ITS RADAR INTERNATIONAL

Identifying ITS Opportunities for the HA

Cooperative Vehicle Highway Systems Fact Sheet: September 2009

Summary

In the last few decades, an increased demand for safer road transport has been met by a range of passive features (which seek to mitigate the effect of accidents, such as air bags) and active safety features (which seek to prevent accidents from happening, like anti-lock brakes) built into vehicles. In the last decade new technologies have enabled systems to be developed which provide extra information to drivers, improving their awareness of their surroundings via communication capabilities built into their vehicles. In the last decade, the concept of Cooperative Vehicle Highway Systems (CVHS) has been developed, in which the vehicles exchange information with each other and with the roadside infrastructure so that drivers and road operators have access to live, up to date information about the road environment. Drivers may benefit from additional safety features and information, and because road operators can use information transmitted from vehicles to improve the safety and efficiency of their road networks, journeys become more convenient and reliable.

These cooperative systems have the potential to provide significant improvements in safety for drivers, their passengers and other road users, as well as additional information and support for drivers and enhancements in traffic management and network efficiency.

This Fact Sheet summarises the benefits and technological challenges involved in CVHS, European activities and standards. Projects related to CVHS, in Europe, Japan and the USA are summarised and developments in the UK in general and the Highways Agency in particular are discussed.

Key Words

Communications, Cooperative vehicle systems, European Commission, Project, Standard

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What are Cooperative Vehicle Highway Systems?

Ultimately, the vision for Cooperative Vehicle Highway Systems (CVHS) is accident-free, congestion-free journeys and journey times which are both predictable and reliable. CVHS aims to bring new intelligence to vehicles, roadside infrastructure, road operators and individual drivers by creating a common language which allows vehicles and infrastructure to share information and cooperate with each other. This uses wireless media, which can include for example the existing mobile phone network or other short or long range communication media, or a combination of each, optimised for the mobile environment. These new systems can support a wide range of applications and services which have the potential to improve the safety and quality of journeys on the road network.

Benefits of Cooperative Vehicle Systems

Cooperative systems can be used to enhance and support a wide range of traffic management, safety and information services, benefitting both travellers and road operators. Examples of the types of benefits which can be realised include:

- Route planning: continuous route planning based on real time traffic information makes it possible to divert vehicles and avoid congested routes, thus reducing traffic jams, increasing traffic flow and smoothing out road network usage
- Road pricing schemes can charge users on the basis of road use or environmental impact, as well as being a toll for traffic management
- Parking management: real time information about available parking spaces can be of benefit in urban areas, reducing search times and congestion, and ultimately directing users to individual parking spaces
- Safety: Cooperative systems can have two types of benefit. They can help to prevent accidents by constantly monitoring other vehicles on the road and warning drivers as they approach hazards. In the event of an accident they can notify the emergency services and help emergency vehicles to identify the exact location of the incident to aid response and also reduce traffic jams by providing information so that other road users can make arrangements to avoid the accident scene
- Applications for passengers: New entertainment, leisure activities and services can be used by cooperative systems improve the quality of long journeys, for example internet access, other information sources and network games
- Traffic Management and Control: data from vehicles can provide real time traffic information to road operators, supporting journey time information services, incident management, adaptive traffic signal control and other services
- Adaptive Speed Limiting systems of two types are possible, in which vehicles receive speed limit information from the roadside: passive systems warn drivers when they exceed the speed limit, while active systems intervene to prevent drivers from exceeding them, unless overridden by drivers

- Network efficiency gains can be made through automatic lane control systems and from headway control systems which maintain a constant safe distance between vehicles
- Value added services are available for vehicle owners, such as remote vehicle diagnostics in case of faults, or security and tracking services for stolen vehicles
- Environmental benefits are also possible, by enabling vehicles to 'see' the road ahead and adjust vehicle speed, acceleration and deceleration to suit the road environment and minimise fuel consumption and emissions.

These are just a few examples that show that cooperative systems can have far-reaching effects, and have the potential to improve safety, reduce journey times and improve the efficiency of the road network.

Technological Challenges of Cooperative Vehicle Systems

The core technology upon which cooperative systems rely is communications, both Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V). This is often supplemented by location awareness, normally using Global Navigation Satellite Systems (GNSS) - such as GPS, and in the future Galileo, technology, as many CVHS applications rely on the vehicle knowing its location. Other on-board sensors (e.g. radar distance sensors) can also be used as further inputs to cooperative applications.

To reap the maximum benefit from cooperative systems, the communications systems need to be both 'pervasive' (i.e. available at all times and in all locations) and fully inter-operable (i.e. able to work with other systems which may be based on different technologies); much of the research has been focussed on this area. Once the vehicle is in full contact with both the surrounding infrastructure and other nearby vehicles, cooperative applications can be developed.

Pervasive communications can only be achieved by providing multiple communications channels and using the most appropriate channel as required. Thus cooperative communications systems range from long-range (satellite, GSM/GPRS, 3G) through medium (WiFi, WiMax) to short-range (DSRC, Infra Red, UWB). The selection of the most appropriate channel should be invisible to the user. Clearly not all channels will be appropriate to all applications, so the applications need to be aware of the available bandwidth and latency of the currently available communications channels.

With communications technology in place, it is possible to start building applications. The integration of multiple applications leads to its own challenges in terms of prioritisation, user interface, interoperability and integration. Presenting information from multiple applications to the driver in a consistent and particularly safe manner is not a trivial task.

Multiple industry, national and international projects have been addressing these issues and are further described below.

Challenges for Implementation

As with many ITS services, wide scale deployment of these systems depends not only on these technological challenges, but also on political will, organisational and institutional arrangements and the development of appropriate business models.

While CVHS has the potential to provide some benefit almost immediately, the full benefits of these systems can only be realised if they are used by the majority of the stakeholders as the cooperative aspects improve with increasing penetration. Therefore a gradual implementation (typical of a market-led approach) can adversely affect public acceptance and hence significantly slow down the spread of the technology. Thus a central and regulatory implementation could be the key to its success.

There are also considerable technical challenges, but the significant perceived benefits of CVHS systems means that there are numerous national and international projects addressing the technical issues; the key projects are summarised below.

The nature of cooperative systems means that standards will almost certainly be required to ensure reliable communications between multiple disparate systems, and some of the projects listed have links to standards organisations to ensure the relevant standards are developed.

Inevitably, on-board systems mandated by policy will incur additional costs to vehicle manufacturers, and these costs will need to be passed on leading to higher costs for motorists.

European and International Activities

The European Commission sees cooperative systems as one of the measures that can be used to reduce the number of road accident casualties. The EC is involved in a range of activities which are designed to stimulate developments in this area including the eSafety Forum, work on standards and frequency allocation, and supporting EC funded research projects such as CVIS, Coopers and Safespot which are demonstrating applications and technologies. Vehicle manufacturers have also set up an organisation to support the development of interoperable systems.

Frequency allocation

The radio frequency spectrum is a valuable resource with many competing interests seeking exclusive or shared access to spectrum space. Safety-critical systems relying on wireless communications will normally need guaranteed (i.e. exclusive) spectrum assigned to them.

In the EU, the allocation of radio spectrum is in the hands of the Member States, although they have to comply with the EU laws and international radio spectrum agreements. The development of radio spectrum policy in the Community is based on the Radio Spectrum Decision 676/2002/EC.

Intelligent Transportation Systems have a number of frequency bands allocated. The most widely used are as follows:

- 5.725-5.875 GHz DSRC Europe
- 5.770-5.850 GHz DSRC Japan
- 5.850-5.925 GHZ DSRC USA
- Commission Decision 676/2002/EC: A European Commission Decision dedicated the 5.875-5.905 GHz frequency band for ITS usage

- Outdoor Doppler and sensing devices (eg. Traffic light sensors) use the 10.577-10.597 GHz frequency band.
- Pre-sidecrash warning technologies use the 24GHz band.
- Traffic speed sensors usually work at 34.7GHz.
- Infra-red DSRC is direct line-of-sight only. It does not need licensing.

Although the precise allocation of the "5.8 GHz Band" varies internationally, the frequencies are close enough so that common equipment can be used.

The European Telecommunications Standardisation Institute (ETSI) is responsible for producing standards in relation to frequency allocation in Europe. These standards ensure that compliant ITS equipment avoids causing harmful interference.

Standards

The standardisation process is a vital aspect for cooperative systems, because multiple communicating entities are involved from different manufacturers and these need to be able to understand each other. Various topics are introduced below.

CALM

Communications, Air-interface, Long and Medium range (CALM), also known as Communications Architecture for Land Mobiles, is an initiative hosted by the International Standards Organisation (ISO) to define a set of wireless protocols and parameters for medium- and long-range, high-speed ITS communication across a variety of methods of transmission.

The communication protocols form the foundations necessary for cooperative vehicles technology. CALM aims to create a continuous communication link, independent of the type of media used. Methods of transmission used by CALM include: infra-red; Global System for Mobile communications (GSM) and 5.9GHz Dedicated Short-Range Communications (DSRC).

Working Group 16 of ISO TC 204 is responsible for the development of CALM standards. This is an area of great development, currently with 8 published standards and 22 draft standards. This work is to be shadowed by the recently established Working Group 16 of CEN TC 278.

ETSI has also recently established a Technical Committee for ITS (ETSI TC ITS). ETSI TC ITS is active in the development of CALM standards, as well as other topics.

Further information can be found from the CALM website: www.calm.hu.

Dedicated Short-Range Communications (DSRC)

DSRC is used for one-way and two-way short-range communications. It can be used to create a gateway on a short section of road, and is therefore particularly useful for electronic fee collection applications.

The standards for the definition of DSRC were originally drafted by Working Group 9 of the European body, CEN TC 278. Four standards were published 1997-1999 and updated in 2002 and 2004. Working Group 15 of ISO TC 204 has also adopted one of these standards.

ETSI TC ITS has also been involved in the development of DSRC standards.

IEEE 802.11p

The IEEE 802.11 Working Group develops standards for Wireless Local Area Networks (WLAN). IEEE 802.11b and 802.11g are the widely accepted standards used in home and office wireless computer networks.

Task Group p is currently defining enhancements required to support Intelligent Transportation Systems (ITS) applications. "WAVE" is a mode of operation for use by IEEE Std 802.11 devices in environments where the physical layer properties are rapidly changing and where very short-duration communications exchanges are required.

The standard is on course to be published by January 2010.

Cooperative warning and control systems

Several published standards exist for the performance requirements and test procedures for cooperative warning and control systems. These includes:

- Warning Systems – vehicle collision, lane departure
- Control Systems – full speed range adaptive cruise control, low speed following systems, lane change decision aid systems, manoeuvring aids.

These are maintained by Working Group 14 of ISO TC 204.

European Projects

This section summarises relevant European projects related to cooperative systems, most of which are currently on-going. This is followed by a description of the largest projects in the USA and Japan.

There are differences between Europe, the USA and Japan in the approach to support for Cooperative Vehicle Highway System projects. There is strong governmental support in USA and Japan. In Europe governmental support is indirect via the European Commission, and the picture is more heterogeneous with many different countries involved. Thus there are more projects in Europe than in the USA and Japan, and more differences between them compared to USA and Japan.

eSafety Forum

The eSafety Forum was established in 2001 by the European Commission in collaboration with the industry, industry associations and public sector stakeholders.

Its general objective is to promote and monitor the implementation of the recommendations identified by the *e*Safety Working Group and to support the development, deployment and use of *e*Safety systems. The Forum is an open public-private platform and has established 16 industry-led Working Groups, including the following which are relevant to CVHS:

- Communications: deals with all topics related to communication technologies relevant to the general objective of eSafety
- Intelligent Infrastructure: focuses on the road infrastructure side of the cooperative systems. It also identifies issues which need to be solved at the infrastructure level, in order to ensure the implementation of the most relevant cooperative services on the road infrastructure side

- Intercontinental Cooperation: the main purpose of this Working Group is to make sure that there is plenty of communication and experience exchange between ITS experts around the world
- eSecurity: addresses the vulnerability of all the information stored and transferred during the usage of CVHS.

Car 2 Car Communication Consortium (C2CCC)

The Car 2 Car Communication Consortium is a non-profit organisation initiated by European vehicle manufacturers, which is open to suppliers, research organisation and other partners. Its main objective is to ensure the interoperability between the different vehicles and manufacturers by standardising interfaces and protocols used by cooperative vehicle systems in order to guarantee the flawless communication between them. The consortium has links with various European Commission projects and also industry projects such as Network on Wheels (NOW) which aims to solve technical key questions on the communication protocols and data security.

COMeSafety

This project began in 2006 and its main purpose is to support the eSafety Forum in topics related to vehicle-to-vehicle and vehicle-to-infrastructure communication and act as a platform for exchanging and presenting information between the stakeholders.

It is actively supporting frequency allocation for ITS systems due to the common concern of related projects. COMeSafety has compiled the diagram below which summarises the links between the activities in this area.

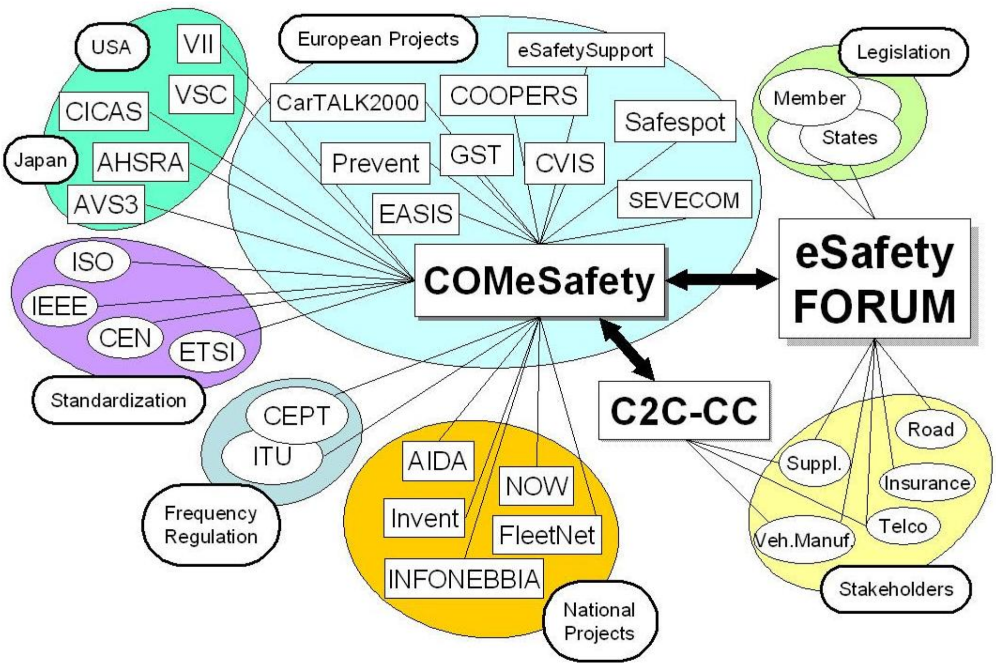

Figure 1 Overview of COMeSafety

COMeSafety has compiled comprehensive reference documents, including:

- COMeSafety European ITS Architecture
- COMeSafety Standardisation Overview.

COOPERS

COOPerative SystEms for Intelligent Road Safety (COOPERS) project began in 2006 as an EC FP6 project with 39 partners and it is planned to be finished in 2010. Its main focus is defining, developing and testing safety related services, equipment and applications in regard vehicle-to-infrastructure (V2I) communication. Its goal is to enhance road safety by providing faster and real time information exchange to drivers related to traffic, weather and road infrastructure etc.

The COOPERS system is being tested and validated on public roads in France, Belgium, Netherland, Germany, Austria and Italy.

CVIS

Cooperative Vehicle Infrastructure Systems (CVIS) project is also part of the EC FP6 programme and started in 2006 with 60 partners. It is intended to design, develop and test technologies required for vehicles to communicate with each other and with the infrastructure (V2V and V2I). The focus is not only on safety related issues, but other convenience oriented applications (i.e. parking management) are being developed as well.

Trials are being carried out in seven European countries: Belgium, France, Germany, Italy, Netherland, Sweden, United Kingdom.

SAFESPOT

Safespot is another example of an EC FP6 project started in 2006. The consortium has 51 partners and their focus is on preventing road accidents by developing a "Safety Margin Assistant" which extends the driver's awareness of the surroundings in space and time. It is designed to have vehicle-to-vehicle and vehicle-to-infrastructure (V2V and V2I) communication capabilities.

The validation and tests are taking place in France, Germany, Italy, The Netherlands, Spain and Sweden.

SeVeCOM

Secure Vehicular Communication (SeVeCOM) is an EC FP6 project started in 2006 with 8 partners, with the goal of defining the security architecture of V2V and V2I networks and proposing a roadmap for integration of security functions in these networks.

Geonet

GeoNet – Geographic addressing and routing for vehicular communication - is an EC FP7 project which started in 2008. The consortium has seven partners and their focus is on the exchange of information with vehicles in a particular geographic area which requires reliable and scalable communication capabilities, called geographic addressing and routing (geonetworking). V2V and V2I communications are both addressed in this project.

GST Project

Global Systems for Telematics (GST) project was funded partly by the European Commission between 2004 and 2007. It was designed to create an open and standardised end-to-end architecture for automotive telematics.

PReVENT

The Integrated Project PReVENT was a European automotive industry activity co-funded by the European Commission to contribute to road safety by developing, demonstrating and evaluating preventive safety applications and technologies based on advanced sensor and communication devices. It included sub projects on safe speed and safe following, lateral support, intersection safety and safety for vulnerable road users.

Overseas Projects

Intellidrive (USA)

IntelliDrive (formerly known as Vehicle Infrastructure Integration (VII)) started in 2005, combines leading edge technologies providing the capability for vehicles to identify threats and hazards on the roadway and communicate this information over wireless networks to give drivers alerts and warnings.

At IntelliDrive's core is a networked environment supporting very high speed transactions among vehicles (V2V) and between vehicles and infrastructure components (V2I) or hand held devices (V2D) to enable numerous safety and mobility applications.

The system identifies, collects, processes, exchanges, and transmits real-time data to improve the driver's awareness of the surroundings. IntelliDrive provides the vehicle with the ability to respond and react, when the driver cannot or does not react in time, significantly increasing the effectiveness of crash prevention and mitigation applications.

The Consortium (30 members) consists of the U.S. Department of Transportation, light vehicle manufacturers, state and local governments, and their representative associations. They also work with other sectors and industry experts on specific aspects of IntelliDrive, such as applications development.

ASV (Japan)

The goal of Advanced Safety Vehicle (ASV) is to drastically reduce accidents caused by driver error. Important aspects are:

- Development of inter-vehicle communication which includes "vehicle intelligence".
- Introduction of some inter-vehicle communication (V2V) type driver assistance systems
- Inter-vehicle communication will provide support when onboard sensors are not sufficient.

This project consists of four phases. Phases 1-3 were finished by 2005 and currently phase 4 is in progress, which is due to end in 2010. One of the goals in this phase is to introduce full-scale autonomous detection type driver assistance systems and some inter-vehicle communication solutions.

This project is promoted by the Road Transport Bureau of the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Cooperative Vehicle Systems in the UK

There are several UK based companies and institutions participating in European Projects, including Coopers, CVIS and Safespot.

A futuristic research and development centre based in the UK is currently being developed, called 'innovITS – ADVANCE'. "The new facility will enable customers from the telecommunications, automotive and electronics industries, as well as highways authorities and operators, to develop, test and validate future transport technologies in a safe highly controlled environment. By facilitating innovation in cooperative vehicle, highway and telecommunications technologies, innovITS – ADVANCE aims to reduce accidents, improve environmental efficiency and help to alleviate traffic congestion through the efficient and intelligent interaction of vehicles and highway infrastructure."

In the first phase of the development an urban area will be constructed to enable the testing and simulation of the urban environment.

HA Involvement

The Highways Agency as the network operator for England's motorways and trunk roads has an interest in cooperative technologies. The HA is involved in one project in this area: the System Validation of the Interurban Cooperative System Application (CINT) subproject in the CVIS project. CINT will develop and validate cooperative services to improve the efficiency, safety and environmental friendliness of traffic on the inter-urban road network and offer a safe and comfortable journey to drivers and passengers. The CINT sub-project, like the CVIS project itself, is due to be complete in the first quarter of 2010; a demonstration was provided at the 2009 ITS World Congress in Stockholm.

Currently there are two example applications which have been developed under the CINT sub-project.

- The EDA (Enhanced Driver Awareness) application focuses on the safety of the drivers by enhancing their awareness of traffic hazards and mandatory local rules (whether static, temporary or dynamic). This application makes an intensive use of cutting edge Information and Communication Technologies to build a dynamic and adaptive link between drivers, road managers and navigation service providers
- The CTA (Cooperative Travellers' Assistance) application focuses on assistance to drivers by increasing their awareness of the evolving traffic situation downstream on the road network. It personalises information to travellers, enabling them to make optimal use of the road network and assists them with making the right choices when navigating the road network. It is based upon full cooperation between roadside systems, in-vehicle sensors, traffic managers and service providers.

Future Prospects

Currently highway authorities are deploying more and more traffic monitoring systems which provide them with up-to-date information about the state of their network which can help them to make more sophisticated decisions. At the same time, modern vehicles are equipped with advanced on-board systems which in turn help drivers to make better decisions during their journeys. The value of CVHS is in interconnecting these two separate entities and thus providing valuable information to travellers and road operators alike.

The HA as a road network operator has a great interest both as a user and an operator of these new systems and the potential exists for the HA to realise the following benefits from new services based on cooperative systems:

- Constant monitoring of network utilisation
- Help to improve their existing capacity and safety without the need for physical expansion
- Help in the design of road network: where/what to build
- Reduced impact of incidents
- Improved satisfaction of their customers
- Make best use of new technologies to manage and operate the network and to inform road users of travelling conditions, through in-vehicle services which may reduce the need for roadside VMS and infrastructure

The extensive nature of the benefits of these systems should help to ensure widespread interest in their deployment. However there is also a need for commitment from governments and road operators to develop the business case for investment, and for industry to continue working towards common standards and support for interoperable services, before the full benefits of this new technology can be realised.

Bibliography

European ITS Communication Architecture – 2009: http://www.comesafety.org/uploads/media/COMeSafety_DEL_D31_EuropeanITSCommunicationArchitecture_v2.0_02.pdf

COMeSafety Forum: www.comesafety.org

Coopers website: http://www.coopers-ip.eu/

CVIS website: http://www.cvisproject.org/

eSafety Forum: http://www.esafetysupport.org/en/esafety_activities/esafety_forum/

GeoNet website: http://www.geonet-project.eu/

GSTForum website: http://www.gstforum.org/

Innovits website: http://www.innovits.com/

Prevent website: http://www.prevent-ip.org/

Radio Spectrum Decision 676/2002/EC: http://www.anacom.pt/render.jsp?contentId=548589

Radio Spectrum Policy Group website:
http://rspg.groups.eu.int/index_en.htm

Safespot website: http://www.safespot-eu.org/

Glossary

3G	Third Generation of Mobile Phones
ADAS	Advanced driver assistance systems
ASV	Advanced Safety Vehicle
C2CC	Car to Car Communication Consortium
CALM	Communications Architecture for Land Mobiles (also known as Communications Access for Land Mobiles)
CINT	Interurban cooperative System Application
COOPERS	Cooperative Systems for Intelligent Road Safety
CTA	Cooperative Travellers Assistance
CVHS	Cooperative Vehicle Highways System
CVIS	Cooperative Vehicle Infrastructure System project
DSRC	Dedicated Short Range Communication
EC	European Commission
EDA	Enhanced Driver Awareness
ETSI	European Telecommunications Standards Institute
FP6	Sixth Framework Programme
FP7	Seventh Framework Programme
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service (a standard for data transmission)
GSM	Global System for Mobile Communications
GST	Global System for Telematics Project
HA	Highways Agency
ISO	International Standards Organisation
ITS	Intelligent Transportation System
NOW	Network On Wheels project
PReVENT	PReVENTive and active safety applications project
SeVeCOM	Secure Vehicular Communication Project
UWB	Ultra Wide Band, short range high speed data communications
V2D	Vehicle-to-Handheld Device Communication
V2I	Vehicle-to-Infrastructure Communication
V2V	Vehicle-to-Vehicle Communication