systems developed in the major Cooperative Systems projects, including:

- The roadside units developed in both COOPERS and CVIS;

- The wireless sensor network developed in SAFESPOT;

- Communications technologies used in COOPERS and CVIS;

- Eco-driving approaches developed in CVIS.

During the test period, a rigorous programme of measurements will be carried out to produce detailed results not only relating to the environmental impact (CO_2 emissions and energy efficiency) but also traffic efficiency and safety. Initial results will be available by the end of 2011, and the full results by mid-2013.

Further details are available from the project website: www.cosmo-project.eu

Easyway

(cf. EW_CSTF_First_Priority_Services report)

EasyWay is a deployment project of almost all European road operators with its duration extending only to 2013. It is obvious that the large-scale deployment of real cooperative systems is not expected to take place in this time frame. However, the EasyWay project covering "all" European road operators at a time where major decisions are being made concerning cooperative systems, provides an optimal platform for common road operator agreement and support to the large-scale deployment of the cooperative systems regarded as priorities from the road operator point of view.

The aim was to identify the end user services and systems with sufficient maturity for preparing, piloting and evaluation during EasyWay by the EasyWay partners for eventual large-scale deployment as first priority services in close cooperation with the other stakeholders such as the commercial automotive and device manufacture industries, user organisations and other relevant partners.

The task was carried out as a desktop analysis by the task partners who scored the possible cooperative systems and services (as listed comprehensively by earlier R&D projects, standardisation bodies and European test sites) according to agreed criteria.

As a result, the task group proposed the following services for EasyWay first priority cooperative services:

- Hazardous location notification

- Traffic jam ahead warning

- Road works warning

- Decentralised floating car data

- Traffic information and recommended itinerary

- In-vehicle signage (incl. speed management)

- Automatic access control / parking management (incl. Intelligent Truck Parking)

It is important to note that the selected priority services still require a positive business case and all major deployment issues would need to be solved for them before the EasyWay partners can conclude that these services are the actual priority services ready for piloting and deployment. This will be ensured in the other work packages of the Cooperative Systems Task Force.

SMART063 and SMART067

Smart063 is a study tendered by the EC which has the main objectives to:

- better describe the scope of required infrastructure and a further elaboration of the definition of intelligent infrastructures and the ICT requirements imposed by cooperative systems,
- recommend a realistic step-by-step road map for the infrastructure operators, national authorities, traffic management centres and other relevant stakeholders to rollout and comply with such new requirements and
- identify existing gaps in knowledge and future research needs.

The motivation for this study is the stalemate in the Intelligent Infrastructure developments. On the one hand, there is a vision for a seamless use of ITS, making use of a European Intelligent Infrastructure, interoperable over the whole EU. In spite of successful completion of European Projects, the true deployment of necessary infrastructure to support cooperative systems lags behind. Industry waits for EU member states to invest in new infrastructure. Despite the willingness of member EU states to invest, they do not know in what. This study will shed light on the actions that stakeholders such as infrastructure operators, telecom operators and the EC need to take in order to achieve move cooperative system deployment forward through deployment of the necessary architecture.

Smart067 is the follower study of Smart063. The objectives in the tender are described as follows:

"The main objective of the study is to perform an analysis on how ICT applications can contribute to the optimization of mobility within the recently emerging European Smart Cities.

The study shall focus on:

- New developments, trends and policy changes in the urban environment that would require new ICT research and development to optimize/replace mobility;

- Assessing the impact of new urban policy objectives in order to facilitate the definition of future strategic research and innovation agendas and EU policies for ICT for mobility;

- Identification of new ICT concepts, on EU or international level, that have the potential to offer more optimized urban mobility solutions, while still creating a safe, clean and smart transport system;

- Providing a scenario for potentially changed mobility patterns based on available travel surveys, demographic prognosis and statistics;

- Potential for new ICT-based mobility services for goods in urban and inter-urban environment.

- Existing gaps in knowledge and future research needs should be identified and stated.

The study is intended to support the decision making process concerning required policy actions in the area of ICT research, development and innovation by providing an assessment of the most important systems and models able to resolve some of the challenges related to smart, efficient, safe and clean mobility."

Appendix C   Standardisation activities

ETSI and CEN services

As part of the response to European Commission's Mandate M/453 the two European Standards Development Organisations have produced a list of the main areas of cooperative systems operation for which it is believed standards will be required. These areas of operation are divided into several topics – see E-FRAME Deliverable D16 for a complete list. One of these topics is "Applications" which is divided up as follows:

- Cooperative Awareness Driving Assistance for safety (V2V): information from other vehicles as basis for the generation of in-vehicle warnings, Emergency Vehicle Warning, Intersection Collision Warning, Slow Vehicle Warning, Motorcycle Approaching Indication.

- Floating Car Data Collection for Infrastructure Applications (V2I): the collection of information from vehicles for use by infrastructure applications.

- Event Driven Road Hazard Warning (V2I and I2I): based on a certain event a warning message is sent out. These events may comprise but not be limited to, roadworks warning, wrong way driving warning, collision risk warning from an ITS-Station located at the roadside, traffic condition safety warning and weather condition warning.

- Event Driven Road Hazard Warning (V2V): based on a certain event a warning message is sent out. These events may comprise but not be limited to, emergency electronic brake light, stationary vehicle warning, roadworks warning, wrong way driving warning, traffic condition safety warning, weather condition warning.

- Traffic Management (V2I and I2I): optimum traffic throughput via speed limits, centrally determined routing, road network management, no overtaking for trucks, monitoring and routing of dangerous goods.

- Traffic Management (V2V): improved traffic throughput based on information from other vehicles e.g. position, speed, acceleration information.

- Cooperative Traveller Assistance (V2V, V2I and I2I): navigation taking into account information received about restricted access, etc., parking information/booking and Point of Interest (POI) information.

- Cooperative Traveller Assistance (V2V): navigation taking into account information received about restricted access, etc., parking information/booking.

- Value Added Services (V2V, V2I and I2I): comprising insurance and financial services.

As may be noticed, there is some duplication of the names for the classes of services but their contents are slightly different. This is because different standards are needed for the various forms of communications.

The important point about the services identified in this list is that they are those that are likely to be candidates for initial deployment. Some of them, such as parking for heavy goods vehicles feature in the ITS Action Plan and ITS Directive.

Appendix D   Safety issues

There are three safety topics that need to be considered when planning the deployment of any ITS: (Functional) System Safety, Traffic Safety, and Human Machine Interaction (HMI) Safety Whilst these overlap to some degree, the techniques involved in the corresponding safety analyses are quite different. These topics, and their relationship with ITS, were studied extensively during the European Framework Programmes 2, 3, 4 and 5, as well as in other R&D programmes. The following sub-sections provide a brief overview, together with some references to documents in which details can be found. There is, however, one document that brings the three topics together for ITS, namely [UTMC22 1999].

(Functional) System Safety

This topic relates to the ability of a system to behave in a manner that does not lead to the harm of people or the environment, either when the equipment is working as intended, or in the presence of a fault or defect. Such safety-related systems normally require third party assessment, e.g. Type Approval, before they can be used by the general public.

A key issue is how to identify all the possible hazards that relate to an ITS, and how to assess their risk. A modelling technique that is suitable for undertaking a safety analysis on any ITS, including cooperative systems, was developed by the DRIVE II PASSPORT project [PASSPORT 1995].   Risk assessment for ITS hazards has had ongoing development since Framework 2, and the current refinement has been published in [MISRA 2007].

The risks associated with most hazards are mitigated by reducing their probability of occurrence to a suitably low value, and there are two approaches on how to do this. The imperative approach, which is taken by the generic Standard IEC 61508, mandates the use of certain development techniques to achieve a given reliability. The alternative is a goal-based approach, which is described in [MISRA 1994], and requires the developer to add assurance/quality to gain increasing reliability. ISO TC22/SC3/WG16 is currently producing an automotive version of IEC 61508 (to be known as ISO 26262), but cooperative systems are outside its scope. See also [HOBLEY 1995], [JESTY 1997], [MISRA 1994]

Human Machine Interaction Safety (HMI safety)

This topic concerns the interaction between a driver and vehicle during the driving task, as well as between a driver and ITS equipment inside the vehicle or on the roadside. The principal issue involved is the risk of mental overload, or inattention of the driver, especially at critical times. The key question is: "How much information can you present to a driver before it stops being a help and starts to be a distraction?". A large number of studies have

been made of HMI, among which the HASTE project which devised a set of evaluation techniques to answer the above question. [HASTE 2005, HMI TF 2000]

One way to manage the provision of information to the driver is to ensure that it is only presented either when it is needed (in an emergency) or when the driver is able to accept additional information without affecting the safety of the situation. This topic was studied by the FPII project GIDS, which published its results in the book: [GIDS 1993]

Traffic Safety

This topic concerns the overall safety of vehicles and people within road traffic situations. It is possible that some cooperative system services could lead to relationships between vehicles and their drivers that make the overall traffic situation less safe than before, e.g. due to inattention brought on by overconfidence in the information being provided. This aspect has been examined in the following document, [DRASKOCZY 1997].

A further concern for some types of cooperative ITS service are the issues raised by the Vienna Convention on Road Traffic, which was first published in 1968 and revised in 1993. This states, in Article 8, that "every driver shall at all times be able to control his vehicle or to guide his animals". Whilst this was written at a time when all vehicle controls were mechanical, it still forms the basis of all the current laws that relate to safe driving. The increasing use of programmable devices which "interpret/modify" the driver's commands, raises the question as to how much intelligence one can include in systems before a driver is no longer in full control of his vehicle.