Cooperative systems
An overview

Ellen Grumert
Preface

This report is the result of a literature study in the area of cooperative systems. The project has been initiated by the Swedish Transport Administration (Trafikverket) and it is the first part of the project toward the licentiate degree for Ellen Grumert, carried out at the Swedish National Road and Transport Research Institute (VTI) and Linköping University. The supervisor for the project has been Andreas Tapani. The project has had a time line from August 2010 to February 2011.

The report can be seen as an introduction to cooperative systems and the issues related to cooperative systems, as well as a reference document for projects and initiatives that have been carried out and are ongoing as at the end of 2010. The reason for only looking at cooperative systems is that it is a new and fast growing area with many concepts still under development. The Swedish Transport Administration did request a report that included the most relevant facts and that summarized projects in the area. The report is also a great reference document for me in the continuing process of my research studies in the area.

Linköping February 2011

Ellen Grumert
Quality review

Review seminar has been carried out on 8 February 2011 where Mattias Hjort reviewed and commented on the report. Ellen Grumert has made alternations to the final manuscript of the report. The research director of the project manager Maud Gőthe-Lundgren examined and approved the report for publication on 18 February 2011.

Kvalitetsgranskning

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Cooperative systems – an overview

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Summary

The objective of this report is to give an introduction to the subject of cooperative systems and an overview of projects related to cooperative systems. Issues related to cooperative systems are also discussed in the report. Two areas of great importance for cooperative systems are the standardization process of cooperative systems in Europe and the communication frequency used for cooperative systems. These two subjects are therefore discussed in more detail in the report.

Projects within Europe, U.S. and Japan are included in the report. The reason for doing this limitation is that these countries/regions are the ones that have been found to be most developed and biggest with respect to cooperative systems. A lot of research and projects have been and are carried out in these countries. The aforementioned conclusion together with the extent of this project resulted in the investigation of projects in Europe, U.S. and Japan.

The information related to the projects discussed in this report has mostly been found on project homepages and in reports presented on the homepages, such as EU Deliverables etc. CORDIS (Community Research and Information Service) has been a big information source for the projects related to Europe. It should also be mentioned that information from the projects in Japan was harder to find and homepages did in some cases only exist in the Japanese language. Therefore some of the information related to the Japanese projects has been taken from presentations performed in Europe.

The report has been focusing on cooperative systems, which is a part of the wider concept Intelligent Transport Systems (ITS). The ’traditional’ Intelligent Transport Systems use technology, inside or outside of the vehicle, to give the driver some kind of information. The driver gets the opportunity to act upon the given information. Along with the increased amount of new technology the use of information and communication in the transport area has increased. Today cooperative systems are well-known in the transport area. The idea is to extend the more ’traditional’ Intelligent Transport Systems and build systems that are able to communicate with each other. These systems could be located inside the vehicle or as a road-side unit outside of the vehicle. The benefit with cooperative systems is the ability to send and receive real-time information and to use this information in order to increase safety, efficiency and environmental impacts on the roads. The increased amount of information together with the faster information flow and the fact that the information reaches the driver in real-time could contribute to more effective systems than the traditional Intelligent Transport Systems that exist today.

To our acknowledgement there are no other surveys with the same extent in the subject so far.
Samverkande system – en översikt

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Sammanfattning

Syftet med denna rapport är att ge en introduktion till området samverkande system och en översikt av projekt med anknytning till samverkande system. Problemställningar relataterade till samverkande system diskuteras också i rapporten. Två områden av stor betydelse för samverkande system är standardiseringsprocessen av samverkande system i Europa och den kommunikationsfrekvens som används till samverkande system. Dessa två ämnen diskuteras därför mer ingående i rapporten.

Projekt inom Europa, USA och Japan inkluderas i rapporten. Anledningen till denna avgränsning är att dessa länder/regioner är de som visat sig vara mest utvecklade och störst med avseende på samverkande system. Mycket forskning och många projekt har utförts och utförs idag i dessa områden. Den förut nämnda anledningen tillsammans med storleken på detta projekt har resulterat i att projekt i Europa, USA och Japan har inkluderats.

Det finns ingen andra litteraturstudier med samma omfattning i ämnet idag.

Rapporten har fokus på samverkande system, som är en del av begreppet Intelligenta Transportsystem (ITS). I de ‚traditionella’ Intelligenta Transportsystemen används teknik, i eller utanför fordonet, för att ge föraren någon form av information. Föraren ges möjlighet att agera på den givna informationen. Tillsammans med den ökade mängden av ny teknik har användningen av informations- och kommunikationsteknik inom transportområdet ökat. Idag är samverkande system ett välkänt begrepp inom transportområdet. Tanken är att utveckla de mer ‚traditionella’ Intelligenta Transportsystemen genom att utveckla system som kan kommunicera med varandra. Dessa system skulle kunna placeras inuti fordonet eller som en enhet längs med vägen. Det främsta syftet med samverkande system är möjligheten att skicka och ta emot information i realtid och att använda denna information för att öka säkerhet, effektivitet och miljöpåverkan på vägarna. Den ökade mängden av information tillsammans med att informationsfödets när ut snabbare och i realtid skulle kunna medverka till mer effektiva system än de ‚traditionella’ Intelligenta Transportsystemen som finns idag.

Enligt vår vetenskap finns det inga andra litteraturstudier med samma omfattning i ämnet idag.
1 Introduction

The world has been going through big changes in the transport area during the recent decades. The development of new and improved technologies for vehicles has been increasing rapidly. The development is of course different depending on country and climate, but the big industry countries is continuously developing new vehicles with more and more advanced technologies. Along with the increased amount of vehicles driving on the roads, the congestion has increased tremendously.

Another problem with the increased traffic flows on the roads is the risk for accidents and incidents. Many countries endeavor to decrease the accidents and the number of dead people on the roads and works actively to make this happen. In Sweden the Zero vision (’Nollvisionen’) (Trafikverket, 2010) is a big traffic safety work, where the vision is that everything that possibly could be done, in order to prevent death and serious personal injuries, should be done. The vision accepts that nothing as the perfect person exists and as a result of this accidents occurs, but it does not accept serious personal injuries. The thoughts of the vision have also been utilized in other countries and solutions to safety related issues in the traffic are today a big part of the research in the transport area.

The environment is another well-known and discussed topic. Governments, scientist etc. all over the world are trying to work together to finding solutions to the increasing environmental impacts. The transport area is a big part of the problem with increasing pollutions. When the amount of vehicles is increasing, the pollution is also increasing and apart from this, the problems with congestions that appear from the increased amount of vehicles, makes the pollutions even bigger.

Researchers all over the world are working actively to find good solutions for issues related to increased efficiency, increased safety and lately also decreased environmental impacts.

One area, which is believed to have great impact on safety and efficiency, is the Intelligent Transport Systems (ITS) area. Systems and technologies supporting ITS have been, and are being developed, in order to give the driver support in his driving. Systems like intelligent speed adaption, variable message signs, different types of traffic lights etc., with the purpose to improve safety and decrease congestions on the roads, have been developed and deployed.

The ’traditional’ Intelligent Transport Systems are one-way communication systems, which aims to inform the driver about different situations. Based on these ITS systems, the idea with vehicles that were able to communicate with each other and the surrounding infrastructure was introduced, i.e. cooperative systems. Cooperative systems have become more and more common in research and development in the transport area. Many projects related to cooperative systems have been carried out during the 1990’s and 2000’s, both in Europe but also in the rest of the world. Cooperative systems today are in many cases only on a development and research stage.

The European Union has given the following definition of cooperative systems

’Cooperative systems are ITS systems based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and infrastructure-to-infrastructure (I2I) communications for the exchange of information. Cooperative systems have the potential to further increase the benefits of ITS services and applications.’ (European Commission, 2009)

The idea behind cooperative systems, compared to the more ‘traditional’ Intelligent Transport Systems, is to improve the information given to the driver by two-way com-
munication between vehicles and vehicles and the infrastructure, by rel-time informa-
tion. Also the information given to road maintenance operators and the road authori-
ties, by the exchange of real-time information. The driver will be able to receive more
data from the environment and vehicles located close to him and the information will
be given to him in real-time (or almost real-time). There will, in some cases and with
some applications, also be opportunities for the vehicle to act without any interaction
and decision-making from the driver. Also the road authorities and road maintenance op-
erators could get great benefits from cooperative systems. For example roads with great
demand for reparation could be identified with information from the vehicles related to
how much the vehicles moves in vertical direction when driving on the road segment.
The increased information could also have a great impact on the research in the transport
areas. If the information was collected into databases, these databases could be used for
research purpose.

Some examples of applications that could be seen on the market in a close future is co-
operative adaptive cruise control, where the use of information exchange between ve-
hicles and roadside units could increase the dynamics on the roads and lead to a more
stable traffic flow with decreased accelerations and decelerations, information and
warnings about hazards could be given to the vehicles in real-time in order to prevent
accidents and incidents, re-routing systems that uses information about congestions
accidents etc. in order to redirect the traffic to a more efficient route, and intersection
management applications, to steer the traffic in an efficient and safe way with the use
of the local information shared between the vehicles and vehicles and the infrastructure
at the intersection. Applications with the purpose of informing about road conditions
could, apart from warn the drivers, also give important information to the road mainte-
nance operators. For example if a road is very slippery due to could weather and/or snow
the road maintenance operators has the possibility to act faster if they could get detailed
real-time data on the road conditions from the vehicles on the road.

Since many of the systems today haven’t yet been developed or at least not be imple-
mented on the market one can only imagine how much influence the systems will have
on the traffic flows. The usefulness of the application is of course also dependent on the
degree of implementation. In order for the systems to have an effect, more than a few ve-
hicles needs to have the systems inside the vehicle and road-side units most be installed.
Cooperative systems has great potential due to all the new technologies that are being
developed. It is today impossible to predict the impact the systems will have on the traf-
fic in the future and in which areas the systems can be useful, but one thing is clear and
that is the cooperative systems increases the possibilities for future innovations in the
area.

This report aims to give an overview of cooperative systems, and bring together and give
a short summary of the biggest and most well-known projects and initiatives/activities
in Europe, U.S. and Japan related to cooperative systems. An overview of cooperative
systems together with the main issues related to cooperative systems and the commu-
nication frequency used for cooperative systems are discussed in chapter 2. Chapter 3
summarizes finalized projects within cooperative systems in Europe, U.S. and Japan. In
chapter 4 a summary on ongoing projects and initiatives within cooperative systems in
Europe, U.S. and Japan is done. Finally a discussion and comparison of the projects and
activities is done in chapter 5. Three Swedish projects/initiatives are presented in the re-
port, two finalized projects OPTIS and SRIS, which can be found in chapter 3 and one
ongoing initiative IVSS and FFI, which can be found in chapter 4.
2 Cooperative systems – an overview

This chapter includes a short overview of cooperative systems as well as the issues related to cooperative systems and a description of the media used for communication within cooperative systems.

2.1 What are cooperative systems?

What if we could have a world where vehicles could be self-driven or almost self-driven?, and where the driver, through the vehicle could get help in dangerous situations or to prevent dangerous situations. This is the idea with cooperative systems.

Intelligent Transport Systems (ITS) are systems inside or outside the vehicle that helps the driver in different situations, either by giving information about situations or by warnings etc. The actuated traffic light is a good example of an early ITS system, which has the purpose to help the drivers to keep order in intersections with high traffic flows. The intelligent transport systems are systems that are standalone, i.e. they have one purpose and are communicating in one direction, giving the driver information or advice.

Cooperative systems aim to take another step towards an information, advice and communication based environment on the roads. The idea is to make vehicles ‘talk to each other’. An on-board unit inside the vehicle should be able to send and receive information from other surrounding vehicles, with the use of already existing technologies and by the development of new technologies. This type of communication is called vehicle-to-vehicle communication and is often abbreviated to V2V communication. The other type of communication that is assumed to be used within the cooperative systems is the vehicle-to-infrastructure communication and infrastructure-to-vehicle communication (often abbreviated to V2I resp. I2V communication). The vehicles should be able to send and receive information from roadside units when passing by it. Another term that often is used is V2X communication, meaning both V2V and V2I communication.

One of the first big projects within Intelligent Transport Systems was PROMETHEUS, (Diebold, 1995), which stands for Program for European Traffic with Highest Efficiency and Unprecedented Safety. The project started in 1986 and was part of the European Research Coordination Agency(EUREKA). The project partners included only vehicle manufacturers and the focus within the project was therefore on the vehicle side. One of the difficulties with the PROMETHEUS project was the technologies available at that time, which limited the use of the results from the project.

Since then the technologies, which can be used within the area, has had a tremendous development. Today many projects are working within the area of cooperative systems, both on national level and international level. Many projects with focus on cooperative systems, as well as the closely related intelligent transport systems, have been funded by the European commission through the Fifth, Sixth and Seventh Framework Programmes. Also countries outside of EU, such as the U.S. and Japan, have been focusing a lot on projects within the area. Many research cooperations and agreements have been carried out between different regions/countries.

The basic idea for all the projects, independent of country or region, is that the development and deployment of cooperative systems will increase safety and efficiency on the roads a lot. During the later years the environmental impacts of road traffic have also become an important improvement area within cooperative systems. Today some projects are only focused on the environmental issues and applications that might reduce the environmental impacts of road traffic.
Until now, many of projects have been on an early research, development and field test stadium. The main issue today is to get an as fast as possible deployment of the systems. This is the same all over the world. All stakeholders, independent of if they are authorities, vehicle manufacturers etc., agrees on this. The most important issue today and a few years forward in time, is therefore to get standardizations of, for example technologies used, applications and legal issues, within the area of cooperative systems, in order to get interoperability all over the world or at least in big regions. European standardization organizations as well as national standardization organizations are working with this at the moment. Cooperation between these organizations is of course essential and important to get standards that work not only in one country, but in many countries.

Besides the standardization work the projects are continuing with their research to find better applications with focus on increased safety, efficiency and the reduction of the environmental impacts.

### 2.2 Issues

In order to deploy cooperative systems within Europe and the rest of the world and get it to work in an interoperable and efficient way some issues needs to be considered and carefully treated. The most important issues has been listed by and discussed in CVIS (2010a) (a project within cooperative systems, discussed in more detail in chapter 3) and are summarized in table 2.1.

**Table 2.1 Main issues regarding implementation of cooperative systems, affected persons/organizations and possible solutions according to CVIS.**

<table>
<thead>
<tr>
<th>Issues</th>
<th>Affected</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardization</td>
<td>• Vehicle and telecom industry (worldwide)</td>
<td>• Standardization organizations in all parts of the world should work together and also cooperate with industry in order to develop standards that are interoperable as soon as possible (hereunder technology, applications, legal issues, etc.)</td>
</tr>
<tr>
<td>User acceptance</td>
<td>• Drivers point of view</td>
<td>• Questionnaires to affected persons</td>
</tr>
<tr>
<td></td>
<td>• Road authorities point of view</td>
<td>• Studies</td>
</tr>
<tr>
<td></td>
<td>• Usability of the system (i.e. applications used, type of driver, etc.)</td>
<td>• Field tests</td>
</tr>
<tr>
<td>Security and privacy</td>
<td>• Private vehicle users</td>
<td>• The design of the architecture need to be good and well composed</td>
</tr>
<tr>
<td></td>
<td>• Providers applications/platforms</td>
<td>• &quot;Future-proof&quot; solutions to ensure that the platforms stays secure when technology changes</td>
</tr>
<tr>
<td>Legal issues and</td>
<td>• Vehicle users</td>
<td>• Stakeholders must be aware of the person responsible if anything goes wrong</td>
</tr>
<tr>
<td>liabilities</td>
<td>• Service providers</td>
<td>• Consideration regarding these issues needs to be done before the system is deployed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• People needs to be informed about their responsible (fully responsible)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Implementation of methods for monitoring the transfer data to be able to prove any inconsistencies (proof service providers mistake)</td>
</tr>
<tr>
<td>Multi stakeholders</td>
<td>• Telecom industry -</td>
<td>• Inclusion of all stakeholders</td>
</tr>
<tr>
<td>cooperation</td>
<td>• Authorities</td>
<td>• Founded projects that brings different stakeholders together</td>
</tr>
<tr>
<td></td>
<td>• Car industry</td>
<td>• Ensure that all stakeholders has a good business plan for developing cooperative systems</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
<td></td>
</tr>
</tbody>
</table>

The issues discussed in CVIS are presented in more detail in the sections below.
2.2.1 Standardization

For the cooperative systems to work efficient and in an interoperable way, not only within one platform, but in cooperation with other platforms some kind of standards are needed. These standards should include not only standardization of applications, but also standardization of the technology used, standardizations for the facilities used, and so on. In the process of making standards for cooperative systems it is important to include all relevant stakeholders, in order to cover all aspects and for the final standardizations to be useful for all parties. It is also important to have a close cooperation with other regions/countries/other parts of the world in order for the cooperative system to be interoperable worldwide. The standards should also minimize any extra work that might be needed when converting one system to another system.

2.2.2 User acceptance

It is important that the cooperative system fulfills its purpose for all users. This involves utility and usefulness for both drivers and the road authorities/holder of the systems. To make the system useful, consideration should be given to both the type of applications and the type of drivers, that the system focuses on. An investigation in what might be useful can be done by questionnaires, simulator studies and field operational tests etc.

2.2.3 Security and data privacy

Cooperative systems does often has the aim to be developed within open platforms, where everyone with some basic knowledge has the possibility to add applications etc. The advantage with an open platform is that the interoperability is getting as big as possible, and all different kind of stakeholders can easily add their applications to the system. But when keeping this high level of openness it might be hard to keep a good level of security and privacy and solutions for protection of users and producers needs to be developed.

In a questionnaire done by the CVIS project, 77% answered that they did care about if the system was invading their privacy. It is therefore important to find a way to protect private users from exposure of sensitive data. It is also important to protect providers of applications/platforms against vicious attacks, false messages and so on.

2.2.4 Legal issues and liabilities

It is important to clearly state who has the final responsibility in situations that might lead to violation against the law. When the vehicles get more and more directed by the cooperative system the driver might feel that his/her responsibility is less than before. It is therefore important to make the driver aware of that he/she is still the person, who has the last responsibility, when something happens, and the cooperative systems should only be seen as a guiding system to the (standalone) driver.

But in some cases it might be the service provider that gives wrong information to the driver. In this case, the local authority might want to be able to locate the service provider and monitor the information sent out by the service provider, in order to determine who has the responsibility for the false information.

2.2.5 Multi stakeholders cooperation

Cooperative systems are expected to be able to be used by many different stakeholders with different aspects to cooperative systems. It is therefore important that all relevant
stakeholders are included in the process of the development and deployment of cooperative systems, in order to get interoperability of the system. The different stakeholders to take into account are summarized below:

- **Creation and development of system:**
  - Vehicle manufacturers
  - Equipment manufacturers
  - Research institutions
  - Software developers

- **Users:**
  - Local authorities
  - National road authorities
  - Road operators
  - Freight operators
  - Public transport operators
  - Private road users

- **Promoters:**
  - Users organizations
  - Transport organizations
  - Service providers.

Cooperation between stakeholders is an important element in the ongoing standardization process.

### 2.3 Communication frequency used for cooperative systems

In 2008, the European Commission (2008), decided that the frequency band 5.875–5.905 MHz. should be allocated to ITS road safety applications. The time horizon for the implementation was set to six month for designation and as soon as possible after that the frequency band should be available on a non-exclusive basis.

In addition to the European Commission's decision the European Conference of Postal and Telecommunication Administrations Electronic Communications Committee (2008a) (CEPT ECC), decided, to use the same spectrum for ITS safety related applications, both for inter vehicle communication and roadside to vehicle communication. It is not mandatory for the members to use this frequency band but it is strongly recommended by CEPT ECC.

CEPT ECC has in their decision assigned the frequency band 5.905–5.925 MHz for future development of ITS.

This means that it will be mandatory for the 27 European Union Member states, but also recommended (but not mandatory) for the 48 member states of the CEPT ECC, to use the assigned frequency for inter vehicle communication and roadside to vehicle communication.

Besides the decision, European Conference of Postal and Telecommunication Administrations Electronic Communications Committee (2008b) has also made a recommendation on the frequency band 5.855–5.875 MHz to be used for non-safety application for ITS.

The European Radiocommunications Committee (1999) (ERC), decided that harmonized frequency bands should be used for High Performance Radio Local Area Net-
works (HIPERLANs). The frequency band that should be used is 5.250–5.350 MHz and 5.470–5.725 MHz.

These frequency bands was also designated to Wireless Access Systems with Radio Local Area Networks (WAS/RLANs) by the European Commission (2005).

Three standards regarding frequency bands have been developed by ETSI (The European Telecommunications Standards Institute) (Weber, 2010):

- **ETSI EN 302 571**: Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5.855 MHz to 5.925 MHz frequency band. (Harmonized European standard, 2008-09)
- **ETSI EN 301 893**: Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN (Harmonized European Standard, 2008-12)
- **ETSI ES 202 663**: Intelligent Transport Systems (ITS); European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band (ETSI standard, 2010-01).

The ETSI ES 202 663 is only an ETSI standard, but it is expected to become European norm as well. In standard ETSI ES 202 663, a table summarizing the frequency bands used for ITS and cooperative ITS can be found. See table, 2.2, for a summarization of the standards.

**Table 2.2 Frequencies used in Europe for cooperative systems**

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Usage</th>
<th>Regulation</th>
<th>Harmonized standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.470 – 5.725 MHz</td>
<td>RLAN(BRAN, WLAN)</td>
<td>ERC Decision</td>
<td>ETSI EN 302 571</td>
</tr>
<tr>
<td>5.855 – 5.875 MHz</td>
<td>ITS non-safety applications</td>
<td>ERC Recommendations</td>
<td>ETSI EN 301 893</td>
</tr>
<tr>
<td>5.875 – 5.905 MHz</td>
<td>ITS road safety</td>
<td>ERC Decision</td>
<td></td>
</tr>
<tr>
<td>5.905 – 5.925 MHz</td>
<td>Future ITS applications</td>
<td>ERC Decision</td>
<td></td>
</tr>
</tbody>
</table>

Apart from the European commission and CEPT ECC, the car industry in Europe has also identified the frequency band 5.875–5.925 MHz for deployment and development of road safety application for ITS. According to the ECC Decision in 2008, on the harmonized use of the 5.875–5.925 MHz frequency band for Intelligent Transport Systems (ITS), the U.S. use the frequency band 5.850–5.925 MHz for the Dedicated Short Range Communications (DSRC) providing ITS applications with specific channels for safety. And in Japan the frequency band 5.770–5.850 MHz has been assigned for DSRC and ITS application. Both USA and Japan allow their bands for both inter vehicle communication and roadside to vehicle communication.

This shows that frequency bands, similar to each other, are used, or recommended to be used, by Europe as well as USA and Japan.

Although, in a presentation from the 2:nd EU-Japan ICT Cooperation Forum on ICT Research (Satoshi Oyama, 2009), it is indicated that Japan is going to use a new bandwidth for vehicle-to-vehicle and vehicle-to-infrastructure communication from 2012 and onwards. The new bandwidth is going to be 700 MHz (715–725 MHz is going to be used for ITS). It is a result of an investigation of the available bandwidth and the potentially new bandwidth, performed in 2007–2009. The investigation included a pre-FOT (Field Operational Test) in 2007 and a large scale FOT in 2008. In the FOT two cases were considered, warnings of rear-end collisions and intersection collision avoidance. Both cases included scenarios with obstacles on the roadside and which in turn might lead to
problems in the communication. The investigation has been done because it is believed that the 700 MHz bandwidth better can handle communications when obstacles are on the road. The houses etc. doesn’t block the information as often as when the 5.8 GHz bandwidth is used.

The change in frequency range for Japan will lead to different allocations of bandwidth compared to EU and U.S.

The frequencies presented in table 2.2 are related to applications which needs fast communication alternatives with very little delay of the information sent, i.e. safety applications etc. If the information is not related to safety, other communication alternatives might also be considered, such as ‘traditional’ telecommunication. The wireless communication modes are also being more and more developed and might in the future be more and more used as communication tools within cooperative systems. Examples are 3G, 4G and GPS systems.
3 Finalized projects within cooperative systems

A lot of projects have been finalized within cooperative systems. In this chapter an overview of some of the projects will be presented. The projects are divided into European projects, U.S. projects and Japanese projects. A lot of the projects within Europe are funded by the European Commission within the Framework Programmes. This overview includes many of the most important projects, but since there are a lot of projects within cooperative systems not all of them are listed. The first projects are described more in detail, since they are some of the biggest and most extensive ones and also because the results from the projects has been used and referred to in many other projects. Also more focus has been made on projects carried out during the later years. The applications considered within the biggest projects have been listed and described in more detail.

3.1 European projects

This section summarizes some of the projects that have been performed in Europe. The first part of this section introduces the most extensive projects within the area of cooperative systems. More focus has been given to the applications within the projects. The following subsection, 3.1.8, gives a brief overview of cooperative systems projects in Europe, not included in the first part, and finally a presentation of projects within cooperative system, but with a clear focus on the technologies is given in in section, 3.1.9.

3.1.1 CVIS

CVIS (2010a) stands for Cooperative Vehicle-Infrastructure Systems. It is a major European research and development project. The aim with the project has been to design, develop and test Cooperative system technologies, i.e. the technology of V2V communication and V2I communication. CVIS uses real-time data to increase road safety, efficiency and reduce the environmental impact. The project has been supported by the European Commission within the Sixth Framework Programme. It has also been a big part of the COMeSafety project (Bechler et al., 2010), described in section 3.1.5.

The project has had over 60 partners from different areas covering different aspects and interests for the development of cooperative systems. The partners include public authorities, software developers, system integrators, road operators, public transport operators, system suppliers, vehicles manufacturers, research institutions and user organizations.

The project started in February 2006 and the time line for the project was four years (i.e. spring 2010). The CVIS project has been focusing on:

- development of applications for
  - cooperative urban network management
  - cooperative destination-based control
  - cooperative acceleration/deceleration
  - dynamic bus lanes
  - enhanced driver awareness
  - cooperative traveler assistance on inter-urban highways
  - commercial vehicle parking
  - monitoring and guidance of hazardous goods
  - freight vehicle access control to sensitive areas
- high-precision vehicle positioning and creation of local road maps
• a system that gathers and integrates monitoring data from moving vehicles and roadside detectors in order to be able to have communication between vehicles, and vehicles and the infrastructure in a transparent and continuous way. This includes data sharing between vehicle, roadside infrastructure and service centers for traffic, weather and environmental data

• a secure and open application framework to allow access for on-line services. The open application framework is available for anyone to use (in terms of software) and it should have a few or no copyright restriction in order for anyone to use it

• defining an architecture within cooperative systems. This means to find a method to ensure that all the components that are included in the cooperative system work efficiently together (the people, the software, the hardware etc.) The architecture should be easy to update and improve when new technologies are available

• address issues with the cooperative system such as user acceptance, data privacy and security, system openness and interoperability, risk and liability, public policy needs, costs/benefit and business models and roll-out plans for implementation

• creating a router which can maintain a continuous Internet connection over a wide range of media (cellular, mobile Wi-Fi networks, infra-red, short-range microwave). The router needs to have full interoperability with all components in the system

• models, guidelines and recommendations for deployment in the areas of: openness and interoperability; safe, secure and fault-tolerant design; utility, usability and user acceptance; costs, benefits and business models; risk and liability; cooperative systems as policy tool; deployment roadmaps.

The media used in the CVIS project has been a communication architecture based on the CALM standards (Communications Access for Land Mobiles) and an evaluation of the ISO CALM standards was carried out in the project. The communication tool used to communicate between different communication media and different application types in the CALM standard is the IPv6 (Internet Protocol Version 6).

Tests of the CVIS’s technologies and applications were done in six European countries: France, Germany, Italy, Netherlands/Belgium, Sweden and the UK.

Applications

CVIS has presented a number of applications and use cases within the project, which are included in the document ‘D.CVIS.2.3 Final Use Cases and System Requirements’ (Kovacs et al., 2010), presented within the project. These applications and use cases are the ones that have been evaluated during the project. CVIS has concluded that these applications are the ones, which are of most interest and with most impacts of the system. CVIS definition of use cases and applications are as follows.

Applications are defined as: ‘Several pieces of Software which are designed to deliver a specific service functionality in a distributed cooperative systems environment. Applications can be distributed in several components over several vehicles/roadside unites/centres. For example services like cooperative Routing in CINT(Cooperative Inter-urban applications sub-project)/FOAM/Framework for Open Application Management) or cooperative monitoring applications may be composed of several distributed modules which all need to co-operate for achieving the desired functionality.’ (Kovacs et al., 2010)
Use cases are defined as: ‘The specification of a sequence of actions, including variants, that a system (or other entity) can perform, interacting with actors of the system.’ (Kovacs et al., 2010)

An overview of the final applications can be seen in table 3.1.

**Table 3.1 Table of final applications and use cases given in the CVIS project.**

<table>
<thead>
<tr>
<th>Application type</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic and management applications</td>
<td>• Route planning and re-routing</td>
</tr>
<tr>
<td></td>
<td>• Provision of accurate input data for Traffic Management Centers</td>
</tr>
<tr>
<td></td>
<td>• In-vehicle display of dynamic traffic signs and speed advice</td>
</tr>
<tr>
<td></td>
<td>• Dynamic lane allocation</td>
</tr>
<tr>
<td></td>
<td>• Traffic prioritization</td>
</tr>
<tr>
<td></td>
<td>• Intermodal journey planning (This application has not been implemented as a prototype in CVIS project.)</td>
</tr>
<tr>
<td></td>
<td>• Dynamic tolling / congestion charging (This application has not been implemented as a prototype in CVIS project.)</td>
</tr>
<tr>
<td>Logistics and Freight Management Applications</td>
<td>• Parking zone management</td>
</tr>
<tr>
<td></td>
<td>• Truck access control</td>
</tr>
<tr>
<td></td>
<td>• Dangerous goods management</td>
</tr>
<tr>
<td></td>
<td>• Multi-modal/freight transport planning (This application has not been implemented as a prototype in CVIS project.)</td>
</tr>
<tr>
<td>Safety Applications</td>
<td>• Cooperative Manoeuvring</td>
</tr>
<tr>
<td></td>
<td>• Emergency Broadcast</td>
</tr>
<tr>
<td></td>
<td>• Safety Warning</td>
</tr>
<tr>
<td></td>
<td>• Pre-crash Mitigation</td>
</tr>
<tr>
<td></td>
<td>• Cooperative Sensing</td>
</tr>
<tr>
<td></td>
<td>• Coordinated braking</td>
</tr>
<tr>
<td></td>
<td>(As CVIS had very good cooperation with SAFESPOT, its system project dealing with cooperative road safety, majority of safety applications were not implemented as prototypes.</td>
</tr>
<tr>
<td></td>
<td>• Safety Warning [Hazardous warning – CVIS name] application has however been implemented in order to demonstrate interoperability between the two projects.</td>
</tr>
<tr>
<td>Maintenance Applications</td>
<td>• Sensor Calibration</td>
</tr>
<tr>
<td></td>
<td>• Remote Diagnostics</td>
</tr>
</tbody>
</table>

The applications and use cases presented above are mostly related to safety and efficiency, but also maintenance in means of calibration of sensors and collection of diagnostic information from vehicles to service centers are considered in order to be able to evaluate and improve the information reliability and standard of the equipment.

The pure safety applications are obviously used for safety reasons. Emergency Broadcast is a post-crash application which purpose is to send information about an emergency for fast help and to give information in advance to the emergency personnel. Cooperative manoeuvring, safety warning, pre-crash mitigation, cooperative sensing and coordinated braking are preventive applications with the purpose to help the driver with information in order to reduce the risk of accidents in dangerous situations.

The traffic and travel management applications and the logistic and freight management applications are more efficiency applications, but when the efficiency is increased the safety is often also implicitly increased. For example, with clear guidelines on specified routes (route planning and re-routing), the risk for congestions is decreasing and thereby the risk of an accident is decreasing as well, since there are a higher risk of an accident or incident in congested areas. Dangerous goods management is another example where safety will increase as a result of more efficient and controlled transportation of the dangerous goods.
3.1.2 COOPERS

COOPERS (2010a,b) is a research and development project funded by the European Commission within the Sixth Framework Programme. COOPERS stands for COOPera-tive SystEms for Intelligent Road Safety. 39 partners was included in the project and the coordinator was Austria Tech. The project started in February 2006 and had a time line of 4 years. The project has played a great role in the COMeSafety project (Bechler et al., 2010) discussed in section 3.1.5.

COOPERS has been focusing on the development of telematics (also known as Information and Communication Technology) applications for the infrastructure. The aim is to reduce the increasing gap that has been evolving between the car industry and the infrastructure operators within the development of telematics applications, i.e. COOPERS wants to increase the cooperative traffic management between infrastructure and vehicles, and by doing this increase the road safety.

The final validation and tests of the COOPERS project has been performed on public motorway sections. The countries that have been included in the tests are Germany, Austria, Italy, France, and the Netherlands. Some of the tests have only been based on local technical tests due to limitations, but most of the tests included the field tests.

Services

In the COOPERS project the term applications is not used, instead the term Services is used. COOPERS has together with its partners decided on 12 services, which are going to be tested on the test sites. The final 12 services are presented in a final report, Delivery D6100 (COOPERS, 2010b), and can be seen in table 3.2.

Table 3.2 Table of final applications and use cases given in the COOPERS project.

<table>
<thead>
<tr>
<th>Application type</th>
<th>Services within COOPER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real time data communication between infrastructure and vehicle to exchange safety related information</td>
<td>- S1: Accident/Incident warning (Including wrong way driver information)</td>
</tr>
<tr>
<td></td>
<td>- S2: Weather condition warning (Ice Road Warning, Fog Warning)</td>
</tr>
<tr>
<td></td>
<td>- S3: Roadwork Information</td>
</tr>
<tr>
<td></td>
<td>- S4: Lane utilization Information (Lane banning, Keeping in Lane, Auxiliary Lane Accessibility)</td>
</tr>
<tr>
<td></td>
<td>- S5: Legal speed limit</td>
</tr>
<tr>
<td></td>
<td>- S6: Traffic congestion warning</td>
</tr>
<tr>
<td></td>
<td>- S7: Recommended speed limit</td>
</tr>
<tr>
<td></td>
<td>- S8: International service handover</td>
</tr>
<tr>
<td></td>
<td>- S9: Road charging</td>
</tr>
<tr>
<td></td>
<td>- S10: Estimated journey time (Route navigation)</td>
</tr>
<tr>
<td></td>
<td>- S11: Recommended next link (Route navigation)</td>
</tr>
<tr>
<td></td>
<td>- S12: Map information check to inform of current update for digital maps (Route navigation)</td>
</tr>
</tbody>
</table>

Service 1–7 are ‘Safety Critical Services’ and 8–12 are ‘Convenience Services’. All of the services have been tested. S4 (lane banning and lane keeping) and S5 has been tested with local technical tests, but all other service tests are based on field tests.

The applications related to safety will often have impact on efficiency as well, since when the driver has more information about for example a roadwork or a traffic congestion, then he/she has the opportunity to change route in advance, leading to increased efficiency.

The convenience services are not likely to have much impact on safety, but in some cases there might be some influence. Like for example in the case of recommended next link, where the driver in advance know how to drive and thereby gets a more consistent and smooth driving style. It is also possible to get a scenario, where the driver is given
the estimated journey time ahead and gets stressed and therefore change his/her driving style to a more offensive driving style leading to decrease safety.

The efficiency on the other hand are maybe more likely to be affected of the services related to convenience since the driver can plan his route with map information, estimated journey time and recommended next link. The road charging will probably also increase the efficiency, since the driver has the opportunity to pay inside the vehicle and doesn’t have to stop, resulting in more effective driving.

3.1.3 Safespot

Safespot (2010) is a European Commission funded project within the Sixth Framework Programme. The time line for the project has been 2006 to 2010. The project has been part of COMeSafety (Bechler et al., 2010) discussed in section 3.1.5.

The vision of Safespot has been to find solutions for the vehicles and infrastructure, in order to reduce the congestion and the growing number of injuries that appears every year in the traffic. This has been done by looking at cooperation between infrastructure and vehicles, i.e. cooperation systems with focus on some critical areas. One of the goals with the project has been to develop a Safety Margin Assistant, which detects potentially dangerous situations and gives information to the driver to make him/her aware about the surrounding environment.

The objectives have been to develop an open architecture and a platform that work as a communication area for different applications. The work has been performed in cooperation with 52 partners from 12 European countries, and the project has been tested in seven countries (France, Germany, Italy, Netherlands, Spain and Sweden (Stockholm and Gothenburg)).

Applications

To find appropriate use cases, that should be further investigated in the project, the user needs were identified. The user needs should reflect the requirements the users of the system had on the system, in order for it to work and be useful. The requirements were functional requirements, non-functional requirements and context requirements. The user needs together with the systems requirements and some accident analysis ended up in some final use cases used in the two sub-projects. The use cases has been presented in the deliverable, SP8-HOL-SP Horizontal Activities, Use cases, functional specifications and safety margin applications (Brignolo et al., 2008).

The definitions of application and use case for the Safespot project has been:

‘In SAFESPOT each application acts as a primary and a secondary actor. The primary actor is related to the generation of a warning to the driver of the ego-vehicle (i.e. the vehicle in which the application is running). The secondary actor is a vehicle or infrastructure node responsible for generating information to be communicated to other vehicles or to the infrastructure. According to this logic an infrastructure node is always a secondary actor providing the right information (raw data or driver oriented messages) to the vehicles.’ (Brignolo et al., 2008)

‘Use cases are goals (the terms ‘use case’ and ‘goal’ are used here interchangeably) that are made up of scenarios. Scenarios consist of a sequence of steps to achieve the goal. Each step in a scenario is a sub-(or mini-)goal of the use case. As such, each sub-goal represents either another use case (subordinate use case) or an autonomous action that is at the lowest level desired by our use case decomposition.’ (Brignolo et al., 2008)
In table 3.3 and 3.4 the applications and use cases, used in the Safespot project are presented. The applications are divided into two sub-categories, vehicle based applications (table 3.3) and infrastructure applications (table 3.4). The division is based on the two sub-projects, SCOVA and COSSIB, that has been working with the applications in the Safespot project.

Table 3.3 Table of applications and use cases for the Vehicle based applications given in the Safespot project.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Use case</th>
</tr>
</thead>
</table>
| Road Intersection Safety | * Accident at intersections  
                          | * Obstructed view at intersection  
                          | * Permission denial to go-ahead  
                          | * Detect traffic signs  
                          | * Other vehicle brakes hard due to red light  
                          | * Approaching emergency vehicle warning |
| Lane Change Manoeuvre  | * Lane Change Manoeuvre for trucks with blind spots  
                          | * Lane Change Manoeuvre for car/trucks  
                          | * Lane Change Manoeuvre for ramp in motorways |
| Safe Overtaking        | * Safe overtaking in urban and semi urban roads with PTWs (Powered Two Wheelers) already overtaking the Other Vehicle (OV)  
                          | * PTW overtaking OV while OV is turning left to park area  
                          | * PTW overtaking OV while a different OV is turning left to park area |
| Head On Collision Warning | * Head On Collision Warning due to hazardous overtaking attempt by host vehicle  
                          | * Head On Collision Warning due to hazardous overtaking attempt by second vehicle  
                          | * Head On Collision Warning due to the presence of a coach vehicle climbing down through a hairpin curve |
| Rear End Collision     | * Rear End Collision due to the presence of a heavy vehicle climbing up through a hairpin curve at a low speed  
                          | * Rear End Collision due to the presence of a slower vehicle at the end of a hilly road segment |
| Speed Limitation and Safety Distance | * Speed Limitation and Safety Distance and trucks driver recommendations  
                          | * Safety Margin Assistant on black spots – tunnels  
                          | * Safety Margin Assistant on black spots – reduction of lanes |
| Frontal Collision Warning | * Frontal collision warning due to a static obstacle in front  
                          | * Frontal collision warning due to a static obstacle in a tunnel  
                          | * Frontal collision warning due to abnormal vehicle behavior in front |
| Road Condition Status – Slippery Road | * Road Condition Status – V2I Based  
                          | * Road Condition Status – V2V Based |
| Curve Warning           | * Curve Warning in rural black spots, based on a transponder in the infrastructure keeping memory of the speeds adopted by passing vehicles |
| Vulnerable Road User Detection and Accident Avoidance | * Vulnerable Road Users crossing a road, based on on-board detection system  
                          | * Vulnerable Road Users crossing a road, based on environment analyses  
                          | * Vulnerable Road Users in blind spots of a truck |

The applications in the Safespot project has a clear focus on safety and all of the applications are mainly focusing on the improvement of safety and decreased accidents/incidents in the traffic. This will be achieved with help of information to the driver from surrounding vehicles and from the infrastructure, but there will of course also be efficiency effects in the system.

The driver will get information about different situations, such as Road conditions, collision warnings of different types, road intersection information, hazard and incident warnings etc. This will result in increased safety in different situations, but as an effect of the information, which is given to the driver a head, also the efficiency will be increased. The driver will be able to act upon the information he/she has been given, which might result in for example a new route to the destination in case of an accident, speed adaption, etc. This will reduce the congestion and increase efficiency in the traffic.
3.1.4 Pre-Drive C2X

The Pre-Drive C2X project (Schulze, 2010) is an EU-funded project within the Seventh Framework Programme. It started in July 2008 and was finalized in June 2010.

The objective for the project has been to establish a European architecture framework for cooperative systems with vehicle-to-vehicle and vehicle-to-infrastructure communication applications that are interoperable within the architecture. The final architecture has been based on the COMeSafety architecture description (see section 3.1.5 for a description of the COMeSafety project). Pre-Drive C2X has developed: robust prototypes of hardware and software, methods and tools for field operational trials for vehicular communication, an integrated simulation tool set to be able to measure the impacts of technical aspects, traffic and safety aspects and environmental aspects for vehicular communication and finally the project has been developing implementation strategies and business models for the deployment of cooperative systems within Europe. A socio-economic impact analysis as well as a business economic analysis has been done.

The results has been contributing to the standardization work within Europe.
Table 3.5 Table of final use cases given in the Pre-Drive C2X project.

<table>
<thead>
<tr>
<th>Type of use case</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety related use cases</td>
<td>• Approaching emergency vehicle</td>
</tr>
<tr>
<td></td>
<td>• Emergency electronic brake lights</td>
</tr>
<tr>
<td></td>
<td>• Wrong way driving warning</td>
</tr>
<tr>
<td></td>
<td>• Post crash warning</td>
</tr>
<tr>
<td></td>
<td>• Car breakdown warning</td>
</tr>
<tr>
<td></td>
<td>• Slow vehicle warning</td>
</tr>
<tr>
<td></td>
<td>• Overtaking vehicle warning</td>
</tr>
<tr>
<td></td>
<td>• Intersection collision warning</td>
</tr>
<tr>
<td></td>
<td>• Hazardous location notification</td>
</tr>
<tr>
<td></td>
<td>• Traffic jam ahead warning</td>
</tr>
<tr>
<td></td>
<td>• Signal violation warning &amp; pre-emption</td>
</tr>
<tr>
<td></td>
<td>• Stop sign violation</td>
</tr>
<tr>
<td></td>
<td>• Lane change assistance</td>
</tr>
<tr>
<td></td>
<td>• Pre-Crash sensing warning</td>
</tr>
<tr>
<td></td>
<td>• Co-operative forward collision warning</td>
</tr>
<tr>
<td></td>
<td>• Co-operative merging assistance</td>
</tr>
<tr>
<td></td>
<td>• Co-operative glare reduction</td>
</tr>
<tr>
<td></td>
<td>• Left-turn collision warning</td>
</tr>
<tr>
<td></td>
<td>• Right-turn collision warning</td>
</tr>
<tr>
<td></td>
<td>• Curve speed warning</td>
</tr>
<tr>
<td></td>
<td>• Road works warning</td>
</tr>
<tr>
<td></td>
<td>• Vulnerable road user warning</td>
</tr>
<tr>
<td></td>
<td>• Motorcycle warning</td>
</tr>
<tr>
<td></td>
<td>• Decentralized floating car data</td>
</tr>
<tr>
<td></td>
<td>• Regulatory and contextual speed limit</td>
</tr>
<tr>
<td></td>
<td>• Green Light optimal speed advisory</td>
</tr>
<tr>
<td></td>
<td>• Traffic information and recommended itinerary</td>
</tr>
<tr>
<td></td>
<td>• Enhanced route guidance and navigation</td>
</tr>
<tr>
<td></td>
<td>• Intersection management</td>
</tr>
<tr>
<td></td>
<td>• Co-operative flexible lane allocation</td>
</tr>
<tr>
<td></td>
<td>• Adaptive drive train management</td>
</tr>
<tr>
<td></td>
<td>• V2I Traffic Optimization</td>
</tr>
<tr>
<td></td>
<td>• Limited access warning</td>
</tr>
<tr>
<td></td>
<td>• In-vehicle signage</td>
</tr>
<tr>
<td></td>
<td>• Co-operative adaptive cruise control</td>
</tr>
<tr>
<td></td>
<td>• Co-operative vehicle-highway aut. system</td>
</tr>
<tr>
<td>Traffic efficiency use cases</td>
<td>• Point of interest notification</td>
</tr>
<tr>
<td></td>
<td>• Automatic access control / parking management</td>
</tr>
<tr>
<td></td>
<td>• Local electronic commerce</td>
</tr>
<tr>
<td></td>
<td>• Car rental / sharing assignment / reporting</td>
</tr>
<tr>
<td></td>
<td>• Electronic toll collect</td>
</tr>
<tr>
<td></td>
<td>• Media downloading</td>
</tr>
<tr>
<td></td>
<td>• Map download and update</td>
</tr>
<tr>
<td></td>
<td>• Ecological driving</td>
</tr>
<tr>
<td></td>
<td>• Instant messaging</td>
</tr>
<tr>
<td>Infotainment, business and deployment use cases</td>
<td>• Remote personal data synchronization</td>
</tr>
<tr>
<td></td>
<td>• SOS service</td>
</tr>
<tr>
<td></td>
<td>• Stolen vehicle alert</td>
</tr>
<tr>
<td></td>
<td>• Remote diagnosis and just in time repair notification</td>
</tr>
<tr>
<td></td>
<td>• Fleet management</td>
</tr>
<tr>
<td></td>
<td>• Design Re-Use and Change Management</td>
</tr>
<tr>
<td></td>
<td>• Business Intelligence for High-Volume Service Parts</td>
</tr>
<tr>
<td></td>
<td>• Vehicle software provisioning and update</td>
</tr>
</tbody>
</table>

Applications
As a first step the use cases, that were going to be used in the project, has been decided and classified. The functional requirements and a description of the use cases has been made, where after a selection of the most interesting use cases has been made based on a scoring system considering maturity, feasibility of field testing and available evaluation methods, e.g., simulation tools. Finally a functional architecture verification has been made to find the final use cases. In the document, D4.1, Detailed description of selected use-cases and corresponding technical requirements, produced by Pre-Drive C2X (Enkelmann et al., 2008), the final applications and use cases has been presented. These are presented in table 3.5.
The applications are safety and efficiency related, as well as ‘infotainment’ applications. The latter ones are comfort applications that have the main purpose to give the driver increased comfort in different situations.

Some of the applications in the infotainment category might also serve as an efficiency or/and a safety application as a secondary effect. Some applications might for example reduce congestions due to faster service on the road, i.e. toll electronic commerce, which gives the driver the opportunity to pay from the car and no stops are necessary, or map download and update, which gives the driver the opportunity to better plan his/her route, resulting in a more stable driving behavior. Also traffic efficiency and traffic safety applications might have secondary effects giving increased safety respectively efficiency besides the main purpose.

3.1.5 COMeSafety

COMeSafety (2010) is a project within cooperative systems that started in January 2006 with a time line of four years. It is funded by the European Commission within the Sixth Framework Programme.

The project’s aim has been coordination and consolidation of research projects within cooperative systems. COMeSafety has been acting as a support for the eSafety forum within the cooperative intelligent road transport systems area. The project has also been working as a platform for exchange of information and presentation of results from European and national research projects, both for private and public stakeholders. Another important part of the project has been the harmonization, with other parts of the world, within cooperative systems, where the VSC and VII consortia in the US and programs like AHSRA and ASV3 in Japan have been considered (See section 3.2 and section 3.3 for a description of the projects). There has also been a lot of focus on the standardization of the European frequency allocation and all type of work related to cooperative systems done by standardization organizations worldwide has been considered, where especially the standardization organizations ETSI(The European Telecommunications Standards Institute), CEPT(The European Conference of Postal and Telecommunications Administrations), ISO(International Organization for standardization) and IEEE(Institute of Electrical and Electronics Engineers) have been considered.

Several projects within the Sixth Framework Programme have been focusing on eSafety and the COMeSafety project has been collaborating with some of them. Already at the start of the project there has been cooperation with CVIS, SAFESPOT, COOPERS and eSafetySupport. Exchange of information has also been done with many projects, among those are CYBERCARS, GEONET, GST, PReVENT and SEVECOM.

In the report, ‘Delivery 31: Specific Support Action, European ITS Communication Architecture, Overall Framework, Proof of Concept Implementation’ (Bechler et al., 2010), the baseline for European ITS communication architecture for cooperative systems is introduced. The document consists of three parts: the architecture of the cooperative system platform, the communication technology that should be used and a description of the implemented prototypes and a first common demonstration of some of the projects involved. Many projects have been involved in the document and the main projects are COOPERS, CVIS, SAFESPOT, GeoNet and PRE-DRIVE C2X. There has also been cooperation with Car2Car Communication Consortium, ETSI, IETF and ISO and input comes from IEEE and SAE.
Table 3.6 Table of applications and use cases for the Traffic safety applications given in the COMeSafety project.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Traffic safety</th>
<th>Use cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency vehicle warning</td>
<td>• “Warms drivers to yield right of way to an approach in emergency vehicle.”</td>
<td></td>
</tr>
<tr>
<td>Overtaking vehicle warning</td>
<td>• “An overtaking (passing) vehicle signals its action to the vehicle being overtaken to secure the situation.”</td>
<td></td>
</tr>
<tr>
<td>Lane change assistant</td>
<td>• “Provides information about cars on neighboring lanes when the driver intends to make a lane change.”</td>
<td></td>
</tr>
<tr>
<td>Cooperative merging assistance</td>
<td>• “Vehicles negotiate the merging process with each other and give advice to the driver.”</td>
<td></td>
</tr>
<tr>
<td>Cooperative glare reduction</td>
<td>• “Enables automatic switching of headlights (high-beam to low-beam) of the vehicle when it approaches an oncoming vehicle.”</td>
<td></td>
</tr>
<tr>
<td>Intersection collision warning</td>
<td>• “Crossing vehicle collision warning: informs/warns driver in case of potential collision with crossing vehicles.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• “Left (right) turn collision warning: informs/warns driver in case of potential collision with oncoming vehicles.”</td>
<td></td>
</tr>
<tr>
<td>Signal/Sign violation warning</td>
<td>• “Red traffic violation warning: Warms driver when they are going to violate a red traffic signal.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• “Stop sign violation warning: Warms drivers when they are going to violate a Stop sign rule.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• “Speed limit violation warning: Warms drivers when they are going to violate a speed limit indication.”</td>
<td></td>
</tr>
<tr>
<td>Emergency electronic brake light</td>
<td>• “Warms drivers before driving into a (suddenly) hard-breaking vehicle.”</td>
<td></td>
</tr>
<tr>
<td>Wrong way driving warning</td>
<td>• “Detects wrong way driving vehicles and warns affected, endangered drivers.”</td>
<td></td>
</tr>
<tr>
<td>Pre-crash sensing</td>
<td>• “Prepares for imminent and unavoidable collisions by exchanging vehicle attributes after a non-avoidable crash is detected.”</td>
<td></td>
</tr>
<tr>
<td>Cooperative flexible lane change</td>
<td>• “Considers the flexible allocation of a dedicated lane (e.g. reserved to public transport) to some vehicles, which get a permanent or temporary access right.”</td>
<td></td>
</tr>
<tr>
<td>Cooperative forward collision warning</td>
<td>• “Warms drivers when collisions (rear-end collisions, etc.) might happen.”</td>
<td></td>
</tr>
<tr>
<td>Hazardous location notification</td>
<td>• “Warms driver against upcoming bad weather/road conditions (slippery road, fog, rain, etc.).”</td>
<td></td>
</tr>
<tr>
<td>Car breakdown warning</td>
<td>• “Warms drivers when approaching a breakdown car either by the stranded car itself or by a following car that detects a disabled vehicle (e.g. detecting zero velocity).”</td>
<td></td>
</tr>
<tr>
<td>Traffic jam ahead warning</td>
<td>• “Warms drivers when approaching the tail of a traffic jam.”</td>
<td></td>
</tr>
<tr>
<td>Slow vehicle warning</td>
<td>• “Warms drivers to prevent rear-end collisions to slow moving vehicles.”</td>
<td></td>
</tr>
<tr>
<td>Road works warning</td>
<td>• “Informs drivers of ongoing road works and associated obstruction of road traffic in the vicinity.”</td>
<td></td>
</tr>
<tr>
<td>Post crash warning</td>
<td>• “Warms drivers when approaching a crashed car either by the crashed car or by a following car that detects a crashed vehicle warning ahead.”</td>
<td></td>
</tr>
<tr>
<td>Curve speed warning</td>
<td>• “Based on received curve information the safe speed is calculated for the vehicle entering the curve and the driver will be warned if current speed is higher than safe speed.”</td>
<td></td>
</tr>
<tr>
<td>Vulnerable road user warning</td>
<td>• “Provides warning to driver of the presence of vulnerable road users, e.g. motorcycles in case of dangerous situations.”</td>
<td></td>
</tr>
</tbody>
</table>

Applications

In the report presented by COMeSafety the definition of use case and application are as follows: ‘An application is a general service for the ITS user. An example of an ITS application is the intersection assistant, which supports the driver at an intersection to avoid collision. The description of the environment and the reason for which the collision occurs define the use case that triggers the application. Examples of use cases of the intersection assistant are vehicles turning left warnings or warning a driver that another vehicle has not given priority.’ Bechler et al. (2010)

In the report, discussed above, three types of basic applications are introduced together with its subclasses and use cases: Traffic safety, traffic efficiency and value-added services. These applications and use cases are presented in table 3.6, 3.7 and 3.8. The applications and use cases are taken straight from the report and no change has been done to the formulation given in the text Bechler et al. (2010).

Applications both within traffic safety and traffic efficiency are represented in the project.
Table 3.7 Table of applications and use cases for the Traffic efficiency applications given in the COMeSafety project.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Traffic efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decentralized floating car data</td>
<td>“Informs driver with advice about the conditions along his future route.”</td>
</tr>
<tr>
<td>Green light optimal speed advisory</td>
<td>“Drivers receive a recommendation in order to hit the next traffic lights in green phase and to avoid waste acceleration.”</td>
</tr>
<tr>
<td>Traffic information and recommendation itinerary</td>
<td>“Recommends a route for the vehicle navigation system to direct the driver around congestion locations and to distribute traffic load on alternative routes.” “A special use case is the guidance to a parking place which helps to avoid unnecessary drivers searching for a free slot.”</td>
</tr>
<tr>
<td>Enhanced route guidance</td>
<td>“Exploits traffic information provided by a public traffic monitoring authority to empower a better navigation.”</td>
</tr>
<tr>
<td>Traffic light optimization</td>
<td>“The intersection controller optimizes the traffic light phases based on the information from the vehicles at the intersection in order to reduce the overall waiting time for the vehicles.”</td>
</tr>
<tr>
<td>Limited access warning</td>
<td>“Controls the entrance to an area or road segment where some or most vehicles have limited access. An ITS Roadside Station at the entrance announces its presence and approaching vehicles may validate themselves to seek access.”</td>
</tr>
<tr>
<td>In-vehicle signage</td>
<td>“Informs the driver about effective speed limits along the road including special or contextual variations.”</td>
</tr>
<tr>
<td>Cooperative flexible lane allocation</td>
<td>“Considers the flexible allocation of a dedicated lane (e.g., reserved to public transport) to some vehicles which gets a permanent or temporary access right.”</td>
</tr>
<tr>
<td>Adaptive power train management</td>
<td>“Infrastructure informs about road structure ahead (such as slope, curve) and possible dynamic road traffic information (for example queue warning). The vehicle uses the information to prepare and optimize the power train performance (shift, throttle, brakes...).”</td>
</tr>
<tr>
<td>Cooperative adaptive cruise control and</td>
<td>“Automated positional and velocity control of vehicles to operate as a platoon on a highway.”</td>
</tr>
<tr>
<td>cooperative vehicle highway automation system</td>
<td></td>
</tr>
</tbody>
</table>

and since this is a joint effort between many projects in the area the applications are results of these projects and they are the ones that seems to be most effective and useful. Also value added services are represented. The main focus for these applications is to give the driver higher comfort when driving. But some of the value added applications will also contribute to efficiency in the traffic, due to the increased information. For example the SOS service will give the service center possibility to act faster and more planned, if they get information about the situation in advance and the electronic toll collect will reduce the number of stopped vehicles, when entering a road where payment is expected, which will increase the flow on the road. There are many examples of when value added services, that has a main purpose to give the driver better service along the road, also could act as an efficiency increaser and in some cases also a safety increaser.
Table 3.8 Table of applications and use cases for the Added service applications given in the COMeSafety project.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Value Added Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point of interest notification</td>
<td>“Drivers receive notifications informing about local peculiarities.”</td>
</tr>
<tr>
<td>Automatic access control/parking management</td>
<td>“Grants access to restricted areas automatically.”</td>
</tr>
<tr>
<td>Local commerce</td>
<td>“Vehicle drivers get in touch with local business and consume offered services.”</td>
</tr>
<tr>
<td>Car rental/Sharing assignment/reporting</td>
<td>“A Roadside Unit, which has the capability to manage the booking of non-assigned vehicles and release of returned vehicles.”</td>
</tr>
<tr>
<td>Electronic toll collect</td>
<td>“A vehicle pays the road toll electronically and fully automatically by means of communication without stopping.”</td>
</tr>
<tr>
<td>High speed Internet access</td>
<td>“Media download: Download of multimedia content (audio-video) for entertainment.”</td>
</tr>
<tr>
<td>Stolen vehicle alert</td>
<td>“The information about a stolen vehicle provided to relevant authorities.”</td>
</tr>
<tr>
<td>Remote diagnosis and just in time notification</td>
<td>“A vehicle exchanges information with a vehicle service center for a remote functional diagnosis.”</td>
</tr>
<tr>
<td>Fleet Management</td>
<td>“Communication and data processing for assisted management of vehicle fleets, including vehicle maintenance and vehicle tracking, driver management and transport logistics.”</td>
</tr>
<tr>
<td>Vehicle software provisioning and update</td>
<td>“A vehicle service station provides new software updates for vehicles.”</td>
</tr>
<tr>
<td>SOS service</td>
<td>“Automated transmission of emergency messages to a service center in case of life-threatening emergency (in-vehicle detection).”</td>
</tr>
<tr>
<td>Vehicle relationship management</td>
<td>“Connects vehicles to an IP-based backbone infrastructure. General objectives to establish a bi-directional information exchange in order to support commercial and business opportunities.”</td>
</tr>
<tr>
<td>Design re-use and change management</td>
<td>“Management of product design reuse and change in the automotive industry economical system.”</td>
</tr>
<tr>
<td>Business intelligence for high-volume service parts management</td>
<td>“Optimization of service parts management in the automotive industry economical system.”</td>
</tr>
<tr>
<td>Insurance and financial services</td>
<td>“On-demand and real-time interaction with financial and insurance coverage service providers.”</td>
</tr>
</tbody>
</table>

3.1.6 INVENT and AKTIV

INVENT (2005; 2004; 2010), is a German project, supported by the Federal Ministry for Research and Education. The project has had a duration of four years and was finalized in 2005. INVENT stands for Intelligent Traffic and user-oriented technology and its goal was to make the future traffic safer and more efficient. There have been 24 partners included in the project. The INVENT project was divided into three projects:

- **Driver assistance/Active safety** – The project has been focusing on driver assistance systems that helps the driver to make decisions in situations that are potentially dangerous. The project has been divided into sub-projects, which are:
  - Detection and Interpretation of the Driving Environment – the project has been working on how to get the systems to think, see and communicate
  - Anticipatory Active Safety – development of systems for lane changing and turning maneuvers
  - Congestion Assistance – helps the vehicles to act in congested situations by taking a lot of burden from the driver, i.e. use of safe distance control in the system and so on
  - Driver Behavior and Human Machine Interaction – the project has been fo-
cusing on how drivers acts in different situations, in order to see which sys-

• Legal Issues and Acceptance – investigation of legal issues and acceptance
regarding the new technologies used in the new systems.

• Traffic Management 2010 – development of intelligent traffic solutions in order
to avoid congestion by redistribution of traffic flows and guidance of drivers from
their starting point to their destination. The sub-projects within the project are:

– Traffic Performance Assistance – the component project has developed a
system, which will help to increase traffic jams and adapt vehicles speed in
order to, as fast as possible, get back to an uncongested situation. Interaction
between vehicles has also been developed in order to warn drivers of upcom-
ing congestions
– Network Traffic Equalizer – traffic management strategies has been incorpo-
rated into navigation systems in order to help drivers to find the best way to
their destination. Not only the drivers demand is taken under consideration,
but also the public traffic management policy, safety, and the environment is
taken under consideration.

• Traffic Management in Transport and Logistics – Development of technologies
that improves the planning of courier service delivery routes. The current traffic
situation has been taken into account.

AKTIV (Adaptive and cooperative technologies for intelligent traffic)

AKTIV (2007; 2010) is a German project, which was funded by the Federal Ministry
of Economics and the Federal Ministry for Research and Education. AKTIV’s work is
based on the results from the earlier project INVENT. There have been 29 partners from
the automobile electronics and telecommunications industries, software companies, re-
search institutes and transport authorities included in the project. This has given a wide
range of input and many different aspects to the project. The project started in 2006 and
was finalized in August 2010.

The project has been divided into three projects, which are divided into 15 sub-projects.
The focus areas for the three projects have been road safety, traffic management and mo-
bile communication based on traffic data exchange.

The aim of the project has been to develop solutions that will improve the road safe-
ty and the optimal efficiency in the traffic flow. This has been done by evaluation and
improvements of existing driving assistance systems, knowledge and information tech-
nologies, solutions for efficient traffic management and vehicle-to-vehicle and vehicle-
to-infrastructure communication, as well as development of new systems for future co-
operative systems applications.

The project Traffic management (AKTIV-VM) has been focusing on interactions be-
tween intelligent vehicles systems and between intelligent vehicles systems and intelli-
gent infrastructure. Six applications have been developed within the project.

The project Active Safety has been focusing on safe driving and functions which helps
the driver to a safer drive.

The project CoCar has done research in the area of vehicle-to-vehicle communication
and vehicle-to-infrastructure for future cooperative vehicle application, where cellular
mobile communication technologies are being used.

According to the article ‘An AKTIV partner for traffic safety and management’ (Today,
2010) has it, along with the development of new technologies within the project, not only been focus on improved driver safety and convenience but there has also been focus on improvements in terms of congestion and CO2 emissions.

A number of applications have been developed within the project. The definition of application in this case is a bit unclear, since the project also refers to the applications as sub-projects on the homepage. The idea is that each sub-project works with one of the applications, but since the applications/sub-projects are some kind of systems within or outside of the vehicles communicating with the driver in different ways, they could be seen as applications. The applications are presented in table, 3.9.

Table 3.9 Table of applications/sub-projects given in the AKTIV project.

<table>
<thead>
<tr>
<th>Project</th>
<th>Applications/subprojects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Traffic Management</td>
<td>• Network Optimizer</td>
</tr>
<tr>
<td></td>
<td>• Virtual Traffic Guidance System</td>
</tr>
<tr>
<td></td>
<td>• Cooperative Traffic Signal</td>
</tr>
<tr>
<td></td>
<td>• Adaptive Navigation</td>
</tr>
<tr>
<td></td>
<td>• Situation Responsive Driving</td>
</tr>
<tr>
<td></td>
<td>• Information Platforms</td>
</tr>
<tr>
<td>Active Safety</td>
<td>• Active Hazard Braking</td>
</tr>
<tr>
<td></td>
<td>• Integrated Lateral Assistance</td>
</tr>
<tr>
<td></td>
<td>• Intersection Assistance</td>
</tr>
<tr>
<td></td>
<td>• Pedestrian and Cyclist Safety</td>
</tr>
<tr>
<td></td>
<td>• Driver Awareness and Safety</td>
</tr>
</tbody>
</table>

The traffic management applications will obviously increase the efficiency within the traffic, but also the safety might be affected as a secondary effect, since a more planned route will probably result in less congestion and a more stable driving behavior from the driver, which will lead to less accidents. Also the efficiency might be affected by the safety application, even if the effects in this case is a bit more unclear. The project Cooperative Cars does not include any applications, probably because the focus within the project has been on the communication technologies.

3.1.7 CODIA

CODIA stands for Cooperative Systems Deployment Impact Assessment. It is a Finnish study, which aim was to make an impact assessment on selected applications with respect to safety, traffic efficiency and environment. The study was carried out in 2008 and its duration was 8 months. The results from the assessment has been presented in the document ‘Final study report CODIA Deliverable 5’ (Kulmala et al., 2008). The applications selected to be investigated were:

- Speed adaption due to weather conditions, obstacles and congestion (V2I and I2V communication)
- Local danger/hazard warning (V2V)
- Post crash warning (V2V)
- Cooperative intersection collision warning (V2V and V2I).

The project has been evaluating the effects of the different applications from today and up to 2030 (since road safety will be improved a lot even without cooperative systems). The project took into account the system functionalities, technologies, HMI, costs, vehicle market penetration, infrastructure coverage, and effects on driver and travel behavior. Three cooperative system Research and Development projects have been contacted.
in the process (CVIS, COOPERS and SAFESPOT) in order to get detailed data about the system specifications. The basic data used in the project has been collected from the eIMPACT project, the TRACE project, the DG Environment FLEETS project and the TRENDS database and the three Research and Development projects (some of them presented in this document).

The impact assessment was based on micro simulation modeling and the package used was SISTM. Some of the cooperative systems were addressed to both motorway and rural roads and some were only addressed to motorway. Three situations were modeled: accident, congestion and weather.

The results indicated that all systems were giving benefits with respect to the safety impacts. The direct traffic impacts were not so big for the relevant systems, speed adaption and local danger warning. The emission effects were very small for all systems, as well as the noise impacts. But the indirect emission effects, due to reduced accidents related to congestion, showed a larger decrease of emissions. The cost effects was also large with respect to socio-economic profitability for the systems speed adaption and local danger.

3.1.8 Short summary of projects

In this section, a short summary of finalized projects in the area of cooperative systems is presented. The projects shows the fast development of cooperative systems during the later years and the wide range of projects within the area of cooperative systems. Some of the projects are focused on Intelligent Transport System, but the results have been important in the continuous work of cooperative systems.

PROMETHEUS

PROMETHEUS (Auto Spectator, 2010) stands for Program for European Traffic with Highest Efficiency and Unprecedented Safety. The project started in 1986 and was finalized eight years later (1994). The project has been carried out in cooperation with several European manufacturers, electronic producers and suppliers, universities and institutes. The idea within the project was to increase safety, minimize the energy consumption, make comfort for the driver and improve the environmental compatibility. The focus for the project was to make the vehicles ready for the future. The project was one of the earliest of its kind and the vision for the project was far ahead of its time. Already available technology was used, as well as new technologies, that were developed along the way, in order to make it easier for the driver and to give him/her advices on the way. The technology was incorporated into the vehicle for the driver to get support along a route. Some of the sub-projects within PROMETHEUS was developing and focusing on: an autonomous intelligent cruise control system (DISTRONIC PLUS), Vision Information Technology Application (VITA) (an autopilot which was able to brake, accelerate and steer), automatic pre-safe brake (PRE-SAFE), car-to-car communication (like warnings sent between cars about black-ice patches), cargo and fleet management. This shows that already in the PROMETHEUS project, in the middle of 1980’s to the middle of the 1990’s, the importance of cooperative systems had been discovered, even if the systems wasn’t called cooperative systems and some of the applications was one-way communications applications, meaning that they can be classified as ITS systems rather than cooperative systems.
CarTALK2000

CarTALK2000 is an EC funded project within the fifth Framework Programme (European Commission, 2010b). It started in 2001 and was finalized three years later (2004). CarTALK2000 was one of the first projects within cooperative systems and the aim was to develop a mobile ad-hoc network, in order for vehicles to be able to communicate in dangerous situations to increase the road safety. 7 partners were included in the project, including a car manufacturer, a parts supplier, research institutes and universities.

The main issues in the project were the assessment of today and future applications for cooperative driver assistance systems, development of the techniques that should be used for the cooperative systems and the testing of the cooperative drivers’ assistance systems in real or constructed traffic scenarios.

On the home page of the CarTALK2000 (2010) project the coordinator of the project, Dr Christian Maihoer of DaimlerChrysler, states that he believes that the systems or spin-offs of the systems developed within the project will have a great impact on the safety on the road in the future. Within the project no direct product was ready to be launched and this was not the aim with the project. The research was very visionary and no ready product would be able to be introduced before 2010 according to Maihoer.

The CarTALK2000 project gave a ground for other projects to continue the research in the area. For example projects like PReVENT (discussed in section 3.1.8) and Safespot (discussed in section 3.1.3) uses the results from the project, but with more focus on short-term realization and production probability.

Sevecom(Secure Vehicular Communication)

Sevecom is an EC funded project within the sixth Framework Programme (European Commission, 2010a). The project started in 2006 and was finalized in 2008. The project has to some extend been included in the COMeSafety project, discussed in section 3.1.5 and is therefore presented in the final report by COMeSafety (Bechler et al., 2010).

The focus area within the project has been security and security elements for vehicular communications, where both security and privacy is taken under consideration. The aim has been to provide a full definition and implementation of security requirements within vehicular communication and design the security architecture of a network, which includes communication between vehicles and communication between vehicles and infrastructure. Road traffic has been a big part of the project and three major aspects has been examined: threats (denial of services, identity cheating, bogus information etc.), requirements (authentication, availability, privacy etc.), and operational properties, which includes network scale, privacy, cost and trust.

PReVENT

PReVENT (2010) is a European automotive industry project, which has been co-funded by the European Commission within the Sixth Framework Programme (European Commission, 2010a). It started in 2004 and was finalized in 2008.

The aim of the project has been to develop preventive safety applications and technologies to use, in order to reduce the accidents in dangerous situations. Depending on which state the vehicle is in when a dangerous situation occurs the safety system will act differently, i.e. the safety system will inform, warn or actively assist the driver when a dangerous situation occurs. The applications will also maintain a safe speed, keep a safe
distance, drive within the lane, avoid overtaking in critical situations, safely pass inter-
sections, avoid crashes with vulnerable road users and reduce the severity of an accident
if it occurs.

The technologies used in the project has been technologies for applying information
and, communications and positioning technologies. The technologies has been based
on both standalone features and cooperative features (vehicle-to-vehicle and vehicle-to-
infrastructure communication). And this project is therefore not a project only within co-
operative systems but rather a project within safety applications. The applications might
be used in cooperative systems, but in some cases this is not necessary.

ADASE II

ADASE II (2010) stands for Advanced Driver Assistance Systems in Europe and it is
a European Commission funded project within the fifth Framework Programme (Eu-
ropean Commission, 2010a) with focus on Advanced Driver Assistance Systems. The
project started in 2001 and was finished in 2004. The projects objective was to col-
lect and disseminate information about Advanced Driver Assistance Systems. Related
projects on international level, as well as national and regional level where integrated
by a thematic network governed by the ADASE II project. Both experts in the field, au-
torities and the public have been involved in the project. The focus in the project has
been to improve safety and efficiency with telematics (information and communication
technology) which builds links between service providers, vehicles and management
centers. The ADASE II project has also been focusing on improved interfaces to other
transport modes and profitable additional applications and services, such as smart travel
advice, tele-commerce, in-car entertainment, mobile office support etc. A lot of differ-
ent activities have been done within the project in order to reach its goal, for example,
workshops has been held and results and information has been disseminated to relevant
persons/organizations and the general public, etc.

Predit (France)

Predit (2010) is a French research program. The focus for the program has been to en-
couraging development of a transport system that is safer, more energy saving, envi-
ronmentally friendly and economically and socially more effective. The program was
launched by the ministries in charge of research, transport, environment and industry,
the ADEME and the ANVAR, in 1990. It has been developed over the years and there
have been three related programs during the years, which all have the focus mentioned
above, but with different aspects, due to development in the project and the in worldwide
development.

The first program, Predit1 (1990–1994), did focus on technical innovations inside the
vehicles. The second program, Predit2 (1996–2000) was, besides technical innovations,
also looking at the involvement of other factors such as the human factors and the so-
ciety and also what the aim of the research was. Finally, in the third program, Predit3
(2002–2006), focus has been on goods transportation and energy and environment is-
sues, but it has also included diversified research on safety.

FleetNet

FleetNet (CVIS, 2010b) was a consortium consisting of six companies and three univer-
sities in Germany. The project was carried out between 2000 and 2003 and the project
Network on Wheels has been a successor to the project. The project did focus on get-
ing Internet on the roads. The main objective was to create and demonstrate a platform
for inter vehicle communication systems. The services and applications were divided into three categories: cooperative driver-assistance applications, local floating car data applications and user communication and information services. The results have been presented to relevant standardization organizations.

NOW

NOW (2010) stands for Networks On Wheels. The network started in 2004 and the idea was to have a network that could produce technical solutions for vehicle-to-vehicle communication and present the results to the Car-2-Car Communication Consortium, which was active in the standardization process. As a starting point in the project, the results from the FleetNet was used. The network was funded by six vehicle manufacturers in 2004 and was closed in 2008.

COM2REACT

The project COM2REACT (Cooperative communication system to realize enhanced safety and efficiency in European road transport) is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). It started in 2006 and was finalized in the end of 2007.

The objective of the COM2REACT project has been to increase safety and efficiency by establishing the feasibility of a three layer cooperative system. The three layers include a high control level with Regional Control Centre, which acts as a strategic controller, a middle control level including sub-centres, which all have a number of nodes they are in charge of, and a low control level, which is implemented inside each vehicle in the system. The implementation of such a system involves vehicle-to-vehicle communication and vehicle-to-infrastructure communication. The main focus in the project has been on the middle control level and the implementation of a virtual traffic control sub-centre (VSC).

CONVERGE

The CONVERGE project, was funded by EC within the Fourth Framework Programme, (European Commission, 2010b). The main focus for the project was the development and assessment of system architectures and a system analysis tool within Intelligent Transport Systems. The project was finalized in 1998 and came at that time out with a publication with guidelines for the development and assessment of Intelligent Transport System Architectures.

COVER

COVER is an EC funded project within the Sixth Framework ProgrammeEuropean Commission (2010a). The project started in 2006 and was finalized in 2009. The projects objective has been to investigate and develop next generations’ cooperative systems and the development of semantic-driven cooperative vehicle infrastructure systems for advanced e-safety applications. The project has been focusing on safety applications for cooperative systems in the area of road transport.

CYBERCARS-2

In the project CYBERCARS, which is part of part of the Fifth Framework Programme (funded by EC) (European Commission, 2010a), research was done based on the vision of having Cybernetic Transport Systems (CTS), which means that vehicles are fully
automatic. These types of vehicles have after finalization been deployed, but the problem is that they only work at low demand environments with little interaction with other vehicles. The new project, CYBERCARS-2, which is part of the Sixth Framework Programme (funded by EC) (European Commission, 2010a), has been continuing the research within the area. There has been more focus on the interaction between vehicles and to find a communication architecture that enables vehicles to communicate. Also the Advanced Drivers Assistance Systems and its ability to be fully automatic have been evaluated. The project started in 2006 and was finalized in the end of 2008.

DIVAS

DIVAS (CVIS, 2010b) is an ANR (French National Research Agency) sponsored project. It started in May 2007 and was finalized in May 2010. The aim of the project has been to develop an information exchange system, which is used to give personalized information to vehicles, like road surface, visibility and so on, to increase safety. The technology suitable, as well as acceptability and credibility, are aspects the project has been looking at.

eIMPACT

eIMPACT (2010) stands for Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe. The project was part of the Sixth Framework Programme (European Commission, 2010a) and its purpose was to assess the socio-economic aspects on IVSS. Also the introduction of IVSS with respect to impact study, the stakeholders’ roles and the policy options was investigated. Fourteen partners has been included in the project. The project has been carried out in close cooperation with TRACE (see section 3.1.8), which is another EC funded project in the Sixth Framework Programme. Other projects within the Sixth Framework Programme has also been considered, like for example PReVENT, COOPERS, SAFESPOT and CVIS. The project started in January 2006 and was finalized in June 2008.

TRACE

TRACE (2006, 2010) stands for TRaffic Accident Caution in Europe. It is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). TRACE has been focusing on updating accident caution issues and evaluating the safety benefits of the technologies. The project has been carried out in cooperation with other EC funded projects, especially eIMPACT and SafetyNet. The project has been performed in cooperation with 16 full listed partners as well as 7 subcontractors, 8 observers and a scientific committee with experts within the areas covered in the project. Eight countries have been included in the project. The project started in January 2006 and was finalized in June 2008, after 6 months extension.

FESTA

FESTA stands for Field Operational Test Support Action. It is an EC funded project within the Seventh Framework Programme (European Commission, 2010a), with the purpose to come up with a handbook (manual of best practice) with respect to the design and implementation of field operational tests for cooperative and stand-alone Intelligent Vehicle Safety Systems. The project started in May 2007, with a duration of 6 months.
FIDEUS

FIDEUS stands for Freight Innovative Delivery in European Urban Spaces. The project has been funded by EC within the Sixth Framework Programme Programme (European Commission, 2010b). It started in 2005 and was finalized in 2008. The aim of FIEDUS has been to improve the freight transports within the cities. The project has been introducing three new types of vehicles, an innovative small electric transporter for sensitive areas and pedestrian zones, an improved 3.5 ton van and a 12 ton truck, equipped with advanced technology and other equipment, to be able to improve the efficiency and reduce the environmental impacts. Logistics has been an important part of the project, as well as the whole delivery chain, in order to be able to maximize the efficiency in the cities.

Fricti@n

Fricti@n is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). The project has been led by a Finnish organization. It started in January 2006 and was finalized in December 2008. The projects objective has been to create an on-board system that can estimate friction and road slipperiness. This has been integrated with cooperative systems in order to increase the usefulness of these types of systems and the applications for the systems. The project existed of 10 partners from automotive and supplier industries.

GOODROUTE

GOODROUTE is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). The project started in January 2006 and was finalized in December 2008. The purpose of the project has been to develop a cooperative system, which is able monitor and make routes for dangerous goods transportation. The idea has been to minimize the Societal Risks related to the movements of the dangerous goods and also to take all of the actors involved, into account, in the logistic chain, in order to find the most cost efficient solution.

HeavyRoute

HeavyRoute (2010) is a project, that has been focusing on the development of a route guidance and a driver support system for heavy vehicles. The coordinator of the project has been VTI(Swedish National Road and Transport Research Institute). The project started in September 2006, with a duration of 30 months. The aim of the project has been to improve road safety and the capacity on the roads and reduces negative impacts, such as environment and the cost of the maintenance of bridges and roads. Already developed technology has been used in the project. The applications investigated and developed within the project has been Pre-trip route planning, Driving support and Bridge management.

HIGHWAY

HIGHWAY (CVIS, 2010b; European Commission, 2010a), is an EC funded project within the Sixth Framework Programme. It started in 2004 and was finalized in December 2006. The project has been developing a location-based service, which gives the driver useful real-time information about the conditions on the road, in the area where he/she is located. The digital maps and geographic tools, that give the driver information about e-Safety and added-value services, did play a central role in the project.
The information can be weather information, traffic jams, accidents, etc. The prototype developed within the project has been tested on the motorway between the Finnish cities Turku and Helsinki with a successful result.

I-WAY

The project I-WAY is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). It started in February 2006 and was finalized in January 2009. The project has been focusing on the driver and improvements on the drivers reactions in critical traffic situations. This has been done by improvements of environmental real-time information, given to him/her from other vehicles and closely located roadside units. The idea with this is to support the driver with warnings and suggestions in situations like traffic jams, accidents, etc., in order to increase road safety and efficiency. The development of a cooperative driving platform and an intelligent cooperative system inside the vehicles has been part of the project.

i2010

The i2010 (2009) is an intelligent car strategy presented by the European Commission, which aims to fasten the development and deployment of advanced intelligent vehicle systems and cooperative systems. The activities within the area of Information and Communication Technologies(ICT) for ITS systems and cooperative systems was located within the project and a policy framework was set up for the area. The strategy has been carried out between 2005–2009.

INFONEBBIA

INFONEBBIA (CVIS, 2010b) is a project that has been focusing on the development of a fog monitoring system. The driver will be given advices about the visibility through variable message signs, on board units or other information based technology. The project was carried out in cooperation between FIAT Research Center and ANAS(Italian Road Authority).

INTRO

INTRO (2010) is an EC funded project within the Sixth Framework Programme. The project started in March 2005 and was finalized in February 2008. The purpose with the project has been to increase the impacts from the infrastructure, on the vehicles, by using intelligent roads. The idea was to increase safety, efficiency and the wellbeing for the road users. New technology, as well as already existing technology, was used in the project. The project coordinator was VTI (Swedish National Road and Transport Research Institute).

MITRA

MITRA stands for Monitoring and intervention for the transport of dangerous goods. The project is EC funded within the Sixth Framework Programme (European Commission, 2010a). It started in September 2004 and was finalized in October 2006. The project has been developing a system that can track dangerous goods in Europe. Real-time information about the dangerous goods (speed, location etc.) is transmitted to a variety of databases. The databases also include information about special events, road infrastructure, roadwork’s, etc. in order to be able to detect a potential dangerous situation. The final product included a system providing emergency services and giving alerts in dangerous situation, in order for the emergency services to respond faster and more
efficiently. Real-time information about the position and contents of the dangerous vehicles within a certain area is given to the emergency services.

MORYNE
MORYNE is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). The project started in January 2006 and was finalized in March 2008. The aim with the project has been to develop the area of public transportation in order to improve safety and efficiency and decrease the environmental impacts. The technology used has been mobile sensor networks. During the project a validation of the developed technologies has been done by field testing and an analysis of potential impacts has been performed.

OPTIS
OPTIS (2003) stands for OPTimised Traffic in Sweden. It is a Swedish project and it has been part of the ‘Green cars initiative’ (2000–2006), which is an initiative signed by the state and the car manufacturers. The project started in the spring of 2000 and a final report was presented in January 2003. The project has been performed in cooperation with car manufacturers and the Swedish Road Administration. The aim with the project is to develop technologies for collection of traffic data. The data should be used to give traveler information in order to improve their behavior on the road networks, and as an effect of that, increase safety and reduce the environmental impacts.

The project was based on Floating Car Data. The technology was tested during a six years period in Gothenburg in Sweden and included 250 vehicles. Also, simulation techniques were used prior to the field tests to evaluate the system and to decide on the number of vehicles needed in the field test. The output from the systems used was travel time, which was presented on a web site. The results from the project showed that the travel time with good quality could be shown on the web site and the travel time could be reduced with up to 25 minutes when using the system. Some rough calculations have also been made on the emissions, showing an indication of reduced emissions as a result of the decreased travel time.

PRECIOSA
PRECIOSA (2010) stands for Privacy enabled capability in co-operative systems and safety applications. It is an EC funded project within the Seventh Framework Programme (European Commission, 2010a). The project started in March 2003 and was finalized in February 2010. The focus within the project has been on security and privacy issues regarding applications for cooperative systems. In the project a privacy-protecting mechanism and a privacy policy language for expressing privacy preferences were developed. An example application, which from the beginning did not include privacy protection, was used in order to demonstrate the privacy-protecting mechanism.

REACT
REACT (CVIS, 2010b; European Commission, 2010a), stands for Reaction to Emergency Alerts using voice and Clustering Technologies. It is an EC funded project within the Sixth Framework Programme. The project started in September 2006 and was finalized in February 2009. The projects objectives have been to optimize road safety and the flow of traffic. This has been done by collecting data from different sources and combines
them with the REACT’s mobile sensors. The combined data has been analyzed in models, developed by REACT, in order to give better and improved information to drivers resulting in increased safety.

SAFETY TECHOPRO

SAFETY TECHOPRO (2010) is a support action funded by EC within the Sixth Framework Programme (European Commission, 2010a). The project started in October 2006 and was finalized in September 2008. The goal with the action was to develop a training system for professionals in the automotive sector, in the area of safety applications for the vehicles. The training system was carried out in form of workshops and dealerships. The purpose with the project was to increase the awareness and acceptance for new safety technologies for the end user. The professionals like mechanics, sales persons, etc. should be trained to transmit information about safety technologies, in a way that ensured that high quality information was given to the end user.

SMARTFREIGHT

SMARTFREIGHT (2010) an EC funded project within the Seventh Framework Programme (European Commission, 2010a). The project has been carried out between January 2008 and June 2010. The focus within the project has been freight transports in urban areas and the improvement on efficiency and increased environmental impacts due to congestions. The project has been focusing on improvements in traffic and freight management and the cooperation between the two. On-board units have been used as a communication tool between the management systems and the vehicles. The technology used is based on CALM, which is developed by ISO (see section 4.7.1). The idea has been to monitor freight transports in urban areas and, by use of management, steer the transport in the network in a more efficient way, with the use of real-time information, as well as information about loading and unloading of the goods etc.

SUMMITS

SUMMITS (Driessen et al., 2007; van Arem, 2007) stands for SUsustainable Mobility Methodologies for Intelligent Transport Systems. The project has been a cooperation between seven TNO institutes (Netherlands) in 2003 to 2007. The SUMMITS project has been focusing on supporting the development and deployment of cooperative systems. The SUMMIT Suite tool has been developed within the project as a result of this. The tool suite can be used in many different areas of cooperative systems, such as measuring effects on traffic flow, safety and the environment (with the use of traffic simulation models), assessment of human factors (through driving simulators and Inca instrumented vehicles), evaluation cooperative architectures alternatives, feasibility of the technology and implementation etc.

TRACKSS

TRACKSS (2010) stands for Technologies for Road Advanced Cooperative Knowledge Sharing Sensors. The project has been funded by EC within the Sixth Framework Programme (European Commission, 2010a) and the time line for the project has been January 2006 to October 2008. The focus within the project has been on development and improvement of technologies for on-board equipment and roadside equipment, for sensing and predicting flow, infrastructure and environmental conditions of surrounding traffic. The goal of the project has been to improve safety and efficiency in the traffic with the new or improved technologies.
WATCH-OVER

WATCH-OVER stands for Vehicle-to-Vulnerable roAd user cooperaTive communication and sensing teCHnologies to imprOVE transpoRt safety. It is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). The architecture of the project and the functional specifications has been presented in the document 'D3.1 System Architecture and Functional Specifications' (Andreone et al., 2007). The time line for the project has been January 2006 to December 2008. Focus has been on vulnerable road users and cooperative systems that can handle vulnerable road users. The final WATCH-OVER system has been designed to handle some use cases. The use cases considered has been evaluated and decided on within the project. The final use cases used in the project are:

- Pedestrian or cyclist crossing the road.
- Pedestrian (or cyclist) crossing the road occluded from the parked or stopped cars or other obstacles.
- Vehicle turning left at an intersection, pedestrian crossing the road from the right to the left (or from the left to the right).
- Vehicle turning right at an intersection, pedestrian crossing the road from the right to the left (or from the left to the right).
- Vehicle on a crossroad, pedal cyclist crossing the road from the right (or from the left).
- Powered Two Wheeler(PTW) arrives from the left side (or from the right side) at intersection, paths perpendicular.
- PTW arrives from left side at intersection, paths perpendicular, occluded from parked car or other obstacles.
- PTW(or pedal cyclist) and vehicle traveling in opposite directions, vehicle turns in front of PTW.

SRIS

SRIS (2008) stands for Slippery Road Information System. The project is a Swedish initiative and is a cooperation between nine stakeholders. The project was carried out between 2006 and 2009. The aim with the project has been to, with exiting technology develop an information system with the purpose to give information to the drivers and road maintenance operators about the road conditions. Sensors inside the vehicles are detecting information about the roads and the information is transformed to the end-users through existing technologies. The information can give comfort to private drivers about road conditions when driving on the roads, but also give indications to road maintenance operators about the conditions on the roads and the need for some kind of action to improve the conditions. According to the project has the project been very successful and that it is possible to build the systems from a technical point of view. An socioeconomic analysis has been carried out by a traffic consultant company (Gunnar Lind and Esbjörn Lindqvist, 2008) showing that the systems has great potential with respect to improve the maintenance work during the winter and to work as a warning system for the private drivers, but further investigations needs to be done in order to quantify the benefits. According to SRIS, are the biggest barriers related to politics and industry politics.
3.1.9 Summary of projects within the field of cooperative systems with focus on the technology

This section includes a short description of projects within cooperative systems with focus on the development of the technology used, such as the Internet protocols, etc.

**ANEMONE**

ANEMONE is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). It started in 2006 and was finalized in 2008. The purpose with the project has been to act as a test bed for validation of the IPv6 technologies for use in cooperative systems.

**ARTIC**

ARTIC is an EC funded project within the Seventh Framework Programme (European Commission, 2010a). The purpose with the project has been to perform antenna research for cooperative system. The project started in April 2008 and was finalized in March 2010.

**ATESST2**

ATESST2 stands for Advancing traffic efficiency and safety through software technology phase 2. The project is EC funded within the Seventh Framework Programme (European Commission, 2010a) and focus has been on the software and electronics behind the automotive functions that are being developed today. The project started in July 2008 and was finalized in June 2010. The aim of the project has been to reduce the gap between cooperative systems and, enabling design and verification technologies. Within the project the architecture description language EAST-ADL2, which was developed in the project ASSET, has been used.

**CFVD**

CFVD (CVIS, 2010b) stands for Cellular Floating Vehicle Data and the project focuses on the real time information, such as traffic trends, using mobile phones. Within the project, an investigation of if the mobile phones located inside a vehicle, which could be used to produce real-time information, has been made. The project, which started in 2004, was the first one investigating this area. The project did find that mobile phones could be used to detect trends in the traffic over time per road segment.

**DAIDALOS and DAIDALOS II**

DAIDALOS stands for Designing advanced network interfaces for the delivery and administration of location independent, optimized personal services. The two projects have been carried out within the Fifth and Sixth Framework Programme (2003–2006 resp. 2006–2008) (European Commission, 2010a). The objective of the projects has been to develop and demonstrate an open architecture based on IPv6 (network protocols). The idea is to develop heterogeneous networks so all users have access to content and services. Existing technologies have been used and new technologies has been developed in Beyond 3G systems (B3G).

**EMMA**

EMMA (2010) stands for Embedded Middleware in Mobility Applications. It is an EC funded project within the Sixth Framework Programme (European Commission, 2010a).
The project started in May 2006, with a duration of 2.5 years (finished in October 2008). EMMA has been focusing on the future communication between wireless objects and the new applications that are being developed within this area and which are being used in the automotive and transport sector. The main goal has been to develop an embedded middleware, which supports the logics and communications that are required for cooperation of wireless objects. Eight partners have been included in the project.

**KAREN and FRAME**

KAREN and FRAME (CVIS, 2010b) was both projects with focus on the European ITS Framework Architecture. The KAREN project had a time line from April 1998 to September 2000. KAREN stands for Keystone Architecture Required for European Networks. The idea with the project was to give support around planning and preparation when ITS systems were implemented. The KAREN project and its aims has been overtaken and updated by the more recent projects, the FRAME-projects, where e-FRAME is the most resent one.

**GeoNET**

GeoNET is an EC funded project within the Fifth Framework Programme (European Commission, 2010a). The time line for the project has been February 2008 to January 2010. The purpose with the project has been to implement a reference implementation of a geographic addressing and routing protocol for vehicle safety communication. The geographic addressing and routing protocol is supporting IPv6. The goal with the project has been, as for many other projects within cooperative systems, to increase safety. Results from the Car-2-Car Communication Consortium have been used as a ground in the project.

**GST**

GST stands for Global Systems for Telematics. It is an EC funded project within the Sixth Framework Programme (European Commission, 2010a). The project started in March 2004 and was finalized in March 2007. The project has been focusing on collecting results, at European and national level, together with cooperative research programs, in order to be able to find the requirements needed for an open system. The purpose with this has been to be able to install and use Information and Communication Technology (ICT) functionalities in all new vehicles and to have an open market for ICT services for the vehicles. The project included more than 50 key stakeholders in the European Telematics industry.

**ROADSENSE**

ROADSENSE stands for ROad Awareness for Driving via a Strategy that Evaluates Numerous SystEms. It is an EC funded project within the Fifth Framework Programme (European Commission, 2010b). The project started in February 2001, with a duration of three years. The aim of the project has been to coordinate research projects within the area of HVI (Human Vehicle Interfaces) and develop standards for validation and design of HVI. The main objective has been to develop an industry standard evaluation framework for Human Vehicle Interactions strategies.

**RTMS**

RTMS (CVIS, 2010b) stands for Road Traffic Monitoring by Satellite. The project has been developing a trial satellite application, which should be used to gather information...
about congestion for a small population. The vehicle in the system needs to have an on-
board unit, which reports to a central system. The results from the project have been
presented in a field trial. The idea is that the system and the information gathered should
be used in combination with other systems such as route guidance systems.

SP and V2X

SP (CVIS, 2010b) is a Swedish technical research institute (SP Sveriges Tekniska
Forskningsinstitut). The project V2X is a project within SP and the focus for the project
has been on the antenna design for communication between vehicles and between vehi-
cles and infrastructure.

SISTER

The project is part of the Sixth Framework Programme (European Commission, 2010a).
It started in November 2006 and was finalized in April 2010. The description of the
overall objective that has been given by the project is: 'The SISTER project will pro-
 mote the integration of satellite and terrestrial communications with GALILEO(satellite
navigation system) to enable mass-market take-up by road transport applications’ (SIS-
TER, 2007). The focus of the project has been to investigate GALILEO applications and
the communication requirements needed for the system, construct a prototype to see the
effects of a satellite system (GALILEO) used for communications and develop a satellite
component for the ISO CALM standard.

3.2 U.S. projects

U.S. is a large nation with a huge consumption of transportation. The development of
cooperative systems will therefore have a great impact on the road, regarding safety and
efficiency, as well as on the environmental impacts. This section summarizes some of
the biggest projects within cooperative systems in the U.S.

3.2.1 VII (Vehicle Infrastructure Integration)

Already in the 1960 U.S. Department of Transportation’s (US DOT’s) have had research
related to the transport system and in the 1990’s, research on communication within
transportation systems started. In the beginning focus was to adapt already deployed
systems, i.e. surveillance systems and systems engineering to transport systems. In ear-
ly 2000 the US DOT’s discovered that the technology of vehicle-to-vehicle (V2V) and
vehicle-to-infrastructure (V2I) communication probably would have a great impact on
the transportation systems further development. In 2003 the research program VII (Vehi-
cle Infrastructure Integration) (ITS Joint Program Office, Research and Innovative Tech-
nology Administration(RITA), U.S. Department of Transportation, 2010) was started, in
order to develop technologies related to this.

It was soon clear that for the V2V communication to be deployed, with the right tech-
nology installed in all vehicles on the roads, it would take at least 15–20 years according
to the researchers in the project. Therefore the focus within VII was given to V2I com-
unication, since the VII believed that a device inside the vehicle talking to the roadside
infrastructure would be much faster to deploy, and thereby increase road safety quicker.
Both V2V and V2I communication required a dedicated short-range communications ra-
dio in order to be able to communicate. The frequency 5.9 GHz. was allocated for safety
applications, by the Federal Communications Commission. Unused parts of the frequen-
The cy band were allowed to be used for other types of applications such as mobility and convenience. In 2008 and 2009, proof-of-concept tests were made, in order to see that the method with using a dedicated short-range communications radio was useful in V2V and V2I communication. These tests showed that dedicated short-range communications radio could be a good way to continue the development of communication between vehicles and vehicles and infrastructure, although the test was quite uncertain since only 30 vehicles of the same type where included in the test.

There were also big uncertainties regarding the deployment. Questions’ regarding the number of roadside units that needed to be installed and the fact that many of them were needed was an issue. There were also questions from the manufacturers view, regarding the actual usefulness of an advice in a vehicle and if investments in equipment for the vehicles were a good idea if there were no infrastructure to ‘talk’ to.

During the evaluation of the usefulness of the systems new technology was developed and deployed, including many different types of wireless communication technologies. These technologies could also be used as communication tools for the V2V and V2I communication. This new widely deployed area together with new innovated information technology contributed to the continued work within the VII project.

In 2009 VII has reached to more commercial testing and marketing and US DOT’s decided to change the name from VII to Intellidrive, to better reflect the more widespread area of research.

In December 2009 a new strategic research plan was developed for the IntelliDrive project, which has a time line from 2010 to 2014. Much has changed in the focus areas regarding research, when changing form the VII to IntelliDrive. This is due to that new aspects has been introduced along the way together with the development of new technologies. But the visions for the programs remain the same and they include improving safety on the roads and the potential for revolutionary improvements in mobility. Recently, a third goal has been added, that has become important in the later years and this is to decrease transportation’s impact on the environment.

**Applications within VII**

In the final technical report, "Final Report: Vehicle Infrastructure Integration, Proof of Concept Technical Description - Vehicle" (The VII Consortium, 2009), seven proof-of-concept applications are presented. In the beginning of the project around 100 use cases were considered. 20 of these use cases were selected and further investigated. These use cases was named ‘Day-1’ use cases and had the purpose to be working when the system was deployed. From these 20 use cases, seven use cases have been tested in the project. These use cases is known as the Proof-of-concept applications and are presented in table 3.10.

The proof-of-concept applications used in VII are mainly information applications. The use of information from the surrounding environment is the base and there is no communication between vehicles. Many of the applications focuses on the effectiveness in the traffic and the information is used to inform and give advices to the driver about alternative routes, payment zones etc.

Apart from increased efficiency, safety is probably also going to be improved, as an effect of the more planed routes and faster toll systems etc., but none of the applications have a main focus on safety.
### 3.2.2 VSC I

VSC I (Laberteaux, 2006; Shulman och Deering, 2004) stand for Vehicle Safety Communications I. The project is a CAMP project carried out between May 2002 and December 2004. For an introduction to CAMP see 4.4.3. The manufacturers included in the project are the seven manufacturers included in CAMP. There has also been cooperation with the FHWA (Federal Highway Administration) and the NHTSA (National Highway Traffic Safety Administration). The focus within the project has been on safety applications. 34 applications have been developed and evaluated in the project. Among them 8 applications have been selected as high priority applications and for these applications preliminary communications requirements have been identified. The DSRC (Dedicated Short Range Communications) has been evaluated and the conclusion was that most of the applications supported the 5.9 GHz. DSRC wireless technologies. In the end of the project recommendations regarding vehicle-to-vehicle communication and vehicle-to-infrastructure communication, for DSRC-based safety applications was stated. In order to establish feasibility the development of prototypes should continue.

#### Applications

The applications presented by the VSC project are summarized in table 3.11.

The applications Curve Speed Warning, Left Turn Assistant, Stop Sign Movement Assistance, Traffic Signal Violation Warning, Cooperative Forward Collision Warning, Emergency Electronic Brake Lights, Lane Change Warning and Pre-Crash Sensing are the 8 applications that are seemed to be the high priority applications. As in many previous projects the many focus for the applications has been on safety and the improvement of safety, but as a secondary effect many of the applications might also have efficiency impacts on the road network. If the driver gets information ahead, the driving style is more planed and the driver will probably drive smoother and more stable, which will probably lead to a more efficient traffic flow.

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**Table 3.10 Table of proof-of-concept applications within the VII project.**

<table>
<thead>
<tr>
<th>Project</th>
<th>Proof of concept Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Vehicle Signage (Information is received from a roadside unit and presented inside the vehicle on a onboard unit)</td>
<td></td>
</tr>
<tr>
<td>Probe Data Collection (collects data from vehicles as 'snapshots' of status, time and location)</td>
<td></td>
</tr>
<tr>
<td>Electronic Payments – Toll (A roadside unit sends out information about payment in a toll zone to a vehicle which receives it on the onboard unit and a payment can be made)</td>
<td></td>
</tr>
<tr>
<td>Electronic Payments – Parking (A roadside unit sends out information about payment regarding parking to a vehicle which receives it on the onboard unit and a payment can be made)</td>
<td></td>
</tr>
<tr>
<td>Traveler Information/Off-Board Navigation (The vehicle can receive information and navigation about requested routes to his onboard unit via an roadside unit)</td>
<td></td>
</tr>
<tr>
<td>Heartbeat (sends heartbeat messages at a configurable rate, used to test DSRC (Dedicated Short Range Communication))</td>
<td></td>
</tr>
<tr>
<td>Traffic Signal Indication (Signal Phase and Timing messages are sent out via a roadside unit to an onboard unit in order to test the effectiveness in handling and prioritizing safety application while supporting lower priority operations)</td>
<td></td>
</tr>
</tbody>
</table>
3.2.3 EEBL

Some of the OMEs (Original Equipment Manufacturers) that has been working with the VSC I project, decided to continue investigating the Electronic Brake Light Application (EEBL). The EEBL project (Laberteaux, 2006) started in June 2005 and was finalized in March 2006.

3.2.4 VSC-A

VSC-A (Schulman, 2009) stands for Vehicle Safety Communications - Applications. The project started in 2006 and was finalized in 2009. It is a CAMP project carried out in cooperation with the US DOT (US Department of Transportation). The project has been focusing on the development of an interoperable architecture that can be used for future deployment. The communication and positioning issues has been an important part of the project and the DSRC (Dedicated Short Range Communication) frequency 5.9 GHz. has been investigated. The project has been looking at results from the projects VSC and EEBL.

3.2.5 IVBSS

IVBSS (Sayer et al., 2010) stands for Integrated Vehicle Based Safety Systems. The project is a five years project led by the University of Michigan Transportation Research Institute and carried out in a cooperative agreement with the US DOT (US Department of Transportation). The project started in November 2005 and was finalized in October.
2010. The project was going to implement crash-warning systems into vehicles (both heavy and light vehicles) and conduct field operational tests. The systems investigated were:

- Forward crash warning – warns the driver of possible rear-end collisions
- Lateral drift warning – warns the driver when he/she is driving to the right or the left and is on the way to drift away from the lane or departing the roadway
- Lane-change/merge warning – warns the driver of unsafe lane changing. The application is dependent on surrounding vehicles and their position.

In phase 1 of the project (2005–2008) all the important work behind the Field Operational Test (FOT) was performed and a prototype vehicle was built.

In phase 2 of the project (2008–2010) the developed system was refined, the FOT was performed and an analysis of the result was finalized. The FOT was carried out between February 2009 and December 2009 and included 20 participants.

3.3 Japanese projects

Japan has been a large vehicle industry for a long time and the development of advanced systems for vehicles has therefore played an important role during the years. Japan is also a country with an increasing number of people, resulting in increased demand for transportation. Along with the new technology in the area the demand has increased even more. This results in problems with congestions and increased environmental impacts, which needs to be solved. This section introduces some of the projects that have been carried out within cooperative systems and the related Intelligent Transport Systems. Although the information about the projects has sometimes been limited by languages on the homepages and difficulties to find relevant project information.

3.3.1 SSVS

SSVS (King W. Gee, 1997) stands for Super Smart Vehicle Safety. SSVS was a research project funded by the Ministry of International Trade and Industry (MITI). The project builds on vehicle-to-vehicle and laser radar warning systems research carried out in the 1970’s and the 1980’s. The project’s aim has been to reduce the drivers load in the traffic by increasing the information given to the driver through vehicle-to-vehicle and vehicle-to-infrastructure communication. The development of inter-vehicle cooperation and interactive systems with intelligent intersection traffic management systems has also been part of the project.

3.3.2 AHSS

AHSS (King W. Gee, 1997) stands for Advanced Highway Safety Systems. The project started in 1989 and was a research program initiated by the Ministry of Construction (MOC). The project was finalized in November 1995. The focus for the project has been on decreasing the accidents in conjunction with the infrastructure. The automatic driving was not a part of the project in the beginning, but became important at a later stage. In 1991 cooperation between a private sector organization and MOC was initiated and in 1992 a three phase program was presented by MOC, including:

- Warning system
- Prevention system
- Automated driving.
In 1994, 24 private organizations had joined the research program with the purpose of developing technologies regarding road-ahead danger warning, position indication of surrounding vehicles and rear-end collision prevention.

3.3.3 AHSRA

AHSRA (King W. Gee, 1997; Matthias Schulze, 2006) stands for Advanced Cruise-Assist Highway System Research Association. It was an organization created in 1996–1997 with the purpose to structure the development and research of AHS road infrastructure. AHSRA took over the research from the AHSS program. The association consisted of 21 organizations in the area of automobile, manufacturing, electronics and telecommunications. The program had a design which included three phases within the development of vehicle-to-infrastructure communication:

- AHS-i: Danger warning
- AHS-c: Assistant for driving
- AHS-a: Automated highway systems.

In 2000 there was a demonstration of the feasibility of the systems developed. Between 2001 and 2005 limited tests was carried out on public roads in Japan. AHSRA did gradually change into the project Smartway.

3.3.4 Smartway

The Smartway project (Matthias Schulze, 2006) did evolve from the AHSRA project and the purpose with the project was to develop a service (‘Smartway service’) based on vehicle-to-infrastructure within the 5.8 GHz bandwidth. The service should be able to combine many applications, such as electronic toll collection, e-payment services, VICS (Vehicle Information and Communication Systems) traffic information etc., and use it to communicate with the driver via an on-board unit.

The Smartway service was tested in field trials and on public roads in 2004 and 2005, and the production of the service was officially introduced in February 2006. In the summer of 2006 the ‘Smartway driver information and warning service’ was operational and ready to use. The Smartway service was the first operational system that was able to communicate information and give warnings to the driver.

3.3.5 ASV I

ASV (IATSS Research, 2006; Kenji Wani, 2006; King W. Gee, 1997) stands for Advanced Safety Vehicle. The project was presented by the Ministry of Transportation (MOT) (now Ministry of Land, Infrastructure, Transport and Tourism) in 1991 and was finalized in 1995. The project has been organized by the Study Group for Advanced Vehicle Safety. The study group included government agencies, experts within the area with professional experience or academic standing, vehicle manufacturers, user groups and other organizations. The project has been focusing on improved safety and easier driving for the driver. Four technology areas have been considered in the project:

- Preventive safety
- Accident avoidance
- Crash injury reduction
- Post-collision injury reduction.
The project was the first phase of a long project within ASV and a joint effort between companies within the academia, industries and the government. 9 car manufacturers were part of the project. Phase I of the project has mainly been focusing on the study of technical feasibility.

3.3.6 ASV-II

The ASV-II project (IATSS Research, 2006; Kenji Wani, 2006; King W. Gee, 1997) was the continuing research of the ASV-I project or as it is also denoted, phase II in the ASV project. The project started in 1996 and was finalized in 2000. A demonstration was performed (Demo2000), in order to be able to test and evaluate the technologies developed in phase I. The main areas under consideration in the second phase of the project was:

- man-machine interface
- vehicle-infrastructure interaction.

There has also been work on harmonization of the results in the project, compared with the results in the AHS project. In addition to the work done in phase I buses, trucks and motorcycles have been included and 13 new manufacturers within these areas has also been part of the project. In phase II of the project, focus has been on research and development of practical applications.

3.3.7 ASV-III

ASV-III (IATSS Research, 2006; Kenji Wani, 2006) is phase 3 in the ASV project. The phase has been carried out between 2001 and 2005. The third phase of the project has been focusing on the deployment and the promotion of the systems. Development of new technologies has of course been part of this phase as well as previous phases. Within the third phase several applications has been introduced to the market including Crash mitigation brake, lane keep distance, ACC (Adaptive Cruise Control), etc. Both vehicle-to-vehicle and vehicle-to-infrastructure communication has been considered within the project. When the project was finalized in 2005 a demonstration open for the public was performed, where the public had the opportunity to try the vehicles equipped with the new technology.
4 Ongoing initiatives and projects on cooperative systems

A lot of work has been performed within the development and deployment of cooperative systems, and there is a wide range of projects covering different parts and aspects of the cooperative platforms. Some of them has been funded on a European level, in Japan and in U.S., and some of them are smaller projects performed in different countries. Besides all the projects that have been finalized, a lot of standardization work has been carried out, in order to get interoperability, not just within each country but on a worldwide level or at least on European level. With the projects and standardization works described in the chapters 3 and 2 as a background, new standards are being developed and new projects on cooperative systems are continuing to being developed, along with many supporting initiatives in the area. These initiatives and projects are described in the sections below.

4.1 Ongoing projects in Europe

In this section a description of ongoing projects within the area of cooperative systems are given. Some of the projects are described in more detail. It can be seen that more and more focus has been given to the environment and on environmental effects and there are project that are dealing only with these questions.

4.1.1 simTD

simTD (2010) stands for Safe and Intelligent mobility test field Germany. The project will use results from finalized research projects, which has been focusing on cooperative systems and ITS applications, and use it in practice. Tests will be set up by real traffic scenarios, and the infrastructure used as a test field, will be around the Hessian city of Frankfurt. The projects taken under consideration are: AKTIV, COMeSafety, COM2REACT, COOPERS, CVIS, Pre-Drive C2X, Safespot, Sevecom, travolution, Fleetnet, GST, Invent, PReVENT, NOW. The most important one in the context of field testing is the COMeSafety project and the findings from the project are being used within these tests.

The project is funded by the German Federal Ministry of Economics and Technology, the Federal Ministry of Education and Research, and the Federal Ministry of Transport, Building and Urban Development. It started in 2008 and will be finished in 2012. There are many partners involved in the project with different backgrounds, such as automotive and telecommunication companies, the Hessian state government, universities and research institutions.

Functions

A number of functions have been selected for implementation by the partners in the project. These functions are divided into three categories: traffic function, driving and safety functions, and additional services functions. These functions can be divided into an even finer level. In table, 4.1, the functions and its sub-functions are shown.

Both safety, efficiency and infotainment applications are considered within the project.
### 4.1.2 SPITS

SPITS (SPITS, 2010; University of Twente - CTIT, 2010) stands for Strategic Platform for Intelligent Traffic Systems and it is a Dutch project that aims to improve mobility and road safety. The objective of the project is to create an open, interoperable platform for ITS applications based on existing infotainment systems. The project started in July 2009 and is finalized in July 2011. It is funded by 13 partners and the Dutch Ministry of Economic Affairs.

There are three main focus areas within the project:

- Traffic management – communication technologies used for traffic management can utilize existing road networks more efficiently but also help to improve safety
- In-vehicle solutions – the solution helps vehicles to be connected to each other and to exchange useful information. An open upgradeable platform that is developed in SPITS allows for implementation of updated/new applications
- Service download and management solution – SPITS are going to create a service download and management solution for in-vehicle services. The idea is that applications and services will be deployed faster and the improvements and innovations of cooperative systems are fastened within the system.

### 4.1.3 eCoMove

eCoMove (2010) is an EC funded project within the Seventh Framework Programme. It started in April 2010 and is expected to be finalized in March 2013.

The project focuses on eco-driving within the area of cooperative systems. The project will be searching for improvements in three areas: drivers’ behavior, route choice and traffic management. This will be done by focusing on and finding solutions for the driver, the fleet manager and the traffic manager.

The project is going to use Information and communication Technologies and the latest

<table>
<thead>
<tr>
<th>Type of function</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic functions</td>
<td>Monitoring of traffic situation and complementary information/basic functions</td>
</tr>
<tr>
<td>Traffic (flow) information and navigation</td>
<td>Formulated road/traffic information</td>
</tr>
<tr>
<td>Traffic management</td>
<td>Alternative route management</td>
</tr>
<tr>
<td>Driving and safety functions</td>
<td>Local traffic-adapted signal control</td>
</tr>
<tr>
<td>Local danger alert</td>
<td>Obstacle warning</td>
</tr>
<tr>
<td>Driving assistance</td>
<td>In-vehicle signaller/traffic rule violation warning</td>
</tr>
<tr>
<td>Internet access and local information services</td>
<td>Internet-based usage of services</td>
</tr>
</tbody>
</table>
technology within vehicle-to-vehicle communication and vehicle-to-infrastructure communication, in order to achieve its goals. Applications within the area of environmental improvements are going to be developed.

The target is to reduce the fuel consumption and thereby the CO2 emissions by 20%.

Applications

A number of applications are going to be developed. These applications are presented in table 4.2.

Table 4.2 Table of applications under development in the EcoMove project.

<table>
<thead>
<tr>
<th>Application</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>EcoSmartDriving applications</td>
<td></td>
</tr>
<tr>
<td>ecoTripPlanning</td>
<td>The ecoTripPlanning calculates the optimal route taking into account start and destination point, vehicle and drivers characteristics. It is based on ecoMap and the calculation is based on minimizing the environmental impact.</td>
</tr>
</tbody>
</table>
| ecoSmartDriving                   | • dynamic green routing – selecting the route with lowest fuel consumption/CO2 emission  
• eco driving assist – provides dynamic advices such as acceleration, consumption prediction, gear and so on.  
• eco information – related to in-vehicles conditions that might affect the fuel consumption such as air conditioner, etc. |
| ecoPostTrip                       | Gives information to the driver post trip about how ecologically he/she has been driving. This application also contributes to a database about drivers behaviors which can be distributed anonymously to traffic control centres. |
| ecoFreight & Logistics            |                                                                          |
| ecoDriver Coaching System         | • Pre-trip – gives the driver training prior to the trip by using a virtual simulator as a eco driving training system  
• On-trip – the driver receives real-time eco driving instructions based on the environment and the current state of the vehicle (a HMI is used)  
• Post-trip – data from the route is sent to a fleet management back office, the trends of the driver is being analyzed and the driver is getting feedback on his driving style. Good eco-drivers should be rewarded with incentives |
| ecoFleet Planning & Routing       | The most efficient combination (vehicle, trailer, route, driver, etc.) is selected based on mission information, management data, truck and driver models and routing systems |
| in-vehicle truck ecoNavigation    | The most fuel efficient route is calculated based on the specific attributes for the truck, traffic patterns, eco maps and real-time traffic information |
| eco Traffic Management and Control| Traffic is coordinated and distributed in the network according to the traffic demand and the capacity of the network. The traffic locally is governed by traffic light coordination. Vehicle-to-infrastructure plays a major role for this application |
| ecoAdaptive Balancing and Control | Personalized recommendations are given to the driver in order for the vehicles operations to be efficient and for optimal driving strategy |
| ecoAdaptive Traveler Support      | Energy-optimized traffic management is used at the interurban areas together with eco-support of individual vehicles (lane change advices, speed, etc.) |

The applications used in the eCoMove project will mainly focus on management both from the drivers’ point of view and form freight management point of view, when freight companies are considered. Also management on a greater level is considered such as management and control over network steered from a control centre which has responsibility over a predefined area.
4.1.4 FREILOT

FREILOT (2010) stands for Urban Freight Energy Efficiency Pilot. The project is partly funded by the European Commission and 19 partners are included in the FREILOT consortium. The project started in April 2009 and has a duration of 2.5 years.

The project aims to increase energy efficiency in the goods transport in the European urban areas. The goal and a believed reachable target is to reduce the fuel consumption with 20-25%. This will be done by designing services within the area, which will contribute to the energy efficiency. The services the project will pilot are:

- energy efficiency intersection control (by providing priority to trucks at intersections)
- adaptive speed and acceleration controls
- eco-driving support
- real-time loading/delivery space booking.

Another important goal with the project is to deploy the results from the pilot, in order for them to be widely spread among relevant stakeholders. The believes is that the information given to the stakeholders will make them aware of the possible improvements and increase the probability for the surveillance of the results after the project has ended.

As a last point the project wants to make fleet operators, cities and other relevant stakeholders more involved. The project believes that by increase the involvement from these parts the energy efficiency can be increased a lot.

The project believes that the benefits will be many with the new services introduced. The cities will be able to steer goods traffic in certain predefined routes resulting in lower fuel consumptions, CO2 emission reduction, and a better control over traffic flow. The fleet operators will be able to lower their fuel consumption, they will also have priority at intersections, at certain road, on certain times of the day, resulting in reduced travel times for the driver as well as reduced risk of accidents.

There are four pilot cities within the project: Bilbao(Spain), Helmond(The Netherlands), Lyon(France) and Krakow(Poland).

Services

A number of services and use cases has been selected and are going to be evaluated at the four pilot sites within the project. These services and use cases has been presented in the reports 'FREILOT, Urban Freight Energy Efficient Pilot, D.FL.4.1 Evaluation methodology and plan' (Blanco et al., 2009) and 'FREILOT, Urban Freight Energy Efficient Pilot, D.FL.2.1 Implementation plan' (Tevell et al., 2009) and are summarized in table 4.3.

The focus within these applications is of course the environmental impacts, but also safety and efficiency will probably be improved as a secondary effect of the application. In many cases eco-driving and traffic efficiency are closely related.
4.1.5 INTIME

The INTIME (2010) project is an EC funded project within the Seventh Framework Programme (European Commission, 2010a). The project started in April 2009 and the duration of the project is 3 years. INTIME stands for Intelligent and Efficient Travel Management for European Cities. The project will be focusing on reduction of the environmental impacts and increased energy efficiency, by using multi-modal real time traffic and travel information services. The information will be delivered to the end-user through the use of Internet or through navigational devices (for example mobile phones). Within the project three main services will be developed. These services are summarized below:

### Table 4.3 Table of services and use cases that are going to be evaluated within the FREILOT project.

<table>
<thead>
<tr>
<th>Services</th>
<th>Use cases</th>
</tr>
</thead>
</table>
| **Intersection control** – gives priority to Heavy Goods Vehicles (HGV) at intersections | • Intersection control with passive detection – All HGV are assumed to be equipped to request priority. If it is detected as a long vehicle it is classed as a HGV and the traffic light will turn into green as soon as possible.  
• Intersection Control with active detection – Only FREILOT vehicles are able to request priority. The vehicle is identified by a tag and the priority request is forwarded to the traffic light controller which will turn the traffic light into green as soon as possible.  
• Cooperative Intersection Control – FREILOT vehicles coming to an intersection requests priority and the traffic light controller calculates the time until the traffic light is able to turn into green. The driver is given advice about the speed depending on the time until green.  
• Green wave – traffic signals coordination depending on the time of the day but also taking into account special features of trucks especially additional time to start and a new timeslot during the end of the night which allows for efficient early deliveries. Different features of green waves will be studied (different time cycles and time lags etc.) |
| **Speed Limiter** – Speed limits are set out at certain predefined zones in the city. The driver accepts the speed limits on his GPS. | • Define Speed Limitation Zones – The speed limitations are defined by the fleet operator for a set of trucks. Input can be given from the city operator.  
• Download Speed Limitation Zones – The predefined zones are downloaded to the vehicle.  
• Evaluation – The fleet operator will be able to control if the driver is following the limitations or not.  
• Zone detection – Identification of zones by the GPS position. The system detects if the truck enters a limited zone.  
• Acceptation of speed limitation – The driver can decide if he wants to accept the speed limitations or not.  
• Log and upload – The drivers actions are logged and sent to the fleet operator, who then can evaluate the driver behavior. |
| **Eco Driver Support** – Gives real-time advices to the driver during the drive in order to help improve his driving style and minimize fuel consumption. | • Driver evaluation report – A specific route for a specific truck is defined  
• Set configuration – The driver has the possibility to choose which advice he wants to get and which kind of feedback he wants to receive  
• Get real-time advice – Advice is given to the driver depending on how he performs. Advice is based on Engine speed at shift up in start and acceleration section, Accelerator position in start and acceleration section, Engine speed in cruise section, Max vehicle speed in start-stop section and the percentage of coasting in deceleration section.  
• Upload trip result – The fleet management system gets the results from the trip  
• Get trip evaluation – An evaluation of the trip can be given to the driver |
| **Delivery Space Booking** | • Request Delivery Space Zone – A booking request from the fleet operator or the driver regarding a delivery zone at a predefined time and date  
• Confirm Booking – The fleet operator can confirm the request from the driver  
• Cancel Booking – The delivery space zone booking can be cancelled by the driver or the fleet operator  
• Check Reservation – The parking zone operator should be able to check the reservations in real-time and present information if requested  
• Send alerts to enforcement personnel – Vehicles that are illegally parked at zones should be informed by the parking zone operator  
• Get Reservation Status – The driver can retrieve all reservations made by the fleet operator  
• Send arrival/departure notification – The vehicle sends information about arrival/departure at a delivery space zone to the booking system/Delivery space operator  
• Update Estimated Time of Arrival (ETA) – Prediction of the arrival time is provided to the system |
• Pre-trip information – The traveler has the opportunity to plan the trip before the trip has started by using for example Internet with real time traffic information

• On-trip information – The traveler gets real time information about the traffic situation for different modes, in order to avoid congestions etc. that occurs during the trip. This can for example be received through a navigational device or a smartphone. This is delivered as an e-service via established European Traffic Information Service Providers

• Traffic Management/Operation – The use of traffic management will also be a big part of the project and the believes are that it will contribute to reduced environmental impacts and increase the energy efficiency. This will be achieved by the use of optimizing traffic control (Eco-flow), enhancing product life-cycles, and by reducing power consumption by using LED (Light-Emitting Diode) technologies.

A central part of the project is the Regional Data/Service Server, which includes the data/services that can be delivered to the end-user. This Server should be interoperable and will include data/services in the area of: individual traffic, public transport, weather, location based services and inter-modal transport planning.

4.1.6 e-FRAME

e-FRAME (CVIS, 2010b) has the purpose to extend the European ITS Framework Architecture. It is an EC funded project within the Seventh Framework Programme (European Commission, 2010a), which has as a mission to provide knowledge about the ITS Framework Architecture and how to extend it when new application should be included. The project is also going to investigate and show how the Framework Architecture can be deployed across European Member States and Regions. The requirements from COOPERS, CVIS and SAFESPOT have been summarized into one set of requirements and are going to be used in the project. The project started in 2008 and is going to be finalized in 2011. A lot of the tasks investigated by FRAME (see section 3.1.9) have been overtaken by e-FRAME.

4.1.7 EVITA

EVITA (2010) stands for E-safety vehicle intrusion protected applications. It is an EC funded project within the Seventh Framework Programme. The purpose with the project is to develop an architecture, where the relevant safety precautions are incorporated in the intra-vehicle systems in order for the security-relevant components to be protected against sabotage and so on. Also data needs to be protected against hazards. The project started in 2008 and is expected to continue until 2011.

4.1.8 INTERSAFE 2

INTERSAFE 2 (2010) is an EC funded project within the Seventh Framework Programme. The purpose with the INTERSAFE 2 project is to develop and demonstrate a Cooperative Intersection Safety System. Warning and invention functions are going to be developed and demonstrated on three vehicles: two private vehicles and one heavy goods vehicle. A traffic flow simulator is used within the project for further research of the functions. The project started in June 2008 and is expected to be finished in June 2011.
4.1.9 iTETRIS

iTETRIS (2010) is an EC funded project within the Seventh Framework Programme European Commission (2010a). The project is going to develop an open and sustainable vehicular and traffic simulation platform, that could be used for tests and analysis of cooperative ITS at city level. The platform is going to be in line with the ETSI standards, some of them mentioned in section 2.3. The aim with the platform is to create close cooperation between engineering companies, road authorities and communications experts in order for them to develop solutions for the cooperative ITS systems that are adequate and where the key issues has been addressed for all involved stakeholder. The project started in 2008 and is expected to be finished in the end of 2010.

4.1.10 Mediamobile

Mediamobile (CVIS, 2010b) is a French company, which was created as a result of a European research and development program within Intelligent Transportation in 1996. The company has been focusing on navigation devices and they, together with two partners from the industry, has been producing the Visionaute, which is the first portable navigation device with the possibility to give estimated travel time depending on the traffic situation. The first road guide service available on WAP portals was produced in 1999 by Mediamobile together with another industry partner. Mediamobile has, when cell-phones have become more and more common, looked into the use of cell-phone networks to broadcast traffic information. The V-Traffic has been developed as a result of this and it is available to any navigation system which is linked to a cell-phone.

4.1.11 P3ITS

P3ITS (ERTICO, 2010b) stands for Pre-commercial Public Procurement for ITS innovation and deployment. It is an EC funded project within the Seventh Framework Programme (European Commission, 2010b). The project started in January 2010 and is expected to be finalized in June 2011. The project will focus on the deployment and innovation of Intelligent Transport Systems (ITS). There are and has been a wide range of Research and Development projects within ITS. The P3ITS will focus on a specific structure for procurement, pre-commercial public procurement, which has special options and mechanisms for risk sharing and stimulation for innovation. The focus will be on transforming Research and Development project into Cooperative ITS services on a large scale market. The project will be carried out within a network consisting of 13 procurement experts, professionals from the ITS sector and industry, and public procurement agencies.

4.1.12 SISCOGA (and C2ECom)

C2ECom (Fernández, 2010) is a Spanish project with the partners CTAG (Centro Tecnológico de Automoción de Galicia) and University of Vigo. The time line for the project was 2007 to September 2010. The project has been developing applications, in the field of safety and convenience, for C2X communication (i.e. car-to-car and car-to-infrastructure communications). The applications developed are:

- Accident and Traffic Jam information
- Floating Car Data (FCD)
- Adverse weather information
- Variable Speed limit
- Road Works information
• Merge Assistant
• Alternative Route information.

SISCOGA (Fernández, 2010) stands for SIStemas COoperativos GAlicia. It is a Spanish project with the partners CTAG (Centro Tecnológico de Automoción de Galicia) and DGT (The Spanish road ministry). The project started in 2009 and is expected to be finalized in September 2011. The project is developing a FOT (Field operational test) based on the results from C2ECom. SISCOGA includes an intelligent corridor (including 60 km of motorway roads controlled by the Traffic Management Center of Galicia), which is going to be used in the FOT.

4.1.13 citylog

citylog (2010) is an EC funded project within the Seventh Framework Programme (European Commission, 2010a). It started in January 2010 and is expected to be finalized in December 2012. The project will be focusing on the goods transports and the improvements of management through 'an adaptive and integrated mission management tool’, in order to increase the sustainability and the efficiency within the urban areas. The project is going to look into improvements in three areas, logistic-oriented telematic (Information and Communication Technologies) services, vehicle technologies (interoperability among vehicles) and innovative load units (the vehicles load is considered, i.e. should a simple container be used or a mobile pack station (includes de-synchronization between the operator and the final customer for the deliveries to be successful)).

4.1.14 TSN (Test Site Norway)

Test site Norway (2010) is a test site in Norway that aims to test new ITS technology, applications and services. The test site, which is located in the city of Trondheim, is equipped with wireless communication technologies based on CALM and vehicle-to-infrastructure communication supporting the frequency 5.9 GHz. A large number of roadside units are installed at the test site. The test site can offer equipped vehicles and an infrastructure with road, railway and short sea modes. The test site has access to a driving simulator, which includes models and real-time feeds from the road network in Trondheim. The supporting organizations to Test Site Norway are Q-FREE, NTNU (Norwegian University of Science and Technology), Statens vegvesen and SINTEF. TSN has cooperation with many different actors such as the industry, the public road administration, the university, the municipality and research institutes. European research and development projects and activities such as CVIS, Safespot, CALM etc. has connections to the test site.

4.1.15 CVHS Research program

CVHS (CVIS, 2010b; Department of Transportation (UK), 2010) stands for Cooperative Vehicle Highway Systems and it is a research program within cooperative systems. The Department for Transportation, DfT, in UK did in 2000 set out a 10 year plan for the transportation area, in order to make the traveling on the roads safer and more efficient. Also the environmental impacts were taken under consideration. The CVHS is a government policy tool to reach the goals that has been set up in the DfT 10 year plan. The idea with the CVHS is to act as a bridge between vehicles and roadside infrastructure in order for it to communicate and in that way increase the road safety and the efficiency on the roads. A lot of research has been done on in the area of Cooperative Vehicle Highway Systems in UK and the CVHS research program has been developed during that process.
4.1.16 ITS platform in Denmark

Denmark is planning to develop an ITS platform. This has been announced on ERTICO (2010) homepage. The platform should be open and interoperable with the possibility to add many different type of applications. The platform is planned to be built in the North of Denmark, which is going to be the ITS region in Denmark. The idea is that all the ITS applications are going to be developed and tested there before they are deployed in the rest of Denmark. The project has a planned time line from 2010 to 2013. 500 vehicles are going to be used as test vehicles within the platform. This far four applications are planned to be developed within the project:

- Parking – the payment is made automatically and the driver can park without thinking about the parking ticket. The driver will also be warned about time limits if there are any
- Driving statistics – this application aims to collect data on the behavior of the driver, i.e. energy efficiency driving, hazardous driving. The data can be used both by the driver, or if the driver are professional, any potential employer of the driver. The data can also be logged and printed for later use
- Traffic information – optimization of traffic information with focus both on drivers that has on-board equipment’s, but also drivers without the system
- Traffic statistics – collection of information regarding congestion, speed etc. This can be used for route planning, deciding travel time, and location of violation of speed limits.

4.2 Ongoing initiatives in Europe

In this section a summary of some of the initiatives within cooperative systems in Europe are presented. The summary includes standardization work, as well as support actions and initiatives on European level and international level.

4.2.1 Seventh Framework Programme

The Seventh Framework Programme (2010) is a program within the European Community, set out to fund research and development in Europe in a number of areas. One of the areas is cooperation, where focus is on collaborative research. The budget for this area is 32 billion Euro. 4.1 billion Euro of the total 32 billion Euro is earmarked for the area transport. The Seventh Framework Programme has a time line of five years (2007–2013).

Cooperative systems focus on interoperability between systems in the transportation area. The believes is that a working cooperative system will result in many benefits, such as for example increased efficiency of the public transport systems, reduced emissions and pollutions, improved traffic safety for all road users, reduced congestion etc. This is in line with the Seventh Framework Programme, and the research of Cooperative systems is therefore becoming an important part of the programme.

4.2.2 Action Plan for Deployment of Intelligent Transport Systems in Europe

The European Commission did, in December 2008, give out an action plan for the deployment of Intelligent Transport Systems in Europe (Commission of the European Communities, 2008). The purpose of the action plan is to accelerate and coordinate the deployment of Intelligent Transport Systems. The focus is on road transport but interfaces with other modes are also included. The idea with the action plan is ’greening’ of
transport (equipment for improving the environment when traveling), improving transport efficiency, improving road safety and security. A set of goals are stated within the action plan. These goals are stated below and comes directly from the action plan published by the European Commission (Commission of the European Communities, 2008):

- Addressing the complexity of ITS deployment, with the large number of stakeholders involved and the need to ensure synchronization both geographically and between the various partners
- Supporting the market penetration of advanced mobility services for the citizens, whilst promoting public transport alternatives to private car use
- Enabling the generation of scale-effects for a more cost-effective, faster and less risky deployment of ITS
- Accelerating the current pace of ITS deployment in road transport, and assuring the continuity of services throughout the Community
- Enhancing the leading role of the European ITS industry in worldwide markets by fostering the supply of innovative products and services to vehicle manufacturers, transport operators, logistics providers and users.

The goals set out in the action plan can be achieved by EU through financial support, standardization initiatives, legislative and non-legislative measures. When developing the action plan many stakeholders from different areas were consulted. Interviews with private and public stakeholders, workshops, an Internet questionnaire and target discussions in existing stakeholders forum were performed. From these consultations it was clear that the stakeholders thought that ITS deployment should be policy led with clearly identified responsibilities. Coordination between different stakeholders was also an important issue and the involvement from the European Union in deployment of ITS should be greater. The consultations also resulted in six prioritized areas where action area 4, 'Integration of the vehicle into transport infrastructure', is of special importance for the development of Cooperative systems. The area has four focus points with a target date following to each of the action points. The action points in action area 4 is shown below, stated as in the action plan published by the European Commission (Commission of the European Communities, 2008):

- (4.1) Adoption of an open in-vehicle platform architecture for the provision of ITS services and applications, including standard interfaces. The outcome of this activity would then be submitted to the relevant standardization bodies. (Target date: 2011)
- (4.2) Development and evaluation of cooperative systems in view of the definition of a harmonized approach; assessment of deployment strategies, including investments in intelligent infrastructure. (Target data: 2010–2013)
- (4.3) Definition of specifications for infrastructure-to-infrastructure (I2I), vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication in cooperative systems (Target date: 2010 (I2I), 2011 (V2I), 2013 (V2V))
- (4.4) Definition of a mandate for the European Standardization Organizations to develop harmonized standards for ITS implementation, in particular regarding cooperative systems. (Target date: 2009–2014).
4.2.3 Standardization work

The European Commission (2009) did send out a mandate, called mandate M/453 EN, addressed to ETSI (The European Telecommunications Standards Institute), CEN (Committee for European Standardization) and CENELEC (the European Committee for Electrotechnical Standardization). The three European standardization Organizations (ESO) was asked to prepare a coherent set of standards, specifications and guidelines for support (to the European Commission) in the implementation and deployment of the cooperative ITS systems. The purpose with the mandate is to ensure interoperability and deployment within Europe, but also, as much as possible, with the rest of the world, in order to establish an effective and user-friendly environment for the cooperative ITS systems in different areas and countries. The mandate is in line with the action plan, point 4.4 under action area 4, published by the European Union in 2008 (see section 4.2.2). The time line for the mandate is thirty months after its acceptance.

Goal for the mandate

The standardization work stated in the mandate should include European Commission (2009):

- An analysis of the required European standardization activities which should include:
  - A detailed work program covering the necessary standardization works in support of Cooperative ITS services (only including road-bound traffic).
  - Identification of the potential functionalities that the new systems can supply to drivers, infrastructure providers, emergency services, public administrations and any other identifiable stakeholder.
  - Identify the minimum set of European standards required in the field of Cooperative systems to ensure interoperability between the different elements (V2V, V2I, I2I (between infrastructure operators). The standards should be divided into communication, information and security standards.

- Development of the identified minimum set of European standards (ENs) contained in the work programme within the stated time schedule
- Development of test methods for assessing the conformity of the identified minimum set of standards
- Development of the rest if the identified standards and technical specifications for Cooperative systems.

Research included in the standardization work

Research on cooperative systems started in Europe under the Fifth and Sixth Framework Programmes and is continuing under the Seventh Framework Programme.

European Research and Development projects within cooperative ITS systems has already been developed and finalized within the 5:th, 6:th and 7:th Framework Programmes of the European Commission. The results from these projects gives technical and scientific background, which is useful in the standardization work.

Except from EC funded projects, there has also been a lot of research done within the car industry, for example Car2Car consortia is promoting a common industry approach.

All of these different projects needs to be included when the standards are being developed in order to avoid any unnecessary work and close cooperation with all stakeholders are needed.
It is also important to take other countries under consideration when developing the standards in order to have interoperability between the European Union and other parts of the world, as well as inside the European Union.

Response to the European Commission

A joint response was sent from ETSI and CEN (ETSI, CEN, 2010), to the European Commission in April 2010. Both ETSI and CEN accepted the mandate. CENELEC did not accept the mandate and is therefore not a part of the work with implementing standards for Cooperative systems. Since both ETSI and CEN have accepted the mandate in 2010 the deadline for the work is in 2013.

Apart from the response, there has been one workshop in the subject this far. The workshop did focus on technical issues in a number of predefined areas related to the mandate. 36 ITS experts from CEN-ETSI-ISO groups were attending the workshop.

Definitions of cooperative systems

The mandate has provided definitions both for ITS systems and Cooperative systems.

Definition of ITS systems: 'Intelligent Transport Systems (ITS) means applying Information and Communication Technologies (ICT) to the transport sector. ITS can create clear benefits in terms of transport efficiency, sustainability, safety and security, whilst contributing to the EU Internal Market and competitiveness objectives. To take full advantage of the benefits that ICT based systems and applications can bring to the transport sector it is necessary to ensure interoperability among the different systems throughout Europe at least.' (European Commission, 2009)

Definition of Cooperative systems: 'Cooperative systems are ITS systems based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and infrastructure-to-infrastructure (I2I) communications for the exchange of information. Cooperative systems have the potential to further increase the benefits of ITS services and applications.' (European Commission, 2009)

The formulation of Cooperative systems has been accepted by ETSI and CEN.

ETSI and CEN have later on, in the response, provided a more detailed definition, which is suggested to be used:

'Co-operative ITS is a subset of the overall ITS that

• communicates and
• share information

between ITS stations to

• give advice or
• facilitate actions

with the objective of improving

• safety, sustainability, efficiency and comfort

beyond the scope of standalone systems.' (ETSI, CEN, 2010; European Commission, 2009).

Technology

ETSI and CEN are going to make a starting point in the already existing work and standards that are available for the cooperative systems (see section 2.3). There are advantages with using the bandwidths suggested, since the bandwidths used in for example
Japan and USA are close to the ones decided to be used in Europe and thereby interoperability is close between different parts of the world. This is not taking under consideration that Japan probably is going to change their bandwidth in 2012. Another important aspect is that the car industry in Europe has recommended the same bandwidth as the already introduced standards, which gives a uniform view on the subject for many different stakeholders. The bandwidths discussed, and recommended as standards, covers the most important areas when implementing ITS applications on a cooperative platform, with the advantage of using different bandwidths for different types of applications. Also communication via mobile communication systems (2G, 3G, LTE), WLAN and infrared based systems are considered very important for communication in cooperative systems. The problems with these systems are that the communication between vehicle-to-vehicle and vehicle-to-infrastructure allows for very short delays without any costs. The mobile systems are widely spread systems and the transmission of data has to be paid for even though it is becoming less relevant due to the growing introduction of flat rate charging. ETSI and CEN will focus on the 5GHz. bandwidth including the 5 GHz. WLAN introduced in section Media(2.3). There will also be focus on the already existing 2G and 3G public mobile systems. The harmonized standards, already existing, are going to be revised, and new standards are being developed as well. At the moment the standards that are going to be used and that have been presented by ETSI (Weber, 2010) are:

- **Existing standard (from 2008-12)**
  - ETSI EN 301 893: Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN (Harmonized European Standard, 2008-12)

- **Existing standard (from 2010-01):**
  - ETSI ES 202 663: Intelligent Transport Systems (ITS); European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band (ETSI standard, 2010-01)

- **Revised standard**
  - ETSI EN 302 571: Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 5855 MHz to 5925 MHz frequency band. (Harmonized European standard, 2008-09)

- **New standard (approval stage)**
  - ETSI EN 302 686: Intelligent Transport Systems (ITS); Radiocommunications equipment operating in the 63 GHz to 64 GHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive.

**Considered projects/organizations**

The mandate has pointed out many projects/organizations that already has been focusing on cooperative ITS. These systems are going to be taken into account during the work by ETSI and CEN. The works taken into account are:

- EU-supported R&D (research and development) projects
  - CVIS – Cooperative Vehicle-Infrastructure System
  - Safespot – Cooperative vehicles and road infrastructure for road safety
  - Coopers – Cooperative systems for intelligent road safety
  - PreDrive C2X – Preparation for driving implementation and evaluation of C2X communication technology.
All of the projects above has been coordinated by the COMeSafety project and has been presented to ETSI and ISO, which already has resulted in published standards.

- Upcoming projects from the 7th Framework programme
- A number of national R&D (research and development) projects and national FOTs (Field Operational Tests)
- Technology developments in the Car-2-Car Communication Consortium (standardization on interfaces and protocols of wireless communication between vehicles and their environment in order to get the vehicles from different manufacturers operable and to get them to communicate with different road side units)
- Standardization organizations
  - ISO (International Organization for standardization)
  - IEEE (Institute of Electrical and Electronics Engineers)
  - SAE (Society of Automotive Engineers)
  - IETF (The Internet Engineering Task Force)
  - Others.

The joint declaration between US and EU (Introduced under section 4.8.1) is also an important agreement in order to get cooperation between EU and US regarding the standardization work.

In order to be able to get an overview of the ITS specification activities in the European region the members of the ICT Standards Board (ICT = Information and Communication Technologies) has established an ITS Standardization Steering Group (ITS-SG). ETSI and CEN has in their answer mentioned that ITS-SG will be monitoring the activities in the work program and ensure the contact from different stakeholders with the two standardization organizations.

**Structure**

The structure of the ‘ITS Architecture’, presented on the CEN/ETSI workshop in May 2010 (Bossom, 2010), is built up according the ISO 7-layer OSI (open system interconnection) model. It is a layer model for network architecture developed by ISO (International organization for standardization) and documented in ISO 7498 (ISO, 1989). This means that the architecture is supported on a national level. In figure, 4.4, the structure of the network is shown.

![Figure 4.4 Structure of the ITS Architecture](VTI notat 6A-2011 63)
The two layers, which include applications, are given below:

- **ITS Applications**: ITS Applications are together with some parts of the Facilities layer the physical viewpoint. It is a system that defines and implements an ITS-service to users of the system. The ITS applications include:
  - Road safety applications
  - Traffic Efficiency applications
  - Other applications

- **ITS Facilities**: ITS Facilities are functions or data, which are common for several applications. The ITS Facilities acts as a support for the applications. The Facilities layer includes:
  - Application support
  - Information support
  - Session support.

The other layers in the architecture are used for communication.

**Minimum set of standards**

The work programme within CEN and ETSI are based on a minimum set of standards (Lin, 2010; Schade, 2010). These standards are the ones that are seen as the basis for the development of a working cooperative ITS. The areas included in the minimum set of standards are the ones shown in figure, 4.5.

![Figure 4.5 Areas included within the minimum set of standards](image-url)
Within the minimum set of standards the following application classes are considered:

- **Cooperative Awareness Driving Assistance (safety)** – Information from 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 Roadside Applications** – Collection of Information from vehicles for infrastructure applications
- **Event Driven Road Hazard Warning** – Based on a certain event a warning message is sent out: Roadwork Warning, Wrong Way Driving Warning, Collision Risk Warning from an ITS-S Roadside, Traffic Condition Safety Warning, Weather condition warning, Emergency Electronic Brake Light, Stationary Vehicle Warning
- **Traffic Management** – Optimum throughput via speed limits, centrally determined routing, road network management, no overtaking for trucks, Monitoring and routing of dangerous goods
- **Cooperative Traveller Assistance** – Navigation considering information received about restricted access, etc. Parking information/booking
- **Value Added Services** – Insurance and Financial Services.

The application classes follows directly from the definition presented on a CEN/ETSI workshop in may 2010 (Schade, 2010). A basic set of applications has been produced by ETSI (2009) (ETSI TR 102 638). These applications, should be included, when the development of standards regarding framework architecture and communication architecture) are considered. The applications should be able to be deployable and implemented in the system, the directly after completion of the standardization work.

**Basic set of applications (BSA)**

The basic set of applications focuses on V2V, V2I and I2V communication, using the frequency band described above, together with other access technologies, such as cell networks (2G, 3G, 4G) and/or broadcasting systems (DAB, T-DBM, DVB). The basic set of applications is used to scope the standardization work. The standardization work is necessary to enable deployment of the basic set of applications. The target audience is the stakeholders developing standards for applications in the BSA and the BSA document should also serve as a reference document for different stakeholders developing ITS services.
The applications in the BSA have been considered against some criteria divided into the following classes:

- Strategic requirements
- Economical requirements
- System Capabilities requirements
- System performance requirements
- Organizational requirements
- Legal requirements
- Standardization and certification requirements.

The criteria’s are based on the needs from users and stakeholders. ETSI (2009) has published a technical report (ETSI TR 102 638 V1.1.1 (2009-06)), which includes the definitions of the BSA. The existing applications presented in the document are constantly being updated/revised and new ones are being created when the technology is improved and new technology is taken into account. The basic set of applications is divided into three classes. The applications from ETSI TR 102 638 V1.1.1 (2009-06) is shown in table 4.6.

4.2.4 Car 2 Car Communication Consortium (C2C-CC)

The Car-2-car Communication Consortium (2010) is an industrial consortium which includes almost all of the European manufacturers, several suppliers, research organizations and other partners. The consortium was introduced in 2002. The consortium has been included in the project COMeSafety (Bechler et al., 2010), discussed in section 3.1.5.

The interest in getting a voice from the industry is big with respect to the development of cooperative systems, and vehicle-to-vehicle and vehicle-to-infrastructure technologies. The Car-2-Car Consortium focuses on the deployment and release of European standards for these kinds of systems. The focus for the Consortium is road safety and efficiency on the roads and the 5.9 GHz bandwidth has been used for communication. Both radio, networking and information technology is included as communication tools. In the Consortium the speed-up of the deployment of the systems is an important issue and strategies and business models for doing this are being introduced.

The European work within standardization of cooperative systems has been a big focus area and the Consortium contributes a lot in these processes, especially in the standardization work carried out by ETSI TC ITS. Since the industry is a big part of the deployment of cooperative systems, there view on standardization is extremely important and the close cooperation with the standardization organizations is very important in order to get interoperability between the systems.

Car-2-Car Communication Consortium does also highlight and work on a worldwide harmonization of Car-2-Car communication standards.

As a final result Car-2-Car Communication Consortium also wants to demonstrate the Car-2-Car System as proof of technical and commercial feasibility.

Applications

The Car-2-Car Communication Consortium has in 2007 developed a manifesto (Car-2-car Communication Consortium, 2007). This document is the first public document published form the Consortium and it includes the main building blocks of the vehicle-to-vehicle(V2V) and vehicle-to-infrastructure(V2I) systems, as it is intended to be presented by the Car-2-Car Communication Consortium. The document was developed in the beginning of the project and the intention is that it should be a living document within the Consortium. Results, activities and so on will be presented in the document.

In chapter 5 of the Manifesto from August 2007 the applications and their use cases within the scope of the Car-2-Car Communication Consortium are presented. An overview of the applications and its use cases are given in table 4.7.
Table 4.7 Table of final applications and use cases given in the Car 2 Car Communication Consortium Manifesto.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Use cases</th>
</tr>
</thead>
</table>
| Vehicle 2 Vehicle Cooperative Awareness | - V2V Merging Assistance  
- Cooperative Forward Collision Warning  
- Emergency Electronic Brake Lights  
- V2V Lane Change Assistance  
- Approaching Emergency Vehicle Warning  
- Highway/Rail Collision Warning  
- Wrong-Way Driving Warning  
- Cooperative Glare Reduction  
- Cooperative Adaptive Cruise Control |
| Vehicle 2 Vehicle Unicast Exchange | - Pre-Crash Sensing/Warning  
- V2V Merging Assistance  
- Cooperative Vehicle-Highway Automation System (Platoon)  
- Instant Messaging |
| Vehicle 2 Vehicle Decentralized Environmental Notification | - Slow Vehicle Warning  
- Post-Crash Warning  
- In-Vehicle Amber Alert  
- Safety Recall Notice  
- Traffic Jam Ahead Warning  
- Hazardous Location V2V Notification  
- Safety Service Point  
- Decentralized Traffic Car Data |
| Infrastructure 2 Vehicle (one-way) | - Hazardous Location I2V Notification  
- Green Light Optimal Speed Advisory  
- V2I Traffic Optimization |
| Local RSU Connection | - Automatic Access Control  
- Personal Data Synchronization at Home  
- Infrastructure-based Cooperative Merging Assistance  
- Remote Diagnostics  
- Free-flow Tolling  
- Drive-Through Payment  
- Remote Diagnostics  
- Vehicle Computer Program Updates  
- Signal Violation Warning / Signal Preemption |
| Internet Protocol Roadside Unit Connection | - SOS Services  
- Just-In-Time Repair Notification  
- Media Download  
- Map Downloads and Updates  
- Enhanced Route Guidance and Navigation  
- Fleet Management  
- Instant Messaging |

The applications presented by the Car-2-Car Communication Consortium are widespread and are both safety and efficiency related as well as infotainment applications.

4.2.5 eSafety, eSafety Forum and eSasfety Support

eSafety (eSafetySupport, 2010) is an initiative driven by the European Commission, which aims to increase road safety in Europe by the development and deployment of Intelligent Vehicle Safety systems. The initiative is within the industry-public sector which is co-chaired by ERTICO-ITS Europe and ACEA (Association of European Car Manufacturers).

eSAfety Forum

The eSafety Forum (eSafetySupport, 2008) was established in 2002 by the European Commission and involves all road safety stakeholders. There is cooperation with the industry, industrial associations and the public sector. The eSafety Forum is divided into several working groups which has their own focus areas, but all of the areas are included in the development, use and deployment of Intelligent Vehicle Safety systems. The eSafety Forum also include promotion and monitoring of the implementation of the
eSafety recommendations identified by the eSafety working groups.

**eSafety Support**

The aim with the eSafetySupport (2010) is to give support to the eSafety Forum and the working groups within the forum and to monitor the activities, progresses and results within the Forum. Also other research and development projects and activities that might be of interest are monitored within the eSafety Support. The eSafety Support are reaching out to stakeholders by events, promotion of the recommendations from the working groups and meetings (work shops, steering meetings etc.). Results are given out via the web page and through other dissemination material. The eSafety Support, supports all work that might be related to eSafety such as implementation of a European eCall system, Road Map for all eSafety systems and the i2010 initiative (especially the part who deals with deployment of smarter, safer and cleaner vehicles in the future). The i2010 initiative was the EU policy framework for the information society and media between 2005–2009. Finally the eSafety Support are helping out with administrative support.

**4.2.6 IVSS (Sweden) and FFI**

IVSS (Aaro et al., 2008; IVSS, 2010) stands for Intelligent Vehicle Safety Systems. It is a Swedish research program, which aims to bring together different stakeholders and projects within traffic safety. The idea is to have a platform for all operators interested in the IVSS area. Public authorities, private companies and industrial organizations are represented in the program. The program started in 2003 and will be finalized in the end of 2010.

The projects within the program need to go through an application process before they are accepted by the program. This application need to show that the project can live up to the aspects of safety improvement, economic growth and technical solutions and can be successfully commercialized. Projects that could be included in the program are Swedish companies, universities and institutes, foreign companies or organizations legally registered to operate in Sweden and foreign companies/organizations in partnership with an IVSS party or parties.

The areas of research within the program are:

- Drivers assistance tools – HMI(Human Machine Interface) machines
- Communication platforms
- Sensors and in-vehicle systems
- Intelligent roads and informatics
- Biomechanics, prevention of collisions and injuries at collisions, collision worthiness
- Reliable and failure-tolerant systems
- Vehicle dynamics for safety.

FFI (2010) is a Swedish cooperation agreement between the government and the vehicle industry. FFI stands for ‘Fordonsteknisk Forskning och Innovation’. An agreement was signed between the parties in January 2009, with the primarily planned timeline, 2009–2012. No final end date has been decided for the project. The cooperation means that the partners, included in the initiative, have decided to come together to finance projects in the area of climate and environment, and safety. The project aims to carry on with the research programs in the area of transportation which ends in 2008–2010, there among IVSS.
4.2.7 FOT-net

FOT-net (2010) is a network for Field Operational Test activities. It is funded by the EC within the Seventh Framework Programme (European Commission, 2010a). The purpose with the network is to bring together European and international stakeholder in a common platform, in order to share experience and information about finished and ongoing Field Operational tests on a national, international and European level. The platform is open both for public and private stakeholders. The network started in June 2008 and it has an expected duration of 31 months.

4.2.8 NEARCTIS

NEARCTIS (2010) stands for Network of Excellence: Advanced Road Cooperative Traffic management in the Information Society. It is an EC funded project within the Seventh Framework Programme (European Commission, 2010a). The project started in July 2007 and is expected to be finalized in June 2012. The NEARCTIS is an academic network, which aims to bring together all relevant research programs within the area of traffic management and optimization, with focus on cooperative systems. The main problems considered when implementing cooperative systems are: safety, energy consumption, environmental impacts and congestion as an obstacle to mobility. The project will build up a so called ‘virtual research institute’, which purpose is to have a harmonized research program, bringing together many research programs, and get consistency within these programs, find resources that can be used within different programs(such as data, bibliographical databases etc.) and share knowledge and results. Relationships between traffic operators, local authorities, consultants, manufacturers as well as international scientific communities are an important part of the project in order to get a full picture of issues within cooperative systems.

4.2.9 ERTICO - ITS Europe

ERTICO - ITS Europe (ERTICO, 2010a) is a ITS network within Europe. The network started in 1991 with 15 members. Today the network consists of more than 100 members, with representatives from many different organizations, such as public authorities, industry players, infrastructure operators, users, national ITS associations etc. The purpose with the network is to bring forward the research and the development within the ITS area, help with deployment and, inform and raise awareness in the area. The network is focusing on four areas: CooperativeMobility, EcoMobility, SafeMobility and InfoMobility.

4.3 Ongoing projects in U.S.

Many of the projects within cooperative system in the U.S. are carried out in cooperation with the U.S. Department of Transportation. Two of the biggest projects in U.S. are presented in the sections below.

4.3.1 IntelliDriveSM

In 2009 the VII (Vehicle Infrastructure Integration) project changed name to IntelliDriveSM (Research and Innovative Technology Administration, U.S. Department of Transportation, 2009). The purpose with the new name was to make the project more commercialized and to cover new areas of interest within the V2V and V2I research. The project is carried out in collaboration with the U.S. Department of Transportation’s (US DOT’s) and it’s ITS program (ITS JPO), American Association of State Highway
and Transportation Officials (AASHTO)/local agencies and the vehicle manufacturers. The project is sponsored by U.S. DOT’s. The visions stated in the VII project stayed the same, but since a lot of new research and technologies had been developed during the years, new useful inputs and focus areas has been introduced.

The areas in the VII project that have changed, with new or other focus areas, when changing to IntelliDriveSM are:

- **The technology used**: In the VII project only dedicated short range communications (DSRC) was considered. In the IntelliDriveSM project new technologies can be used as options to the DSRC.
- **Production area**: In the VII project only Original Equipment Manufacturer (OEM) products were considered, i.e. the final product, sold on the market. In the IntelliDriveSM project, after market and retrofit products, are also considered.
- **Type of vehicles**: In the VII project only one type of vehicles were considered (light vehicles). In the IntelliDriveSM projects, there will be focus on all types of vehicles.
- **Stakeholders involved**: A limited number of stakeholders were included in the VII project, but in the IntelliDriveSM project a broader number of stakeholder are included.
- **Publication and marketing**: In the VII project there was a limited visibility to people not involved in the project. In the IntelliDriveSM project there will be more focus on program transparency.
- **Deployment area**: The deployment area was limited to U.S. in the VII project, but in the IntelliDriveSM project, there will also be focus on international harmonization.
- **Program structure**: The structure of the VII program wasn’t as clear and straight forward as it will be in the IntelliDriveSM project. In the IntelliDriveSM project a lot of support, coordination and leadership will come from the US DOT’s.

And the areas that will stay the same in the new IntelliDriveSM project, compared with the VII project are:

- **The connectivity**: V2V and V2I communication
- **Technology for safety applications**: The dedicated short range communication will still be used for safety applications
- **National interoperability level**: Open standards will be used for communication and data
- **Types of applications**: The types of application will be the same, i.e. safety mobility and convenience applications
- **Safety and security focus**: The focus is on safety and security and no compromises should be done in these areas
- **Collaboration parities**: US DOT, AASHTO/local agencies and vehicle manufacturers are still an important part of the project.
4.3.2 AERIS

One important issue that also has become a big part of the project is the environmental aspects, with focus on emission, green house gases and particulates. For this part US DOT–ITS JPO has sponsored a new sub-project, which is a part of the IntelliDriveSM project, with focus on the environment. The name of the sub-project is AERIS (IntelliDrive, 2009), which stands for Applications for the Environment: Real-Time Information Synthesis.

The vision for the subproject is to generate, capture and analyze data, which can be used by the users and operators of the system, in order for them to be able to make ‘green’ transport choices. The project will try to collect real-time environmental data coming from vehicles and integrate it with other sources. The data will be used for transportation management and performance improvements. And finally, applications will be developed and/or investigated, to find the applications that have the most impact on the environment. Not only applications, which are directly connected to the environment, will be considered but also application that indirectly might influence the environment, such as parking applications, transit and freight applications etc.

4.3.3 CICAS

CICAS (Minnesota Department of Transportation, 2009) stands for Cooperative Intersection Collision Avoidance System. The project started in 2006 and is expected to be finalized in 2012. The partners included in the project are: USDDOT, State DOTs, University of Minnesota and auto manufacturers. The project is focusing on the intersection problems, and to find solutions within vehicle-to-vehicle and vehicle-to-infrastructure communications that can contribute to a safer environment around intersections. The project is divided into four areas:

- CICAS-CBAT (Cost Benefit Analysis Tool)
- CICAS-V (Violations)
- CICAS-SLTA (Signalized Left-Turn Assist)
- CICAS-SSA (Stop Sign Assist).

Cooperation has been carried out between CICAS and VII (later IntelliDrive).

4.4 Ongoing initiatives in U.S.

In this section some initiatives within cooperative systems are presented. U.S. Department of Transportation is the biggest one, but there are also some other organizations, which focuses on bringing different stakeholders, interested in cooperative systems, together.

4.4.1 U.S. Department of Transportation’s – ITS Joint Program Office (ITS JPO)

The U.S. Department of Transportation’s – ITS Joint Program Office (ITS JPO) (ITS Joint Program Office, Research and Innovative Technology Administration, U.S. Department of Transportation, 2010a) (U.S. DOT ITS JPO) is a research program in U.S., which is coordinated by the Research and Innovative Technology Administration (RITA). The purpose with the ITS program is to improve and continue the development and deployment of intelligent transport system, by research, operational field testing, technology transfer, training and technical guidance. The program is investing in programs related to ITS systems, and among them some projects that are focusing on cooperative
systems. VII (Vehicle Infrastructure Integration) project (see section 3.2.1), one of the biggest projects within cooperative systems, was supported by the U.S. DOT ITS JPO. The project changed structure and name in 2009. The updated project, IntelliDriveSM (see section 4.3.1), is also sponsored by the U.S. DOT ITS JPO.

**Strategic Research Plan**

In December 2009 the ITS Management Council, presented the ITS strategic research plan (ITS Joint Program Office, Research and Innovative Technology Administration, U.S. Department of Transportation, 2010b). The aim of the research plan is to continue focusing on research and deployment related to ITS systems. Focus is, among others on V2V and V2I communication. The IntelliDriveSM project, described in section 4.3.1, is a big part of the plan. Six sub-programs, within IntelliDriveSM, are provided in the strategic plan, with focus on: ITS Standards, National ITS Architecture, ITS Technology Transfer, ITS Professional Capacity Building, ITS Evaluation and ITS Outreach and Communications. The time line for the research plan is 2010–2014. Cooperation within different areas is an important part of the plan. Vehicle manufacturers, researchers, consumer electronics and telecommunications firms, Federal State and local transport officials are planned to come together, with their different points of views, in order for the deployment to be satisfactory for the different users/developers of the systems.

### 4.4.2 OmniAir

OmniAir (2010) is a consortium focusing on the deployment of the 5.9 GHz DSRC (Dedicated Short-Range Communications). In 1999 the Federal Communication Commission (FCC), in the U.S., decided to use the 5.950–5.925 GHz. bandwidth as a national interoperable communication network for safety, mobility and commercial applications within the transport area. In 2003 the FCC decided to use a specific technology, Dedicated Short Range Communication (DSRC), based on open IEEE (Institute of Electrical and Electronics Engineers) standards. The reason for doing this was to have a common set of standards for safety applications, which enables interoperability between regions and vehicles. The OmniAir consortium was established in 2003 to help with the deployment of the DSRC through the member-defined OmniAir Certification Program. The OmniAir consortium is funded thought partnerships, with the U.S. Department of Transportation as one of the partners. The safety and mobility goals stated by USDOT and IntelliDriveSM are consistent with the goals produced by the consortium. OmniAir is also supporting the development of intelligent transport systems in general but the main focus is on the deployment on DSRC.

### 4.4.3 CAMP

CAMP (Laberteaux, 2006; Shulman och Deering, 2004; U.S. Department of Transportation, Research and Innovative Technology Administration, Intelligent Transport Systems, 2010) stands for Crash Avoidance Metrics Partnership and it is a partnership founded by Ford Motor Company and General Motors Corporation. The partnership started in 1995. The idea with the partnership is to have cooperation between Ford Motor Company and General Motors Corporation, as well as additional partners, such as OEM’s (Original Equipment Manufacturer) and US DOT’s (US Department of Transportation), for cooperation in projects, focusing on crash avoidance for vehicles. (Shulman och Deering, 2004) Projects that has been carried out within CAMP are among others:
Today CAMP includes seven working groups within vehicle manufacturers: BMW, Daimler-Chrysler, Ford, General Motors, Nissan, Toyota, and Volkswagen.

4.4.4 CVPC

CVPC (2010) stands for Connected Vehicle Proving Center. It is a program led by the academia and the industry. The aim of the program is to connect researchers and developers in order to accelerate the deployment of new technologies within cooperative systems. The program offers help in testing and evaluation connected vehicles technologies. The Connected Vehicle Proving Center was funded in 2007 and was, in 2009, established on the campus of the University in Michigan. The Center is continuing to grow and increase in the area of cooperative systems.

4.4.5 CVTA

CVTA (2010) (Connected Vehicle Association) is an U.S. association, which connects different stakeholders, working within vehicle communications and opens up for cooperation between them. The vision is to create a safer, more efficient and effective environment on the roads. The association is open for anyone and it is non-profitable.

4.4.6 ITS America

ITS America (2010) is an American Society funded in 1991. The idea with the society is to have a platform for stakeholders in the ITS industry. The platform should work as a centre for finding research partners and develop networks, in order to fastened the deployment of ITS technologies and to have interoperability within the ITS area.

4.5 Ongoing projects in Japan

In this section a summarization of two of the ongoing projects in Japan will be made. There are probably more ongoing projects on cooperative systems in Japan, but the limitations due to language and poor information on different homepages has resulted in a presentation of two projects that seems to be two of the biggest ones. The VICS project has had a long duration and started already in 1995. ASV IV is a newer project (started in 2006), but it is building on the earlier projects ASV I, ASV II and ASV IV. The projects can therefore be seen as phases more than standalone projects. ASV I started already in 1991.

4.5.1 VICS

VICS (2010) stands for Vehicle Information and Communication System Center. The project started in July 1995 and has been continuously developed since then. The purpose with the project has been to increase safety on the roads, increase the comfort for the driver and to increase the social economy. The increased demand for transportation, resulting in congestions and increased environmental impacts, have given rise to a request for a national project, promoting ITS systems, in order to reduce the negative impacts of the increased traffic. This resulted in the VICS project, which was the first
national project within the ITS area in Japan.

VICS collects real-time information about the road infrastructure and transmit it to equipped vehicles (infrastructure-to-vehicle communication). The information is sent through the Japan Road Traffic Information Center to the VICS center. The VICS center edits the information and sends it out to equipped vehicles. The vehicles pays a monthly fee in order to be able to get the information on their displays, inside the vehicles. Information that the system are able to send out are congestion information on the roads and lane restriction information due to road works or accidents. There are three media used to transmit information:

- **Radio wave beacon** – The beacons are installed on entrances and exits of expressways, intersections and often in congested areas, in order give good and reliable information to the vehicles. Information given via the radio wave beacon are: traffic congestion, traffic hindrance, restriction, interval-travel-time, link-travel-time on expressway, etc. Information can be given in an area of 200 km ahead of the beacon. The beacon sends out information two to three times when the vehicle is in the area of 70 m.

- **Infrared beacon** – The infrared beacon is mainly installed on major ordinary roads. Information on traffic congestion, restriction, interval-travel-time, link-travel-time, parking lots, etc. is given by the infrared beacon. Information 1 km backwards and 30 km forward can be given to the vehicle. The vehicle needs to be in a zone of 3.5 m around the beacon in order to receive information.

- **FM multiplex broadcasting** – FM multiplex broadcasting can send out information in a large area. Huge amount of information can be sent out through the NHK FM stations. The stations can also send out information for up to 10 km within the neighboring station’s area. The information sent out is traffic congestion, restriction, interval-travel-time, link-travel-time, parking lots, etc.

### 4.5.2 ASV-IV

The ASV-IV (Kenji Wani, 2006) is the fourth phase of the ASV project described in section 3.3.5, 3.3.6 and 3.3.7. The project started in 2006 and is expected to be finalized in 2010. The focus within the project is, as it also has been in previous phases, on promotion and development of new technologies. The goal is that promotion should be a full-scale introduction to autonomous detection type driver assistance systems and development of new technologies within the area of inter-vehicle communication (vehicle-to-vehicle communication) type driver assistance systems.

### 4.6 Ongoing initiatives in Japan

Japan has been focusing on the development of Intelligent Transport Systems for many years. This section will summarize some of the main initiatives within the area of cooperative systems and the related Intelligent Transport Systems.

#### 4.6.1 Overview of Japan strategies for ITS systems

Japan has, during the years, had four strategy plans (Hideyuki Oku, 2010) for the development of ICT (Information and Communication Technology). Cooperative systems are a big part of this, since ICT technology is used for building the systems and applications. The first plan was introduced in 2001 and is called the e-Japan strategy. The main goal with the strategy was to establish a broadband structure. Besides that, there was also focus on E-commerce, E-government and human resources.
In July 2003, the e-Japan Strategy II was set out. In the second strategy, there were more focus on application and effective use of IT.

In January 2006 the ‘New IT Reform Strategy’ was set out, with the main purpose to ‘pursuit IT Structural Reform Capabilities and solving social problems through utilizing ICT’ (Hideyuki Oku, 2010). This strategy covered a wide range of activities, for example, infrastructure, environment, safety and security, international contribution, R&D, etc. And finally in July 2009 the ‘i-Japan Strategy’ 2015 was set out. The new strategy was set out as a result of major changes in how the internet was used. Also other areas of technology did going through some big changes. In top of that the financial crisis had highlighted the need of economic stimulus measures.

When the first plan was set out in 2001 there was a reformation of the governmental bodies in Japan. Five government ministries became four ITS-related ministries which have been working with ITS-related questions since then. The four governmental bodies are (ITS Japan, 2010):

- National Police Agency
- Ministry of Public Management, Home Affairs, Posts and Telecommunications (former Ministry of Posts and Telecommunications)
- Ministry of Economy, Trade and Industry (former Ministry of International Trade and Industry)

### 4.6.2 ITS info-communications Forum

ITS, info-communications forum (2010) was created in 1999. It is a forum for ITS activities, which aims to fasten and bring together all the activities in the area. There is focus on research and development, standardization, as well as promotion of ITS systems. Coordination is made between different organizations involved in ITS activities. There are around 100 members within the forum. The members come from different organizations, such as manufacturers and governmental agencies. The secretariat is led by ARIB (Association of Radio Industries and Businesses).

### 4.6.3 ITS Japan (former VERTIS)

ITS Japan (2010) is an organization that aims to fasten the deployment of ITS systems. The organization was renamed in 2001. Before 2001, the name of the organization was VERTIS(Vehicle, Road and Traffic Intelligence Society). VERTIS was funded in 1994 as a response to the European and American organizations working in the ITS area (ERTICO and ITS America). The organization was supported by the governmental organizations, National Police Agency, Ministry of International Trade and Industry, Ministry of Transport, Ministry of Posts & Telecommunications, and Ministry of Construction. VERTIS has been focusing on research and development in the ITS area, as well as deployment and information exchange activities between Europe and America. One of the missions was to organize the ITS World Congress together with ERTICO and ITS America. The expectation has been to bring all types of stakeholders together, such as academia, government and industry, but it has also been important to get the media and the end user involved and promotion of ITS related systems has therefore been important.

In 2001 there was a reformation in the Japanese government, which led to a new structure of the governmental organizations working with ITS related questions, see section
4.6.1. When this happened VERTIS changed name to ITS Japan. ITS Japan’s focus is still on bringing together public and private organization, as well as the academia within the ITS research area, promoting ITS systems to the wider public and to support the standardization of the systems. The ITS world congress is still organized by ERTICO, ITS America and ITS Japan. An Asian-Pacific forum has been developed to bring together different parities in this region and ITS Japan also works as a platform for the Asian-Pacific ITS congress to be able to bring together organizations in the area.

4.7 World wide initiatives

There are also ongoing initiatives that are cross-boarders. One of them is ISO standardization work.

4.7.1 ISO standardization work

ISO (Antipolis och Csepinszky, 2010; ISO, 2010) stands for International Standardization Organization. In 1992 a Technical Committee, TC204, was created. The purpose with the technical committee was to develop standards within the area of Intelligent Transport systems. ISO/TC 204 is responsible for the overall structure of the systems and infrastructure for intelligent transport systems. The committee includes 18 working groups. The groups (and convener country) are summarized below:

- WG1: Architecture (UK)
- WG3: ITS Database Technology (Japan)
- WG4: Automatic Vehicle Identification (Norway)
- WG5: Electronic Fee Collection (Sweden)
- WG7: General Fleet Management (Canada)
- WG8: Public Transport (USA)
- WG9: Integrated Transport Information Management (Australia)
- WG10: Traveler Information Systems (Germany)
- WG11: Route Guidance and Navigation Systems (Vacant Seat)
- WG14: Vehicle/Roadway Warning and Control Systems (Japan)
- WG15: Dedicated Short-Range Communications (Germany)
- WG16: Wide Area Communication (use of CALM) (USA)
- WG17: Nomadic device (Corea)
- WG18: Cooperative Systems (Germany).

WG18 works with standardization of cooperative systems. ISO/TC 204 has 25 participating members and 29 observing members with a great geographic diversification between the members.

CALM

Working group number 16, in ISO/TC204, is focusing on making standards on CALM (2010) (Communications access for land mobiles). The standards involve the architecture of the system, the network protocols and communication interface definitions for wired and wireless communication. For the wireless and wired communication, one or more of several media, are going to be used. The CALM technology has been part of many of the projects in the area of cooperative systems and intelligent transport systems, a lot of them presented in this document (for example CVIS).
4.8 Cooperation between countries

Many agreements and liaisons have been made between different countries, during the years, in order to ensure that the interoperability is as good as possible and also to limit overlap of work.

4.8.1 Cooperation between the European Union and the United States

The European Commission Information Society and Media Directorate-General (EC/DGINFSO) and the Research Innovative Technology Administration of the United States Department of Transportation (USDOT/RITA) did come up with a joint declaration of Intent on Research Cooperation in Cooperative Systems in November 2009 (Stancic och Appel, 2009). This declaration states that both parties believes that Cooperative systems can bring a lot of benefits, for both private road users and the public, in terms of safer, more energy efficient and environmentally friendly transport.

The joint declaration also focuses on the importance of continuing cooperation between EC/DGINFSO and USDOT/RITA that was agreed in January 2009 in an Implementing agreement (Stancic och h. Appel, 2008) between the two parties. The implementing agreement included cooperation in research and activities regarding Information and Communication Technologies (ICT) and especially the research on ICT applications for road transport (i.e. Cooperative systems). EC/DGINFSO and USDOT/RITA has the intention to inform stakeholders involved about the activities in the deployment of Cooperative systems. This includes in particular standardization organizations and automotive industry.

EC/DGINFSO and USDOT/RITA will identify areas of research where cooperation might lead to benefits. Research in EC/DGINFSO and USDOT/RITA (separately or joint projects) is funded for through normal Research and Technology Development (RTD). In Europe it will be supported by the relevant research program of the Seventh Framework Programme.

Further EC/DGINFSO and USDOT/RITA believes that globally harmonized standards are essential in the process of deployment of Cooperative systems. The parties support at sets of global and open standards, which ensure interoperability. The standards should be as few as possible and multiple standards in the different areas should be limited as much as possible. This can be extra hard in areas where there are demonstrated technical needs (differing frequency allocation) or where legal requirements are needed (privacy protection laws etc.) and country specific standards might be necessary in these areas. The parties also encourage participation from other parts of the world especially Asian Pacific region.

The implementing agreement is expected to continue within a five years period, but can be renewed after that if both parties still believe that there are gains in the cooperation.

4.8.2 Cooperation between the European Union and Japan

Japan and the European Union have been in cooperation for a long time. In 1991 they signed a joint Declaration, with the purpose to straighten the overall cooperation between EU and Japan since they both are strong industrialized countries with the same core values. In 2001 this was further straighten via an action plan, which was a 10 years cooperation plan.

Japanese Information and Communication Technologies (ICT) companies located
in EU have been part of the European research and development projects for a long
time, especially in the Sixth Framework Programme, but Japanese ICT companies lo-
cated in Japan have not been a big part of the European research. Therefore, the COJAK
project started, in 2008, in order to increase the EU-Japan and South Corea cooperation
in the ICT area. The project is an EC funded project within the Seventh Framework Pro-
gramme (European Commission, 2010a). It started in January 2008 and was finalized in
June 2009. A lot of activities has been carried out within the project to ensure increased
cooperation, there among workshops, forums and seminars. A homepage, EuroJapan-
ICT.org (2010), has been created within the project, outlining the workshops, forums
and seminars, that has been held.

In the part of the cooperation, that included cooperative systems, the conclusions was
that collaboration was needed when developing standards in order to have a harmonized
architecture and applications worldwide. The project believes that this is possible even
though Japan have (or are going to have) another bandwidth than EU.

4.8.3 Cooperation within standardization
Apart from the US-EU and the Japan-EU cooperation, there are also signed agreements
on partnerships between ETSI (2010) and a number of standardization organizations in
order to get interoperable standards that works worldwide. The agreements are:

- Memorandum of Understanding with APT (Asia-Pacific Telecommunity), Asia-
  Pacific
- Letter of Intent with the Association of Radio Industries and Businesses (ARIB)
  Japan
- Memorandum of Understanding with ECC (Electronic Communications Commit-
  tee) of CEPT (European Conference of Postal and Telecommunications Adminis-
  trations), Europe
- Body Memorandum of Understanding with ENISA (European Network and Infor-
  mation Security Agency), Europe
- Memorandum of Understanding with ERTICO-ITS Europe, Europe
- Memorandum of Understanding with IEEE-SA (Institute of Electrical and Elec-
  tronics Engineers Standards Association), world wide
- Liaison with ISO TC 204 (Intelligent transport systems), world wide
- Co-operation Agreement with TIA (Telecommunications Industry Association),
  U.S.
- Memorandum of Understanding with TTA(Telecommunications Technology As-
  sociation of Korea), Korea
- Memorandum of Understanding with TTC (Telecommunication Technology
  Committee of Japan), Japan.

The international standardization organization, ISO (2010) and the Technical Commit-
tee, TC 204, involved in standardization of cooperative systems, are also working in liai-
on with some other standardization organizations. The organizations within the liaison
are:

- APEC (Asia Pacific Economic Cooperation), Asia Pacific
- ETSI (European Telecommunications Standards Institute), Europe
- ITU (International Telecommunication Union), world wide
- OGC (Open Geospatial Consortium, Inc.), world wide.
4.8.4 Cooperation ITS Japan, ITS America and ERTICO

ITS Japan (2010), ITS America and ERTICO are cooperating in the area of ITS systems. The purpose is to exchange information, and to integrate work done in other countries/regions with the work done in the own country/region, on cooperative systems. The three are jointly involved in the World congress on ITS.
5 Cooperative systems this far and in the future

The transportation area has gone through some big changes during the last decades. The increased demand of travel, along with rapid changes and developments in the technologies used in the transport area has led to congested roads and more accidents around the world. The focus on Intelligent Transport Systems has increased along with this development and lots of money has been given to research projects in the area.

Technology like wireless communication etc. has been more and more widespread and today most of the vehicle owners also have some kind of equipment for exchange of information. Most common are the mobile phones, smartphones and iPhones that could be used for information exchange, but also equipment inside the vehicle has become more and more common. The car industry and research projects all over the world has therefore seen a lot of potential in communication between vehicles via some kind of on-board equipment, installed in the vehicle or as a hand-held unit used by the driver. Also communications between vehicles and the infrastructure via roadside equipment and the same kind of on-board equipment as mentioned above have been seen as important and useful. Therefore the cooperative systems, which covers communication between vehicles and communication between vehicles and the infrastructure have become more and more common in research and development projects.

5.1 Projects

Many projects have been focusing on cooperative systems. Some of the earliest ones, like PROMETHEUS in Europe, AHSS and ASV in Japan and VII in U.S., indicated the importance of cooperative systems already in the 1980’s and the 1990’s (VII started later than that (2003)). During the following years many research and development projects have been performed within the cooperative system area.

5.1.1 Europe

Europe has been promoting and supporting the development of projects related to Intelligent Transport Systems and cooperative systems for a long time. The main funding within Europe comes from the European Commission and the Framework Programmes, starting from the Fifth Framework Programme. At this point the Seventh Framework Programme is in full action, with many projects covering cooperative system.

Some of the most exhaustive projects in Europe in later years are projects like CVIS, SAFESPOT, COOPERS and PreDrive C2X. The projects have been carried out within the Framework Programmes. The results from these projects have been used in many other projects and the European Commission has used the projects as a base for further development.

Another project, that is of great importance, due to the coverage, is the COMeSafety project. This project collects the results from some of the biggest projects, both within and outside of the Framework Programmes. Some examples of included projects are COOPERS, CVIS, SAFESPOT, SEVECOM, GeoNet, FRAME, E-FRAME, SafetyForum and Car-2-Car Communication Consortium, which are all Framework projects. Apart from the projects mentioned above, some of the standardization organization have also been involved in the COMeSafety project: CEN, ISO, ETSI, IEEE and IETF. Projects outside of Europe have also been considered in the project. The project has been looking at questions regarding the requirements for an overall framework within cooperative systems and an open and interoperable architecture for the systems.
Many projects within the Framework Programmes are not as big as the ones mentioned above, but they are still important and plays an important role in the development and deployment of cooperative systems.

Some of the projects have been focusing on the technologies behind the cooperative systems and others have been focusing more on the development of one or more applications.

Finally some projects has been focusing more on testing and evaluation of cooperative systems with for example field operational tests and simulation platforms etc., in order to see the usefulness of the systems developed. Some, or maybe most, of the projects does of course include both development and testing. In some of the projects especially during the later years, there has also been focus on deployment and business plans has been developed.

Figure 5.1 shows a picture of how the projects are connected.

![Figure 5.1](image)

Figure 5.1 An overview of how the projects in Europe are connected. From development projects, to testing, evaluation and deployment projects, to summarizing projects, which collects the most important results from other projects. Some of the more comprehensive projects might include both development, and testing, evaluation and deployment.
Apart from the projects in the Framework Programmes, many national projects within Europe have also been carried out within the cooperative systems area. These projects are also important, especially for the nation in question. The nation specific projects can address issues like specific laws restricting the systems or other land specific questions that might be considered under the development of the systems.

Also the manufacturers are developing new systems covered in the cooperative systems area, and forums including manufacturers have been developed, to take care of and promote their interests. There has been cooperation between the forums and some of the projects, especially for projects on EU level. Some of the forums include only (or mostly) manufacturers, such as Car-2-Car Communication Consortium, which is the 'voice' of the vehicle industry, and others try to bring together different stakeholders and projects, like ERTICO, for cooperation and knowledge sharing. The Car-2-Car Communication Consortium has been included in a lot of the biggest projects in Europe and their opinion is seen as very important since they represent the vehicle industry.

Besides all of the projects and forums in the cooperative systems area in Europe, some of them summarized in this document, there have also been a lot of initiatives taken regarding cooperative systems. The European Commission has set out an action plan for the continuous process within the Intelligent Transport Systems area (including cooperative systems) and the standardization process of cooperative systems is in full action.

### 5.1.2 U.S.

The U.S government (U.S. Department of Transportation (U.S. DOT)) did early support and promote the development of cooperative systems. Some big projects have been performed within the area, such as VII, VSC and EEBL. Today, a big ITS program and a strategy research plan are in process, organized by the U.S. DOT. Within the program, the extensive project, IntelliDrive (former VII), is included.

The IntelliDrive project is the far most extensive project in U.S., and when the project changed name from VII to IntelliDrive, U.S. DOT became a bigger part of the project. Today U.S. DOT is not only funding the project, but also supporting the project with administrative help etc. Apart from U.S. DOT, manufacturers and American Assiciation of State Highway and Transportation Officeials and their local agencies are also included in the project.

Organizations/forums has also been created, with the aim to bring together different stakeholders, and to create a platform for research and development within cooperative systems, in order to build up cooperation’s and relationships between the stakeholders. Among them CAMP, OmniAir, ITS America, CVPC and CVTA has been mentioned. CAMP is an organization composed by some of the vehicle industry operators. The organization has been part of many projects where development of applications and technologies has been in focus. CAMP can be compared with Car-2-Car Communication Consortium in Europe, but with not as many partners as Car-2-Car and with more focus on funding projects.

### 5.1.3 Japan

Japan has, on governmental level, highlighted the importance of Intelligent Transport Systems and later cooperative systems. In 2001, the first strategy plan was set out for ICT (Information and Communication Technology), including Intelligent Transport Systems.
But already in 1989 the AHSS project started with support from the government. Many other projects have also been performed with support from the governmental bodies, such as ASHRA, Smartway and ASV.

Today the big projects, VICS and ASV-IV, are in process. Both of them are extensive projects with a long history. The ASV-IV has been developed from the former ASV projects (or phases of the ASV project) and the VICS project has been ongoing since 1995.

The main focus for many of the Japanese projects has been vehicle-to-infrastructure communication, where Japan has been introducing applications not only on research level, but also on the market. The ASV (Advanced Safety Vehicle) project has during the two later phases (III and IV), where the last one is still ongoing, been focusing on vehicle-to-vehicle communication, as well as vehicle-to-infrastructure communication.

5.1.4 Comparison

All, or most of the projects, irrespectively of country or union, has the main goal to increase safety and efficiency in the traffic. Higher traffic demands in all countries/regions has resulted in congestions and increased number of accidents. The believes in both EU, Japan and U.S. is that cooperative systems can contribute to decrease the number of injuries (increase safety), increase the efficiency on the roads and make the traffic flows more stable and diversified. The focus within the projects this far has been on the technologies used, frequency bandwidth, the system architecture and the applications. The applications in the projects regardless of country or union are often split in safety applications and efficiency application. In some of the projects management applications and infotainment applications has also been considered.

During the later years, when the environment has become more and more important and pollutions are increasing, more consideration has been taken to the reduction of environmental impacts. The believes is that cooperative systems can be used in order to reduce the environmental impacts as well. Europe, as well as U.S., has started projects with the main purpose to develop applications that contributes to reduction of pollutions. In Europe the projects EcoMove, FREILOT and INTIME, part of the Seventh Framework Programme, are focusing on these issues and in U.S., the sub-project AERIS, part of the IntelliDrive project, has been focusing on environmental issues. In Japan the consideration regarding the environmental impacts has not been as explicit as in U.S. and Europe. No specific project has been focusing on the environmental impacts, even if the environmental impacts is included indirectly in some of the project, with for instance route guidance applications, warnings of congested roads, etc. Some of the projects, in Japan, have also mentioned the need for decreased pollutions.

It can also be seen that Europe has a large amount of projects, most of them sponsored by the European Commission, but also projects on national level are common. Some of the projects are therefore very closely related to each other and there might be overlaps between them. This means that Europe has a wide range of viewpoints and many different approaches has been and are investigated and evaluated regarding cooperative systems, but it can also mean that there are too many projects resulting in that it can be harder to find the important results among the projects. It is also possible that the projects closely related to each other compete instead of cooperate.

In U.S. there is one big project, funded by the government, IntelliDrive (former VII), and some smaller projects some of them are supported by the government and some of them are CAMP projects (a partnership of seven manufacturer). The impression is
that the projects are fewer in the U.S. The intelliDrive project is the far most extensive project and it is also part of the U.S. government strategy research plan in the area of cooperative systems. There are a few big leading stakeholders in the top of the research and development, within the area of cooperative systems. The strategy in U.S. is differentiating a bit from the strategy in Europe. The benefits from having one strong leading project funded by the government together with CAMP projects (often projects in cooperation with U.S. DOT), which is a complement to that, makes the structure simple and it is easy for the government to keep track on the process. It is also easy for the government to steer the projects in a desired direction. On the other hand, if there are only a few stakeholders involved there might be aspects left out and stakeholders not involved might feel overlooked.

In Japan, it is harder to find information due to language difficulties and less information on the project homepages, and it is thereby harder to evaluate the projects. The feeling is that the documents related to the projects doesn’t become public as often as they do in Europe and U.S. Japan has more focus on deployment and to get the systems out on the market, than Europe and U.S. Both U.S. and Europe have been focusing more on research and development and they have only recently begun to investigate the deployment of the systems more thorough.

Many of the biggest national projects in Japan are driven by four ITS-related ministries, which makes it harder to get a clear picture of the strategies and the projects. Besides the national projects, the vehicle industry is developing applications and technologies related to cooperative systems, often developed only with one manufacturer included.

All of the nations (U.S., Japan and Europe), has a strong governmental support or in Europe’s case via the European Commission. The government and the European Commission are funding many projects and supports the projects with huge amounts of money, which shows how much the countries believes in cooperative systems and the further development in the area.

5.2 Cooperation between stakeholders and cooperation over nations

Cooperation is seen as relevant in order to get an as fast and widespread deployment of the systems as possible. Both manufacturers and governments can benefit a lot from cooperation activities. The manufacturers can reach a bigger market, if the systems they produce and sell are interoperable and work cross-boarders, and the governments can ensure a faster and more effective deployment of the systems, hopefully resulting in increased safety and efficiency on the roads, as well as interoperable and useful systems.

There are cooperation between Europe, Japan and U.S., mostly within the standardization organizations, but also within projects by sharing of results etc. The believes within these countries/unions is that cooperation is important and clearly one of the main focus areas as of today, especially in the standardization process.

Liaisons and agreements has been signed between U.S. and Europe, and, Japan and Europe. Within the Seventh Framework Programme, cooperation between Japan and Europe, has been in focus in the project COJAK (see section 4.8.2).

Another type of cooperation is done between the organizations ITS America, ITS Japan and ERTICO. They have been working on bringing together relevant stakeholders within each region, but also with cooperation across borders. The ITS world congress is a joint
effort between the three organizations. These three organizations are important in the
process of exchange of information within the different regions.

Cooperation within the nations is also seen as important. There has been a lot of ef-
forts made on cooperation within nations/regions already and forums and initiatives,
with many different stakeholders included, has been developed both in Europe, U.S. and
Japan.

Finally cooperation between stakeholders inside the projects is important to cover the
issues regarding interoperability and to cover all different viewpoints.

It is a big challenge to try to have cooperation in projects and organizations. To do this,
clear guidelines needs to be set out and all relevant stakeholders needs to feel that they
are included and a part of the organization/project.

It is also a challenge to cooperate over nations since there might be huge differences
in how the nation is governed and what is seen as important issues, as well as cultural
differences. There might also be competition issues related to cooperation in different
projects and it is possible that not all of the information can be revealed due to confiden-
tiality, especially if the project is a vehicle industry project.

Cooperation will also in the future be important and the efforts made this far will be
used as a base for further cooperation. The stakeholders can gain a lot of benefits and
reduced workloads as a result of the cooperation, but it is also important to consider the
issues that can occur.

5.3 Standardization

Europe, Japan and U.S. agree on the importance of standardizations regarding the archi-
tecture, in order to get interoperable systems. The most important question this far has
been the frequency bandwidth, where all the three unions/countries has decided to use
the same or almost the same range for the bandwidth.

In Europe most of the standardization work at this stage is carried out by CEN (Euro-
pean Committee for Standardization) and ETSI (European Telecommunications Stan-
dards Institute) as a result of the mandate sent out by the European Commission in Oc-
tober 2009. The standardization work will cover the whole architecture needed in or-
der to be able to develop and build Intelligent Transport Systems/cooperative systems
platforms, including a number of ‘basic’ applications (developed by ETSI), that will be
working from day one after the release of the standardizations.

Another standardization organization working with Intelligent Transport Systems is ISO
(International Organization for Standardization). The organization is worldwide and the
standards developed will therefore be known, and they will be able to be used regardless
of nation. The work is huge and many nations are involved in the development. One of
the working groups is especially focusing on cooperative systems, WG18.

ISO and ETSI/CEN are cooperating and a liaison has been agreed upon, which will en-
sure that no overlaps and unnecessary work will be done. This ensures that the two orga-
nizations recommends the same type of standards when possible.

In Japan, ARIB (Association of Radio Industries and Businesses), is working with stan-
dardization within cooperative systems. But Japan does also use a lot of the standards
produced in ISO and ITU-R (International Telecommunication Union – Radiocommu-
nications).

There are also some other standardization organizations working with cooperative sys-
tems, some of them only in U.S.

The standardization processes, as well as the cooperation among organizations, seems to give a good ground for the stakeholders interested in the development of cooperative systems, but on the other hand there are three big nations/unions, which should try to cooperate in the big work of finding standards. It will need a lot of effort, from all involved, to make it work, and where to many overlaps and cultural differences can interfere with the possible cooperation.

5.4 Technology

The technology used for cooperative systems and Intelligent Transport Systems have been developed a lot during the 1990’s and 2000’s. The fast development of wireless communication techniques makes it much easier to make use of cooperative systems, and to actually implement the systems on a wide range, where end-users has the ability to easy get hold of and buy the technologies used.

In later years one of the big issues has been the bandwidths that are going to be used for communication between vehicles and between vehicles and the infrastructure. Investigations within nations/regions, together with cooperation and knowledge sharing between nations/regions, has resulted in standards and recommended bandwidths, that are in the same range both for U.S., Japan and Europe (the 5.8 GHz frequency band).

Japan has recently investigated the option of using a new bandwidth for vehicle-to-vehicle and vehicle-to-infrastructure communication. This has resulted in a decision to change to a new bandwidth in 2012 (the 700MHz frequency band). Thereby different bandwidths will be used in Japan, compared with U.S. and Europe. Japan believes that the new frequency will not affect the cooperation with other nations, but even so there might be problems. Consideration needs to be taken when equipped vehicles are exported from Japan to for example Europe.

There will probably be a continued development of new technology and at this stage it is interesting to see how much of the ideas that can actually be used and work well on a large scale with the technology available.

One interesting issue relates to the coverage, for example obstacles and hills can make connections between different units hard. Japan has been evaluating this, with the conclusion that the 700 MHz bandwidth is much better to use in order to get a higher coverage. The question is if we need to have full coverage all the time or if it is enough to get a percentage of the information. And in that case how many percentages is enough? It might even be the case, that if the driver knows that he/she is not always getting the information, the awareness in the traffic is higher than if he/she fully relies on the systems in the vehicle.

5.5 Applications

Intelligent Transport System comes in a wide range, from really simple applications like variable message signs and traffic lights to more advanced systems like warning systems inside the vehicle and route navigation systems. All the different applications can make it hard to actually decide what is useful and what is not useful. A lot of applications have also been developed within the area of cooperative systems, even if they in most cases haven’t been deployed on the market yet.

The projects performed during the past years have resulted in a wide range of different applications, where some of them seems to be used in all or almost all projects. The
most important issue to solve is to increase safety and the applications are therefore often safety related, but also efficiency, management and infotainment applications have been considered. A new type of applications, that have been considered more important during the later years, are the environmental-focused applications.

The different types of applications are sometimes hard to differentiate. Safety related applications can have efficiency effects as well, and the other way around. Environment applications are probably most related to efficiency applications and efficiency benefits will probably also result in environmental benefits. The link between safety and environment applications are not that clear as it is for efficiency and environmental applications.

The focus on the environment will probably lead to that more and more applications related to the environment are being developed. These type of applications haven’t been tested yet since the projects related to environmental applications have just recently started and the effects from these kind of applications are still unclear.

5.6 User acceptance

One other issue that is important and that has been included in many project is the user acceptance, both from the end-users point of view, but also from the governments and actors point of view.

Some of the projects that have been carried out today have been focusing on evaluation and analysis of the applications and systems within cooperative systems. It seems like main focus during the evaluation of the applications and systems has been on the usefulness in the network and if the applications/systems covers its purpose, rather than on how useful the application is for the driver/government/infrastructure operator.

This is an important and relevant area to investigate. Even if the application or system serves its purpose well, the application or system might have a negative impact on the user. Evaluations of applications and systems are therefore needed with respect to how useful the application is for the end-user.

In order for a system to work well and serve its purpose it is of course also a question of in which degree the applications exists in the vehicles. So in order for a system/application to give desired effects the implementation degree needs to be over a certain percentage. How many of the vehicles that needs to have the applications could be tested through for example micro simulation. This will give the provider the opportunity to evaluate the application before investing too much money in production costs etc.

5.7 Next steps in Europe

So far many projects have been focusing on research and development, as well as field operational tests and evaluations of systems and applications. The European initiatives, presented in section 4.2, indicate that the focus has been taken away from the research and development level to the deployment level. All over the world organizations agrees on the importance of developing a deployment plan as soon as possible in order to get working systems out in the world at around year 2020. A common opinion is that the best way of doing this is to find standards that are interoperable in bigger regions and preferably all over the world. The time line for the initiatives in Europe can be summarized in a picture, see figure, 5.2.
If this succeeds there will be finalized standards for a lot of applications in 2014 and the industry will be able to produce applications according to these standards after that, and hopefully they will be able to be interoperable between platforms, not only on national level, but also on an international level.
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