CVHS Advice Project
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1 Executive Summary

The project
Cooperative systems communicate and share information dynamically between vehicles or between vehicles and the infrastructure. In so doing, cooperative systems can give advice or take actions with the objective of improving safety, sustainability, efficiency and comfort to a greater extent than stand-alone systems.

This research project involves assisting the Highways Agency (HA) to develop its position on cooperative services and supporting its cooperative systems activities across Europe. This report covers Stage 1 of the project.

Key tasks involved investigating current developments in cooperative systems, understanding how these could benefit the HA and their implications for HA operations, helping to develop an understanding of the HA’s likely role in delivering services and exploring ‘road maps’ for cooperative systems.

This work takes place in the context of tightened economic constraints within the UK, and follows the publication of the Cook report which discusses a move towards a different ownership model, with a view to ensuring that the infrastructure offers value for money for road users and tax payers alike.

Cooperative systems to meet HA objectives

Technology performance considerations lead to the conclusion that the least expensive and most rapid deployment of cooperative services likely to support HA’s objectives will use cellular communication with smartphones. This route does not require any new investment by the HA in in-vehicle or communications infrastructure.

There is much interest in cooperative systems and services in Europe, Japan and the US. Therefore it can be anticipated that the rapid development of technology will continue and that the benefits of using cellular communication and smartphone technology will increase. European field operational tests are likely to provide a useful source of information on deployment prospects.

Vehicle to infrastructure cooperative systems potentially provide the HA with new sources of data which can help to monitor and to manage the road network. Infrastructure to vehicle cooperative services potentially provide an additional channel for the HA to inform travellers and manage the road network. Thus, cooperative services provide new data streams and additional communication channels, offering opportunities for enhancement and economies of service delivery.

The role of a data market

The emergence of cooperative systems and services, coupled with external policy actions on ‘Open Data’, are fundamentally changing the role of the HA in one respect: instead of being a closed data provider - i.e. focussed internal data collection, processing data into traffic information and communicating this to travellers - the HA is becoming one stakeholder (albeit a large and unique one) in a wider data environment. This environment includes other compilers of data, much of it collected through cooperative systems, and other information disseminators.

This new data environment is still in its infancy but has potential to become an efficient and thriving marketplace. There is no single “blueprint” for how such a
market might ultimately operate but there are examples, in Germany and the Netherlands for example, that build on existing standards.

This wider data environment presents a number of opportunities and threats:

- The HA may purchase data to enhance or replace in-house data collection.
- The HA may act as a data processor and a provider of data streams to third parties.
- The HA may act as a provider of apps for travellers.
- HA data appears to be of value to third parties; there are over 150 users of existing data feeds. Future organisational arrangements may even allow the HA to charge for some data.
- There is uncertainty around the quality, robustness, and security of supply of data provided by third parties and the overall viability of the data market.

**Smartphone apps for service delivery**

The widespread use of apps on smartphones is fundamental to the viability of cooperative services based on communications between vehicles and infrastructure. There are many stakeholders and technology platforms. The market for apps is highly dynamic and many are transient, partly because the sources of data and business models are not yet secure or mature. The HA operate one app but the current Government view is that private sector provision of such services is preferred. The most important feature of an HA app (rather than one operated by a third party) is that the HA maintains full control over the service, thus ensuring that it is integrated and consistent with other services. Such an app could provide services covering the HA’s core functions, thus leaving opportunities for third party providers to offer additional services beyond this core.

One concern with apps is their potential to distract drivers, although this can be mitigated to a large extent by good design. From an HA perspective, the most successful apps will probably have high quality data sources and, ideally, be well integrated into back-office traffic management systems.

**Business models**

Calculating the social costs and benefits of potential new services provides only one view of their viability. For sustainable deployment of a cooperative service there has to be a business model in which all the necessary stakeholders can derive sufficient benefit. The operation of an efficient data market could be a key enabler for many cooperative services.

Overall, it can be concluded that cooperative systems, particularly services based on communications between vehicles and infrastructure using cellular communications and smartphones, have the potential to support many HA objectives. Nevertheless, the new business models, yet to fully emerge, will probably require some fundamental changes in the way the HA interacts with other stakeholders.

**Recommendations for further work**

Recommendations for further work in Stage 2 of this project will take the outputs of this work and address the following specific issues:

- How services can be delivered in-vehicle rather than at the roadside
- How floating vehicle data (FVD) can replace roadside infrastructure
How a UK data market can be stimulated to enable third parties to deliver services
How the operational role of the HA will change, and the long term policy implications of this.

The following activities have been identified:

- Engagement in cooperative systems groups and activities
- Data for and policy on, HA services and apps
- Investigation of external uses of HA data among service providers
- Research into the market potential of HA data
- A data innovation event
- An innovation competition
- Quantification of the potential cost reductions and quality improvements arising from cooperative systems
- Continuing actions to support longer term developments, including policy and strategy development.
2 Overview of the project

2.1 The project and its objectives

Cooperative systems communicate and share information dynamically between vehicles or between vehicles and the infrastructure. In so doing, cooperative systems can give advice or take actions with the objective of improving safety, sustainability, efficiency and comfort to a greater extent than stand-alone systems.

This research project involves assisting the Highways Agency (HA) to develop its position on cooperative services and supporting its cooperative systems activities across Europe. The first priority actions in Stage 1 of the project have taken place during the first 12 months: January to December 2012.

Tasks have included investigating current developments in cooperative systems, understanding how these could benefit the HA and their implications for HA operations, helping to develop an understanding of the HA’s likely role in delivering services and exploring ‘road maps’ for cooperative systems. Recommendations have also been developed for more focused work towards developing an HA strategy, to be carried out from 2013 onwards.

This work takes place in the context of tightened economic constraints within the UK and follows the publication of the Cook report which discusses a move towards different ownership models for the HA with the aim of ensuring that the infrastructure offers value for money for road users and tax payers alike.

2.2 Project activities

Through talking to experts and stakeholders, attending conferences and events, and scanning publications and web sites, the project has gathered information on the following aspects of cooperative systems:

- Overview of cooperative systems landscape
- Overview of European activities including demonstrations
- Overview of near-market services
- Specific applications
- Business models and cost-benefit analysis, including support to CEDR
- HA data
- Data markets and open data
- Road maps
- External influences.

The synthesis of this information has been used to develop recommendations for further work in Stage 2 of this project. The project activities are summarised in Annex A, and the recommendations are presented in Section 5.

2.3 State of knowledge on cooperative systems at the start of the project

In 2010 the Highways Agency commissioned an intelligence gathering exercise on cooperative systems. This summarised the state of the art on cooperative systems, identified the range of cooperative systems which may reach commercial viability by around 2015 – 2020, noted the implications for the HA and discussed wider issues such as convergence of technologies, interoperability, legal aspects and business
models (Gelencser, Hopkin, Tindall and Francsics, 2010). The work was informed by the experience gained while participating in the European CVIS (Co-operative Vehicle Infrastructure Systems) project. The findings of the 2010 intelligence gathering exercise, and further developments during 2011, represent the state of knowledge at the start of this project.

The 2010 report identified potential benefits for road operators which can be linked with the HA’s key objectives for improved safety, economy and sustainability. Four applications were shown to be likely to have the greatest benefit for the HA, and were recommended for further investigation to see whether a business case could be established.

The 2010 report recognised that it provided a snapshot of the position at that time, as cooperative systems were continuing to evolve. In addition to recommending an investigation of the business case for the most promising services, it recommended further work, some of which is being carried out in this project.

In 2010, the review of technologies, communications and related developments indicated that cooperative systems would most likely be delivered through fixed in-vehicle equipment (either factory-fitted or aftermarket units), with nomadic devices expected to emerge in the future once cooperative systems had become more established. This view was formed from an expectation that cooperative systems would be complex and required to ‘dock’ with existing vehicle systems, and took account of the legal and standardisation issues involved. Indeed some progress towards this position had already been made: a common hardware platform had been demonstrated in principal, including communications, positioning facilities and an open operating environment for installing applications in vehicles, at the roadside and in a central facility.

Road operators were seen as having a key role in deploying cooperative systems, particularly in planning and managing roadside equipment. One of the key issues affecting deployment was the usual ‘chicken and egg’ problem – namely that there is little benefit in investing in infrastructure if the number of equipped vehicles is small, but there is little benefit in equipping vehicles if there is no investment in infrastructure, and users will not purchase systems unless they can see tangible benefits.

In March 2011, the HA began a dialogue with stakeholders on cooperative systems, with the aim of establishing how best to stimulate progress towards deployment. Stakeholders were invited to attend an ‘industry day’ to explore with the private sector how the HA and DfT might facilitate the market for cooperative systems. The responses indicated a potential for delivering non safety-critical services to drivers using mobile or broadcast communications by extending the HA’s National Roadside Telecommunications Service, but that in the current economic climate there was unlikely to be any interest in private sector investment in roadside infrastructure for short range communications with vehicles. The responses from the consultation have been used by the HA to explore further the strategic approach to cooperative systems on the HA network, including further consultation with industry, and through this project.

In September 2011, the HA became aware of a new development, which led to a shift in thinking because it changed the view on how cooperative systems could be delivered, and indeed the prospects for early deployment of cooperative systems.
This was the VINCI Autoroutes traffic ‘app’ for smartphones (VINCI is a leading motorway operator, with four concessions in France). The app is free to download and can be used to share information between the road user and the road operator. Vehicle position information is sent to the traffic centre, supplying the road operator with floating vehicle data which could be used to supplement other sources of data for traffic monitoring; users can also inform the road operator of incidents. In return, the app user receives a number of personalised services including co-pilot traffic information, mapping, and safety assistance.

One of the first tasks in this 2012 project was to investigate this app further: the results are summarised in Annex C of this report. The arrival of this app on the scene, and the fact that it is becoming widely used, have shown that early deployment of cooperative systems is already taking place through nomadic devices (smartphones) communicating via cellular networks, without the need for roadside infrastructure. The road operator’s role is also different if there is no need for roadside infrastructure – the focus for the road operator becomes receiving data and providing information. Thus by the start of 2012 the chicken and egg dilemma appeared to have been resolved for services which are not safety-critical.

2.4 This report

During 2012, the various strands of investigation in this project have been summarised in unpublished ‘topic’ reports to the HA. This report distils the salient points which are relevant to defining the next steps for the HA in the area of cooperative systems. Section 3 summarises the key findings, looking particularly at:

- Technologies and communication channels (Section 3.1)
- The role of road operators in collecting data and delivering services (Section 3.2)
- Key external factors influencing investment decisions (Section 3.3)
- Future context and deployment prospects (Section 3.4).

The following Section (4) summarises the conclusions and initial recommendations towards an HA strategy for cooperative systems.

The recommendations for further work to support CVHS service development are presented in Section 5.

The annexes provide supporting material on the following aspects:

- Annex A Project management summary - activities, conferences and events, reports
- Annex B Communications
- Annex C VINCI Autoroutes app and its implications for the HA
- Annex D Open data and data markets
- Annex E Summary of investigations into HA data
- Annex F The Cooperative Services ‘Ecosystem’
3 Key findings

3.1 Technologies and communication channels

Technologies

As mentioned in Section 2.3, developments in personal communications, such as the smartphone, have had a profound effect on our thinking about the deployment of cooperative services. The use of technology more generally within transport provides opportunities for increased safety and efficiency. Technology is also developing more widely in consumer, energy, health and space sectors that could impact on transport and the development of cooperative services.

Probably the most relevant technology developments for cooperative services come from the ICT (Information and Communication Technologies) sector. Computing power and software continue to develop as does the technology of personal devices such as smartphones which now have large, bright colour screens as well as sophisticated interaction capabilities. Developments in communication are being matched with new business models such as “white SIMs” that allow more flexible migration between communication providers.

Other technological developments are also expected to influence cooperative systems, with implications for the nature of the services, and benefits to road operators:

- Cloud computing, which enables large amounts of data to be handled and also makes services more ‘portable’ as software is in the cloud rather than individual devices; vehicle manufacturers are currently developing such systems.
- Applications of floating vehicle data are expanding rapidly, and may open up opportunities for new services based on large scale real-time data.
- The emergence of decentralised floating vehicle data would have implications for the role of road operators in processing data for cooperative systems.
- Vehicle manufacturers have recently started to introduce mechanisms for connecting phones into high-end vehicles, and are now working on integrating the interface and controls with those in the vehicle and potentially resolving the question of who pays for the communication costs for data transfer, although legal issues in different countries and business issues between phone companies and vehicle manufacturers remain. Technological solutions are also being developed to overcome the difference between lifecycles of vehicles and technologies.

These developments are expected to decrease costs and reduce barriers to deployment of cooperative services, thus enhancing deployment prospects.

A number of broader implications of technology development can also be suggested:

**Technology democratises** - an effect of the availability and accessibility of personal communications and peer to peer networking such as social media has transferred power from institutions to individuals and groups. Governments and Agencies are scrutinised and are more accountable than ever for their actions and may need to respond more quickly to public pressure. One example is the drive to make data more open and this will have implications for data-driven cooperative services.
Technology creates expectations – the availability and accessibility of data and services, such as Government Online has created expectations (occasionally unrealistic ones) for how all information should be instantly available. This has implications for the HA’s data and operations.

Technology lowers barriers – with the availability of data and computing power it is not necessary to be a large sophisticated organisation to enter the market with a new cooperative service delivered to a mobile phone. This has unleashed innovation and there is a growing number of stakeholders that the HA may need to interact with. Essentially the HA has become one stakeholder (albeit a large and unique one) in the transport data market.

Technology creates legacy systems – New technology and services tend to run in parallel with existing services. Sometimes a new technology will eventually replace an old (e.g. digital TV) and sometimes there are echoes of a previous generation within the new (e.g. rail gauge, QWERTY keyboard). However, parallel running is the normal situation for many applications. The implication for the HA is that, even with cooperative systems and services, there is likely to be a requirement to maintain much of the “old” technology, such as loops and VMS, for a considerable period.

Technology impacts on safety

Before considering communications for cooperative systems, it is important to review the issue of safety. A number of risk and safety issues are raised by cooperative systems. For cooperative services providing information, there is a risk of the driver sharing their attention between the information (typically presented on a smartphone or in-vehicle screen) and other driving tasks such that the risk of a collision or other adverse consequences is increased. Providers of such services recognise this risk and often provide warnings to drivers or advertise the service as being “for the co-pilot”. Of course, such inattention/distraction risks are raised by any presentation of in-vehicle information, not only that arising from cooperative systems and a – largely unresolved – question is how to balance the potential benefit of information with the potential for distraction and accidents. To some extent, the potential negative consequences are being mitigated through technology developments such as larger and better screens and voice recognition, or by communication standards that allow a mobile phone to interact with and make use of dashboard information consoles.

A second issue is the likely degree of trust, and possibly over-reliance, that drivers may ascribe to information, particularly if it is provided through an apparently official source. There are already examples of cases where accidents have been ascribed to over-reliance on satellite navigation systems.

For cooperative services providing more time-critical warnings or assistance services, the safety issues are rather different. Here a driver may not fully understand a warning and may take inappropriate action or a driver may not appreciate or may misunderstand the capabilities of an assistance system, again leading to inappropriate and potentially unsafe driving behaviour.

Since time-critical warning and assistance is likely to be provided through V2V cooperative services and involve vehicle manufacturers, such issues are probably outside of the scope of the HA’s involvement in cooperative systems. Probably of greatest concern and relevance is the distraction potential of visually presented information on in-vehicle displays including smartphones. Ways of managing the safety of these new in-vehicle systems will need to be found; the HA is not expected
to have a role in this. HMI issues are likely to be addressed in the next phase of work under the European Commission’s ITS Action Plan, from 2013 onwards.

**Communications**

Cooperative Systems involve data communications, either between vehicles (V2V), or between vehicles and infrastructure (V2I).

For services involving V2V communications it is widely accepted that Short Range networks can easily be justified by the kind of safety related applications they support (typically, cooperative collisions avoidance applications) which require fully available, very rapid, low latency communications and do not require data from central servers. Such applications involve direct control of vehicle systems which cannot be organised without the vehicle manufacturers.

The US DoT is concentrating effort on V2V services in their connected vehicles programme to address safety. However, V2V has a ‘penetration’ problem - safety systems using V2V become effective only when a significant number of vehicles are equipped. Although industry-wide agreement or legally mandated fitment (which is being considered for new vehicles in the US) could overcome this problem, it seems unlikely to be solved quickly. Militating against V2V roll-out, also, is the increasing capability of autonomous systems rendering the incremental safety improvement offered by V2V services difficult to justify.

However, if and when V2V services are realised, road operators can reap the benefits without incurring costs (e.g. collision avoidance, hazard notification and cooperative traffic management such as merge assistant and shockwave protection).

Concerning V2I cooperative services, it was anticipated, up to about three years ago, that such services would also be served via Short Range networks, with communication points provided through roadside beacons. However, the smartphone has now emerged as a strong contender for the ‘platform’ on which V2I services are delivered and a key advantage of smartphone delivery of services is the reduced cost of on-board hardware since the smartphone is already purchased by the driver and offers quicker penetration into the vehicle fleet than vehicle-based systems. Also, since smartphones communicate through cellular radio, messages do not require roadside beacons but use the GSM transmitter network with communication costs paid by the users.

Road operators may have an interest in a number of V2I services such as probe vehicle data collection, receiving information from users on road conditions and incidents, real time routing advice and in-vehicle signage. Annex B considers a range of relevant V2I services and their communication requirements and demonstrates that the wide coverage provided by Cellular Networks will in most cases provide the communications capability required to support the V2I services of interest to road operators. The opportunities for V2I cooperative services delivered by smartphone have stimulated a new industry and new business models. Also, as new generations of cellular networks are rolled out, their capabilities will improve, further enhancing their ability to support cooperative services (although they may continue to be unsuitable for safety-critical services, as Cellular Networks do not guarantee delivery or latency of information).

Using Cellular Networks to provide the communications requirements of cooperative services means that consideration must be given to who will pay the cost of data transmission. In many cases, particularly where the applications run on
smartphones, it is reasonable to assume that this will be borne by the users as the
data requirements of most cooperative applications are small compared with other
services provided to connected users. Indeed, the data costs may be invisible to
them as they may be included in the data allowance included in their cellular
contracts. However, roaming data charges may be significant are not normally
included in a monthly data allowance, and the unit cost of such data can be
extremely high. Although the European Commission are bearing down on roaming
charges, and new organisations and business models are being discussed, it is also
possible that the data cost issue could significantly limit the viability of cellular
cooperative applications in a multi-national context.

3.2 The role of road operators in collecting data and delivering services

A road operator’s role is to operate a safe and efficient road network, minimising
environmental impacts and informing users about conditions which may affect their
journeys. A road operator has responsibilities towards employees and contractors
as well as to road users and society in general. These roles and responsibilities
define the road operator’s contribution to delivering services.

As mentioned in Section 3.1, road operators can reap the benefits of safety services
based on V2V communications without incurring costs and thus without a direct role
in delivering them (e.g. collision avoidance, hazard notification and cooperative traffic
management such as merge assistant and shockwave protection).

Road operators may have a role in delivering a limited number of services based on
Vehicle-to-Infrastructure (V2I) communications. On the basis of an analysis of
benefits to stakeholder groups, the bundles of services which have been identified as
having potential for road operators are:

- Hazard notification (e.g. slippery road, adverse weather, end of queue)
- Notification of operators in the road
- Real time routing advice (e.g. congestion reduction through route
  optimisation, fuel efficient route choice)
- Cooperative traffic management (e.g. merging, shockwave prevention,
  speeding up as congestion clears)
- Platooning
- In-vehicle signage
- Booking and payment services (e.g. access control, parking, charging)
- Traveller Assistance (e.g. eCall, after-theft recovery).

In the case of traveller assistance services, the road operator’s role is not essential
and they can be provided privately, so that benefits to the road operator can be
realised without incurring costs. Some of the other services are of lesser importance
to road operators. Those which are of highest priority for road operators in delivering
services to users and managing the network are likely to be hazard notification, real
time routing, cooperative traffic management and in-vehicle signage. Notification of
operators in the road is important for minimising casualties among operational staff
but has less impact on users, while the importance of booking and payment services
will vary between road operators, depending on their roles.

The main role for road operators in delivering services based on communications
between vehicle and infrastructure appears to be in collecting data and making it
available. Road operators also obtain data and process it to derive information. In several of these services, the road operator collects real-time data from vehicles acting as traffic sensors; in the case of eCall, the road operator receives information in the event of an accident, whereas data gathered in the other services can be continuous.

Depending on a number of factors, the road operator may collect data for its own use, or collect data for a wider market, either for direct reward or to promote further services based on its data. Road operators can also obtain data and information from the market. Road operators are no longer the only organisations involved in gathering data or providing information services; other service providers are now emerging - they provide real time traffic information services on the basis of data they have gathered from vehicles (from sensors and human input), along with data from other sources (such as historic traffic information provided by road operators and information on planned events).

Once the data gathered has been processed with data from other monitoring sources, the road operator disseminates it to users or to third party service providers. One delivery mechanism for both continuous dissemination (e.g. in-vehicle signage) or on an ad hoc basis as required (e.g. real time routing advice) is cooperative systems; however Variable Message Signs (VMS), radio, internet services and information points in public places are also important methods of information delivery and are likely to remain so in the immediate future (at least the next five years) while the proportion of vehicles receiving information via cooperative systems is relatively low.

The various different ways in which the HA may participate in delivering services based on cooperative systems are summarised in a diagram of the cooperative services ‘ecosystem’ in Annex F.

Clearly the value of the HA’s data to support services (whether provided by the HA or third parties) depends on its quality and security. The HA currently measures and checks data quality using five different, but complementary techniques. Results of a preliminary investigation of data quality are summarised in Annex E. The project has mapped out the current quality of existing HA data sources and shown that cooperative systems have the potential to provide better quality data sources.

**Scope for cost savings by road operators**

The nature of the benefits and scale of costs to road operators arising from cooperative systems vary depending on the services, and are not yet fully quantified. An initial assessment of future scenarios for making increased use of ‘Floating Vehicle Data’, based on different business models, indicates that in the immediate future when the proportion of vehicles providing such data is expected to be low, there appears to be just one area where the HA could potentially make savings on infrastructure-based traffic sensors. Assuming that no new uses are found for ANPR journey time information cameras, floating vehicle data collected from smartphones could enable these cameras to be phased out in the relatively near future. A recommendation for further investigation of this issue is made in Section 5.2.

Analysis of benefits and costs has only a limited potential in establishing the business case for cooperative services. A range of other factors could make deployment and operation of cooperative systems problematic for road authorities. These are discussed in the following section (3.3).
Business models

The HA currently makes available a range of data freely available as ‘open data’ through the direct.gov.uk web portal. The HA also provides data directly to a number of organisations, indicating that there is a demand for such data. Road operators can also benefit from buying data from other sources (e.g. to enhance information services or dispense with expensive infrastructure sensors); the HA already buys some data, and is investigating other sources.

New business models are needed for delivering services based on cooperative systems. It is likely that the HA’s approach to gathering and disseminating traffic data will need to change as the availability of data and the role of the HA evolve.

For road operators a ‘market’ business model appears to be promising: the benefits are its flexibility and its potential to facilitate and encourage new services to develop. The market model is compatible with the trend towards open data in UK government and discussions within the EasyWay project have shown that it is gaining support among other road operators, provided that levels of quality are defined and formats standardised. Disadvantages arise from the risks to security and resilience of data supply, and the need to set up a marketplace and brokerage function. However, developments in Europe indicate that this may be feasible over a short to medium timescale, with pump-priming funding to encourage a market to develop. A market model appears to be an option for further consideration for the HA. Necessary conditions for the success of the market model are that: the public sector must accept this approach and the implications which follow from the market determining the services which are offered; consensus is reached among key stakeholder groups, for example on how quality is defined and validated; and a critical mass of providers and users is established.

Drivers are reported to say that traffic information is the most important app-based service. As mentioned in Section 2.3, commercial services are now emerging, based on smartphones. During 2012 a basic traffic information app was launched “in association with the HA” by a subsidiary of INRIX, as part of the National Traffic Information Service. It is understood that there is a route for obtaining floating vehicle data collected by this app, but the HA does not currently receive this; it is recommended that the HA should seek to obtain this data, or to ensure that it is made available to the market.

As part of the investigation of the role of road authorities and potential business models, the concept of value webs was explored. A value web is similar to a value chain, but depicts a non-sequential, non-linear set of relationships. It shows the flows of services, money and non-monetised value between the main stakeholders involved in a service (whether as providers or users). Value webs were constructed on the basis of information about a number of near-market and new-to-market app-based services and our understanding of the market; the example of the value web representing the VINCI Autoroutes business model is depicted in Figure 1, showing the road operator’s role in providing users with traffic information and receiving data from users.¹

¹ VINCI currently uses alerts received from users but does not yet use the floating vehicle data.
3.3 Key external factors influencing investment decisions

Although social cost benefit analysis provides one measure of the overall “worth” of a project or investment, there are clearly a wide range of additional factors which influence whether an investment is actually made. A number of these relate directly to the cost-benefit calculation itself, for example: how certain are the figures used? What does sensitivity analysis reveal? Is the discount rate actually appropriate for this kind of investment? What benefit/cost ratio warrants investment?

Other important factors can be regarded as external or ancillary to a cost benefit calculation but may be very important or dominant in investment decisions. These have been termed “hygiene” factors (in management literature); they are factors which need to be satisfied before any serious consideration is given to financial aspects of investment decisions. In effect, hygiene factors represent gateway features of an investment decision. The key hygiene factors identified as relevant in a road manager’s investment decision are outlined below:

Compatibility of the cooperative system application with policy objectives of the road authority

This is a broad and important issue. A road authority would not want to be associated with a new service that demonstrably reduced safety but there are other examples of where policy issues outweigh purely financial ones and there are, perhaps best illustrated by example. There is an initiative to drive down road-worker fatalities to zero and so any investment in a cooperative service that is likely to substantially support this aim might be favoured even if it fails on strict benefit/cost criteria. Analysis of ecodriving services has indicated that road operators do not appear to have a role in service delivery, but may benefit from promoting them due to their contribution to environmental objectives of both the road operator and the road authority. As another example, a cooperative service providing a positive...
overall benefit might be rejected if it is socially divisive and favours one particular group of road users.

**Impacts on equipped and non-equipped users**

In general, the impacts of a new cooperative service may affect different groups of road users in different ways. A service might assist equipped drivers or might warn them about incidents or obstacles that will benefit both themselves and other road users (for example by reducing congestion at an incident, thus improving journey times both for those who are able to avoid it and those who have not been informed and are delayed). However, if a cooperative service is expected to substantially and systematically favour one group of road users to the disadvantage of another (for example by providing inappropriate re-routing advice), this might be rejected as an investment on the grounds of equity.

**Requirement for investment and availability of funding**

Clearly, investments need to be funded and if funding is not available or cannot be obtained, even for good investments, then investment cannot be made. This might occur if, for example, there was an organisational policy concerning debt or if financial institutions were prevented from lending.

**Technical and financial risk**

Cooperative services are part of a relatively immature market in which technology is also rapidly evolving. Therefore there is technical risk of failure, limited functionality and obsolescence. As technology develops (e.g. electric vehicles, Galileo satellite positioning, and personal communication services) the needs and requirements for cooperative services will also change and also new commercial markets will evolve. For example electric vehicles could offer a suitable platform for services based on cooperative systems as increasing numbers are equipped with communications for charging purposes, while the charging infrastructure itself could be used to support cooperative systems by gathering and distributing data from vehicles. While Galileo is not expected to make a fundamental change in the cooperative systems which are possible, it is expected to extend the range of cooperative systems available and to improve the reliability of current applications; for example improvements in positioning accuracy will make it possible to locate a vehicle in a lane of carriageway, and improvements in integrity will enable payment services which rely on evidence that can be used in court.

**Reputational risk**

Involvement with cooperative services, even providing data for third party service providers, carries a risk to the reputation of a road authority if the service or data falls short of customer expectations. Involvement in a service that is ultimately unsuccessful may impact reputation; on the other hand, complete inactivity in new dynamic areas may also be viewed negatively. So, before investment, a road authority may wish to evaluate the “downside” and worst-case effects of an investment. A potential method for carrying out such an evaluation has been identified, using an “ecosystem approach” to analyse the interests and drivers, concerns and barriers of the various stakeholder groups involved in a service.
Legal issues including liability, privacy and data protection

These issues will need to be considered as part of the business case for any investment and legal advice may need to be obtained, particularly for services in new areas. For example, licensing arrangements may need to be developed to ensure that any road operator’s data which is used by third parties does not compromise the service received by users or the reputation of the road operator.

Institutional issues and required organisational changes

Cooperative services can be viewed as a new mechanism for both obtaining and disseminating transport-relevant data. They may supplement or even replace existing sources or mechanisms and are likely to require new arrangements either internally within a road authority or in its relationship with external stakeholders. There might, for example, be new requirements for data security, privacy, delivery or quality which require organisational changes. Depending on the nature and extent of such changes, and the consequential changes in responsibilities and power of individuals or groups, the changes might be resisted or deemed disproportionate to potential benefits.

Acceptability of business arrangements to NRA Stakeholders

Similar to the points above is the requirement that any business arrangements entered into by a road authority, e.g. to buy or sell data, would need to be acceptable to stakeholders such as the public and the DfT. As an example, currently the Highways Agency would not be permitted to launch a cooperative service app as it is seen as duplicating a service that could be provided by the private sector.

Note that future organisational and funding arrangements for the HA could change the policy and position on a number of these hygiene factors.

3.4 Future context and deployment prospects

Some road operators, such as those in The Netherlands, Austria, the USA and Japan, are trying to push forward with cooperative systems, for example by deploying infrastructure at ‘hotspots’, using wireless beacons. While these programmes have been developing, cellular communications (3G) have emerged as a more viable alternative, while in some countries 4G is well under way; in the UK roll-out of 4G started in 2012.

The emergence of smartphone apps has triggered a plethora of apps providing real time information to road users. This has completely changed the business case for cooperative systems, which can be deployed rapidly and more cheaply - based on hardware and communications which are already available, having been purchased by travellers for other purposes. A number of services have been identified, some of which involve road operators directly, while other third party services use data provided by road operators to improve the quality of service. Currently the proportion of vehicles involved in cooperative services in the UK is small, but is likely to increase rapidly over the next five years as ownership of smartphones and services based on them continue to grow and to become more integral to all aspects of daily life for many people. In some countries, app providers report that the penetration level is already sufficient for vehicle-generated data, (floating vehicle
data combined with incident reports from users), to support high quality app-based services.

With the emergence of new services based on third parties using data, a number of third party roles which are new in this arena have been identified, including brokers, enablers, intermediaries (enhancing data) and integrators (combining data sources), as well as service providers. These new roles may add further complexity to business models for cooperative systems.

In the US there is a strong focus on V2V to improve road safety and large scale trials of safety-related systems are currently in progress based on this technology; because these systems become effective only when a significant proportion of vehicles are equipped, a decision is expected in 2013 on whether or not to adopt legislation to require vehicle manufacturers to fit new cars with equipment to support such services.

In Japan, a decision was made about 15 years ago to use DSRC for V2I communications and over 40% of vehicles are now equipped; non-stop tolling provided a stimulus for users to buy on-board units and V2I information services have developed. One of the vehicle manufacturers, with about 45% of the Japanese market, is planning to introduce services based on V2V communications from 2015. With this early adoption of DSRC, the potential of cellular communications for delivering transport-related services in vehicles does not yet appear to have been exploited.

In Europe, the approach has been more balanced between apps for information services based on cellular network communications, and research and field trials on the capabilities of V2I and V2V communications for information and safety-related services (see the earlier discussion in Section 3.1 on safety services). At the same time, the EC is legislating for the introduction of eCall as the first cooperative service. This is likely to help to speed up the deployment of additional services based on cooperative systems, particularly on higher mileage vehicles (which tend to be newer); it is anticipated that some vehicle manufacturers will attempt to gain market advantage by providing additional services on separate modules building on the eCall equipment. For similar reasons, any aftermarket eCall devices are also likely to include additional services which will have more appeal to customers than eCall itself.

Any benefits of deployment of additional services in conjunction with eCall are expected to also be realised in the UK, and, as eCall provides an incident detection function, road operators may be able to put systems in place to take advantage of an earlier notification of incidents on their network than would otherwise be the case.

Other developments are also expected to influence the nature, capabilities and uses of cooperative systems, with impacts on road operators. Examples of developments already under way which could influence cooperative systems over the next five years include:

- Social networks and crowd sourcing bring new sources of data, for example smartphone traffic information and journey planning services based on crowd sourced data are becoming available, introducing new ways of influencing modal choice.
• New models of car ownership are emerging, based on car clubs and shared ownership models, which will affect some users’ expectations for portability of services between vehicles.

• Collaboration between organisations in order to deliver services is increasing, and is an essential part of cooperative systems which may result in new business models and new working arrangements between road operators and other stakeholders.

Further into the future, perhaps five to fifteen years ahead, are other developments which could affect road operators, such as:

• Platooning and semi-autonomous systems are now in preliminary trials and are seen as one of the next new developments.

• Increasing integration of car and other modes is expected to influence mode choice for individual journeys, with more ad hoc mode switching in response to conditions, offering alternative ways of responding to incidents and congestion.

• In the UK, the main political parties are concerned about declining revenue from fossil fuels and the rising cost of infrastructure. Road pricing may emerge as an alternative way of raising revenue, which could be delivered through cooperative systems.

As the proportion of vehicles involved in cooperative systems grows, the widely-stated but not yet quantified potential to reduce spending on capital infrastructure and maintenance could become a reality, meeting the current quest of many road operators to deliver ‘more for less’. Some specific cost elements have been identified in this project for further investigation; these are discussed further in Section 5.2.

Currently the HA is a ‘follower’ of developments in cooperative systems based on roadside infrastructure rather than a ‘pioneer’; at this stage this appears to be the most appropriate approach, due to the many uncertainties involved and the emergence of alternative ways of delivering services based on cellular networks. However the HA could be more of a pioneer in making data available under the open data initiative, and in supporting a data market. The UK is further ahead in providing ‘open’ data than many countries in Europe; the HA already publishes data, which is known to be used by at least 150 organisations.

The role of the HA itself may change following the outcome of the current review of the HA’s remit and organisational position, with implications for the part it will be able to play in delivering services.

Although some of the traditional roles of road operators are being taken up by third party service suppliers, it seems certain that for the time being at least, there is a role for the HA as a traffic data supplier, a data processing service provider and a consumer of data to enhance information services or to dispense with expensive infrastructure sensors. With these roles in mind, there are some opportunities for becoming more actively involved in shaping developments in the short term, which will help to position the HA for the longer term. These include: involvement in field operational tests as part of future European projects; providing ‘seed funding’ for small scale innovation trials; and developing the existing HA app for iPhones by

2 The Cook Report and subsequent review
enhancing the service to include providing floating vehicle data and making the service available on further platforms. These, and longer term opportunities, are discussed further in the following section on recommendations for an HA strategy for cooperative systems.
4 Conclusions

The technologies involved in cooperative systems allow a reasonably clear distinction to be drawn between vehicle/vehicle (V2V) and vehicle/infrastructure (V2I) services and the communications channels they use:

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<tr>
<th></th>
<th>V2V</th>
<th>V2I</th>
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<tr>
<td><strong>Vehicle domain</strong></td>
<td>Requires beacons</td>
<td>Requires beacons</td>
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<tr>
<td><strong>Not viable</strong></td>
<td>V2V time critical services</td>
<td>V2I cellular communication</td>
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<td></td>
<td>(such as cooperative vehicle</td>
<td>channels)</td>
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<td></td>
<td>control or collision avoidance)</td>
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<td></td>
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<td>✓: Many V2I services of interest</td>
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<td>to the HA can readily be</td>
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<td>delivered using smartphones</td>
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<td>and existing cellular</td>
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<td>communications infrastructure</td>
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Vehicle domain: V2V services are often time and safety critical and so need Dedicated Short Range Communications. The HA and travelling public derive benefit from these services through safety enhancements but the HA does not need to participate in their development.

Requires beacons: V2I services delivered using short range radio communication require roadside beacons to be installed.

Not viable: V2V time critical services (such as cooperative vehicle control or collision avoidance) cannot reliably be delivered over cellular communication channels - this is further discussed in the main text.

✓: Many V2I services of interest to the HA can readily be delivered using smartphones and existing cellular communications infrastructure.

Technology performance considerations lead to the conclusion that the least expensive and most rapid deployment of cooperative services likely to support HA’s objectives will use cellular communication with smartphones. This route does not require any new investment by the HA in in-vehicle or communications infrastructure.

There is much interest in cooperative systems and services in Europe, Japan and the US. Therefore it can be anticipated that the rapid development of technology will continue and that the benefits of using cellular communication and smartphone technology will increase. European field operational tests are likely to provide a useful source of information on deployment prospects.

Vehicle to infrastructure cooperative services potentially provide the HA with new sources of data which can help to monitor and to manage the road network. Infrastructure to vehicle cooperative services potentially provide an additional channel for the HA to inform travellers and manage the road network. Thus, cooperative services provide new data streams and additional communication channels, offering opportunities for enhancement and economies of service delivery.
The emergence of cooperative systems and services, coupled with external policy actions around ‘Open Data’, are fundamentally changing the role of the HA in one respect: instead of being a closed data provider - i.e., operating focussed internal data collection, processing data into traffic information and communicating this to travellers on the HA network - the HA is becoming one stakeholder (albeit a large and unique one) in a wider data environment. This wider environment includes other compilers of data, much of it collected through cooperative systems, and other information disseminators.

This new data environment is still in its infancy but has potential to become an efficient and thriving marketplace. There is no single “blueprint” for how such a market might ultimately operate but there are examples, in Germany and the Netherlands for example, that build on existing standards.

This wider data environment presents a number of opportunities and threats:

- The HA may act as a purchaser of data that enhances or replaces in-house data collection
- The HA may act as a data processor and a provider of data streams to third parties
- HA data appears to be of value to third parties; there are over 150 users of existing data feeds. Future organisational arrangements may even allow the HA to charge for some data.
- There is uncertainty around the quality, robustness, and security of supply of data provided by third parties and the overall viability of the data market.
- The HA may act as a provider of apps for travellers.

The widespread use of apps on smartphones is fundamental to the viability of V2I cooperative services. There are many app developers and several hardware platforms; however, the market for apps is highly dynamic and many are transient. In part that is because the sources of data and business models are not yet secure or mature. The HA operate one app but there are costs involved in maintenance and continued provision. The current Government view is that private sector provision of such applications and services is preferred. The most important feature of an HA app (rather than one operated by a third party) is that the HA maintains full control over the service, thus ensuring that it is integrated and consistent with other services. In addition, the app has an existing user base which could be extended by enhancing the service in this way. Such an app could provide services covering the HA’s core functions, thus leaving opportunities for third party providers to offer additional services beyond this core.

One concern with apps is their potential to distract drivers although this can be mitigated to a large extent by good design. From an HA perspective, the most successful apps will probably have high quality data sources and, ideally, be well integrated into back-office traffic management systems.

Calculating the social costs and benefits of potential new services provides only one view of their viability. For sustainable deployment of a cooperative service there has to be a business model in which all the necessary stakeholders can derive sufficient benefit. The operation of an efficient data market could be a key enabler for many cooperative services.
Overall, it can be concluded that cooperative systems, particularly V2I services using cellular communications and smartphones, have the potential to support many HA objectives. Nevertheless, the new business models, yet to fully emerge, will probably require some fundamental changes in the way the HA interacts with other stakeholders.
5 Recommendations

5.1 Framework for HA activity in the immediate future

Technologies
From the analysis of technologies and communications it is clear that the HA should focus on services between vehicles and infrastructure based on cellular communications. The wide coverage of cellular communications will, in most cases, provide the capability to support most of the services which are of interest to road operators. Thus there should be no requirement for the HA to invest in beacons to support short range communications with vehicles in the foreseeable future.

In the longer term, the reduction in unit cost of DSRC units fitted to vehicles for V2V applications may make roadside installation viable. However, with vehicles becoming more autonomous by sensing each other, the need for vehicles to communicate with other vehicles may diminish and render the technology redundant. Therefore, the situation regarding communications technology will need to be continually monitored.

Vehicle manufacturers are continuing to develop services based on communications between vehicles. Because these services will be used on the HA network it is important for the HA to monitor these services as they develop and evolve; they have the potential to provide benefits, for example in safety, network efficiency, and reduced environmental impacts without direct costs to the HA, but may also have other impacts which the HA would need to be aware of.

Data
The HA has a key role in providing, receiving and using data within cooperative systems. To support this, the HA should maintain an awareness of the new opportunities arising from data from cooperative systems and find ways of using these to benefit HA operations. It will also be important to continue monitoring new applications as they emerge and are deployed.

The HA capabilities for generating data and the market for this data should also be evaluated systematically, including the role of the HA as a supplier and consumer of data.

There is a need for a detailed quantified assessment of the cost savings, enhancements in data quality and additional benefits which the HA could gain as a result of cooperative systems. An important part of this assessment would be to identify the minimum proportion of vehicles involved in cooperative systems for benefits to begin to be achieved, and the proportion that would be sufficient to enable some elements of existing infrastructure to be phased out, taking account of all available estimates of deployment timescales.

Involvement
Bearing in mind that a data market involves cooperation between the various organisations gathering, processing and using data, it is recommended that the HA should work with such organisations to identify the activities required from different stakeholder groups to stimulate the development of a data market in the UK. The HA itself, as a key player in this area, should be actively involved in stimulating the data market.
Existing initiatives towards data markets in Europe should continue to be monitored with a view to learning from them, for the benefit of a UK market.

The HA has been working with EasyWay and the Amsterdam group on cooperative systems, and this should continue; in the context of EasyWay the most appropriate role for the HA appears to be as a follower rather than a pioneer.

Services
The HA already has a traffic information app but there appear to be differing views on the role which the HA should have in providing such services. A consistent policy is needed; this will depend, in part, on the outcome of the current review of the future role of the HA.

Further European Field Operational Tests of cooperative systems are expected; these are likely to provide the HA with opportunities to become involved in testing new services, to identify their impacts and implications prior to full scale deployment.

5.2 Specific tasks for the immediate future
Within the overall framework set out above, a series of tasks are recommended for the HA, to support its developing role in cooperative systems.

1. Engagement in cooperative systems
The HA should engage in the activities of a number of key groups and activities in the UK and Europe, monitor the outcome and on-going work of key projects, demonstrations and deployed services, monitor European and international activities and assess continuing developments in factors influencing cooperative systems and deployment prospects.

2. HA services and apps
The HA should develop a consistent policy concerning in-house provision of traffic information apps. If the current HA traffic information app is to be retained this should involve making it available on new platforms and ensuring that it is available to be enhanced in future if the HA continues to have a role in providing services.

It is recommended that the HA arrange to receive the data which has been offered from the new Information Logistics service app, and investigate the enhancements in data quality and level and coverage of information services which would become possible if this data could be made available in the long term.

3. External uses of HA data
It is recommended that users of the HA DATEX II feed are investigated to provide insights into aspects of HA data relevant to a data market and future services based on cooperative systems. The HA has recently asked subscribers whether they would be prepared to take part in an investigation of this nature; contact details of those who volunteer will be available in January 2013 and may provide the basis for this investigation. This task could be the starting point for work to develop a data market.

Specific issues to be investigated should include: current and planned uses of data by third parties; ideas on potential additional information or useful developments in
data quality; implications of ceasing to provide specific data; standards and data quality; and subscriptions for different service levels.

4. Market potential of HA data
Specific investigation is recommended to: identify what would be necessary to develop a traffic data market in the UK, and what the HA role could be in such a market; identify views of third party service suppliers as to whether commercial applications could benefit from HA data and how the HA could raise awareness of its data and stimulate further services. Initially, a workshop on the ‘ecosystem’ for providing services based on cooperative systems is suggested for this investigation. This could then be followed by an innovation competition to stimulate developments in specific aspects of data for cooperative systems (below).

5. Data innovation event
It is recommended that the HA arrange an innovation event for app developers and other innovators (possibly over one or two days) at which open data is made available for use in new ways. Recent examples (Manchester City Council and a rail event) have demonstrated the value of open data and shown that they can be used to generate and develop new services. Issues with ownership and intellectual property would need to be dealt with in the rules for participation. Such an event could lead into an innovation competition, (below) using a defined selection process to agree on ideas to be developed further in the competition.

6. Innovation competition
It is recommended that the HA sponsor a ‘seed funding’ programme of trials of innovative services by third parties using HA data. This approach is being used by TfL, and could be used to stimulate developments and investigate possible interest in developing new services such as a new smartphone app. The HA would need to set aside a fund for such proposals, and then invite proposals in specific areas within a set budget (such as £25K). Such approaches have the potential to stimulate dialogue across organisations, engage with industry and could attract SMEs.

7. Quantification of cost reductions and quality improvement potential of Floating Vehicle Data
As is often stated in general terms, cooperative systems offer the potential to reduce spending on capital infrastructure and maintenance. Knowledge gained during this project now allows a focus on more specific potential cost elements, and the following activities are recommended:

- Independent assessment of the costs and benefits of floating vehicle data from the HA’s perspective. This should include a review of European developments to establish the scale of floating vehicle data and assess potential of European approaches to measuring quality of floating vehicle data, evaluation of the current floating vehicle data received by NTIS to assess its quality and coverage, and identifying potential for improvements in quality (e.g. using floating vehicle data to estimate flows where loops are temporarily unavailable), and the level of penetration and data quality needed
to support appropriate apps; an approach to assessing cost savings and
quality improvements is suggested in Annex E.7

- Modelling of journey time and flow information derived from a combination of
probe vehicle and infrastructure sensors to identify how much probe vehicle
data is needed, the penetration rates of equipped vehicles necessary to
support different degrees of data quality of data and the extent to which loops
could be dispensed with

- Investigation of the use of probe vehicle data and the implications of obtaining
real time traffic information from a range of third party service providers to
complement existing sources

- Detailed investigation of the short term potential and development of the
business case for replacement of ANPR-based journey time information
service with probe vehicle data (assuming no new uses are found for the
equipment supporting this service); the existing HA app could be developed to
achieve this, including additional suppliers

- Investigation of the short- to medium-term potential for improvement in real-
time information provision (e.g. timeliness of roadwork information) delivered
through smartphone apps and the impact of reducing provision of
infrastructure-supplied information to drivers through VMS.

5.3 Continuing actions to support longer term developments

Given the rapid pace of change in technologies and the ways in which they are being
used on the road network, the HA needs to be in a position where it can look further
ahead. Work to enable this could include developing a road map, e.g. based on the
concepts developed in the European ROADIDEA project. The road strategy will be
published early next year and the funding model will be published soon. If the HA is
to be more separate from government, some things could be done differently. Some
of this work could be done internally, but the evidence base is important; assembling
the evidence base could be done by independent external research.

For the longer term, the HA will need to build on these initial activities with the aim of
having an operational data market within the next 2-4 years, by continuing to monitor
developments in Europe, among the various stakeholders involved in providing
services and data, and in the emerging data markets.

As service providers deploy new services, the HA should investigate the
enhancements in services which become possible, and the benefits which they
provide for the HA; some examples of existing services have been identified where
the HA may wish to explore the options for formal arrangements for data sharing or
for a trial using their data. Following on from the Mirrorlink guidelines published
recently, an investigation of the potential HA role in the concept of decentralised
probe vehicle data processing would be important in helping the HA to determine its
position. For example, OEMs need access to information on road closures and road
works which presumably the HA would provide. The HA could use floating vehicle
data to validate whether other sensors are working, to improve service quality, and to
evaluate the effectiveness of measures on the trunk road network (without having to
install monitoring equipment).

The policy implications of reducing HA infrastructure controlled data collection and
information provision to drivers also need to be considered.
A more far-reaching area of investigation is the policy and liability implications of the HA withdrawing from direct quality control of information to drivers and leaving the private sector to inform each other and their customers about traffic information and incidents derived from new sources (including social media).
6 Glossary

2G  Second generation of cellular networks for mobile phone communications
3G  Third generation of cellular networks for mobile phone communications
4G  Fourth generation of cellular networks for mobile phone communications
Amsterdam Group  European group comprising representatives of four organisations for road authorities, toll road operators, urban road authorities, vehicle manufacturers and communications
Android  An operating system for touch screen mobile devices (including smartphones)
ANPR  Automatic Number Plate Recognition cameras (currently used by the HA to provide journey time information)
API  Applications Programming Interface – to enable software components to communicate with each other
App  Application software
CEDR  Conference of European Directors of Roads
CVHS  Cooperative Vehicle Highway System
CVIS  European Cooperative Vehicle Infrastructure Systems project
DaaS  Data as a Service
DATEX II  Standards for exchange of traffic information and traffic data in Europe
DfT  Department for Transport (UK)
DSRC  Dedicated Short Range Communications - an example of a Wireless Local Area Network (WLAN)
EasyWay  European Programme for deployment of Intelligent Transport Systems on the Trans-European Road Network
EC  European Commission
eCall  System for enabling automatic calls to made from vehicles to alert the emergency services in case of an accident
FVD  Floating Vehicle Data
Galileo  European contribution to the Global Navigation Satellite System
GPRS  General Packet Radio Service – digital cellular telephony system, designed for data communications
GPS  Global Positioning System
GSM  Global System for Mobile communications
HA  Highways Agency
Hackathon  Event in which computer programmers and others in the field of software development, such as graphic designers, interface designers and project managers, collaborate intensively on software projects.
ICT  Information and Communications Technologies
INRIX  A traffic information service provider
ISA  Intelligent Speed Adaptation – system to encourage (or enforce) drivers to adhere to the posted speed limit
MDM  Mobility Data Marketplace – in Germany
MIDAS  Highways Agency system - Motorway Incident Detection And Signalling
NDW  National Data Warehouse – in The Netherlands
NRA  National Road Authority
NTIS  National Traffic Information Service
ODI  Open Data Institute
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>ROADIDEA</td>
<td>Project on the innovation potential of the European ITS sector</td>
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<tr>
<td>SIM</td>
<td>Subscriber Identity Module</td>
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<td>SME</td>
<td>Small or Medium sized Enterprise</td>
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<td>TfL</td>
<td>Transport for London</td>
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<td>TIH</td>
<td>Traveller Information Highway</td>
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<td>TMU</td>
<td>Traffic Monitoring Unit – inductive loops in the road surface, used by the HA to detect traffic</td>
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<td>TomTom</td>
<td>Traffic information service provider</td>
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<td>UTMU</td>
<td>Urban Traffic Management and Control</td>
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<tr>
<td>V2I</td>
<td>Communications between vehicles and infrastructure</td>
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<tr>
<td>V2V</td>
<td>Communications between vehicles and other vehicles</td>
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<tr>
<td>Vinci Autoroutes</td>
<td>Motorway operator with four concessions in southern and western France</td>
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<td>VMS</td>
<td>Variable Message Sign</td>
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<td>WAVE</td>
<td>Wireless Access in Vehicular Environments (also known as 802.11p) short range communications</td>
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7 References

Annex A. Project Management Summary

A.1.1 Description of activities

Overview of the CVHS ‘landscape’

Initially, the project team carried out a review of the CVHS ‘landscape’ by talking to six key experts to sketch in some of the ‘features’. The discussions helped to identify the main groups, projects and initiatives. All of the experts consulted thought that CVHS have the potential to support the HA’s objectives, with the challenge being to identify suitable business models and business cases.

Near market applications and services were investigated. A scan of transport-related applications and services which are freely available in the marketplace identified a number of relevant smartphone apps. Six near market and new-to-market applications and services were identified as being of particular interest to the HA.

Relevant journals, newsletters and web sites were scanned on a regular basis to identify relevant conferences and events, monitor organisations and projects and discover applications and services which are near to market or already available. Standards developments were noted and EC calls for research proposals were analysed. Key webinars, conferences and other events were attended by members of the project team (some in the course of other work and some specifically for this project), and reports were produced on each one; a few were reported on ‘remotely’ using material published subsequently. The conference and event reports are listed in Annex A.1.2 below.

Two reports were produced, and subsequently updated. One summarised 36 past and 18 current R&D projects, trials and field operational tests; these were largely EC-funded projects but key projects in the US and Japan were also included. The other report covered 16 relevant organisations and working groups in Europe and internationally. Recommendations were made for the HA to be involved in three groups and to monitor a further nine.

Investigation of specific applications

One specific service was identified which appeared to have potential value to the road operator. This is a smartphone app provided by Vinci Autoroutes to drivers using the motorways in southern and western France.

This example was used as a starting point for an investigation of business models and the data needs and flows to support such services. A visit was made to VINCI to meet with key staff, experience the app in use on the road, and understand what was involved in setting up the service, the business case and implications. The VINCI service is discussed in more detail in Annex C below.

Business models and cost-benefit analysis

To support the HA’s contribution to CEDR’s work in the ‘Amsterdam Group’ on cooperative systems (Task 7: business models and cost-benefit analysis), an investigation of business models and cost-benefit analysis for cooperative systems was carried out. For CEDR there was a specific focus on the (common)
requirements of European National Road Authorities and what they need to know when making decisions.

As part of this work, a review of the communications technologies for transferring data between vehicles and between vehicles and infrastructure was carried out. The communications technologies influence service delivery, business models, and the role of different stakeholders in delivering services. This work is summarised in Section 3.1 of this report and reported in full in Annex B.

By means of a desk review of eight key projects and an internal TRL workshop, a list of potential benefits of Cooperative Intelligent Transport Systems (C-ITS) to National Road Authorities was developed. A paper on the limitations of conventional Cost Benefit Analysis was also prepared. A qualitative analysis of the potential benefits and costs of 10 main bundles of services was carried out for the main stakeholder groups, which highlighted which types of service enable the road operator to benefit without incurring costs (because third parties can provide the service), and which types of service need the road operator to be involved in service delivery.

The analysis of business models initially considered ‘open’ and ‘closed’ business models, which led to the conclusion that a ‘market’ business model for data should be considered. In this ‘closed’ business model the road authority would fund, deploy and manage services, while in the ‘open’ model the road authority would invest in infrastructure for communicating with vehicles and provide priority services, but leave the in-vehicle devices and telecommunications to the market. The ‘market’ model identified in this project would involve the road authority supplying information to a market and buying information through this market, but the market would determine which services were offered to users. A favourable environment is developing in Europe and some tentative developments towards a data market are now taking place; these are discussed further in Annex D.

Value chains were considered as a way of analysing business models, and the concept of the value web, a development of the value chain concept, was agreed on as a suitable approach to investigating business models. A value web depicts a sequential, non-linear set of relationships; it shows the flow of services, money and non-monetised value between the main stakeholders in a service (whether as providers or users). Value webs were developed for seven smartphone-based services, which helped to establish the role of road authorities in a range of different types of service. The example of the value web for the VINCI service is discussed in Annex C. An alternative approach - ‘ecosystem’ analysis – was also considered. This is designed to highlight for each stakeholder both the interests/drivers and the concerns/barriers associated with a service. The approach appears to be useful and should be considered in future work on business models.

Data

Having identified the role of road authorities in a market model for cooperative systems, an investigation of various aspects of data for cooperative systems was carried out. This covered the scope of HA data, its quality, costs and potential future scenarios based on floating vehicle data, current data markets and data warehousing initiatives, and the implications of ‘Open Data’. This work is summarised in Annex D and Annex E.
Understanding the external environment

There are a number of developments, external to cooperative systems, which are expected to strongly influence the environment of cooperative systems, their business models and viability. Investigations were also carried out into aspects such as the implications of developments in communications, the impact of Galileo on service provision, and the uptake of electric vehicles with their greater connectivity and need for cooperative services. The findings of the investigations on Galileo and electric vehicles have been summarised in short reports, while other findings have been incorporated in the relevant sections of this report.

Proposed activities in Stage 2

This project has provided a clearer understanding of where cooperative systems could offer potential benefits for the HA in the near future. The final task in this stage of the project has been to use this understanding to identify areas for further investigation in Stage 2, before embarking on a strategy aimed at realising those benefits. These recommendations for further work are presented in Section 5 of the main report.

A.1.2 Conferences and events reported

Reports on the following 15 conferences and events, all held in 2012, were written:

- ETSI Standards meeting: February
- UK SatNav Data Summit: March
- Self-Driving Cooperative Vehicles and CACC demonstration, March
- 9th Annual Road User Charging conference 2012, March
- eCall meeting at innovITS ADVANCE, April
- Content and Apps for Automotive Europe, April
- TfL Industry Day, April
- iMobility Plenary meeting, May
- iMobility Automation Working Group, June
- TomTom Webinar – The ‘FACTS’ about Traffic Data Services, August
- Connected vehicles – moving from research towards implementation, September
- eCall in the UK, October
- ITS World Congress, Vienna, October
- Telematics Munich, October

A.1.3 Reports

In addition to the conference and event reports, the following reports were prepared:

- Publication and IPR issues (February)
- Progress report to iMobility Steering Group (April)
- Support for HA contribution to CEDR Task 7 on cooperative systems (April)
- Report on European groups and activities (May)
- CEDR Task 7 on cooperative systems: business models (June)
- CEDR Task 7 on cooperative systems: cost benefit issues (June)
- Presentation on value webs (June)
- Standards developments (June)
- CVHS: knowns and unknowns (August)
• Summary of relevant projects (September)
• US Connected Vehicles Program (September)
• Project briefing note for iMobility Steering Group (September)
• Progress report to iMobility Steering Group (September)
• Summary of PIARC/FISITA Connected Vehicles Task Force report
• Road maps for cooperative systems (November)
• Implications of electric vehicles (November)
• Implications of Galileo (December)
• Data for cooperative systems (December).

TRL also presented a paper at the RTIC conference in September and at the ITS World Congress in October; this work was not funded by the project. A copy of the paper is included in Annex G.
Annex B. Communications

B.1 Communications channels

Cooperative Systems require a means of data communications, either between vehicles (V2V), or between vehicles and infrastructure (V2I). The actual communications protocols, frequencies and modulation methods can vary quite widely, but mostly fall into two categories:

- Long range, low speed cellular networks, normally called Wide Area Networks (WANs) or Cellular Networks (CNs). We will use the term Cellular Networks in this paper. These are mainly suitable for V2I communications.
- Short range, high speed non-cellular networks, normally called Wireless Local Area Networks (WLANs). Typical examples include DSRC, 802.11p WAVE, Wi-Fi etc. In this paper we will refer to Short Range communications. They can be used for both V2V and V2I communications.

Cellular Networks

Cellular networks are characterised by having a wide area coverage (typically national, but with small areas of limited or no coverage), relatively low data speeds of tens to hundreds of kilobits/second, latencies of hundreds of milliseconds or more and slow channel set up times. The services are provided by Mobile Network Operators (MNOs). Neither ad-hoc networks nor V2V services are supported.

Cellular Networks have evolved through several generations of capability. The first packet data networks called GPRS were deployed on the 2G GSM cellular networks supporting data speeds of tens of kilobits/second. GPRS has been upgraded to EDGE, supporting speeds of hundreds of kilobits/second. With the introduction of 3G networks, data speeds have increased to a few megabits/second, and the current state of the art called HSDPA providing tens of megabits/second.

Currently all generations of packet switched wireless Cellular Networks are in widespread use, with data terminals able to switch seamlessly between the various generations of connectivity. While this ability to switch between data channels maximises coverage, it means the capacity of channels can vary widely as a vehicle travels through the coverage area. No Cellular Network is able to guarantee data packet delivery due to the non-deterministic nature of wireless communications, particularly over a wide coverage area, hence these networks are not considered suitable for safety-critical applications.

Future generations of cellular networks are now being defined. 3G/HSDPA is expected to be replaced by 3GPP Long Term Evolution (normally called LTE). All aspects of performance will be improved. LTE will provide data rates which are similar to Short Range networks. Latency is also expected to improve but may not reach that demanded by many V2V services. There are also questions about geographic coverage which may not reach that of 2G.

The latest generation of cellular networks, called 4G, provide even higher speeds of hundreds of megabits/second. 4G is likely to provide greater bandwidth (data transfer rates) and reduced latency – although the latency is unlikely to reduce to that of dedicated Short Range links. Its geographic coverage will be an economic issue (currently only in large urban areas) and may not surpass 2G. So, overall 4G will be able to enhance cooperative services but may not unite the services provided
through V2V and V2I links. Other technologies are also becoming available, for example WiMAX. Originally designed as a competitor for LTE in 4G, this is becoming popular in point-to-point “last mile” applications. There is a mobile version designed specifically for cellular-like applications, but at this stage it is not widely used and looks likely to lose out to LTE.

**Short Range Networks (Wireless LANs)**

Short range Networks, more correctly called Wireless Local Area Networks (WLANs) are short range, high speed networks. Examples are Wi-Fi (802.11a, b, g and n), Dedicated Short Range Communications (DSRC) operating at various frequencies and using a number of different protocols, and Wireless Access in Vehicular Environments (WAVE, also called 802.11p). Nearly all WLANs use one of two frequency bands, namely 2.4GHz (an open band shared with many other users and technologies), 5.2GHz and 5.8 – 5.9GHz, part of which is dedicated to ITS use and this is where WAVE is located.

These networks are characterised by high data speeds of tens to hundreds of megabits/second, low latencies (WAVE), and in some cases rapid channel set up times. Ad-hoc networks are supported, and both V2I and V2V communications are possible.

Due to their short range, WLANs can only be expected to provide limited network coverage. However, where the coverage exists it is likely to be more predictable in quality and capacity than the Cellular Networks.

In the transport domain, it is necessary to differentiate between the use of WLANS designed for general use (802.11a/b/g/n) and those designed specifically for transport use (802.11p WAVE and DSRC). The former has many advantages in terms of ubiquity, low cast cost and widespread availability, but as it is designed for fixed usage, may be too compromised for use in transport, particularly in the higher speeds found on extra-urban road networks. DSRC/WAVE, being designed specifically for use in transport, will more easily cope with the higher relative speed of terminal equipment, and rapid channel set-up times allows meaningful communications in the very short times (possible less than a second) when the two terminals may be in range.

The table below summarises the technical characteristics of the above communications channels.
Table 1 Technical characteristics of communications channels

<table>
<thead>
<tr>
<th></th>
<th>DSRC/ WAVE</th>
<th>Wi-Fi</th>
<th>GPRS/ EDGE</th>
<th>3G/ HSDPA</th>
<th>4G/LTE</th>
<th>Mobile WiMAX5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data rate</td>
<td>3-27Mbps</td>
<td>6-150Mbps</td>
<td>&lt; 250kbps</td>
<td>&lt; 20 Mbps</td>
<td>&lt;300Mbps</td>
<td>1-32 Mbps</td>
</tr>
<tr>
<td>Latency</td>
<td>&lt; 50ms</td>
<td>Seconds</td>
<td>Seconds</td>
<td>Seconds</td>
<td>100ms, 10ms small packets</td>
<td>50ms</td>
</tr>
<tr>
<td>Range</td>
<td>&lt; 1km</td>
<td>&lt; 250m</td>
<td>&lt; 10km</td>
<td>&lt; 10 km</td>
<td>&lt;30 km</td>
<td>&lt; 15km</td>
</tr>
<tr>
<td>Mobility</td>
<td>&gt; 100 kph</td>
<td>&lt; 10kph</td>
<td>&gt; 100 kph</td>
<td>&gt; 100 kph</td>
<td>&gt;100 kph</td>
<td>&gt; 100 kph</td>
</tr>
<tr>
<td>Nominal Bandwidth</td>
<td>10MHz</td>
<td>20/40MHz</td>
<td>&lt; 3MHz</td>
<td>&lt; 3MHz</td>
<td>1.4 – 20MHz</td>
<td>&lt; 10MHz</td>
</tr>
<tr>
<td>Operating Band</td>
<td>5.86-5.92GHz (ITS-RS)</td>
<td>2.4GHz, 5.2GHz (ISM)</td>
<td>800MHz, 1.9GHz</td>
<td>1.9GHz, 2.1 GHz</td>
<td>Numerous</td>
<td>2.5 GHz</td>
</tr>
<tr>
<td>IEEE std.</td>
<td>802.11p</td>
<td>802.11 a/b/g/n</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>802.16e</td>
</tr>
</tbody>
</table>

B.2 Communication requirements of selected V2I services

To establish whether an application requires or will benefit from Short Range V2I, the advantages of Short Range networks over Cellular Networks can be summarised as:

- High data rates, allowing a relatively large amount of data to be transmitted in a short time
- Low latency allowing messages to be sent and responses to be received in short timeframes (fractions of a second)
- No call routing required allowing local processing at the roadside, again improving response times
- Limited and directional coverage allowing messages to be directed to a particular piece of road, or even a single lane
- Localised transmission, allowing a (temporary) beacon to be set up transmitting warning messages at e.g. roadworks.

Listed below are the extra-urban applications which have been identified in a number of studies\(^3\) as the most important. This table also lists which applications require the use of Short Range V2I, and which may benefit from Short Range V2I Networks.

In this list, some applications are identified as safety-related applications. Note that “safety-related” is a relatively broad term and such applications can be characterised in terms of the time within which they need to react (to provide the safety benefit):

- Short-time critical (typically sub-second) applications include cooperative collision warning
- Time critical (few seconds) applications include in-vehicle signage
- Less time critical applications include routing advice

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3 This list of applications is taken from the priority applications lists of the EasyWay project, SMART2010/0063, Smart 2010/0065 and research conducted by TRL for the UK Highways Agency
The application reaction time requirements and the technical characteristics of the communication channels can be used to identify the most appropriate communication channel for each application.

**Table 2 Applications requiring and benefiting from Short Range V2I Networks**

<table>
<thead>
<tr>
<th>Application</th>
<th>Requires V2I WLAN (Short Range)</th>
<th>Benefits from V2I WLAN (Short Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-vehicle signage (Safety)</td>
<td>N</td>
<td>Y (1)</td>
</tr>
<tr>
<td>Intelligent Speed Adaptation (Safety)</td>
<td>N</td>
<td>Y (1)</td>
</tr>
<tr>
<td>Road works warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Wrong way driving warning (Safety)</td>
<td>N</td>
<td>Y (2)</td>
</tr>
<tr>
<td>Decentralized floating car data (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>SOS service (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Automatic access control / parking management (Efficiency)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Vulnerable road user warning (Safety)</td>
<td>Y (3)</td>
<td>Y (3)</td>
</tr>
<tr>
<td>Hazardous location notification (Safety)</td>
<td>N</td>
<td>Y (4)</td>
</tr>
<tr>
<td>Traffic jam ahead warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Road Condition Warning (Safety)</td>
<td>N</td>
<td>Y (4)</td>
</tr>
<tr>
<td>Low Bridge Warning (Safety)</td>
<td>N</td>
<td>Y (5)</td>
</tr>
<tr>
<td>Traffic information and recommended itinerary (Efficiency)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Eco-driving support (Efficiency)</td>
<td>N</td>
<td>Y (6)</td>
</tr>
<tr>
<td>Post crash warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Enhanced route guidance (Efficiency)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Obstacle on driving surface warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Car breakdown warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Insurance and financial services (Comfort)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Tracking and tracing of hazardous and valuable goods (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Where there is a “Y” (Yes) in the above table, a brief discussion is provided below:

1. **In-vehicle signage and Intelligent Speed Adaptation (ISA).** These two applications both depend on information normally presented on signs (speed limits etc.) being transmitted to the vehicle to be displayed in the vehicle. In the case of ISA, this information is then used by the vehicle to either encourage or force the driver to adhere to the posted speed limit. The added benefit of using Short Range V2I is that locally posted limits or variable message information (for example in road works, temporary limits etc.) can be transmitted to the vehicle directly. This simplifies the
infrastructure requirements and guarantees that only locally relevant information is transmitted to the vehicle. While simpler to implement using Short Range networks, it is believed that there is however no technical reason why this cannot be achieved using Cellular Network communications with suitable data filtering techniques ensuring that only relevant information is transmitted to vehicles.

The benefits to this application spring from the local nature of Short Range networks, allowing messages to be generated and transmitted locally. The improved speed and latency of Short Range networks offer no advantage to these applications.

Another factor influencing the choice of communications technology is the balance between the need to maintain a service which is fit for purpose and of an appropriate quality, and the cost of roadside infrastructure.

(2) **Wrong way driver warning** is an application warning other drivers of a vehicle travelling in the wrong direction along a one-way road (mostly motorways in the case of extra-urban roads). The CVIS project identified two different techniques that may be employed to implement this application:

a. The vehicle has on-board equipment which identifies that the vehicle is travelling in the wrong direction and both informs the infrastructure and warns other vehicles (using V2V). In this case, the use of Short Range V2I can provide a small improvement in performance because of reduced overall system latency. The use of local processing also simplifies implementation. This technique means that the possibility of detection increases linearly with equipped vehicles.

b. The infrastructure detects wrong way drivers using sensors positioned at strategic points, typically motorway off slips. This information is then used to warn other drivers. Using Short Range V2I local to the detection sensor allows very rapid detection and dissemination of information, but there will be a very significant infrastructure cost to deploy sensors widely over the network. As above, the advantage of using Short Range V2I is a slight improvement in speed of messaging due to reduced system latency.

In both the above cases, Short Range V2I provides some benefit, but this is not extensive. To provide significant warning capability, the wrong way driver warning would still need to be implemented using Cellular Networks to continue generating warning messages when the vehicle moves out of Short Range network coverage.

(3) **Vulnerable road user warning** warns drivers of the presence of vulnerable road users (children, elderly, disabled, cyclists etc.) in the near vicinity. This is largely an urban application, but could have a place in an extra-urban environment. Under certain circumstances, only Short Range V2I has the speed and latency required to warn drivers of a rapidly developing dangerous situation involving a vulnerable road user, for example a wheelchair user crossing a road in front of an oncoming vehicle at a blind junction. However to realise this benefit would require a significant investment in infrastructure over the entire road network, and is unlikely to be possible on
cost grounds. Local Short Range networks coverage at specific locations may be of some benefit, for example pedestrian crossings, but the number of these locations on the extra-urban network is likely to be very limited.

(4) **Hazardous location notification and road condition warning** applications warn drivers of possible hazardous locations ahead. A small improvement in speed of response may be useful for rapidly developing hazards, but this would only be feasible at known locations of potential hazards, for example a bend prone to slippery surface under certain weather conditions. There is no technical reason why this functionality could not be achieved using only Cellular Network technology.

(5) **Low Bridge Warning** is a particular case of a hazardous location warning. No benefit would be derived from the high speed nature of Short Range V2I, but it would allow a direct warning to be targeted at appropriately equipped approaching vehicles. Because of the special circumstances of this particular hazard, it would be possible to argue that providing a Short Range V2I capability at locations of this type is justifiable as the locations are isolated, small in number and do not imply a widespread roll-out of Short Range V2I architecture. It is also the case that the majority of these types of locations would fall under local rather than national road authority control.

(6) **Eco-driving support** is an umbrella term for applications which assist drivers in reducing their carbon footprint by driving more economically. Cooperative applications can assist in this by encouraging driving techniques which use knowledge of local traffic and geographic conditions. The majority of the communications functionality required can be delivered by Cellular Networks and Short Range V2V communications. Some small benefit may be achievable from Short Range V2I, but it is extremely unlikely to be significant.
Annex C. Review of VINCI Autoroutes app

C.1 Background
VINCI Autoroutes operates 4,385 km of toll motorways in the West and South of France, under four concession operating companies. In 2010 the company launched an app for smartphones which provides travellers with a number of services free of charge and enables the road operator to gather real time information about traffic and incidents on the network. Figures on use of the app demonstrate that the service is popular. The app is therefore one of the first examples in Europe of a cooperative system with widespread deployment. TRL gathered further details of the service and the way in which it is being used by the road operator through an initial telephone conference and a site visit.

C.2 Motivation, benefits and the business model
The motivation behind providing the VINCI app was to improve the customer experience and to increase the company reputation for quality of service, demonstrating it to be at the forefront of technological developments. Another key driver was to unify the VINCI brand across the concessions. Marketing is an ongoing process, predominantly through posters at toll plazas.

The availability of floating vehicle data from the users was not one of the motivations behind developing the app.

C.3 App features and services
The app is focused on “co-pilotage”, i.e. it should be used by a passenger, not the driver. This was a government requirement for deployment and all marketing and advertising must show the passenger using the app, not the driver.

The app is operated through nine buttons:

- “Co-pilotage” – lists the events and features on the road ahead, including: junctions; service areas; incidents or other events; advisory ISA; VMS messages and variable speed limits. When the motorway splits into two, the user selects which route they plan to take.
- Crowd-sourcing – the user is able to alert the road operator on several types of incident (discussed below).
- Traffic Information – a network map with road works and incident information
- Points of interest – interactive content, such as videos on tourist attractions and other points of interest
- Radio – the traffic radio service, which is run by VINCI Autoroutes
- My alerts – filtered alerts on specific road sections, tailored as required
- Games – a treasure hunt game at service areas for children
- My account – login to update personal details

Screenshots of the app are shown in Figure 2.
C.4 Usage
The app had been downloaded over 500,000 times by October 2012. Typically there are at least 4,000 launches per day with a maximum of approximately 1 million during summer holiday weekends 2012. Users mainly make short enquiries and do not leave the app running, thus reducing the availability of floating vehicle data.

C.5 Crowd sourcing
A key feature is that users can submit incident reports on events such as accidents, obstacles, breakdown, congestion, poor visibility and slippery roads. Alerts are fully integrated into the control centre systems. About half of the alerts are for incidents which have not been detected by other means, and the false alarm rate is low.

C.6 Deployment and integration with back office
The idea for an app was first suggested in 2008, and it was launched two years later.

- The internal business case was challenging, because the main benefit is “improved image”, which is difficult to quantify.
- There have been essentially three versions, expanding from the core service on one of the operators’ networks to additional services and the other three operators.
- A key point was that all areas of the business had to interface with the app (marketing, communications, operations, etc.)
- Indicative costs are: 2 person years to develop the app; 2 person years to build the service into procedures throughout the company; and 2 person years to compile information into a common database and make it future-proof.

C.7 Value web
An interpretation of the value web is shown in Figure 1 on page 13 of the main report.
Some of the key relationships are:

- **Road user to VINCI**
  - Enhancing the relationship with their customers
  - Encouraging customers to use their roads more often
  - Unifying the VINCI brand across the concessions
  - Crowd-sourced reports on incidents and road conditions
  - VINCI receive FVD from the user, but this is currently not used by VINCI. It is supplied to a company called Autoroutes Trafic which then sells it on to customers such as TomTom, TV and radio services; some revenue comes back to VINCI.

- **VINCI to road user**
  - Personalised services
  - Local incident/delays/events updates
  - On-trip local information: rest areas and amenities
  - Interactive map (overview of traffic conditions)
  - Excess speed alerts (not to the police) – i.e. advisory ISA
  - Virtual VMS.
  - Google maps are used free of charge; a requirement for this is that the app is offered free to users.

C.8 Future plans

VINCI are considering the following future enhancements to the app:

- Dynamic route guidance (even if it instructs drivers to use non-toll roads).
- Tailored services – e.g. real-time truck parking for truckers, or more tourist information for leisure travellers.
- Coupons – discounts at restaurants when the app is presented.
- Car park information – collaboration with VINCI park.

There are no short term plans to use FVD to replace ANPR or similar infrastructure, and VINCI are not expecting that the app will lead them to replace or remove any roadside VMS in the next 5-10 years.

One of the VINCI concessions (ASF) began the first dedicated traffic radio service in 1988. Traffic radio has since become a legal requirement for all road operators in France; it is possible that there could eventually be a legal requirement for road operators to provide a smartphone app.

C.9 Implications for the HA

The VINCI Autoroutes app is clearly a great success story as indicated by the high usage figures. The key benefit to the road operator is in building a stronger relationship with its customers and in unifying the VINCI brand across the four concession operating companies. In turn, if road users then choose to use the VINCI road network more, then there is a direct increase in revenue. Currently, this is therefore not directly relevant to the HA. However, the overall principle of treating the road user as a “customer” and improving their experience is within the remit of the HA’s strategic objectives.

VINCI receive FVD from the road users, but this currently provides no benefits, because the amount of data is too small. In contrast, the crowd sourcing element of the app is novel and provides a rich source of data for incident detection and network
monitoring. The service is fully integrated with the processes and systems at the back office and for on-road patrols. Furthermore the app interfaces with many other departments, such as customer relations, marketing and sub-contractors. It is therefore important that VINCI maintains full control over the app and its development. If the HA app is enhanced with similar functionality to the VINCI app (ISA, crowd-sourcing, etc.), it would be necessary to consider the extent to which it integrates with the HA’s systems and processes and therefore whether the HA needs to maintain control of the development of the app.

If the HA is to enhance its existing app, it should consider the relevance of each of the functions in the VINCI app. In particular the “co-pilotage” function is a succinct method of displaying information that is relevant (i.e. only information on road ahead). This was essentially the main function in the first version of the app and other functions were added later.

There is a clear steer from the French Government that the app should only be used by passengers and not drivers. This influences both the functionality of the app and the advertising campaign. An alternative could be to provide a hands-free, voice only app, such as ‘Hands Free Traffic Talker England’ which was developed by Information Logistics and endorsed by the HA.
Annex D. Open Data and Data Markets

D.1 Open Data

In the UK recent initiatives towards ‘Open Data’ include a White Paper and the recently launched Open Data Institute. The European Commission also has an Open Data Strategy for Europe. In Europe, the UK is seen as being in the lead in this area. Open Data has implications for delivering services based on cooperative systems and for a data market as described below.

D.1.1 UK White Paper

The Government published ‘Open Data White Paper: Unleashing the Potential’ in June 2012. This places a strong emphasis on making public sector datasets publicly available (in anonymised form). The default position required should be to publish, unless there is a good reason to not publish.

All Government departments have now published their first Open Data Strategies which include commitments to publish more data and plans to stimulate a market for its use. The DfT Open Data Strategy was published in June 2012.

The online portal, www.data.gov.uk, has been completely overhauled and relaunched in conjunction with this White Paper.

D.1.2 The Open Data Institute (ODI)

The UK Government is funding the Open Data Institute (ODI), which officially opened in December 2012. This is a centre to incubate, nurture and mentor new businesses exploiting Open Data for economic growth. It is based in Shoreditch, London and is intended to be a focal point for entrepreneurs, developers and technologists. The ODI describes itself as a broker between the Government, big business and innovative SMEs.

One of the functions of the ODI is to hold “Innovation Events / Hackathons”; the purpose being to bring together experts from various backgrounds to focus on a particular area and set of challenges. As of December 2012, the ODI had hosted three events: MiData Hackathon (telecoms); Hack4Health (NHS prescription data); an event with a local secondary school. They are able to host approximately 30 to 40 people at their facilities in Shoreditch, which includes a 2000 square foot central area with break-out rooms.

Data is typically released as Open Data with the minimum amount of effort from the Public Sector to prepare it. It is often provided in raw format with limited guidance on how to use it. An emerging business model is that of “Data Intermediaries”. These are companies that take the first steps to download, clean and process the data and then provide a consultancy service to run queries and analysis on the data. As an example, one of these has developed a website which is essentially a repository of public transport APIs (Application Programming Interfaces): “an aggregation and analytics service for UK public transport, designed to offer users, developers and operators access to transport data-as-a-service (DaaS)”.

Data is typically released under the Open Government Licence. Essentially this involves developers complying with three principles: not pretending to be the

4 https://developer.transportapi.com/
Government; not attributing the data to the Government, not mis-using the data. If any of these rules are breached, it is possible to take legal action against the developer. One approach to release of government data is to have several levels of service, whereby users sign up to a “Gold” service of higher quality. Should a particular user mis-use the data their access rights can be revoked. More common than data mis-use is “data-stupidity”. This is where a developer uses the data in a careless way, although not necessarily maliciously. However, such uses typically are not commercially very successful due to bad press and self-regulation in the data community.

In summary, the purpose of the ODI is to “go beyond Open Data”. The Open Data White Paper is a key first step in giving a clear Open Data mandate to the Public Sector; however, the purpose of the ODI is to take the next step to encourage collaboration and realise added value.

D.1.3 Recommendations

The HA is already well advanced in providing Open Data, by publishing a live data feed, both through the TIH and data.gov.uk. However, the White Paper sets out 14 “general principles” on how to make published anonymised data as useful as possible, which may be of relevance to the HA.

Once the Open Data Institute has become more firmly established, the ODI may be able to provide advice to the HA on aspects of HA involvement in a data market. More specifically, the ODI is keen to host an “Innovation Event” on transport data.

D.2 Data markets

Initial steps towards the establishment of data markets are now taking place in some countries in Europe. The most advanced examples are in Germany and The Netherlands. Finland is also developing a ‘transport data warehouse’, which is a joint service between businesses and authorities for static and real-time basic transport information (e.g. traffic and weather information) produced by the authorities. The German and Dutch examples were investigated within this project and further details are provided below.

D.2.1 Germany – Mobility Data Marketplace (MDM)

The ‘Mobility Data Marketplace’ (MDM) in Germany is essentially an implementation of the ‘Open Market’ business model. The MDM is a two-and-a-half year pilot project to provide a marketplace for buying and selling data between road operators and service providers – thus both public and private sector organisations are involved; data can be made available free of charge or at cost. The marketplace is intended to be for processed information, rather than raw data, and for it to be near real-time (with an update frequency of 1 minute).

The pilot, which started in April 2011, is funded by the German Government until the end of 2013. The intention is that government funding will be reduced over time and a long-term operational business model will be developed, possibly through a Public-Private Partnership.

The MDM is described as having two main roles:

- Portal function for market transparency – it provides a platform for advertising and searching, similar to other online marketplaces, such as eBay.
• Brokerage function for secure data exchange – once two interested parties are identified, it enables a contract to be set up, defining the required data quality and other conditions. However, the MDM does not alter or filter the data.

The service has generated considerable interest from local road authorities because they tend not to have the resources for exchanging information with other organisations. Indications of commercial viability are expected to be available after the pilot phase has been completed.

The MDM describes its high-level benefits as follows:

“The MDM: Mobility Data Marketplace offers an independent platform to all market actors and administrations for presenting their available data, clearly structured and via user-friendly processes; in this way new options for the utilisation of traffic-relevant data and services are opened up.”

More specific benefits claimed are:

• “Direct access to a variety of data clients and data suppliers
• Overview of existing offers from both large and small data suppliers
• Easy management of offers and clients
• Facilitation of quality assessment
• Contract models with standardised and agreed content
• Defined billing terms
• Easy, transparent processing of purchasing transactions
• Process reliability and monitoring
• Saving in transfer and distribution of data
• Modular system architecture is easily adaptable to other countries”.

Two key lessons have been learned to date:

• Establishing a long term business model is going to be a significant challenge.
• The market place offers an opportunity for financially constrained public authorities to save costs, and to take part in a service that they would not otherwise have sufficient resources for.

D.2.2 The Netherlands – National Data Warehouse for Traffic Information (NDW)

The Dutch National Data Warehouse (NDW) is a collaborative venture between authorities across The Netherlands to collect, process, store and distribute traffic data. The service began in July 2009, and by October 2012 there were 24 public sector organisations involved; it covers many of the road authorities, and coverage is expected to continue expanding.

The main aim of the NDW was to create a joint database for traffic data between authorities and improve efficiency by working together and sharing information, with a single point of access for nationwide traffic data on primary and secondary roads.

For many years in The Netherlands, third party private sector service providers have had the responsibility for traffic information services, with public sector responsible for collecting and aggregating traffic data. Thus, before the NDW was established the private sector already had processes and business models for using and enriching public traffic data.
The NDW claim that the business model is compliant with the European Commission’s ambitions for open data. The business model can be summarised follows:

- NDW outsources data collection and storage to commercial contractors.
- Data ownership lies with joint authorities.
- Basic data is openly available through a free “Bronze” subscription.
- Data is licensed to third party traffic information service providers through a “Silver” and “Gold” subscription. The connection fee is approximately € 6000 per year; this is seen as a marginal cost. There is a contract, which includes a code of conduct for services providers.

There are mutual benefits to this approach.

- Authorities share the costs of the NDW organisation and the database.
- Each party pays for data on its own road network.
- Partners receive all data from the NDW.
- The service does not currently include FVD; suppliers claim that if commercially collected data is published for free to competitors then prices will increase.

For road authorities, one of the benefits is flexibility for data gathering – they can take advantage of a single tender or organise their own data gathering and enter the data into the NDW database, provided that it meets the functional and quality requirements of the database.

A web-based application has been developed which enables partners to select historic data for analysis, according to time and location. This has substantially increased the amount of historic traffic data which is available for evaluating policies and schemes. The database also provides the raw material for research on traffic and travel behaviour, and forecasting future flows.

Some estimates of the scale of the potential benefits have been made:

- 10-15% reduction in travel times due to the availability of quality traffic information
- 10-15% improvement in traffic flow on inter-urban routes at peak periods as a result of improved traffic management.

**D.2.3 Recommendations on data markets**

The HA could have a significant part to play in providing and receiving information from a marketplace if one were to be established in the UK. It is not yet clear which (if any) of the two approaches represented by the German and Dutch examples is the most appropriate for the HA. However a summary of the key features as set out in Table 3 may be helpful.
### Table 3 Key features of German and Dutch examples of data markets

<table>
<thead>
<tr>
<th>Key features</th>
<th>Data market (e.g. Germany)</th>
<th>Data warehouse (e.g. The Netherlands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business model</td>
<td>Brokerage, putting organisations in touch with each other for making individual arrangements</td>
<td>Jointly owned database, supporting data exchange between authorities</td>
</tr>
<tr>
<td>Organisations providing data</td>
<td>Public and private sector</td>
<td>Public sector</td>
</tr>
<tr>
<td>Organisations able to use data</td>
<td>Public and private sector</td>
<td>Public and private sector</td>
</tr>
<tr>
<td>Services offered</td>
<td>Structured format for presenting data</td>
<td>Specified functional and quality requirements</td>
</tr>
<tr>
<td></td>
<td>Security, quality, and defined conditions are dealt with through contracts between pairs of organisations</td>
<td>Licensing arrangements</td>
</tr>
<tr>
<td></td>
<td>Basic information free of charge, subscription for higher levels of service</td>
<td>Authorities can join forces for data gathering</td>
</tr>
</tbody>
</table>

It is recommended that the HA should maintain contact with the MDM to monitor developments, and particularly review the results of the assessment when the pilot phase has been completed.

In addition, it may be possible to make the technical specifications and software components for the market place available to the HA.

The National Data Warehouse represents a possible model for sharing data with local authorities. This is already done to a certain extent with some local authorities through the UTMC initiative, where local transport data is collected and stored using a standard approach and a common database.

The HA, as an information service provider, is in a different position from the Dutch road authorities which provide data but not information services. As an information service provider, the challenges highlighted by the NDW for requiring certain types of information to be conveyed to drivers are therefore less of a concern to the HA. Other challenges, associated with data quality ownership, adding value with additional data elements are just as relevant to the HA as they are in The Netherlands and it would be worthwhile for the HA to monitor how these are addressed.

Other European data markets should also be monitored.
Annex E. Summary of investigations into HA data

E.1 Data quality
Ten criteria for assessing quality were selected and used to populate a summary table which provides a baseline understanding of the current situation of the quality of all existing HA data sources. The ten data quality criteria were:

- Availability
- Penetration rate
- Sample bias
- Error probability
- Accuracy
- Precision
- Latency
- Update rate / temporal resolution
- Privacy
- Ownership.

E.2 Scenarios for development of apps and Floating Vehicle Data (FVD)

Real-time traffic information services based on Floating Vehicle Data (FVD) can enhance and complement the HA’s traffic information services and could provide a valuable contribution to a data market. Traffic information service providers appear to have sophisticated processes of validation and testing to ensure that the information is of an appropriate quality for their purposes.

A key stakeholder that is emerging is that of the “Data Integrator”. One such example is TomTom, which combines GPS-based data (portable navigation devices, in-dash navigation, smartphones, fleets, third party data) with GSM-based data (from mobile operators), as well as with Government data (road sensors, incident data).

In this project scenarios were considered in which apps are developed for travellers on the HA network. Essentially, the app provides value to the users who receive useful in-vehicle information. A by-product is that most apps collect FVD.

E.2.1 Scenarios 1a and 1b – The HA develops and owns a VINCI-style app

Two options were considered for developing a VINCI-style app (see Annex C) offering slightly different scenarios:

1a. Develop the existing HA Traffic England app and enhance it with further services,
1b. Develop a new VINCI-style app.

The existing HA app is for iPhones and has 0.5 million users per month; it has been downloaded 850,000 times. Because it is established, the HA is considering whether to enhance it with new services (possibly similar to the services offered by the VINCI app), and provide an Android version.

Advantages
- “In-house” development gives HA control over the type of data being gathered and the data would be freely available for HA use without licensing issues or costs.
Full control over the app is also a key advantage if the data is to be fully integrated with back office systems.

Enhancing the current app (Scenario 1a) makes it possible to build on the existing user base.

Disadvantages

- In Scenario 1b, the HA would likely come into competition with third-party app developers and would therefore need to obtain Cabinet Office approval.
- To engage in such competition may require additional resources and may be considered a distraction from the HA’s core business.
- It may also be more beneficial for the UK economy if the private sector is allowed to develop apps without publicly-funded competition.

E.2.2 Scenario 2 – HA works with a third-party to endorse an app in exchange for data

An alternative to developing its own app would be for the HA to engage with a developer in partnership. There could be varying degrees of HA involvement, from endorsing the third party product, to full partnership. The HA could provide seedcorn funding for the developer to produce an app in line with the HA’s needs, in exchange for the HA being granted a licence for use of the data. Alternatively, the developer may be happy to fund the development themselves in exchange for exclusive HA endorsement.

Advantages

- This reduces the development costs and removes exposure to on-going marketing and maintenance costs.

Disadvantages

- This approach provides less security for the HA. The developer would not receive on-going payments from the HA and therefore would not have an incentive to continue to support the app if sales were poor.
- There is also risk to the HA’s reputation should the app or the developer receive poor publicity for any reason.

Current situation

This scenario has come to pass: a hands-free traffic information app was released by Information Logistics in association with the HA in August 2012.

The HA supply data to Information Logistics\(^5\) using an NTIS DATEX II feed, as part of the NTIS contract. The HA has endorsed the service. Currently, the HA receives management information on the number of downloads and usage figures, but does not receive floating vehicle data from the service although it is understood that there is a route for obtaining this in future if required.

\(^5\) Information Logistics is part of the INRIX supply chain delivering the NTIS service
E.3 Scenarios for data markets and Floating Vehicle Data (FVD)

E.3.1 Scenario 3 – HA becomes a consumer and supplier of data through a Data Market

Whilst the idea of establishing a data market is compatible with either of the scenarios described above, here we assume that the HA has chosen to also become a consumer of data. Such a market could operate by either matching up suppliers and users of data or providing a common interface through which data could be made available.

The purpose of a data market is to provide a single, standardised interface for buyers and sellers of data in which it is clear to see what a given supplier is offering and easy to assess its value against alternatives.

Advantages

- In principle, this is of benefit to both buyers and sellers; sellers have an easy and efficient way of marketing their product to many potential buyers and buyers benefit from increased transparency and competition, driving down costs of data licensing and procurement.
- This approach would mean that the HA would have no development or maintenance costs and could procure data ‘off-the-shelf’.
- The cost of licensing data would be determined by market forces.
- If there were multiple consumers and many competing suppliers, this might drive prices down to a level which would make this option attractive.

Disadvantages

- If the HA was the sole consumer of the data and there were few suppliers, then this could result in poor value to the HA, although this would be unlikely to be worse than the situation without a data market.
- If there were few participants, the market would not be efficient and set-up costs could outweigh savings.

E.4 Use of floating vehicle data (current/short term scenario, low penetration)

The project conducted an assessment of the implications of the availability of FVD (regardless of how it is collected or procured).

E.4.1 Cost saving: FVD to replace ANPR?

With a low FVD penetration rate, the only infrastructure-based data sensors which could potentially be removed are ANPR journey time cameras, although this might not be a viable option if there was a requirement for new services based on ANPR cameras.

E.4.2 Quality improvement: FVD to ‘patch’ Traffic Monitoring Unit (TMU) flow data?

An assessment of online data showed that only 80-85% of the links had live flow data. This was typically due to road works or malfunctioning loops. It may be possible to use FVD to estimate flows where the TMU loops are temporarily
unavailable, although a fuller analysis would be required to establish whether there is a viable the business case.

E.4.3 Quality improvement and cost savings: assessment of the INRIX 12-month trial

INRIX Floating Vehicle Data is currently acquired by the HA as part of the NTIS contract for a 12-month trial (ending March 2013). The data is not made available in its raw form to the HA, but is fused with other NTIS data by INRIX and supplied back to NTIS. The Floating Vehicle Data is collected from GPS devices in taxis, service vehicles, airport shuttle services, cars, heavy good vehicles (HGVs) and long haul delivery trucks.

It is likely that compared with all vehicles on the HA network, the data over-represents those driving high annual mileage, with lower-than-average speeds, and is therefore not representatives of all vehicles using the HA network. An independent evaluation of current floating vehicle data received by NTIS is recommended in Annex E.8.3.

E.5 Use of floating vehicle data (longer term/ future scenario, high penetration)

With substantially higher penetration rates, it is conceivable that FVD could be used to estimate total vehicle flow. If virtually all vehicles were equipped, then flow could be measured simply by counting vehicles in the FVD. In this scenario, most infrastructure-based detectors would become obsolete. The only exception would be those which give information not available in FVD such as which lane a vehicle is in (although even this may be measurable with future location technology).

If penetration rates were high enough and quantifiable, flow could be estimated by scaling up the number of floating vehicles (e.g. multiplying by 2 for a 50% penetration rate). It would be necessary to conduct an analysis of penetration on a regional basis, because it is likely that the take-up will vary across the network.

The penetration of FVD required to estimate flow depends on the underlying level of traffic on the road, the required temporal resolution and the required accuracy of the measurement. Some initial modelling carried out within this project has indicated that to obtain hourly flows on typical main road, such that on average 99% of flow measurements are within 10% of the true flow, a 35% penetration of FVD would be required. To obtain one-minute flows on a busy motorway, such that on average 99% of flow measurements are within 10% of the true flow, a 90% penetration of FVD would be required.

If flows could be obtained from FVD, then use of NTIS TMU could also be discontinued, saving maintenance and data processing costs. In principle, MIDAS could also be replaced as the primary purpose of setting signals could be achieved using FVD, although this would require significant system architecture changes as well as safety testing etc. Looking further forward, signals may play a lesser role, being increasingly replaced by in-vehicle systems.
E.6 Potential for cost savings

The costs of the four current real-time sources of data were assessed: INRIX Floating Vehicle Data; NTIS ANPR; MIDAS Inductive Loops; NTIS TMU Inductive Loops. For each of these data sources, the following were considered:

- The cost of acquiring the data source initially
- The on-going costs of maintaining the source to its current level
- The marginal cost of increasing or decreasing coverage
- The reduction in cost of ceasing use of the source
- Any retained value of assets.

This exercise was challenging and costs were not entirely quantifiable. A complication is that each of these elements may be covered by separate contracts and each of these contracts may also cover other costs not relevant to the data source. For example, the HA contracts its maintenance work by area, often with multiple contracts in each area, and to cover different aspects of maintenance. If a particular type of detector no longer requires maintenance, the reduction in cost would not be realised until all the relevant contracts were re-tendered or re-negotiated. Additionally, many of the contracts are commercially sensitive so complete transparency of costs is unobtainable.

E.7 Data enhancements to support or improve HA operations in future scenarios

Work has been undertaken to assess the relationships between HA strategic objectives, functions, information required and supporting data sources. There has also been an assessment of how future CVHS scenarios could provide data of greater quality or of lower cost. The framework is shown in Figure 3.

![Figure 3: Methodology for assessing how data is used by the HA](image)

Work was undertaken to apply this framework to the HA’s data, information, functions and objectives. This was achieved in three steps:

1. Specification of 23 types of information used by the HA. For each type, the current data source used and potential future sources were identified.
2. Mapping of these types of information onto different functions (which in turn help to meet the HA’s strategic objectives).
3. Identification of current and future options for delivering traveller information to road users.

In summary, the assessment showed that cooperative systems have the potential to:

- Provide better quality data sources
- Provide more cost effective data sources
- Provide a new channel for delivering information (in-vehicle)
- Enable new functions in support of the HA’s strategic objectives.

E.8 Recommendations on data quality, apps and Floating Vehicle Data

E.8.1 Data enhancements to support future HA operations

The analysis carried out in this project has highlighted the potential for cooperative systems to support and enhance HA operations. Further In-depth investigations are recommended to assess which scenarios are most likely and which would have the greatest impact. Specifically, it would be useful to investigate the following:

- Cost savings due to data
- Enhanced data quality / information
- Required penetration rate before data from cooperative provide a benefit
- Required penetration rate before existing infrastructure becomes redundant.
- Additional benefits (safety, traffic, environmental)
- Timescales for deployment

The following more specific recommendations address some of these issues in further detail.

E.8.2 Apps for Floating Vehicle Data

The HA is already considering whether to enhance its existing traffic information app. The key advantage of maintaining the HA’s own app is having full control over the data quality and, in particular, the potential for it to be fully integrated with back office systems.

As the Information Logistics app has only recently been released, the number of users is small. However, it is recommended that usage figures for the app be monitored. It is also recommended that the HA should obtain the floating vehicle data if there is substantial take-up of the app.

E.8.3 Potential cost savings and quality improvements from Floating Vehicle Data

It is recommended that the HA conduct further detailed work into the cost implications of various FVD and cooperative systems scenarios, building on the initial assessment carried out in this project.

An independent evaluation of the current floating vehicle data received by NTIS is recommended, to assess the benefits it provides, namely improvements in the data quality.

A detailed investigation of the short term potential and development of the business case for replacement of ANPR-based journey time information service with floating
vehicle data appears to be the most appropriate focus for investigating potential cost savings from FVD in the short term.

It may be possible to use FVD to estimate flows where the TMU loops are temporarily unavailable. This could be achieved by calculating the penetration rate of FVD where there is coverage for local regions and time periods. Then, assuming the penetration rate is constant, it could be applied to provide flow estimates for the gaps in coverage.

E.8.4 Floating Vehicle Data from Third Parties

Further work is recommended to investigate the use of probe data and the implications of having real-time traffic information available from a range of third party service providers. There may be advantages in having several commercial providers who make different route recommendations for diversions, thus spreading the response to incidents. Balanced against this, however, is a concern that commercial providers may use traffic information to recommend unsuitable diversion routes.

More specifically, it appears that third party service providers such as TomTom may offer an opportunity to complement the INRIX data which the HA is currently buying on a trial basis, due to the apparent advantages of less bias and better coverage of trunk roads.

E.8.5 Uses of Floating Vehicle Data in the longer term

Preliminary modelling has been conducted into the required penetration rates for floating vehicle data if it were to be used to estimate flow. It is recommended that further modelling is conducted, addressing questions such as: how much probe vehicle data is needed and what penetration rates of equipped vehicles are needed for what quality of data?; how many loops could be dispensed with?

E.8.6 Strategic and policy issues

This project has also highlighted some important strategic and policy issues for the HA, specifically

- The role of the HA as supplier and buyer in a UK data market (rather than as a collector and user of its own information)
- The potential reduction in HA infrastructure-controlled data collection and information provision to drivers
- The policy and liability implications of the HA withdrawing from direct quality control of information to motorists and leaving the private sector to inform each other and their customers about traffic information and incidents derived from new sources (including social media).

The HA will need to address these issues, as part of the process of developing a strategy to take advantage of the potential benefits offered by cooperative systems.
Annex F. The Cooperative Services ‘Ecosystem’

The mode of data collection will change over time
The mode of service delivery will change over time
Abstract

Strategic studies clearly show that new technology, and especially Information and Communication Technology (ICT), has a key role in meeting transport objectives. Within this broad field, many commentators point to the establishment of cooperative systems (also called Cooperative Vehicle Highway Systems, CVHS, or Cooperative Intelligent Transport Systems, C-ITS) as an enabler of new “connected services” providing safety, congestion and environmental benefits. Nevertheless, for a road authority, the route to deployment is far from clear and this paper discusses the technical and organisational aspects that now need critical attention in order for cooperative systems to achieve successful deployment.

Keywords: ITS, cooperative systems, business models

Cooperative ITS Background

Cooperative systems are being intensively investigated by vehicle manufacturers and National Road Authorities (NRAs). For the purposes of this paper, we propose the following definition:

*Cooperative systems communicate and share information dynamically between vehicles or between vehicles and the infrastructure, to give advice or take actions with the objective of improving safety, sustainability, efficiency and comfort to a greater extent than stand-alone systems.*

European projects have identified cooperative services and demonstrated their operation through pilot trials (CVIS, Coopers, SafeSPOT - Konstantinopoulou et al 2010). Services enabled by Vehicle to Vehicle (V2V) communications can provide additional vehicle safety by effectively extending the vehicle’s sensor range and capability through interaction with other vehicles. V2V can also provide information and other services to drivers and some of these improve traffic flow and, through reductions in accidents, can assist in operating the road network.

For National Road Authorities, C-ITS, particularly those using Vehicle to Infrastructure and Infrastructure to Vehicle communication (abbreviated to V2I) can potentially assist in managing their road networks. Road Authorities need to obtain data on the dynamic performance of the road network in order to manage it efficiently. They also need to communicate critical safety and operational information to the road users. However, these are challenging financial times and finding funding for additional infrastructure investment is difficult. Even maintenance of existing infrastructure is challenging and, as technology progresses, obsolescence and unreliable performance is increasingly an issue. Road Authorities are under pressure to reduce costs and, at the same time improve service to
customers. Another challenge comes from the availability of in-vehicle and nomadic devices that provide new information streams to drivers but which can, on occasions, conflict with the information provided on the road infrastructure. Examples include externally presented diversion routes and variable dynamic speed limits that may conflict with the information available from in-vehicle information systems.

From a road authority’s perspective, the most important potential benefits of V2I cooperative ITS are likely to be:

- Reducing incidents and accidents and their network impacts
- Asset condition monitoring (road surface friction, potholes etc.)
- Reducing cost of traffic data collection
- Road capacity optimisation
- Better information to drivers
- Improved coverage/penetration of both information services on the road network and sensor data from the road network
- Potential to reduce or remove infrastructure (such as loops and VMS)

However, a clear business case for cooperative systems and an understanding of the role of the road network operator is currently missing and these challenges have prompted this new work.

**Cost-Benefit Assessment of CVHS**

To provide an initial assessment of potential benefits of C-ITS, a range of European documents were systematically reviewed with a focus on how cost-benefit assessment of cooperative systems had been carried out and what gaps in data or knowledge had been identified:

- CoCAR D4 (2009)
- CODIA D5 (2008)
- EasyWay WP4.1/4.2 (2012)
- eIMPACT D6&D8 (2008)
- Intelligent Infrastructure WG from eSafety (2010)
- SAFESPOT D6.5.1 (2010)
- SPITS D10.1 (2011)
- VII benefit - cost analysis (2008)
- White Paper on deployment from SAFESPOT/COOPERS/CVIS (2010)

In summary, previous work has been undertaken with limited data and some “heroic” assumptions. At a societal level, the most beneficial cooperative applications appear to be safety-related ones involving V2V communication.

Recent work within the COBRA project (COBRA, 2012) has indicated that that the services most wanted by drivers are dynamic route planning/congestion avoidance/traffic information, and various hazardous location/road works/congestion ahead warnings. Of the other V2I applications, the most attractive to specific Stakeholders appear to be “Pay As You Drive” Insurance and Breakdown-Call. NRAs may be an indirect beneficiary of such services (that are already being offered through proprietary channels). V2I applications that would offer direct benefit to NRAs do not appear particularly beneficial even when sharing common hardware.
Most studies conclude that V2V services will be introduced first with V2I bundles of applications following. One of the key assumptions concerning V2I in all of the studies identified before 2012 has been the necessity for roadside beacons to provide short range communications. Not surprisingly, the largest cost factor in the V2I systems considered appears to be the capital and operating costs for these beacons.

Cost-Benefit Assessment (CBA) is not a precise science and relies on a myriad of policy decisions, predictions and estimations. Even valuing time saved and accidents avoided involve policy judgements, as does the selection of the discount rate. Lack of data about new services is a key factor which generates uncertainty in forecasting.

Three further issues are identified as critical to CBA:

**Bundling:** Constructing combinations of cooperative applications which can share hardware may be acceptable in terms of demonstrating strategic benefits. However to support deployment, value chains, business models and business cases have to be established and this probably requires consideration of a plethora of routes to market and much greater complexity than is captured in the high-level bundle analysis.

**Snapshots:** CBA reported in projects such as Easyway, CODIA and SAFESPOT has, of necessity, adopted a relatively high-level approach to costs and benefits. The “Snapshot” approach of considering costs and benefits in a distant future target year provides a certain strategic context but does not directly support the necessary focus on immediate investment needs and subsequent returns that are required to develop business cases.

**Piggybacking:** Building from the standpoint of V2V communications and formal standards leads to a requirement for roadside beacons for V2I, which greatly increases the initial costs for installation and maintenance. However, the alternate approach of running cooperative applications by piggybacking with Smartphone Apps using cellular communications could present an entirely different picture of costs and benefits for NRAs.

Cooperative services are most likely to be delivered through multiple arrangements involving a number of organisations, with individual business cases and business models. They could involve exchange of data, incremental costs, absorption/sharing of costs and charging consumers, and therefore it is difficult to understand and quantify within a CBA all the individual costs and benefits which will vary with each link in the delivery chain, the consumer and society. Cooperative applications can even be envisaged that provide benefits to specific stakeholders while generating marginal benefits in a social cost-benefit calculation.

**Communication Options and Issues**

Cooperative systems require a means of data communications, either between vehicles or between vehicles and infrastructure. For V2V applications the use of Dedicated Short Range Communication (DSRC) networks can be justified by the safety related applications which require very rapid, low latency communications and do not need data from central servers. Industry consortia like the Car to Car Communications Consortium (C2CCC) are well advanced in producing standards for V2V communications. In previous and current cooperative systems projects, the embedded assumption is that short range networks will also be used for V2I, and this has led to unfavourable business cases due to the high cost of installing and maintaining roadside beacons.
In the light of recent developments in cellular communications Table 1 lists a range of extra-urban applications which have been identified in a number of studies\(^6\) as the most important. The table identifies which applications require or may benefit from Short Range V2I Networks and which could equally well be delivered through cellular communications.

**Table 1 - Priority cooperative services for inter-urban road authorities**

<table>
<thead>
<tr>
<th>Application</th>
<th>Requires V2I Beacons</th>
<th>Benefits from V2I Beacons</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-vehicle signage (Safety)</td>
<td>N</td>
<td>Y (1)</td>
</tr>
<tr>
<td>Intelligent Speed Adaptation (Safety)</td>
<td>N</td>
<td>Y (1)</td>
</tr>
<tr>
<td>Road works warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Wrong way driving warning (Safety)</td>
<td>N</td>
<td>Y (2)</td>
</tr>
<tr>
<td>Decentralized floating car data (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>SOS service (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Automatic access control / parking management (Efficiency)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Vulnerable road user warning (Safety)</td>
<td>Y (3)</td>
<td>Y (3)</td>
</tr>
<tr>
<td>Hazardous location notification (Safety)</td>
<td>N</td>
<td>Y (4)</td>
</tr>
<tr>
<td>Traffic jam ahead warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Road Condition Warning (Safety)</td>
<td>N</td>
<td>Y (4)</td>
</tr>
<tr>
<td>Low Bridge Warning (Safety)</td>
<td>N</td>
<td>Y (5)</td>
</tr>
<tr>
<td>Traffic information and recommended itinerary (Efficiency)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Eco-driving support (Efficiency)</td>
<td>N</td>
<td>Y (6)</td>
</tr>
<tr>
<td>Post crash warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Enhanced route guidance (Efficiency)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Obstacle on driving surface warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Car breakdown warning (Safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Insurance and financial services (Comfort)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Tracking and tracing of hazardous and valuable goods (safety)</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Cooperative collision warning</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

The cases requiring or benefitting from short range communications are further discussed below:

(1) In-vehicle signage and Intelligent Speed Adaptation (ISA) both depend on information normally presented on signs (speed limits etc.) being transmitted to the vehicle. Using Short Range V2I simplifies the infrastructure requirements and guarantees that only locally relevant information is transmitted to the vehicle with predictable latency. However, there does not appear to be any technical reason why this cannot be achieved using Cellular Network communications with suitable mapping and data filtering techniques ensuring that only relevant information is presented to the driver in a timely manner.

(2) Wrong way driver warning is an application warning other drivers of a vehicle travelling in the wrong direction such as the wrong carriageway of a motorway. The CVIS project identified how this might be implemented either through infrastructure or vehicle sensors. Short Range V2I provides some benefit, but this is not extensive and to provide significant warning capability, the wrong way driver warning would also need to be implemented using Cellular Networks to continue generating warning

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\(^6\) This list of applications is taken from the priority applications lists of the EasyWay project, SMART2010/0063, and Smart2010/0065
messages when the vehicle moves out of Short Range network coverage.

(3) Vulnerable road user warning is largely an urban application. Under certain specific circumstances, only Short Range V2I has the speed and latency required to warn drivers of a rapidly developing dangerous situations. However to realise this benefit would require a significant investment in sensing infrastructure over the entire road network, and is unlikely to be viable on cost grounds. Local Short Range networks coverage at specific locations may be of some benefit, for example pedestrian crossings.

(4) Hazardous location notification and road condition warning applications warn drivers of possible hazardous locations ahead. A small improvement in speed of response may be useful for rapidly developing hazards, but this would only be feasible at known location of potential hazard, for example a bend where the road surface becomes slippery under certain weather conditions. There is no technical reason that this functionality could not be achieved using only Cellular Network technology.

(5) Low Bridge Warning is a particular case of a hazardous location warning. No benefit would be derived from the high speed nature of Short Range V2I, but it would allow a direct warning to be targeted at appropriately equipped approaching vehicles. This could be equally achieved using an in-vehicle App using GPS and suitable map data.

(6) Eco-driving support is an umbrella term for applications which assist drivers in reducing their carbon footprint by driving more economically. Cooperative applications can assist by encouraging driving techniques which use knowledge of local traffic and geographic conditions. The majority of the communications functionality required can be delivered by Cellular Networks and Short Range V2V communications. Some small benefit may be achievable from Short Range V2I, but it is extremely unlikely to be significant.

Overall, it can be concluded that the majority of the benefits of cooperative systems of interest to NRAs can be delivered through cellular communication to SmartPhones. This raises the possibility of NRAs benefitting from cooperative services without the need to install an extensive beacon network. Road authorities would also benefit in the medium to longer term from the performance improvement that comes with each new cellular generation.

Case Study – The VINCI App

A specific cooperative service from VINCI Autoroutes has been examined in some detail (VINCI, 2012). VINCI is a leading French motorway operator with 4 concession operating companies (ASF, Cofiroute, Escota and Arcour). The service comprises a free Smartphone App which can be used to share information between the road user and the road operator on any of the concessions. The App has been downloaded by approximately 220,000 iPhone and 25,000 Android users (April 2012).
The user agrees to allow the application to send vehicle position information to the traffic centre; this supplies the road operator with floating vehicle data. In return the application user gets a number of personalised services including:

- major traffic alerts
- local information matched to vehicle location
- information about rest and service areas
- display of virtual VMS signs
- excess speed alert (not transmitted to police)
- allows collaborative feedback to signal incidents and the ends of events
- emergency phone contact with road operator and vehicle location given

VINCI operate this cooperative service under a relatively “closed” business model without other stakeholders except the mobile network communication provider. However, data flows within the system are complex and the model would not, necessarily, transfer to other national contexts.

**Discussion of Business Models**

Cost Benefit Assessment (CBA) has been used to justify cooperative system deployment. Whilst this provides a first general assessment of the potential of cooperative systems to address societal needs, its assistance in establishing a business case for a specific implementation is extremely limited. CBA is predicated on the possibility of expressing (at least) the most important effects in monetary terms but this is often not possible. CBA is a tool to measure efficiency, but decision makers will usually have a range of other objectives that have nothing to do with efficiency such as attracting positive publicity or serving a particular community.
Some additional key factors in business modelling and investment decision-making will include:

- Compatibility of the cooperative system application with policy objectives of the NRA
- Requirement for investment and availability of funding
- Technical and financial risk
- Legal issues including liability, privacy and data protection
- Institutional issues and required organisational changes
- Acceptability of business arrangements to NRA Stakeholders
- Public perception and reputational risk

There has been some limited analysis of business models in previous European projects (Safespot 2010) but the focus has been on relatively high-level strategic analysis. The Dutch national project SPITS (2011) has begun to deal with real-world complexity by using value webs (a more complex and realistic development of the linear value chain) and considering the “Business Canvas” tool (Osterwalder et al, 2010) to begin to summarise and analyse business models. The analysis to date has suggested that business models predicated on the installation of roadside beacons to provide short-range communication links do not appear to be viable.

Our analysis, however, has identified that services provided by cellular communication via in-vehicle Apps appear to offer a much more attractive proposition for National Road Authorities. Nevertheless, new questions are raised: using cellular communications means that consideration must be given to who will pay for the cost of data transmission. More work is required here, but it may be reasonable to assume that it could be borne by the users and it may be invisible to them as long as the data requirements are small in comparison to the data consumed by the user in other applications. Other options, such as cost-sharing between users and particular service providers, may also be possible.

As well as the “closed” business model of cooperative services such as that offered by VINCI, other options may be more appropriate in other national contexts. One possibility would be for the Road authority to install and operate a beacon communications infrastructure and a set of core services and to “open” the communications channels for third party services; this was the approach of the Road Traffic Advisor project (Stevens et al, 1996). Another option would be a more market-oriented approach to data and information in which information is supplied to a market and bought from a market but the market determines which cooperative systems are offered to users. This has some advantages:

- It potentially increases the user base (important for quantity/quality of data and information)
- The technical and financial risk is shared

NRAs usually have data/information and need data/information, and by operating a market, more options may be available, for example:

- The NRA may be in a position to supply unique data (possibly requiring enhancement to existing hardware, procedures or processing) and this can include information which is different (e.g. in timeliness or quality) than it needs for its own internal purposes. Supplying data or information to third parties could be a relatively simple and viable business model.
- The NRA may need information in order to (better) manage its network. With open systems it can buy exactly what it needs from large providers or data/information integrators
Nevertheless, there are challenges with such an approach:

- There could be security and resilience issue if NRAs become overly-dependent on third parties for services
- Limited lifetime of existing NRA data sources (such as loops) and hence revenue streams
- Need for new business models and organisational development by NRAs
- New markets may need to be created

The market for cooperative services is characterised by a large network effect and its take-off requires a minimum critical mass. Cooperative services are characterised by the need to involve several entities and such organisational cooperation is only viable if each derive benefit from the transactions involved. This makes it challenging to build compelling business cases for investment.

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References

COBRA (2012)  


