COBRA Cooperative Benefits for Road Authorities

ERA-NET ROAD

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Getting the most out of Intelligent Infrastructure

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Deliverable 5: Conclusions and Recommendations for Deployment of Cooperative Systems by Road Authorities

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Authors

Kerry Malone, TNO

Martijn van Noort, TNO

Jean Hopkin, TRL

Simon Ball, TRL

Philippe Nitsche, AIT

Isabela Mocanu, AIT

Project Co-ordinator

Kerry Malone

TNO, The Netherlands Organisation for Applied Scientific Research

Phone: +31 888 66859

Email: kerry.malone@tno.nl

TNO

Van Mourik Broekmanweg 6

PO Box 49

2600 AA Delft

The Netherlands

Revision and history chart

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0.2	2013-03-19	KM initial text
0.3	2013-04-03	Addition of TNO, TRL, AIT texts
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1.1	2013-09-03	Final Revisions based on feedback from PEB (KM)

Executive summary

The COoperative Benefits for Road Authorities study (COBRA), financed by the ERA-NET ROAD Mobility Program, investigates costs and benefits of deploying bundles of cooperative systems by Road Authorities, as well as business models for Road Authorities. The project focused on the deployment of 3 bundles of functions, assessing the benefits in terms of safety, traffic efficiency and environmental impact, as well their costs of deployment. The project considered two technology platforms for deployment of the bundles of cooperative systems: cellular and wireless beacons. The bundles investigated in the COBRA project are described in the box below. Bundle 3 is assumed only to be deployed using the cellular platform.

Bundles investigated in the COBRA project

1. **Local Dynamic Event Warnings**: Hazardous location notification, road works warning, traffic jam ahead warning and post-crash warning (eCall)
2. **In-Vehicle Speed and Signage**: In-vehicle signage, dynamic speed limits and Intelligent Speed Adaptation (ISA)
3. **Travel Information and Dynamic Route Guidance**: Traffic information and recommended itinerary, multi-modal travel information and truck parking information and guidance.

The project produced several deliverables, of which 2 are mentioned here:

1. The project developed a first version of the “COBRA tool” which provides insights into the costs and benefits of investments of cooperative systems. These insights are provided on the basis of a decision support tool which enables the costs, infrastructure savings (where applicable) and (monetised) benefits of cooperative services to be compared in various contexts.

2. This **Deliverable D5**, which synthesizes and extends the results of the project by providing an analysis of the business models for each bundle of Traffic Management functions, a quick scan of the legal aspects to address in deployment of the bundles and two migration paths of deployment by Road Authorities which integrates the conclusions from the business models and legal aspects.

Bundle 3 is different from bundles 1 and 2 in terms of legal aspects to address. This, combined with the assumption that bundle 3 will be deployed using cellular technology, leads to a separate analysis.

For **bundle 3**, it can be concluded that there are relatively few non-financial barriers (compared to bundles 1 and 2), and moderate to significant financial barriers. One aspect of the financial barrier could be addressed if the main cost component of in-vehicle operational cost can be reduced further to improve the benefit-cost ratio. The Road Authority has a strong business case in each of the three business models analyzed in detail, mainly because of the cost savings, assuming that it is acceptable, and feasible, to remove some of the existing roadside system, that is, the variable message signs that display traffic and travel information. Therefore the choice of business model largely depends on the extent to which the road authority wishes to remain in control of information provision to end users and the amount of effort the Road Authority is willing to put in. In some countries, It may also depend on policy views on the division between the public and the private sphere, and in some countries this choice may already have been made.

Bundle 3 provides information that also has as a secondary objective to improve traffic flow over the network. Information is provided to drivers; no regulatory information (i.e. information containing legal obligations or prohibitions for road users) is provided. Bundle 3 provides all of the primary information functions of dynamic route information panels (DRIPs), based on analysis of the DRIPs and roadside DRIPs and graphical route information panels (GRIPs).

Because the data provision only relates to traffic and travel information, this bundle is not safety-critical nor does it place requirements on drivers to follow the information provided. Therefore, these applications do not trigger enforcement issues. Liability issues can be limited for the Road Authority.

Whether data protection and privacy is an issue depends on how the service is implemented. Privacy issues arise if the individual or vehicle can be identified, based on the information from the driver or vehicle to the information provider. . In this case, measures must be taken to ensure data protection and privacy.

The case for **bundles 1 & 2** is less strong. Due to high in-vehicle and roadside investment costs, the costs far outweigh the benefits on the societal level. However, the Road Authority has a positive business case in all three business models. In the two wireless beacons business models analyzed, he will be facing significant initial investments, but these can be more than compensated by savings on the existing infrastructure (i.e., matrix signs) in later years.

Bundles 1 and 2 provide warnings and information that also concern 'regulatory signs' (i.e. signs intended to inform of special obligations, restrictions or prohibitions with which they must comply). Due to the more safety relevant nature of these bundles, conformity with current regulation in relation to road signs, enforceability, liability issues and data protection and privacy need to be addressed.

For all bundles, deployment requires actions at the national and international level.

At this point in time, safety relevant applications such as bundles 1 and 2 should be regarded as a complementary service and not as a substitute for road signage that is needed to provide safe roads to all drivers.

The analyses carried out in the COBRA project revealed that a positive business case for deployment of cooperative systems for the Road Authority can be made in some circumstances. Getting to this business case involves addressing both financial and non-financial issues.

A "good" choice of a business model by a Road Authority requires positive business cases for all actors involved in deploying the Cooperative Service. Taking this perspective to the opposite extreme, a Road Authority that chooses the business case that is very positive but means that other actors needed to deliver the service have negative business cases, chooses a path that will doom the deployment of cooperative systems. Simply said: a great business case for the Road Authority may mean a very unattractive business case for another partner. A good choice of business model and Case requires the simultaneous examination of the business models and cases of all the actors needed in deploying cooperative systems

The migration paths reveal actions that the Road Authority can take. At the national and international level legal aspects can be addressed. The Road Authority can investigate the financial and non-financial issues mentioned above. It can investigate which cooperative systems provide services would be most relevant to its goals. It can determine what role it will choose to play in deployment. Furthermore it can determine what role it will choose to play in deployment and it can explore the paths for deployment that result, both in financial and non-financial terms.

In financial terms, Road Authorities that have already invested significantly in existing roadside infrastructure face a more difficult challenge in justifying the investment in cooperative system infrastructure. These Road Authorities will need to build a case for an "in-vehicle service" requiring short and medium term investment and thus an increase in costs with potentially little benefit in the short term above that which has been achieved from the existing road side infrastructure. This may make it difficult to raise funds for these types of services. A careful analysis of investment in new infrastructure and possible reduction in the existing roadside infrastructure over time is required to build the case.

Calculating impacts using the COBRA tool reveal that motorways are often already relatively safe and have a relatively high traffic efficiency. In comparison to other road types, motorways have smaller gains to realize. To achieve higher impacts on a broader geographic scale, and simultaneously to reduce costs, Road Authorities can look for synergies in deployment with other Road Authorities at the provincial and urban levels to achieve impacts on more than one type of road. The synergy is to use applications on a common platform, or even common applications, thus realizing shared costs.

Table of Contents

Table of Figures

Table of Tables

1 Introduction

1.1 Background of COBRA

Cooperative Systems are expected to play a critical role in enabling safe, smart and clean transport. There is today a general understanding of the benefits of cooperative systems but there is still a need for further validation of the estimated benefits based on large scale trials. Progress on standardisation and the design of communication systems and components are now mature enough for large-scale field operational tests, such as those that are taking place in projects like DRIVE C2X and FOTSIS in the EC 7th Framework Program.

Several definitions of cooperative systems exist [5]. The definition from from the EC Mandate M/453 suffices: "Cooperative Systems are Intelligent Transport Systems based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I, I2V) and infrastructure-to-infrastructure (I2I) communications for the exchange of information. Cooperative Systems have the potential to further increase the benefits of ITS services and applications." 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, thus contributing to road operators' objectives.

Cooperative Systems can provide traffic management services now provided by Road Authorities. Cooperative Systems confront Road Authorities with the question of whether they should continue to invest in "existing" traffic management and traffic information infrastructure, or to invest in cooperative systems. This decision is complex. Several aspects play a role in this decision, such as costs and benefits, return on investment, expected deployment of ITS, the decisions of other actors, and legal and privacy issues.

The COBRA project aims to assist Road Authorities by supporting this decisionmaking, with the goal of helping the Road Authorities to position themselves to optimally benefit from the developments in the field of cooperative systems and stay connected to in-car developments.

1.2 COBRA Project Approach and Delivered Results

The COBRA proposal [1] defined six objectives to be achieved in the project. These are:

1. To assess the state of the art about the deployment of cooperative services (CS) and the roles for various actors, among which the Road Authorities.
2. To set up a methodology for the impact assessment of CS on traffic flow, traffic safety and emissions.
3. To analyse the impacts of CS based on real world implementations.
4. To assess the costs and benefits of deployment of CS and road side infrastructure that is required, compared to existing ITS-systems.
5. To analyse the legal issues that play a role around the implementation of CS.
6. To produce a set of clear recommendations for Road Authorities about the actions to take to enable the deployment of CS, including a roadmap to overcome possible barriers of implementation.

Five Work Packages were defined in order to go through a logical sequence of steps to achieve these objectives. Figure 1 illustrates the Work Packages and the relationship among them.

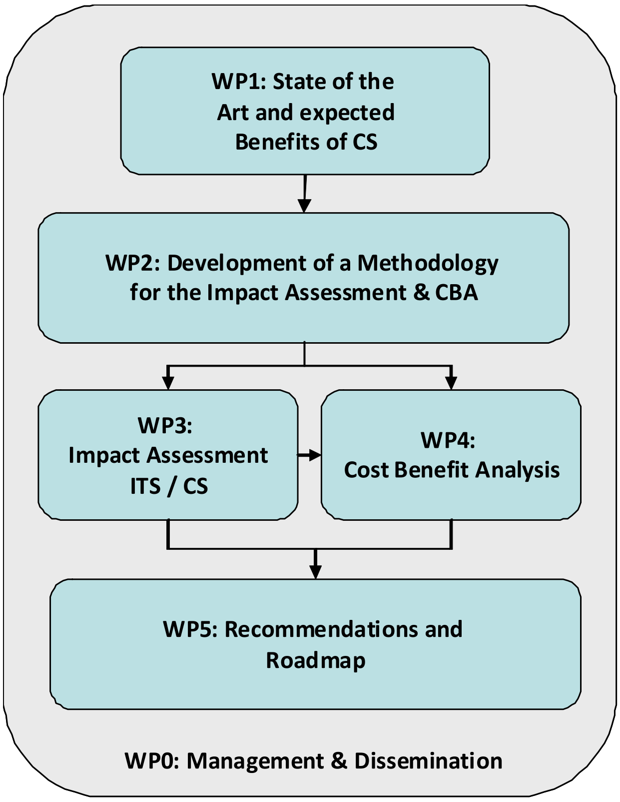

Figure 1: Work Package Overview of COBRA

The COBRA project produced several results to assist Road Authorities in making decisions about cooperative systems. Table 1 describes the work carried out in each Work Package and the results achieved.

Table 1: Overview of Results achieved in COBRA

Type of Result	Description	Results
Deliverable	An overview of the 'state of the art' about the deployment of cooperative systems and the roles for various actors, among which the Road Authorities.	Deliverable 1: State of the Art report
	An overview of requirements for decision making on the deployment of cooperative services and intelligent infrastructure.	Deliverable 2.1: Methodology Framework for the Impact Assessment
	Description of the impact assessment. Definition of services and bundles to be examined in project.	Deliverable 2.2: Initial Decision Support Tool
	Literature review of impacts of cooperative systems in the areas of safety, environment and sustainability, traffic flow and mobility. Integration of findings and estimation of impacts at the bundle level.	Deliverable 3: Impact Assessment
	Creation of the first version of the COBRA tool, described in COBRA Deliverables 4.1 [3] and 4.2 [4]: It provides insights into the costs and benefits of investments of cooperative systems. These	Deliverable 4.1: Example Results of Cost Benefit Analysis Deliverable 4.2: Tool User Guide

	insights are provided on the basis of a decision support tool which enables the costs, infrastructure savings and (monetised) benefits of cooperative services to be compared in various contexts.	COBRA Tool
Meetings with Stakeholders	Stakeholder Workshop to discuss prioritize the functions to analyse in COBRA. With CEDR.	Stakeholder workshop with CEDR working group 14. (19 01 2012)
	Demonstration of early version the COBRA tool to solicit feedback.	Meetings with Road Authorities (UK, the Netherlands, Austria) to test tool in early phase (November – December 2012)
	Demonstration of COBRA Tool with Road Authorities of the ERA-NET PEB members. Consult with ERA-NET PEB members on tool functions.	Demonstration and Workshop with COBRA ERA-NET. PEB members (06-03-2013)

This **Deliverable (D5)** synthesizes and extends the results of the project by providing an analysis of the business models for each bundle of Traffic management functions, a quick scan of legal aspects to address in deployment of the bundles and two migration paths of Deployment by Road Authorities which integrates the conclusions from business models and legal aspects.

1.3 The COBRA tool

The tool is a spreadsheet which enables National Road Authorities to compare the costs and monetised benefits of cooperative systems in various contexts to support investment decisions under different deployment scenarios. These deployment scenarios are for cooperative systems which are implemented in addition to any existing services base on roadside infrastructure. It also enables the business case to be investigated for delivering services under different business models, in which the Road Authority has different degrees of responsibility for setting up and operating the services.

The tool enables Road Authorities to consider investment in cooperative systems involving communication between vehicles and infrastructure to deliver services in three 'bundles' of functions. The bundles are listed below; further details are provided in Section 2.3 of the User Guide [4] and Devlierables D2 and D3 [2,6].

Bundles investigated in the COBRA project

1. **Local Dynamic Event Warnings**: Hazardous location notification, road works warning, traffic jam ahead warning and post-crash warning (eCall)
2. **In-Vehicle Speed and Signage**: In-vehicle signage, dynamic speed limits and Intelligent Speed Adaptation (ISA)
3. **Travel Information and Dynamic Route Guidance**: Traffic information and recommended itinerary, multi-modal travel information and truck parking information and guidance.

For the first and second of these bundles, the options within the tool enable users to choose between two communications platforms for delivery: cellular network communications (e.g. mobile phone) or wireless beacons at the roadside. The third bundle is unlikely to be deployed using wireless beacons so cellular is the only communications platform offered for this bundle.

The tool can be used in several different ways, including:

- Help decision-makers in national Road Authorities to make top level investment decisions which can then be used to define further more specific investigations into the services which appear to offer the greatest potential
- Support local decisions, e.g. on investment for a specific route or region
- To explore the potential for using cooperative systems to replace existing infrastructure-based services

- To assess the relative impact of key parameters, providing an understanding of which factors have the greatest and least influence on the business case
- To investigate different business models for delivery, with varying roles for the Road Authority and the private sector
- To assess the potential impact of changes affecting deployment (such as an EC mandate on equipping vehicles).

This version of the tool includes data for the UK and The Netherlands as examples. An 'Additional Country' area of the tool has been set aside in which users can insert data for another country or a specific route or region. Details of the information required are provided in the Appendix to the User Guide[4].

Although based on the best available evidence, the tool includes many assumptions and parameters; these can be readily updated as better information becomes available. However it is important to use the tool with care – it is intended to provide an input into decision-making, but not to provide the sole basis for investment decisions. The tool could, in the future, be expanded and enhanced to take account of future developments and the availability of additional information.

1.4 Structure of the deliverable

This deliverable has the following structure. Chapter 2 describes the methodology followed in the project. Chapter 3 presents an application of a selection of business models for the bundles, and discusses their consequences. Chapter 4 explores on the legal aspects identified in deploying the three bundles examined in detail in COBRA. Chapter 5 proposes migration paths for deployment of the bundles of cooperative systems, integrating conclusions from the business model analysis and the scan of legal aspects. The report draws overall conclusions and makes recommendations in Chapter 6. The Appendix contains the quick scan of legal aspects to consider in deployment of cooperative systems.

2 Methodology

This chapter on Methodology explains the framework chosen in which to carry out the analysis. It consists of four major components: bundles (Section 2.1). Business Models (Section2.2), Legal Aspects (Section 0) and migration paths (Section 2.4).

2.1 Bundles

Three bundles of cooperative services are considered in COBRA:

- Bundle 1: Local dynamic event warnings
- Bundle 2: In-vehicle speed and signage
- Bundle 3: Information services

This section briefly describes the bundles. For more extensive descriptions the reader is referred to COBRA deliverable D2 and D3 [2, 6].

2.1.1 Bundle 1: Local Dynamic Event Warnings

- Hazardous location notification (incl. slippery road, fog, obstacles, car breakdowns etc.)
- Road works warning
- Traffic jam ahead warning
- Post crash warning/eCall

These are primarily safety functions. Hazardous Location Notification provides a warning notification about potential hazardous areas when approaching these areas, and aims to increase driver attention. It has a particular benefit in dynamic situations such as changing weather conditions.

Carrying out repairs on a motorway usually involves temporary speed limits, lane changes, lane merges and contra flow running which are managed by temporary signs and portable physical barriers to divide lanes. A linked vehicle-infrastructure system for road works warning offers much more flexibility, enabling faster reconfiguring of the work zone and allows precise alerts and instructions to drivers regarding lane choices, speeds, too-close following of preceding vehicles etc.

The traffic jam ahead warning function warns drivers when approaching the tail end of a traffic jam. It will cause drivers to be more aware of the situation ahead leading to lower speeds, longer headways and a reduced risk of rear-end collisions.

If sensors in the vehicle detect a collision, the eCall system in the vehicle automatically makes a 112 call to the emergency services to give the incident location and provide information about the vehicle and its location. The system opens voice and data channels so that the emergency call centre can talk to the driver or any passengers if they are conscious.

2.1.2 Bundle 2: In-vehicle Speed and Signage

- In-vehicle signage
- Intelligent Speed Adaptation
- Dynamic speed limits

In-vehicle signage uses a vehicle-infrastructure link to provide information or a warning to a driver of the content of an upcoming road sign. This can be extended to inform drivers about other oncoming features of the road such as curves, roundabouts, traffic calming installations and road markings such as segregated cycle lanes or bus lanes. This application is often referred to as visibility enhancement - giving the driver information about situations beyond or outside the direct line-of-sight.

Intelligent Speed Adaptation (ISA) is a system that monitors a vehicle's speed and speed limits on road segments and intervenes if the vehicle is detected as exceeding the speed limit. An ISA system can have additional features to influence driver's behaviour by, for example, a haptic accelerator pedal. Three types of ISA can be distinguished:

- Informative - case in which the driver receives information about the speed limit and various types of warning signals (audio, video);

- Warning – where the driver is alerted of exceeding the speed limit through an active warning, e.g. haptic accelerator pedal; and
- Intervening – in case of exceeding speed, the system takes over and limits the speed through automated braking;

In COBRA, only the first two types of ISA were assessed, as the resistance to the Intervening version is strong. The first type is considered to correspond to the cellular platform while the second type corresponds to the wireless beacons platform.
Speed limits are set on a road segment according to the infrastructure (e.g. geography, road alignment, etc.), type of road, traffic flow and other factors. Dynamic speed limits have the advantage of being more flexible. They take into account traffic flow in different conditions and times of day, weather conditions and other environmental factors.

2.1.3 Bundle 3: Travel Information and Dynamic Route Guidance

This bundle consists of the services:

- Traffic information and recommended itinerary
- Multimodal travel information
- Parking information and guidance

This function recommends a route for the vehicle navigation system to direct the driver around congested locations and dangerous roads and to distribute the traffic load on alternative routes.
The multimodal travel information function aids drivers by providing information regarding travel time, schedules and routing information door-to-door by using different types of sources such as built-in vehicle devices, the internet, mobile devices, etc. This function is approximately the same as an Advanced Traveller Information System.
The parking information and guidance function is a service provided to drivers who need a parking place. It monitors the number of available places in a parking facility, detects the location of vehicles in real time, finds a parking place and provides routing information on how to reach the reserved place. The payment is organized automatically.

2.2 Business Models

The COBRA business models describe the roles of the various stakeholders in the deployment and operation of the three cooperative bundles. This description covers the cooperative service and organizational and financial aspects. Another part of this description is a value web, which shows the flows of services, money and non-monetised value between the main stakeholders involved in a service (whether as providers or users). The inclusion of flows of societal benefits is a difference from a usual value web as used for private companies' business cases, which only includes flows of money, goods and services. However, since Road Authorities have a public role, it is appropriate to include societal benefits as well in this case.

The services are described in section 2.1. Organizational and financial aspects will be described in chapter 3, and will cover the following aspects:

- **The societal costs and benefits**. In the COBRA project it is assumed that the societal costs and benefits of a bundle do not depend on the business model[1]. It is important to describe this aspect, because if the societal benefits are higher than the costs, then in principle a business model is possible where every stakeholder involved will gain, in the sense that all private stakeholders have a positive business case, and the public stakeholders will too if monetized societal costs and benefits are taken into account. If on the other hand the societal costs are higher than the societal benefits, then at least one stakeholder will lose.

[1] In reality they may depend on it, for example if one business model is more efficient than another. It is however assumed that this is a secondary effect, and therefore it is not taken into consideration.

- **The monetary costs and benefits to the Road Authority**. This is the business case of the Road Authority, in real money. That is, societal costs and benefits are not taken into account, and only the cash in- and outflows of the Road Authority are considered. This reflects the distribution of monetary costs and benefits between the Road Authority and other stakeholders. This aspect is of importance to those Road Authorities for whom cooperative services are a way to cut spending.
- **The organizational complexity**. This describes how difficult it is to set up the cooperation or collaboration between stakeholders, and set up agreements and contracts, and in general perform all the organizational steps in order to implement the business model.
- **The role of the Road Authority including its span of control**. This describes the role of the Road Authority and the level to which it exercises control over the operation of the cooperative services – for example, to which extent it controls the information that is communicated to the drivers.
- **The Road Authority's tolerance for societal problems**. In case the business model includes a phasing out of existing roadside systems, societal problems like congestion or accident risk may increase for some or all road users. This aspect describes the extent to which such negative consequences are likely to appear, and if so, the societal costs of these consequences that a Road Authority may take into consideration.

The business models generally fall into three deployment contexts:

- Public: Road Authorities want to guard societal values (like level of service, accident avoidance and emission reduction) and therefore are in control of guidance and control of traffic flows.
- Private: the role for Road Authorities is limited to enabling market parties to provide cooperative services to end users.
- Mixed: Road Authorities and market parties cooperate to realize cooperative services, combining optimal individual freedom with guidance where social preconditions are not met.

In a public model, the Road Authority is responsible for delivering the cooperative service to the end user, and the service is usually paid from tax revenues. In a private model, a market party is responsible for the service delivery to the end user, who usually has to pay a fee. If the private service performs a task for the Road Authority, then the business model may include quality agreements or level of service specifications. In a mixed model, such agreements may also be put in place to specify the collaboration.

It should be noted that this terminology is not pinpoint correct because the role of Road Authority can be fulfilled by a private party, like the toll motorway operators in France. Such a Road Authority will have a different business model than a public one, because his goals are different. Indeed, societal goals are external goals for a private Road Authority, laid down in contracts or motivated by monetary or public relations concerns (e.g. cost reduction of incident management, or a "safe" image), while for a public Road Authority they are the internal goals of the organization itself. As the majority of roads is publicly operated, the business models will focus on this setting, and the terms "private" and "public" will be used for brevity. The business models can be adjusted to the case of private Road Authorities with rather little effort.

The subsections below describe the business models one by one. Not every business model is applicable for each bundle, and each business model applies to only one communication platform. A summary of this and other key parameters of the business models can be found in Table 2.

Table 2: Overview of the business models that can be selected, showing who pays which costs (both capital and operational). Costs are attributed to RA = Road Authority, O = other party, - = not applicable.

Business model	Type	Platform	Bundles	In-vehicle device	Wireless beacons	Back office	Application development
BM1	Public	Cellular	All	O	-	RA	RA

BM2a	Mixed	Cellular	All	O	-	RA	O
BM2b	Mixed	Cellular	All	O	-	O	O
BM3	Mixed	Cellular	3	O	-	O	O
BM4	Private	Cellular	3	O	-	O	O
BM5	Public	Beacons	1, 2	O	RA	RA	RA
BM6a	Mixed	Beacons	1, 2	O	O	RA	RA
BM6b	Mixed	Beacons	1, 2	O	RA	RA	O
BM7	Private	Beacons	1, 2	O	O	O	O

2.2.1 *Business model 1: Free Road Authority app*

Business model 1 is a public business model and applies to the cellular platform and all bundles. It describes a Road Authority that controls all aspects of information and warning provision. The value web is shown in Figure 2. In this value web, flows of goods, services, money and societal benefits are indicated by arrows, and stakeholder roles are shown in boxes. A single organization may perform multiple roles. In this model the Road Authority is investing in an application, helpdesk and service. These services are provided to drivers, in this figure via a traffic control centre. The traffic control centre is providing warnings and the application itself to drivers for free. The communication provider is providing the driver with the necessary cellular data communication bundle. The drivers pays for this (e.g., a monthly fee). Optionally the traffic control centre receives floating car data (FCD) from the drivers in return for the free application and warnings.

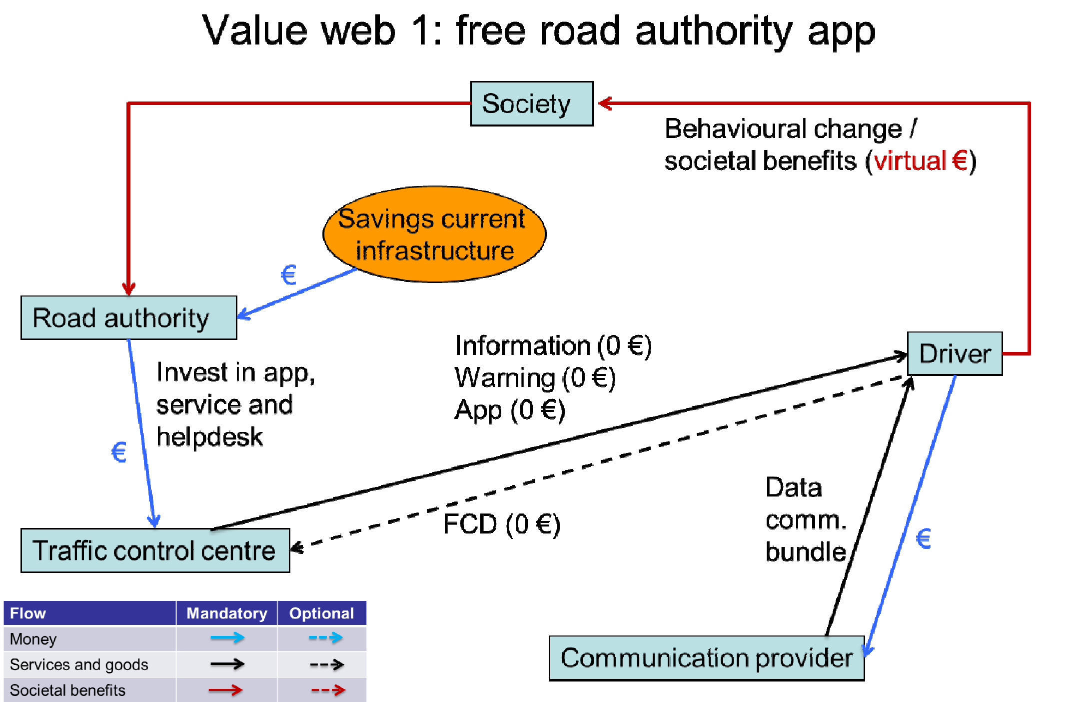

Figure 2: Value web for business model 1, applicable to all bundles and to the cellular platform.

A value web shows the relations between the stakeholders. In this business model the relationships between the stakeholders are as follows:

<u>Between Road Authority and Traffic control centre</u>

The <u>Road Authority</u> invests in the development of an app, and in the underlying service and the helpdesk. The app is able to receive the warning messages and show it to the driver when approaching a local dynamic hazard. The service generates and sends out the warning messages. It uses traffic data from detection loops and FCD to do this.

<u>Between Traffic control centre and Driver</u>

The traffic control centre provides and app and warnings to the drivers for free. Drivers can download the app through the app store from the different smart phone providers. In return, the floating car data that is collected through smart phones is sent to the traffic control centre.

<u>Between Driver and Communication provider</u>

The communication provider is a telecommunication operator, operating a cellular network (CN scenario). In this scenario the communication required for the service is assumed to fit within the driver's data communication bundle. The driver pays a monthly fee and can use the network to transfer a certain amount of data.

2.2.2 Business model 2a: 1€ commercial app

Business Model 2a is a mixed business model and applies to a cellular platform and all bundles. In this value web, see Figure 3, the Road Authority invests in an application, helpdesk and service. These services are provided to drivers via a traffic control center and a commercial application provider. The app provider provides an inexpensive app to road users. The Road Authority provides an information and warning service to drivers for free.

The app provider receives floating car data from the drivers and optionally enriches this data into traffic information for the Road Authority, in exchange for a fee. The delivery of floating car data from drivers to the app provider can be seen as delivering value in kind. The communication provider is providing the driver with the necessary cellular data communication bundle. The drivers pays for the data communication bundle (e.g., a monthly fee).

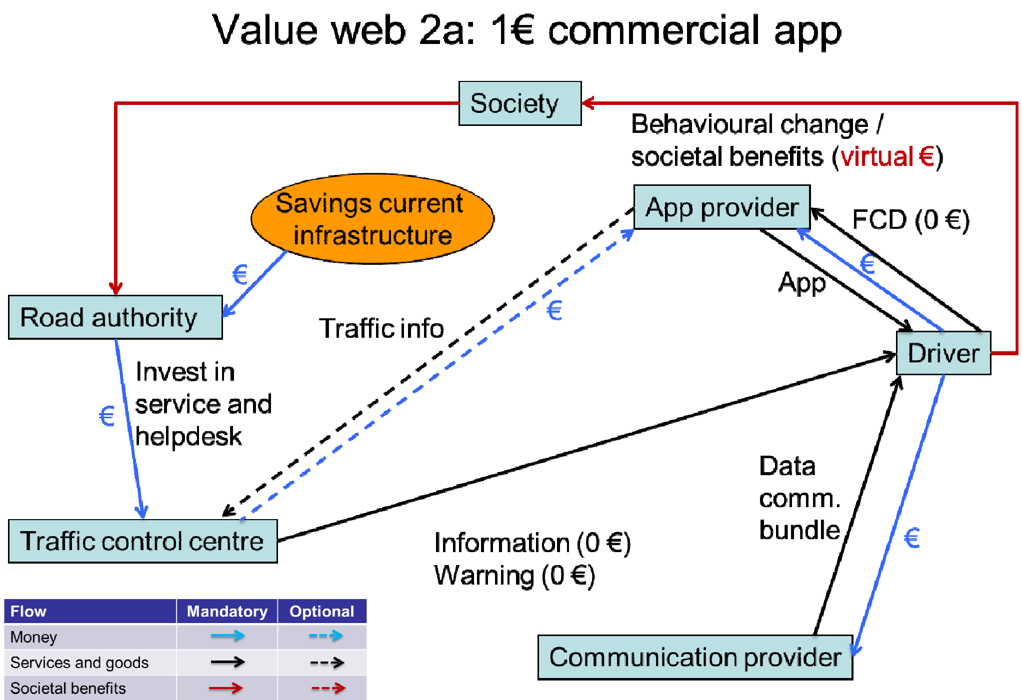

Figure 3: Value web for business model 2a, applicable to all bundles and to the cellular platform.

2.2.3 Business model 2b: Extended navigation

Business Model 2b is a mixed business model and applies to a cellular platform and all bundles. This value web, see Figure 4, is very much like business model 2a, except that the navigation service provider replaces the commercial app. provider. In this value network the Road Authority invests in a helpdesk and service. Information and warning services are provided to drivers via a traffic control center and a navigation service provider. The navigation service provider provides a service via nomadic or aftermarket devices to road users, and includes the Road Authorities' warnings and information in this service.

The navigation service provider receives floating car data from the drivers and optionally enriches this data into traffic information for the Road Authority/traffic control center, in exchange for a fee (in kind and/or monetary). The delivery of floating car data from drivers to the navigation service provider can be seen as delivering value in kind. The navigation service provider delivers value to the driver by providing the Road Authorities' warnings and information. The communication provider is providing the driver with the necessary cellular data communication bundle. The navigation service provider pays for this communication bundle (e.g., a monthly fee).

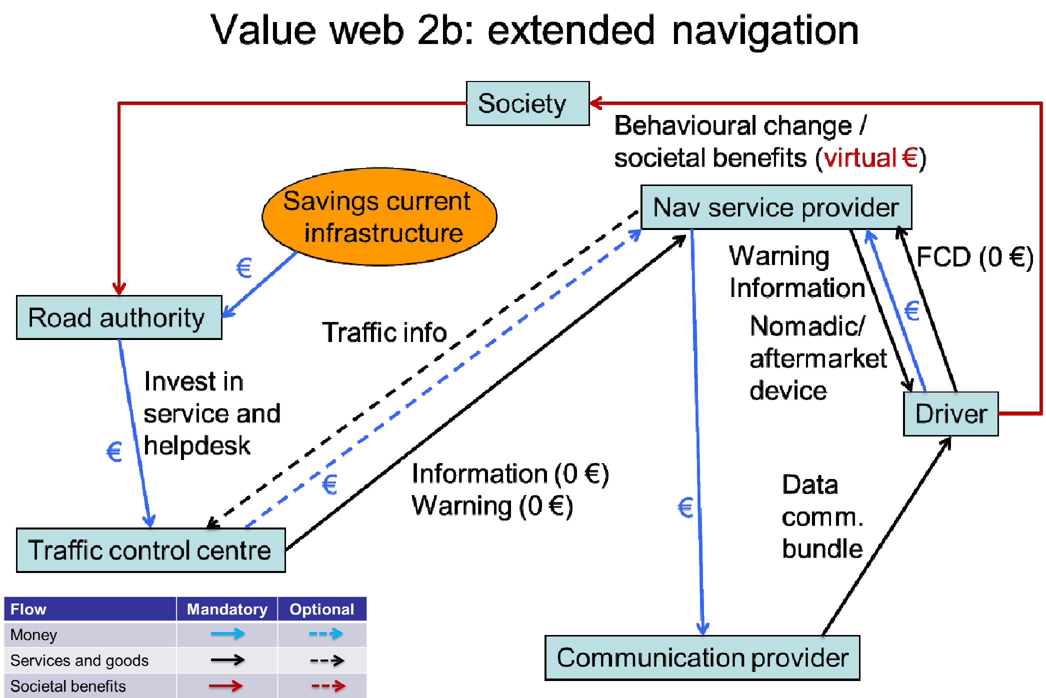

Figure 4: Value web for business model 2b, applicable to all bundles and to the cellular platform.

2.2.4 Business model 3: Public travel time information

Business Model 3 is a mixed business model and applies to a cellular platform and bundle 3. The value web, see Figure 5, is very much like business model 2b, except that the Road Authority (via the traffic control center) provides real time travel times rather than information and warning messages to the navigation service provider. The navigation service provider uses these travel times to provide a route advice service via nomadic or aftermarket devices to road users. As the Road Authority only provides travel times and no warnings or information messages, this business model applies only to bundle 3.

The navigation service provider receives floating car data from the drivers and optionally enriches this data into traffic information for the Road Authority/traffic control center, in exchange for a fee (in kind and/or monetary). The delivery of floating car data from drivers to the navigation service provider can be seen as delivering value in kind. The navigation service provider delivers value to the driver by providing route advice. The communication provider is providing the driver with the necessary cellular data communication bundle. The navigation service provider pays for this communication bundle (e.g., a monthly fee).

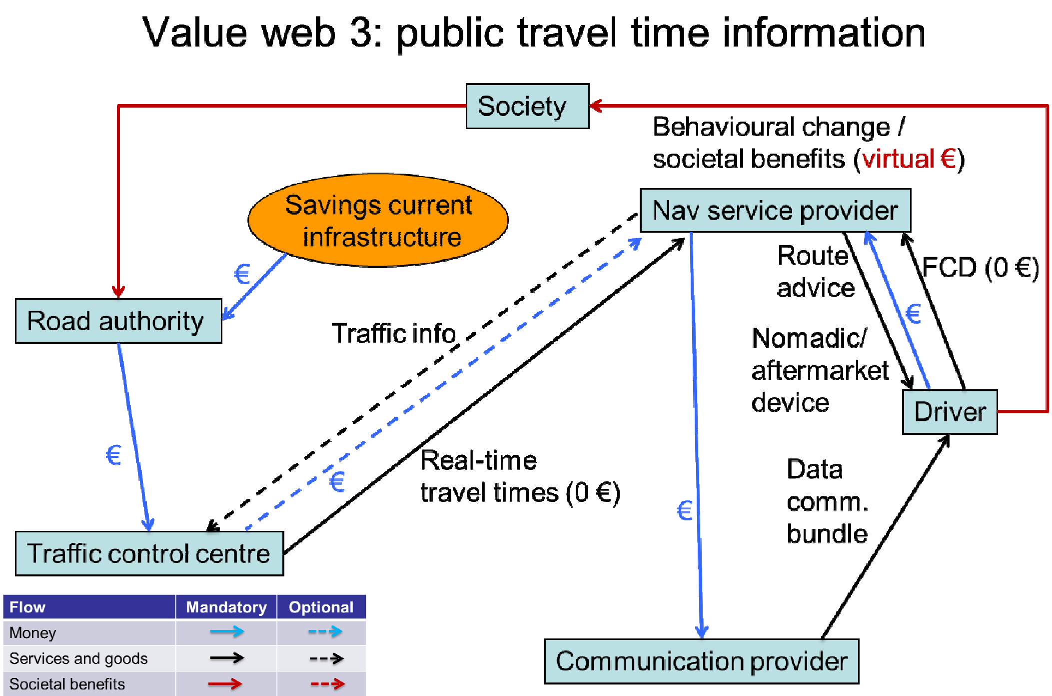

Figure 5: Value web for business model 3, applicable to bundle 3 and to the cellular platform.

2.2.5 Business model 4: Private dynamic navigation

Business Model 4 is a private business model and applies to a cellular platform and bundle 3. The value web, see Figure 6, describes a variant of an existing business model for traffic information provision by private navigation service providers. Via the traffic control center, the Road Authority provides loop detector data to the navigation service provider. The navigation service provider gives route advice to drivers. As no warnings or information messages are provided by the Road Authority, this business model applies only to bundle 3.

The drivers provide floating car data to the navigation service provider. This data is used by the service provider to enhance its route advice service. The delivery of floating car data from the drivers to the service provider can be seen as delivering value in kind. The communication provider is providing the driver with the necessary cellular data communication bundle. This bundle is paid for by the navigation service provider (e.g., a monthly fee).

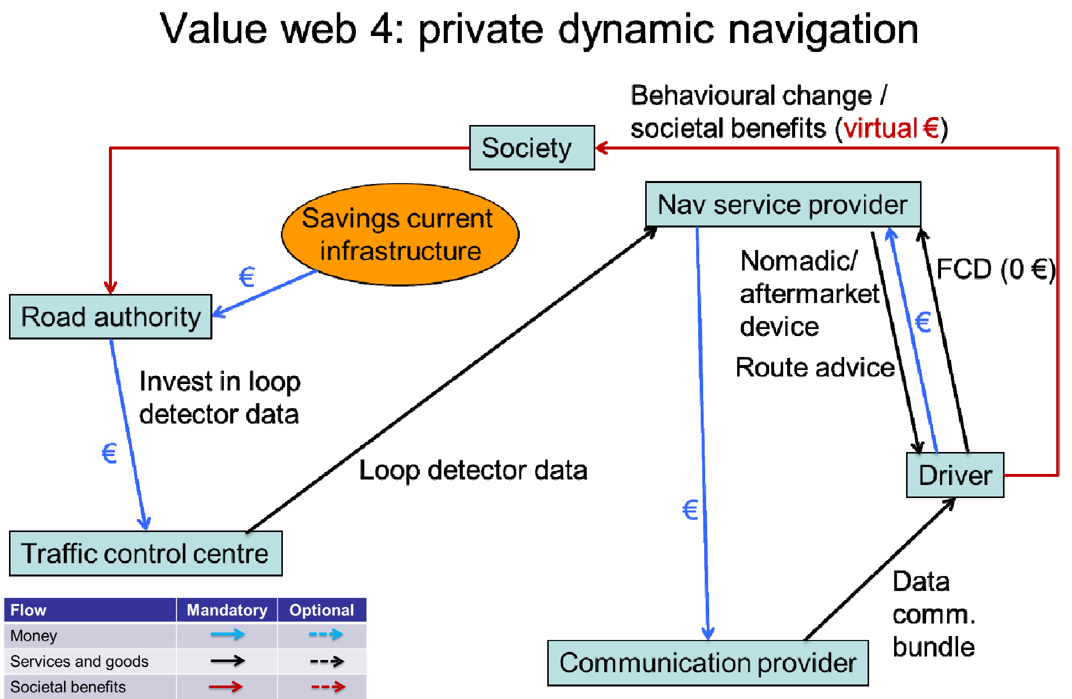

Figure 6: Value web for business model 4, applicable to bundle 3 and to the cellular platform.

2.2.6 Business model 5: Public roadside WLAN

Business Model 5 is a public business model and applies to a wireless beacons platform and bundles 1 and 2, see Figure 7. It represents the situation that the Road Authority installs, operates and maintains the roadside equipment (wireless beacons) for cooperative systems, and invests in the helpdesk and the cooperative warning and information services. These services are provided to the drivers by the traffic control center, while the wireless beacons are managed by the road infrastructure provider (this may be the Road Authority itself). In return, the drivers provide the Road Authority / traffic control center with floating car data, via the cooperative device built-in to the cars. Drivers buy these cars from vehicle manufacturers who deliver the car including the built-in cooperative module. Data communication is for free for the driver, and takes place between road side infrastructure and driver, and between road side infrastructure and traffic control center.

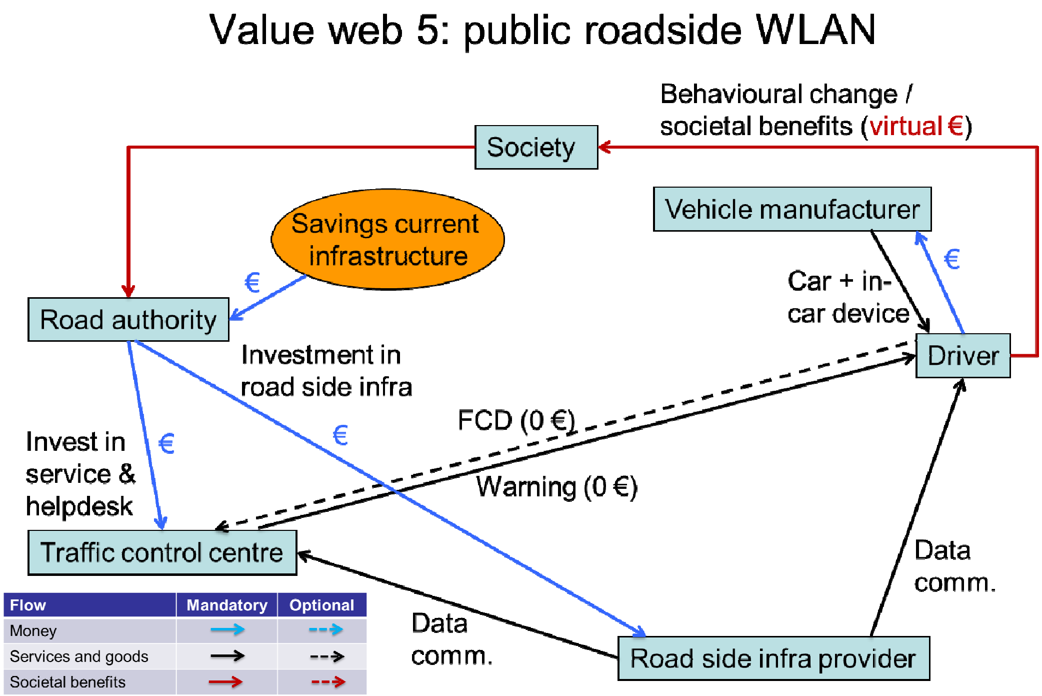

Figure 7: Value web for business model 5, applicable to bundles 1 and 2 and to the wireless beacons platform.

2.2.7 Business model 6a: Mixed with private roadside WLAN

Business Model 6a is a mixed business model with a privately operated roadside WLAN, and applies to a wireless beacons platform and bundles 1 and 2, see Figure 8. In this model, a privately owned company (e.g. a telecom provider) invests in road side WLAN infrastructure (802.11p based Wireless Local Area Network), while the Road Authority invests in a mobile application, service and helpdesk. The Road Authority provides a warning service towards drivers, while drivers optionally provide the Road Authority with floating car data in return, via a built-in platform in their cars. Drivers buy these cars from vehicle manufacturers who deliver a car including the built in platform. Data communication is for free for the driver, and takes place between road side infrastructure and driver, and between road side infrastructure and traffic control center.

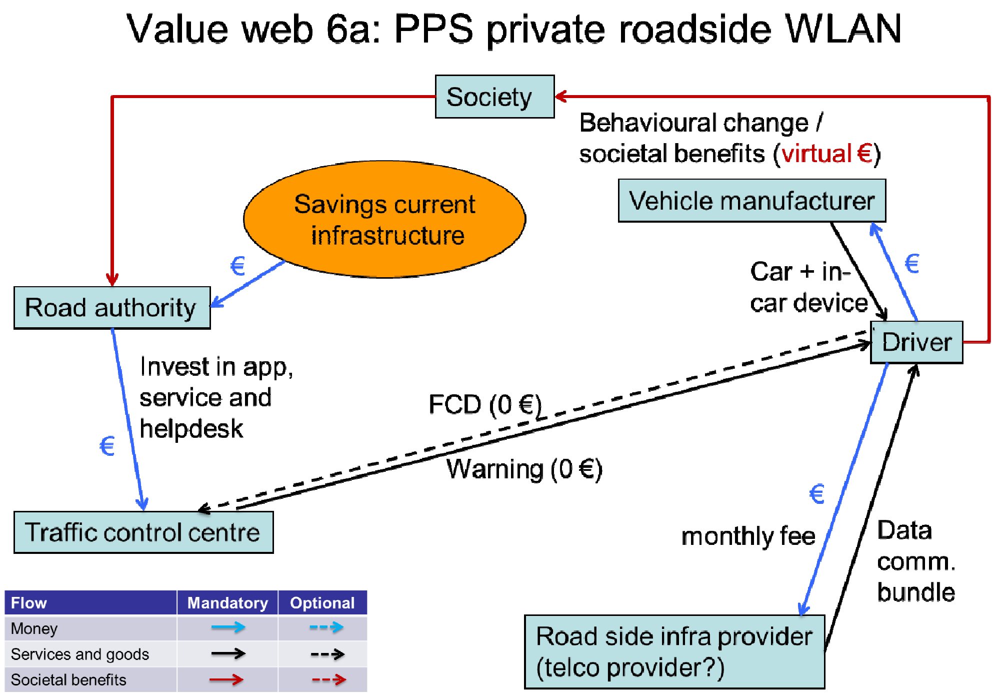

Figure 8: Value web for business model 6a, applicable to bundles 1 and 2 and to the wireless beacons platform.

2.2.8 *Business model 6b: Mixed with public roadside WLAN*

Business Model 6b is a mixed business model with a publicly operated roadside WLAN, and applies to a wireless beacons platform and bundles 1 and 2, see Figure 9. In this model, the Road Authority invests in road side WLAN infrastructure (802.11p based Wireless Local Area Network), service and helpdesk. A privately owned company invests in a mobile application which is open to messages from the Road Authority. The Road Authority provides a warning service to drivers on this application. Drivers provide their app provider with floating car data, which can be considered as payment in kind. Optionally the app provider can sell this data to the Road Authority. Data communication is provided by a public road side infra provider to both drivers and the traffic control center, at no cost to the driver.

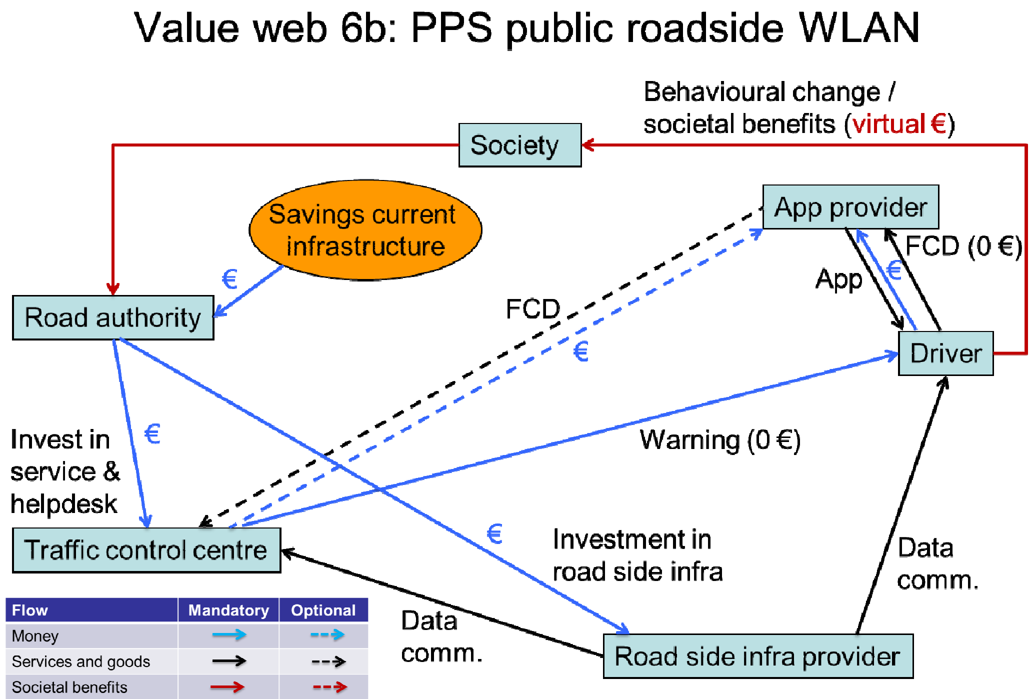

Figure 9: Value web for business model 6b, applicable to bundles 1 and 2 and to the wireless beacons platform.

2.2.9 Business model 7: Free Road Authority app

Business Model 7 is a private business model and applies to a wireless beacons platform and bundles 1 and 2, see Figure 10.

In this model, a vehicle manufacturer sells cars with built-in cooperative module plus the provision of cooperative services to drivers. Drivers pay a fixed price for the car and a monthly fee for the cooperative services to the manufacturer, who will in turn pay a monthly fee to a road side infrastructure provider in order for drivers to receive a data communication bundle, and a monthly fee to a navigation service provider who will provide information and warning services to drivers.

The road side infrastructure provider is a private party (e.g., a telecom provider) investing in road side WLAN infrastructure (802.11p based Wireless Local Area Network).

This could be run as a purely private model, without any involvement from the Road Authority. However, if this model is to replace the existing regulatory functions of bundles 1 and 2, then the Road Authority needs to be involved. This is indicated as an optional extension, where warnings and information from the Road Authority is provided to the driver via the navigation service provider. In return the navigation service provider provides his data to the Road Authority. These information flows could be paid for (in one direction or the other), or could be considered as a fair exchange without further payments. In this setting, the traffic management centre (or a separate entity) could act as a common back office for the generation of warnings and enriched data. The Road Authority may have to invest in the traffic management center to make this happen.

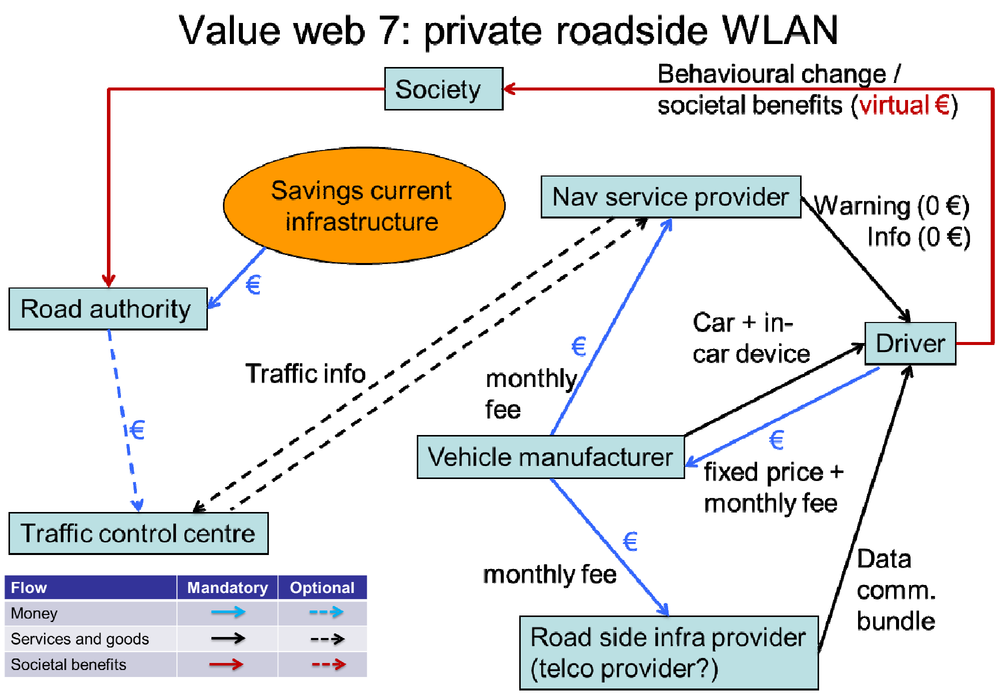

Figure 10: Value web for business model 7, applicable to bundles 1 and 2 and to the wireless beacons platform.

2.3 Legal Aspects

Introduction of cooperative systems (CS) to supplement or replace existing roadside systems requires careful examination of legal aspects. A quick scan of the legal aspects relevant for the deployment of CS, discussed in a consortium partners workshop on March 7, 2013, have been identified to be

- The legality of cooperative systems. The study examines the implications of the existing regulatory framework for in-vehicle provisioning of traffic management.
- The enforcement of cooperative systems. Some existing roadside systems concern regulatory signage. When these signs are provided in-vehicle, the issue of enforcement arises. Proof of the notification of drivers, issues of standards for and certification of systems and in-vehicle apparatus are issues to be addressed.
- Liability aspects of cooperative systems. The way in which CS are provided differs from existing roadside systems. CS are complex, involving several technologies. When some part of the delivery system fails, a complex liability situation is the result. The distribution of responsibilities in the chain of service delivery must be clear.
- Data protection and privacy. CS are data-intensive systems using data from public and private sources as well as the use of geo-localization technologies, resulting in the need to address data protection and privacy issues.

Chapter 4 discusses these legal aspects, and delves into specific issues in deploying the bundles.

2.4 Migration Paths

Migration paths were developed to indicate the actions that Road Authorities might take in the deployment of CS. The Migration paths developed in the COBRA project take into account the business models and legal aspects discussed in Chapters 3 and 4, illustrated in Figure 11.

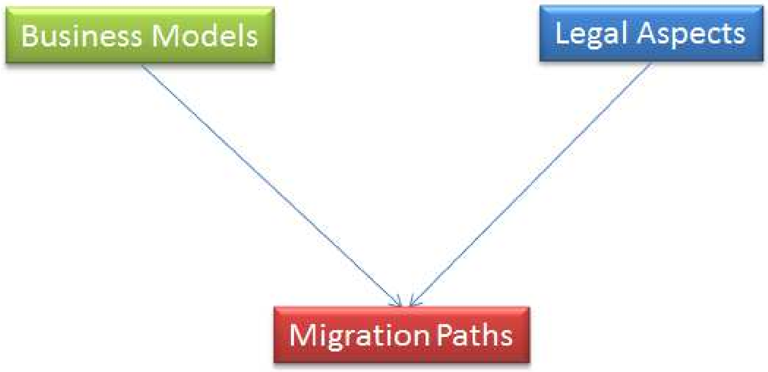

Figure 11: Migration Paths take into account Business Models and Legal Aspects

The migration paths take into account the specific business model and legal aspects identified for the Bundles, in the form of four criteria. These criteria were developed in an Internal Consortium Workshop on 7 March, 2013:

- Actions with **partners in deployment**: Road Authorities must make initial choices of the services to deploy, how to deploy them and with whom. The partners in deployment depend on the choice of *role* that the Road Authority wants to play, and the b*usiness model* to use in deployment.
- Actions to **deploy cooperative systems**: These actions concern planning when to start deployment of cooperative systems, phase out of existing systems and the actual deployment, in relation to other actions.
- Actions to address **legal issues**: These aspects include legality, enforceability, liability, and data protection and privacy aspects; and
- Actions to address **Standardization and other issues at the European level**: These aspects include issues such as requirements for in-vehicle equipment and legal issues above the national level such as changing law to allow the presentation of information in-vehicle.

2.5 Data Issues

The current version of the tool does not take into account the provision of Floating Car Data (FCD) by equipped vehicles. This precludes the option of replacing loop data by FCD. The reason why FCD was not taken explicitly into account was

- A high and reliable but unknown percentage of vehicles need to be equipped and providing data to replace this functionality provided by loops;
- If loops cannot be replaced, then other infrastructure needed in the transmission and processing of loop data also cannot be replaced. In the Dutch situation, this means that the controllers (detector stations and outstations) also cannot be replaced by cooperative systems.

3 Business Model

This Chapter investigates the implications of the choices for business model by Road Authorities when deploying cooperative systems. This investigation walks through several examples, showing how the qualitative and quantitative implications.

The business models will be investigated separately for bundle 3 and bundles 1 and 2. As described in section 2.2, they will address the following aspects of deploying the bundles:

- The societal costs and benefits
- The monetary costs and benefits to the RA
- The organizational complexity
- The role of the RA including its span of control
- The RA's tolerance for societal problems.

For each bundle, several applicable business models are investigated. These business models cover three main categories, namely:

- Public: Road Authorities want to guard societal values (like level of service, accident avoidance and emission reduction) and therefore are in control of guidance and control of traffic flows.
- Private: the role for Road Authorities is limited to enabling market parties to provide cooperative services to end users.
- Mix: Road Authorities and market parties cooperate to realize cooperative services, combining optimal individual freedom with guidance where social preconditions are not met.

Furthermore, a business can make use of cellular communication or wireless beacons. Finally, the cost savings option (i.e., phasing out of the existing roadside system) will be considered, as well as the sensitivity of the business case to the optional cost components of in-vehicle OPEX and CAPEX costs.

In the COBRA tool, there are three cost components that are affected by the business model, namely the cost of wireless beacons, the cost of creating or adapting a back office (for example a traffic management center) and the cost of developing the in-vehicle software application. The costs of in-vehicle devices, including the costs of communication and subscription to a service, are never borne by the Road Authorities, for any business model. These costs are assumed to be paid by other parties, like the end user or a commercial service provider.

The business models are briefly described in the subsections below. For more details the reader is referred to [2]. In the text below, the word "message" is used to mean either "information" or "warning". A variety of scenarios is analyzed in these subsections. Table 3 shows the definitions of these scenarios. The meaning of the column headings is as follows:

- **Figure**: figure number.
- **Bundle**: bundle identifier (1, 2 or 3). These are the bundle numbers introduced in section 2.1.
- **Business model**: business model identifier. These are the business model numbers introduced in section 2.2.
- **Platform**: C for cellular, WB for wireless, in which case the number shows the final deployment rate. Cellular is assumed to have 100% geographic coverage.

- **WB cost**: fraction of total cost of wireless beacons that is included in the scenario.
- **CAPEX**: amount of in-vehicle capital cost that is included in the scenario, as a fraction of the sale price.
- **OPEX**: in-vehicle operational costs in EUR / vehicle / year that is included in the scenario.
- **Phase-out in 2030**: Level of phase-out of the existing roadside system in 2030, as a fraction of the current deployment.

In a table cell, two entries separated by a semicolon indicate that scenario 1 uses the first value and scenario 2 the second one. Multiple entries in square brackets indicate that the outcome will be the same for all values; the first one is the one actually chosen in the file.

Some parameters of the tool are kept the same in all scenarios. For completeness they are listed here:

- Country: Netherlands.
- Aftermarket/Smartphone vehicle penetration curve: medium. This means that the penetration increases linearly over time, so that 59% of all vehicles is equipped with either an aftermarket device or a smart phone by 2030.
- OEM vehicle penetration curve: medium. This means that the penetration increases along an S-shaped curve over time, so that 26% of all vehicles is equipped with a built-in device by 2030.
- Start and end year for deployment of wireless beacons roadside units: 2012, 2030. The number of wireless beacons increases linearly from 0 in 2012 to the level specified in the table in 2030.
- Start year for the phase-out of the existing roadside system, for cost savings: 2015. The deployment level is kept constant until 2015, and then decreases linearly to the level specified in the table in 2030.

Table 3: scenario definitions for the figures shown in the subsections below. See the main text above for an explanation of the column headings.

Figure	Bundle	Business model	Platform	WB cost	CAPEX	OPEX	Phase out in 2030
Figure 12	3	[1 2a 4]	C	-	1/3	10	0%; 15%
Figure 13	3	1; 4	C	-	1/3	10	15%
Figure 14	3	2a	C	-	1/3	10	15%; 4%
Figure 15	1	1	C	-	1/3	10	0%; 15%
Figure 16	1	1	C	-	1/3	0	0%; 15%
Figure 17	1	[5 6b]	WB 10%; WB 30%	100%	1/3	0	0%
Figure 18	1	[5 6b]	WB 10%	100%	1/3	0	15%; 30%

Figure 19	1	[5 6b]	WB 10%	25%	1/3	0	15%; 30%
Figure 20	2	1	C	-	1/3	10	0%; 15%
Figure 21	2	1	C	-	1/3	0	0%; 15%
Figure 22	2	[5 6b]	WB 10%; WB 30%	100%	1/3	0	0%
Figure 23	2	[5 6b]	WB 10%	100%	1/3	0	15%; 30%
Figure 24	1	1	C	-	1/3	10	1%; 15%
Figure 25	1	5	WB 10%	100%	1/3	0	15%; 30%
Figure 26	2	1	C	-	1/3	10	1%; 15%

This chapter is organized as follows. Section 3.1 will do the analysis of bundle 3, which is in some ways the easiest bundle to address and is therefore discussed first. Section 3.2 will analyze bundles 1 & 2, and section 3.3 will present a summary and conclusion on the business models.

3.1 Bundle 3 Analysis

For the *Travel Information and Dynamic Route Guidance* bundle, only the cellular platform is available. The following business models are considered:

- BM1 (public): Free Road Authority app. The service is delivered by the Road Authority in the form of a free application for end users, without help from market parties, except for a cellular communication provider and an in-car hardware provider. The Road Authority adapts his traffic management centre to provide the information service to this application, and develops the software application which is made available to the end user free of charge. The in-car hardware (a smart phone or after-market device) and the cellular communication are not provided by the Road Authority.
- BM4 (private): Private dynamic navigation. The only role of the Road Authority is to provide traffic data (from induction loops) to service providers. A service provider provides an information service to the end user. The in-car hardware (a smart phone or after-market device) and the cellular communication are provided by private parties.This setup exists in the Netherlands.
- BM2a (mix): €1 commercial app. The Road Authority invests in adaptation of the traffic management center to provide the information service. The in-vehicle application is developed and deployed by a commercial service provider. The in-car hardware (a smart phone or after-market device) and the cellular communication are provided by private parties.

The effect of the business model on the attribution of costs is shown in Table 4.

Table 4: cost assigned to road operator for the business models considered for bundle 3

Business Model	Fraction of cost to RA

	In-car device, including operational costs	Roadside wireless beacons	Adapt back office	In-vehicle application development
BM1 - Free RA app (Cellular)	0%	N/A	100%	100%
BM4 - Private dynamic navigation (Cellular)	0%	N/A	0%	0%
BM2a - 1$ commercial app (Cellular)	0%	N/A	100%	0%

3.1.1 Societal costs and benefits

The societal costs and benefits of bundle 3 are shown in Figure 12, for the example of the Netherlands. Scenario 1 shows the case where the existing infrastructure remains at the present level, whereas scenario 2 is a cost savings scenario where 15% of the existing infrastructure is removed by 2030. In both cases the benefits outweigh the costs, though perhaps not enough to make for a very solid investment case. The differences are that in scenario 1 the societal benefits are higher, while in scenario 2 there is a modest cost savings. In both scenarios, the largest benefit is for travel times.

In both scenarios, investment costs of the in-vehicle device are included at 1/3 of the retail price (this is a rule of thumb for the typical societal cost), and modest operational costs are included of 10 EUR per vehicle per year for subscription and communication. As 90% of the total in-vehicle cost is operational, and this is by far the largest cost component, the socio-economic value of this bundle is highly sensitive to the annual subscription and communication costs. Should these costs double, then the benefit-cost ratio drops to 1 or even below 1. Should they disappear, then the benefit-cost ratio rises to a healthy value of more than 10 for both scenarios. As there is not much certainty regarding the true cost of communication and service subscription, it is hard to determine proper values for this scenario. In this deliverable, the annual cost of 10 EUR will be used as an example.

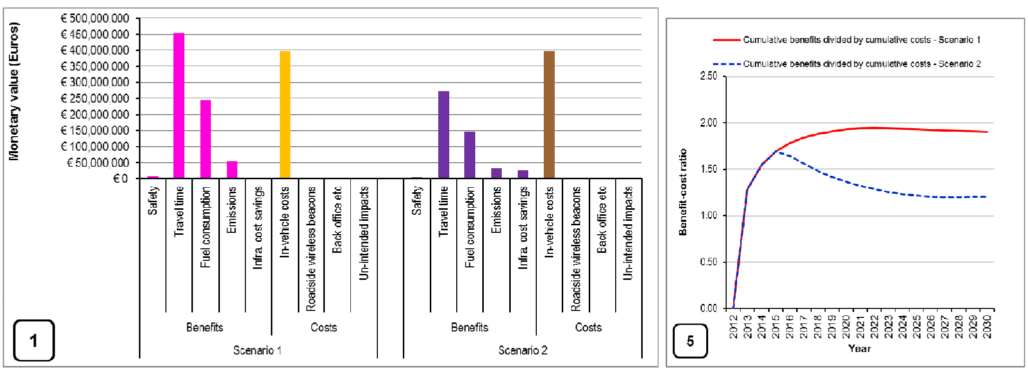

Figure 12: Left: societal costs and benefits of bundle 3 for the Netherlands, without infrastructure cost savings (scenario 1) and with (scenario 2). Right: cumulative cost-benefit ratio over time.

3.1.2 *Monetary costs and benefits to the RA*

As Table 4 shows, depending on the business model the Road Authority may have to pay for the back office adaptations or for the in-car software application development. If the existing system is not phased out, then the Road Authority has no monetary benefits. If its deployment is reduced by 15% like in the cost-benefit analysis, then the cost savings are much larger than the modest investments by the Road Authority. Figure 13 shows this for the case of business models 1 and 4, in the same setting as the CBA above. Business model 2a has the same level of benefits, and the costs are in between business model 1 and 4, see Figure 14. This figure also shows that even with a much more modest phasing out of the existing system of 4% by 2030, the business case for the Road Authority will be positive. Because the savings will massively outweigh the costs, there is little difference between the three business cases from the Road Authority's perspective.

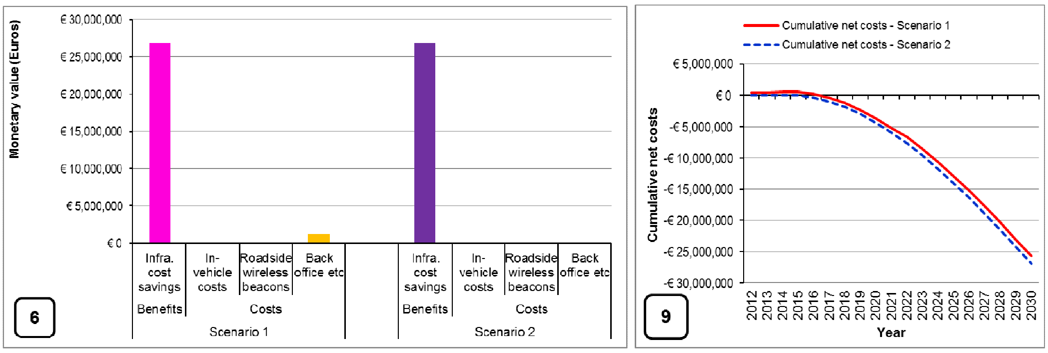

Figure 13: business case of bundle 3 for the Dutch Road Authority, for business model 1 (scenario 1) and 4 (scenario 2). Left: costs and benefits to the Road Authority. Right: net cost to the Road Authority over time.

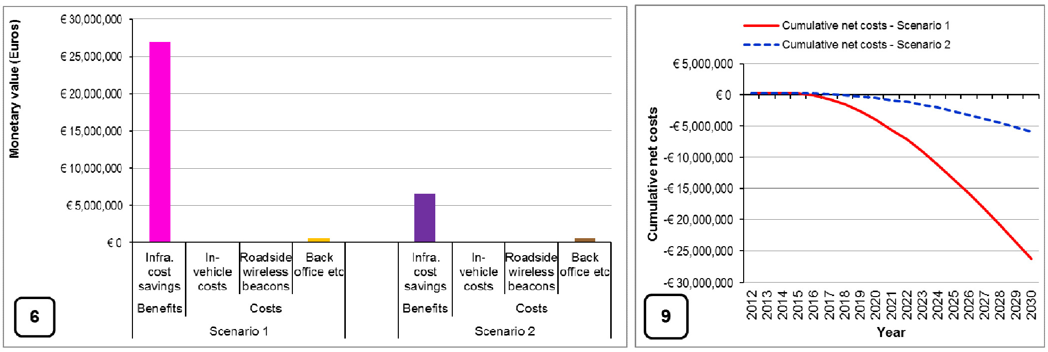

Figure 14: business case of bundle 3, business model 2a for the Dutch Road Authority, for a 15% phase out of the existing system (scenario 1) and a 4% phase out (scenario 2). Left: costs and benefits to the Road Authority. Right: net cost to the Road Authority over time

3.1.3 *Organizational complexity*

For business model 1, the organizational complexity is low, because no other parties are involved in the generation of the information. The only involvement is in well-established roles as communication provider and provider of an after-market in-car device or smart phone. As the information is not time-critical or safety-critical and not legally binding, no specific quality requirements need to be placed on these parties. In the Netherlands the Road Authority agreed to let private parties provide personalized travel information, and hence this business model is not applicable there.

Business Model 4 is more complex than business model 1, because both the Road Authority and commercial parties are involved in the generation of the information, which requires standardized traffic data transfer from the Road Authority to commercial parties. Replacement of the existing roadside system by a cooperative service may require a Level Of Service (LOS) agreement between Road Authority and private service provider if the Road Authority wishes to ensure a minimum quality of information delivered to the end user (e.g. for incident management). This is an existing business model in the Netherlands, as an additional service to the existing roadside system, where traffic data is made available through a National Data Warehouse for Traffic Information (NDW).

Business Model 2a is the most complex of the three because both Road Authority and private service provider develop part of the service. Hence there is a need for standardized traffic information transfer between these parties. This also creates a mutual dependence and thus may require LOS agreements in both directions.

3.1.4 Role of the RA including its span of control

The span of control of the Road Authority is high in business model 1, since the Road Authority has everything in its own hands, except the final delivery of the information to the end user – which depends on the end user having an in-car device with the application activated. This limitation is qualitatively similar to the limitation of the current roadside systems, where the Road Authority can merely offer the information, but not control whether the road user will receive or use the information in the desired manner. Quantitatively the difference depends on the number of equipped vehicles and the user acceptance of the cooperative service compared to the existing roadside system. All in all, it is expected that the Road Authority can to a large extent guide the traffic flow.

In business model 4 his role is limited to data provision and consequently his ability to influence the traffic is low. Indeed, the influence of the Road Authority on the content of the traffic information provided to the end user is limited. It may be possible to require the information to be "correct", but it seems unlikely that service providers would accept requirements for information to be in the public interest, especially when it goes against their clients' interest. Thus, some influence on the service quality can be exercised via an LOS with private service providers, stipulating data provision by the Road Authority under condition of performance by the service provider. The Road Authority needs to ensure a level playing field for all service providers by granting access to the traffic data in an impartial way.

In business model 2a, the role of the Road Authority is between the previous two models. By providing the back office functionality the Road Authority can control the information provided to the end user based on Road Authority data. However, he does not control whether and how this information is presented to the end user, nor which other information is presented in the same context. As in business model 4, the Road Authority can make his traffic information available to the service provider under certain quality requirements. Since the service provider depends on processed information from the Road Authority, the Road Authority may be held to certain quality requirements in delivering this information. The Road Authority needs to ensure a level playing field for all service providers by granting access to the traffic information in an impartial way.

3.1.5 *RA's tolerance for societal problems*

In each business model, if cost savings are pursued too aggressively, then the level of information provision may drop below the current level. From a cost-benefit perspective, this is a disadvantageous trade-off, as the benefits (in terms of reduction of the societal problem) of the existing roadside system outstrip the costs. However, if removal of the existing roadside system is balanced by deployment of the cooperative service, then on the whole the societal benefits may increase, while the Road Authority still saves on costs. The benefits are small for safety and concentrate on travel time and derived effects on fuel consumption and emissions, so the cost savings option may be of less interest to a Road Authority specifically aiming to improve travel times.

In business model 4 and 2a, the benefits of the system lie with the road users who own an in-car device. Since in these models the application has to be purchased from a commercial party, this may lead to an equity issue: only those who can afford the price, will get the benefit, whereas in the existing situation, all users get the benefit of the roadside system in equal measure. This distributional problem is more relevant if the cooperative service is partially funded from taxes, as in business model 2a, or if it replaces the existing roadside system. If it is fully privately funded, as in business model 4, and it is an additional service on top of the existing roadside system, then the distributional consequences will be more acceptable.

In business model 1, the Road Authority provides the application for free, and the only potential unfairness is that end users who do not own an in-vehicle device will not benefit.

3.2 Bundles 1 and 2 Analysis

For the *Local Dynamic Event Warnings* and *In-vehicle Speed and Signage* bundles, both the cellular and wireless beacons platforms are available. As these bundles include functions conveying obligations and regulations such as speed limit information, a fully private implementation is only conceivable as a convenience service additional to an existing roadside service. Under the assumptions made in the COBRA project this will not lead to any additional benefits, and hence this option is ignored. Thus, the business models under consideration all leave the Road Authority in control. The following business models are considered:

- BM1 (public, cellular): Free Road Authority app. The service is delivered by the Road Authority in the form of a free application for end users, without help from market parties, except for a cellular communication provider and an in-car hardware provider. The Road Authority adapts his traffic management centre to provide the information and warning service to this application, and develops the software application which is made available to the end user free of charge. The in-car hardware (a smart phone or after-market device) and the cellular communication are not provided by the Road Authority.
- BM5 (public, wireless): Public road side WLAN. The Road Authority installs, operates and maintains short range roadside telecommunications equipment (wireless beacons), and funds the adaptation of the traffic management centre to issue the necessary messages and warnings. The Road Authority also develops the in-car software application, which is made available for free to the road users. The in-car hardware (a factory built-in device) is not provided by the Road Authority.
- BM6b (mix, wireless): PPS Public road side WLAN. The Road Authority installs, operates and maintains short range roadside telecommunications equipment, and adapts the traffic management center. The application issuing the messages is developed by a private service provider, and has to be certified to issue legally binding messages. The in-car hardware (a factory built-in device) is also provided by a commercial party.

The effect of the business model on the attribution of costs is shown in Table 5.

Table 5: cost assigned to road operator for the business models considered for bundles 1 and 2

Business Model	Fraction of cost to RA			
	In-car device, including operational costs	Roadside wireless beacons	Adapt back office	In-vehicle application development
BM1 - Free RA app (Cellular)	0%	N/A	100%	100%
BM5 - Public road-side (Wireless beacons)	0%	100%	100%	100%
BM6b - PPS Public road side WLAN (Wireless beacons)	0%	100%	100%	0%

3.2.1 *Societal costs and benefits*

Bundle 1: Local Dynamic Event Warnings

The societal costs and benefits of bundle 1 with business model 1 are shown in Figure 15, for the example of the Netherlands. Scenario 1 shows the case where the existing infrastructure remains at the present level, whereas scenario 2 is a cost savings scenario where 15% of the existing infrastructure is removed. In both cases the costs are significantly larger than the benefits. The largest cost component is the operational in-vehicle cost, which makes up about 90% of the total in-vehicle cost. This is illustrated by Figure 16, showing the same scenarios but with the operational in-vehicle cost set to 0. The remaining in-vehicle costs are the investment costs of the after-market in-vehicle devices – the scenarios assume that 20% of all in-vehicle devices is an after-market device with a purchase price of 100 EUR, of which 1/3 is considered as societal cost. This leads to a benefit-cost ratio slightly larger than 1. The second largest cost component is the unintended impact of lower speeds and hence longer travel times caused by the warnings. However, this societal dis-benefit is smaller than the societal benefits of improved safety, fuel consumption and emissions.

On the societal level there is very little difference between the cases with and without cost savings. This is because the amount of cost that is saved is modest compared to the other costs and benefits.

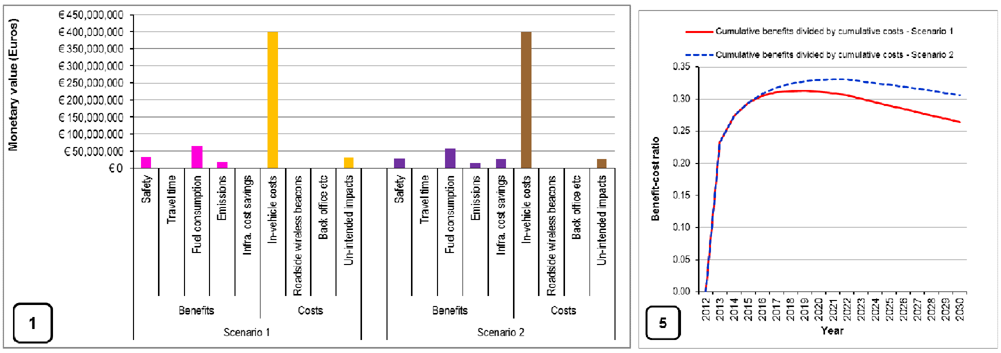

Figure 15: Left: societal costs and benefits of bundle 1, business model 1 for the Netherlands, without infrastructure cost savings (scenario 1) and with (scenario 2). Right: cumulative cost-benefit ratio over time.

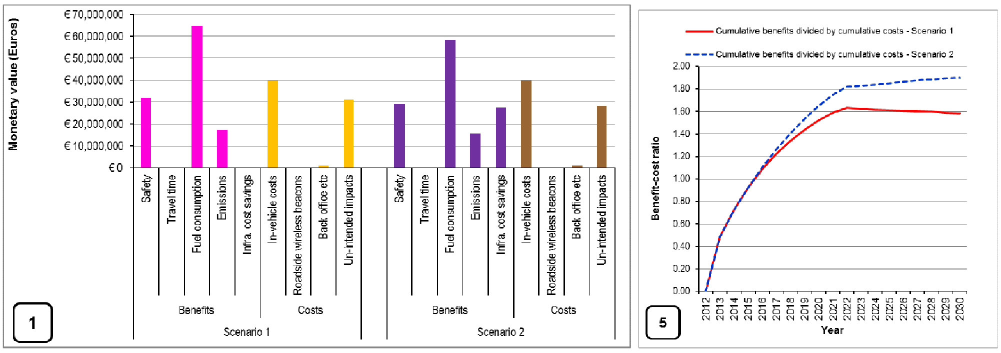

Figure 16: same as Figure 15, except that in-vehicle operational costs are set to 0 in both scenarios.

In business models 5 and 6b, additional costs are incurred for installing wireless beacons, and in-vehicle costs may be different. Figure 17 shows that the benefit-cost ratio is very low, for two different penetration levels of the beacons, namely 10% (scenario 1) and 30% (scenario 2). Cost savings are not included in either scenario. The largest cost components are the costs of the wireless beacons and the costs of the in-vehicle devices. The in-vehicle operational cost is set to zero. If a positive value of e.g. 10 EUR per year per vehicle were set, the costs would increase by another 100 million EUR in both scenarios (not shown).

Cost savings scenarios are shown in Figure 18. Cost savings are the largest benefit, but still a lot smaller than the cost components. The main societal benefit is on emissions, and counter-intuitively it is larger in the more aggressive cost savings scenario (scenario 2). This is because the existing roadside system is assumed to negatively affect CO_2 emissions, so an aggressive phase out may lead to some benefits. Vice versa, the benefits on safety, fuel consumption and other emissions will become negative when the existing system is phased out too quickly, as the figure shows. Thus, apart from emissions, there are only very low societal benefits.

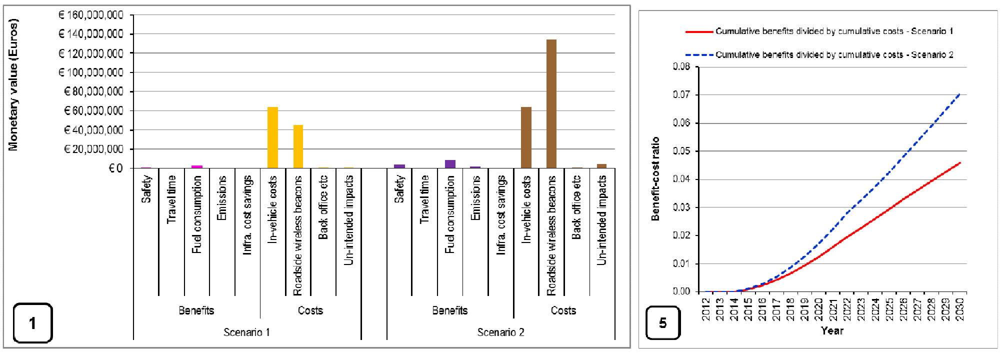

Figure 17: same as Figure 16, except that the business model is now 5 or 6b, with wireless beacons, and cost savings are not included. Scenario 1 equips 10% of the road network, scenario 2 30%.

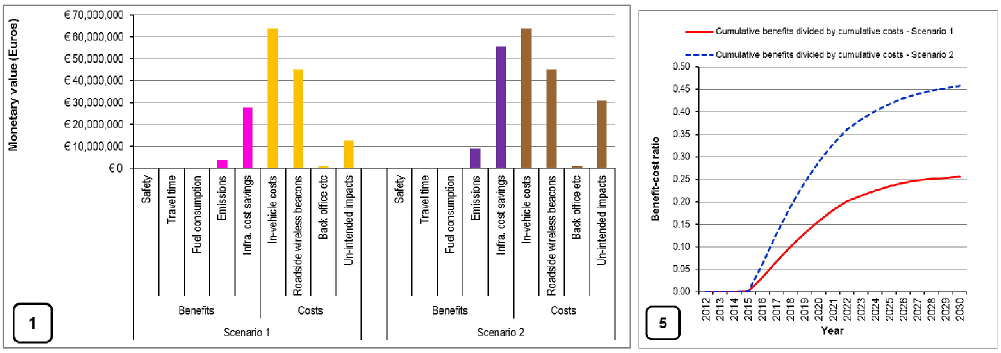

Figure 18: same as Figure 17, except that the scenarios now show two different levels of cost savings, corresponding to a 15% phase out for scenario 1, and 30% phase out for scenario2. In both scenarios, 10% of the roads is equipped with wireless beacons.

The only way to arrive at a favorable benefit-cost ratio is to significantly reduce the cost. Figure 19 shows a purely hypothetical example, where all in-vehicle costs are set to zero, the costs of wireless beacons are reduced by 75%. In both scenarios it is assumed that 10% of the road is equipped, and the same two levels of cost savings as in Figure 18 are applied. Even with these severe cost reductions the benefit-cost ratio remains modest.

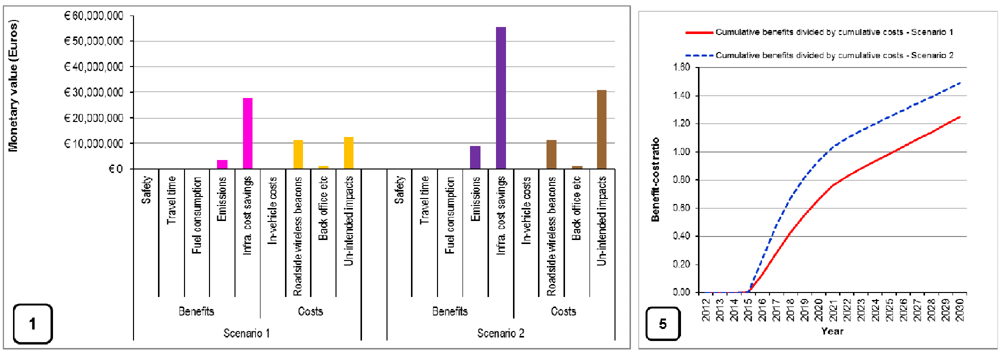

Figure 19: hypothetical example of a benefit-cost ratio above 1 with business model 5 or 6b. The costs of wireless beacons are reduced by 75%, all in-vehicle costs are set to zero. Scenario 1 has a 15% phase out, while scenario 2 has a 30% phase out of the existing roadside system.

<u>Bundle 2: In-vehicle Speed and Signage</u>

The societal costs and benefits of bundle 2 with business model 1 are shown in Figure 20. The cost savings scenario (scenario 2) assumes that 15% of the existing roadside systems is phased out by 2030. Comparison with the case of bundle 1 with business model 1 (see Figure 15) shows some similarities between the two bundles. The in-vehicle costs are the same for both, as the in-vehicle device is assumed to be very similar, but the societal benefits of bundle 2 are higher. Another remarkable difference is that bundle 2 has relatively high costs due to unintended societal impacts. This is due to the lower speeds and hence increased travel times that are assumed to be the consequence of an in-vehicle speed advice system. All together this leads to a somewhat better benefit-cost ratio than for bundle 1, but still below 1.

If the in-vehicle operational costs are assumed to be zero, then 90% of the in-vehicle costs disappear, and Figure 21 shows that the benefit-cost ratio improves and even rises slightly above 1 for a brief period. The high unintended impacts of bundle 2 cause the ratio to be lower than for bundle 1, see Figure 16. Both Figure 20 and Figure 21 show that the effect of cost savings is very modest. This is because the associated cost component is rather low compared to other costs.

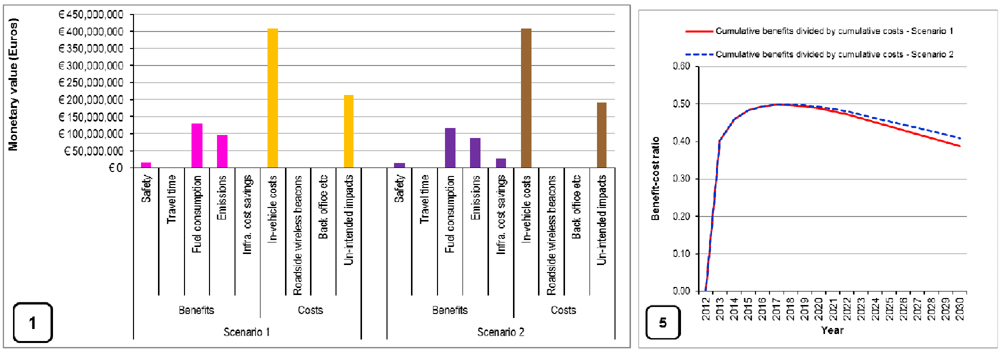

Figure 20: Left: societal costs and benefits of bundle 2, business model 1 for the Netherlands, without infrastructure cost savings (scenario 1) and with (scenario 2). Right: cumulative cost-benefit ratio over time.

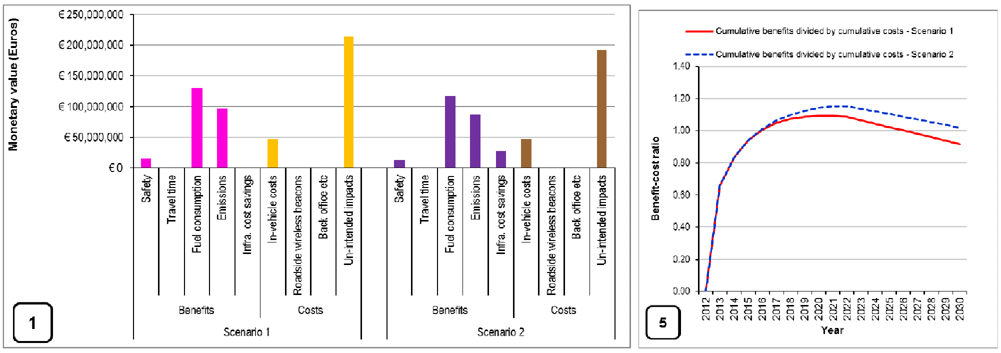

Figure 21: same as Figure 20, except that in-vehicle operational costs are set to 0 in both scenarios.

For business models 5 and 6b there are additional costs for installing wireless beacons, and different in-vehicle costs. The benefit-cost ratio is much lower than 1, as shown in Figure 22 for different levels of deployment of wireless beacons, namely 10% (scenario 1) and 30% (scenario 2), and in Figure 23 for different levels of cost savings, namely a phase out of 15% (scenario 1) and 30% (scenario 2). In both figures, in-vehicle operational costs are set to zero.

In the cost savings scenarios of Figure 23, the only societal benefit is for travel time. This is actually a dis-benefit in disguise. Indeed, the bundle and the existing roadside system that it replaces are assumed to have a negative impact on travel time, but because in the scenarios of Figure 23 the existing roadside system is phased out so quickly that the coverage of the existing system and the cooperative bundle together actually decreases over time, leading to a reduced impact and hence a decrease in travel time. The safety, fuel consumption and emissions benefits that the system is supposed to have thus also become negative and are counted as negative (i.e., “unintended”) impacts.

The in-vehicle costs are higher for bundle 2 than for bundle 1, because the bundle 2 device is assumed to be more expensive. This is because the wireless beacons version of the intelligent speed advisor is assumed to come with an expensive haptic gas pedal.

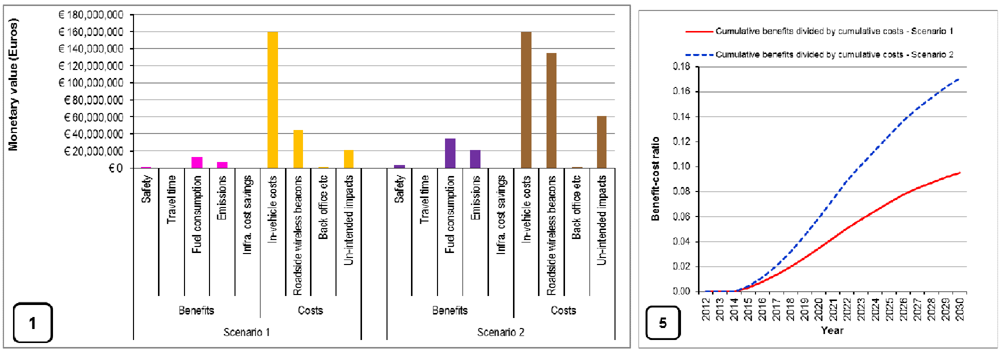

Figure 22: same as Figure 21, except that the business model is now 5 or 6b, with wireless beacons, and cost savings are not included. Scenario 1 equips 10% of the road network, scenario 2 30%.

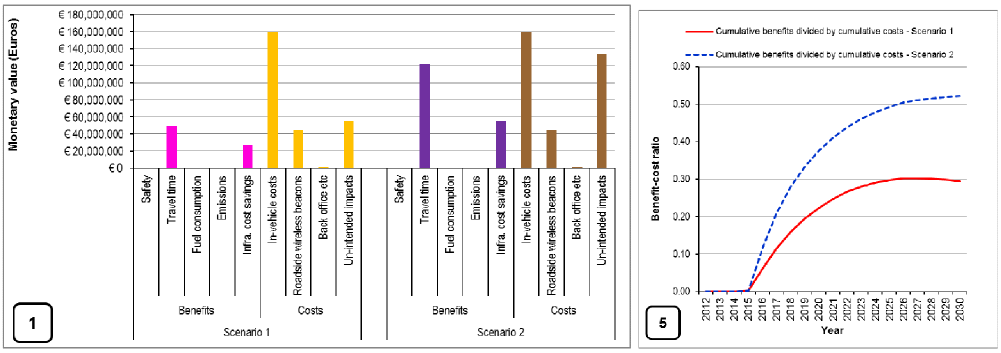

Figure 23: same as Figure 22, except that the scenarios now show two different levels of cost savings, corresponding to a 15% phase out for scenario 1, and 30% phase out for scenario2. In both scenarios, 10% of the roads is equipped with wireless beacons.

Figure 22 and analysis of the underlying values shows that there is only a small difference between the total positive societal impact and the negative societal impact. This makes it very hard to develop a scenario for business model 5 or 6b where the benefit-cost ratio rises above 1 – unless of course one aggressively removes the existing roadside system, thus compensating the costs of the cooperative service by savings on the existing infrastructure, and with the opposite societal effect as the intended one, as discussed above.

3.2.2 Monetary costs and benefits to the RA

As Table 5 shows, depending on the business model the Road Authority may have to pay for wireless beacons, back office adaptations or in-car software application development. The business case for the Road Authority is not influenced by whether in-vehicle device costs or operational costs are included or not, since the Road Authority does not pay these costs. If the existing system is not phased out, then the Road Authority has no monetary benefits. Hence only cases with cost savings are considered.

Bundle 1: Local Dynamic Event Warnings

For business model 1, if the deployment of the existing roadside system is reduced by 15% like in the cost-benefit analysis, then the cost savings are much larger than the modest investments by the Road Authority, as shown by scenario 2 in Figure 24. Scenario 1 shows that even a very modest deployment reduction of 1% will be enough to cover the cost to the Road Authority of the cooperative service. This is because in this business model the only costs for the Road Authority are the one-off cost of adapting their traffic management center and the one-off cost of developing the in-vehicle software application, and both are quite low.

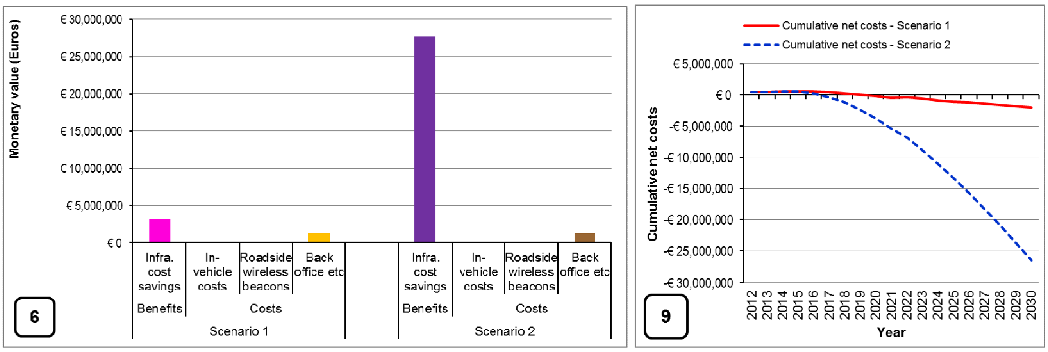

Figure 24: business case of bundle 1, business model 1 for the Dutch Road Authority, for a 1% phase out of the existing system (scenario 1) and a 15% phase out (scenario 2). Left: costs and benefits to the Road Authority. Right: net cost to the Road Authority over time.

Figure 25 shows the situation of business model 5, for two different levels of cost savings. The scenarios are the same as those of Figure 18. It shows that the more aggressive phase out of 30% of the existing road side system will make the business case positive for the Road Authority in the longer run – even though the societal case is negative. Indeed, initially the Road Authority will have to invest in wireless beacons for the cooperative service, but later on he will save by phasing out the existing system. However, if the phase out is too modest, like in scenario 1, the savings will not offset the investments. Initially, 36% of the road network is equipped with the existing roadside system, so a phase out of 15% (scenario 1) or 30% (scenario 2) of the existing system means it is removed along 5% or 10% of the road network. Both scenarios assume that wireless beacons are installed on 10% of the road network, so scenario 2 corresponds roughly to a 1-1 replacement.

The difference between business models 5 and 6b is that in model 6b the Road Authority does not pay for the development cost of the in-vehicle software application. In the graph of Figure 25, this cost is listed under “Back office etc.” and is so small compared to the other cost components that it hardly makes a difference. Therefore no results are shown for this business model.

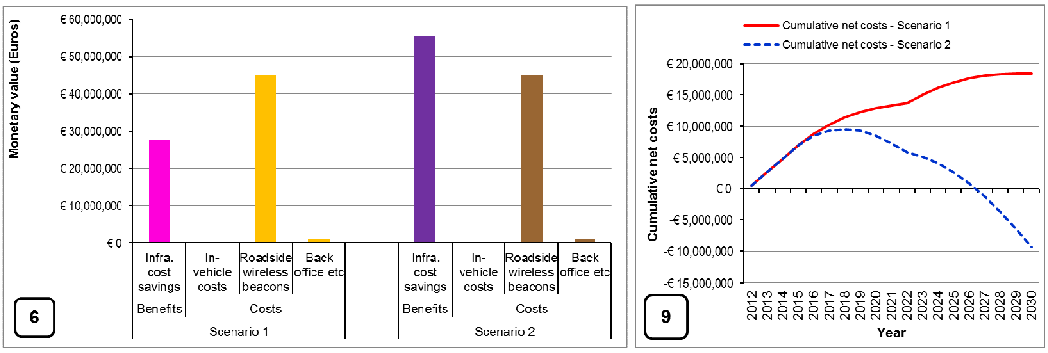

Figure 25: business case of bundle 1, business model 5 for the Dutch Road Authority, for a 15% phase out of the existing system (scenario 1) and a 30% phase out (scenario 2). Left: costs and benefits to the Road Authority. Right: net cost to the Road Authority over time.

Bundle 2: In-vehicle Speed and Signage

For business model 1, Figure 26 shows that the cost savings are much larger than the costs of the Road Authority if 15% (scenario 2) or even only 1% (scenario 1) of the existing roadside system is phased out by 2030. This is because the only costs for the Road Authority are the one-off cost of adapting their traffic management center and the one-off cost of developing the in-vehicle software application, and both are quite low.

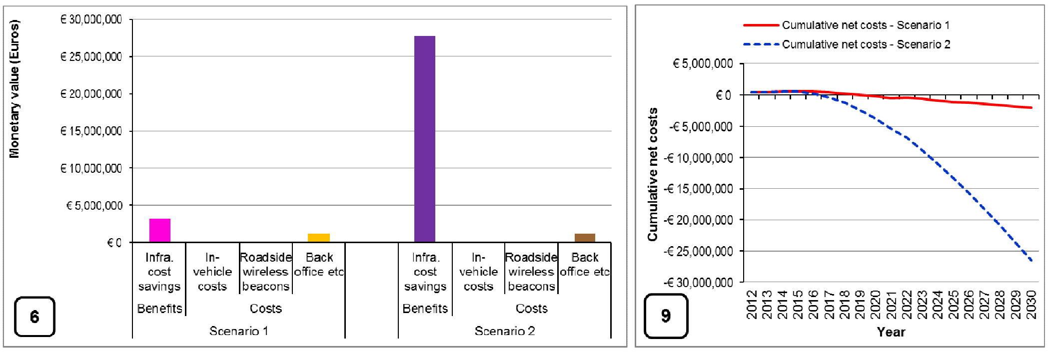

Figure 26: business case of bundle 2, business model 1 for the Dutch Road Authority, for a 1% phase out of the existing system (scenario 1) and a 15% phase out (scenario 2). Left: costs and benefits to the Road Authority. Right: net cost to the Road Authority over time.

Comparison of Figure 24 and Figure 26 shows that the monetary costs and benefits for the Road Authority of bundle 1 and bundle 2 are precisely the same. Indeed, it is assumed that the costs of adapting the traffic management center and developing the in-vehicle software application are the same for both bundles, and furthermore the existing system that is phased out uses the same matrix signs, and hence saves the same infrastructure costs.

A similar argument holds for business models 5 and 6b. Here the Road Authority also has to invest in wireless beacons, but these investments are the same for bundle 1 and bundle 2. Thus, for business case for the Road Authority for bundle 2, business model 5, one may consult Figure 25. For business model 6b, the same comment holds as in the case of bundle 1, namely it is very similar to business model 5 from the Road Authority's monetary perspective.

3.2.3 *Organizational complexity*

In business model 1, the Road Authority keeps most components of the system in his own hands. The only exception is the involvement of a communication provider and a provider of an after-market in-car device or smart phone, in well-established roles. Hence the complexity is low.

In business model 5, apart from the Road Authority only the car manufacturer is involved, in the role of provider of the built-in in-car hardware. There is no need for a communication provider, because the Road Authority handles the communication via wireless beacons. Some additional complexity stems from the need to complete specification for the in-vehicle device and ensure the interoperability of the roadside system with the in-vehicle device. For this reason the organizational complexity is assessed to be medium.

A higher level of complexity is attained in business model 6b, where the driver buys the after-market device and the application software from one or more commercial parties while the Road Authority deploys the roadside part of the cooperative system. On top of the issues mentioned for business model 5, this requires certification of the in-car application.

3.2.4 *Role of the RA including its span of control*

In each of these business models, the Road Authority is fully in control of the messages sent to the vehicle from the Road Authority's back office. Differences appear in the level of certainty with which the messages will actually reach the driver accurately and in time.

In business model 1, the in-vehicle application is built by the Road Authority and hence under his control. However, limitations on the guaranteed communication performance of cellular networks mean that it cannot be guaranteed that a message will reach the in-car device in a timely fashion. This makes it impossible to use this model for legally binding messages as a replacement of existing roadside systems with the current communication technology. Use for warning functions is limited to those warnings which are not time-critical. Moreover, it cannot be controlled by the Road Authority whether the driver has activated the application, which means that this approach cannot be relied upon as the only means of communicating legally binding or safety-critical messages, at least not without further safeguards to ensure the proper functioning of the service.

In business model 5, the Road Authority fully controls the entire system except for the in-car hardware, and the issues plaguing business model 1 can be resolved. Indeed, it is technically possible to guarantee timely transfer of messages to the in-car device by wireless beacons. Agreements with the car manufacturers need to be put in place in order to ensure accurate and timely display of the Road Authority's messages. Such agreements can take the form of an EU wide certification. This business model can be used for time-critical, safety-critical or legally binding messages.

Compared to business model 5, in business model 6 the Road Authority relinquishes control of the in-vehicle application. Thus he has no directly control whether and how his messages are presented to the end user, nor what other messages are presented in the same context. For safety-critical or legally binding information, agreements with the car manufacturers and the application providers are needed to ensure accurate and timely display of the Road Authority's messages, respecting certain quality standards. Such agreements can take the form of an EU wide certification.

3.2.5 RA's tolerance for societal problems

There are several cases to consider, depending on whether the cooperative service replaces the existing system fully or partially, or provides an additional service, and whether all vehicles are equipped or not. One can further distinguish between the legally binding (i.e., regulations and obligations) functions and the non-binding functions (typically information or warnings). If the cooperative service is to replace the existing legally binding roadside infrastructure, then by necessity all vehicles must be equipped and the roadside system must be replaced fully. As mentioned above, this is not possible in business model 1 with current communication technologies' capabilities. If the cooperative service is to replace the existing non-binding functions, then it may be replacing them fully or partially (in the latter case some warnings are no longer given), and not all vehicles need to be equipped.

Equity issues may arise if warnings are issued via the cooperative service that are not provided by a roadside system. In that case, only equipped end users will receive these warnings. This issue is more prominent in business models 5 and 6b than in business model 1, since they require higher investment from the end user and from the Road Authority, hence a bigger expenditure of tax money for a potentially small group of users, namely those who can afford to buy a new vehicle with wireless communication. This problem can arise when the service is additional to the existing warning service, but also when it replaces the existing warning service partially or fully.

It can be argued that for bundles 1 and 2, fairness is a more important issue than for bundle 3, because bundles 1 and 2 address the societal problem of traffic safety while bundle 3 aims to improve the individual driving experience in terms of travel time and comfort. Thus, the services of bundle 1 and 2 benefit society at large, also those who are not equipped, and hence from an equity perspective the costs should be borne by society. For bundle 3 the benefits are first and foremost personal, with some indirect societal gains through a reduction in congestion, and hence it is reasonable that each individual pays for himself.

The total societal problem size may increase if the service replaces the existing roadside warning system, but does so only partially (i.e., not at all locations) or if not all vehicles are equipped. This problem may be more prominent with the wireless beacons business models 5 and 6b because they require higher investment on the roadside and in-vehicle. The benefits are mostly safety related, while travel times may actually increase due to less speeding. Thus the cost savings option may be less appealing to a Road Authority prioritizing road safety. Likely this means that the existing system can be phased out only very slowly in business models 5 and 6b, namely only at those locations where the cooperative service is available at the roadside and the vast majority of vehicles is equipped.

If the service replaces the existing regulatory functions, then all vehicles must be equipped , and hence equity issues cannot arise. If furthermore the presence of the system is at least as large as the roadside system it replaces, then the total societal cost should not increase.

3.3 Conclusions

A summary of the findings of the previous sections is in Table 6. The columns in this table show the following:

- **Bundle**: the identifier of the bundle.

- **Business model**: the identifier of the business model, with a short characterization in brackets, stating whether the model is public, private or a mix of both, and stating the communications platform.
- **BCR**: the benefit cost ratio.
  - "Strong" means the ratio is above 3.
  - "Modest" means it is between 1 and 3
  - "Weak" means it is below 1 (and hence the benefits are smaller than the costs).
- **BC RA**: the business case for the Road Authority.
  - "Strong" means the Road Authority will easily and quickly gain a positive return on investment, even with a moderate phasing out of the existing roadside system.
  - "Modest" means the Road Authority will gain a positive return on investment, but after a period of investment, and possibly requiring a significant phase-out of the existing roadside system.
  - "Weak" means the Road Authority will not gain a positive return on investment, even in the long run and even if the phase-out is large.
- **Complexity**: the organizational complexity, which is qualitatively assessed as "low", "medium" or "high", depending on the number of organizations that are involved and the complexity of their relations and dependencies.
- **Role RA**: the role of the Road Authority, which is qualitatively assessed as "small", "medium" or "large", depending on how large the level of activity of the Road Authority has to be for this bundle and business model.
- **Control RA**: the amount of control of the Road Authority, which is qualitatively assessed as "small", "medium" or "large", depending on how much influence the Road Authority has on the quality and content of the cooperative service in this business model.
- **Soc. problem issues**: the extent to which the phasing out of the existing roadside system may lead to an increase in societal problems, perhaps for certain groups of road users, that conflicts with a Road Authority's policies. This is qualitatively assessed as "low", "medium" or "high", depending on the size and type of societal problems that can be expected, and an assessment of their potential for conflict with Road Authority policy. The latter will of course depend on external factors such as national policy.

Table 6: overview of the characteristics of the bundles and business models. BCR is the benefit-cost ratio, BC RA is the business case of the Road Authority. See the main text for further explanations.

Bundle	Business Model	BCR	BC RA	Com-plexity	Role RA	Control RA	Soc. problem issues
3	BM1 (public, cellular)	Modest	Strong	Low	Large	Large	Low
	BM4 (private, cellular)	Modest	Strong	Medium	Small	Small	Low-Medium
	BM2a (mix, cellular)	Modest	Strong	High	Medium	Medium	Medium
1 & 2	BM1 (public, cellular)	Weak	Strong	Low	Large	Small	Medium
	BM5 (public, wireless)	Weak	Modest	Medium	Large	Large	High
	BM6b (mix, wireless)	Weak	Modest	High	Medium	Medium	High

Bundle 3

For bundle 3, it can be concluded that there are few barriers for deployment, especially if the main cost component of in-vehicle operational cost can be reduced further to improve the benefit-cost ratio. The Road Authority has a strong business case in each of the three business models, mainly because of the large cost savings following the removal of some of the existing roadside system, that is, the variable message signs that display traffic and travel information. Therefore the choice of business model largely depends on the extent to which the Road Authority wishes to remain in control of information provision to end users and the amount of effort the Road Authority is willing to put in. In some countries, It may also depend on policy views on the division between the public and the private sphere, and in some countries this choice may already have been made.

Bundles 1 & 2

The case for bundles 1 & 2 depends on the technology choice. Due to high in-vehicle and roadside investment costs, the costs far outweigh the benefits on the societal level in both cellular and wireless beacon implementations. However, the Road Authority has a positive business case in all three business models. In the wireless beacons models (BM5, BM6b) he will be facing significant initial investments, but these can be more than compensated by savings on the existing infrastructure (i.e., matrix signs) in later years. However, an aggressive reduction of existing infrastructure is needed to make a positive business case for the Road Authority, reducing the societal benefits further.

The strongest scenario from societal perspective is business model 1 for bundle 1. If the in-vehicle operational costs can be brought down to zero, then this combination of bundle and business model is the only one for which the societal benefits will exceed the societal costs. Also the business case of the Road Authority is very strong for this case – it is already positive if only 1% of the existing infrastructure is phased out. It should be noted that with current technology, a cellular platform cannot replace the regulatory functions of the existing roadside system, and one should be careful when replacing time-critical or safety-critical functions. This means that an aggressive phase-out of the existing system may not be feasible – but as said, this may also be unnecessary to arrive at a positive business case. It also means that a Road Authority who wishes to replace the current roadside regulatory systems (like road signs) by a cooperative version will have to choose a business model based on wireless beacons and hence has to address the issue of high costs.

For all other combinations of bundle and business model, further cost reductions would be needed to achieve this, in particular a reduction of the costs of wireless beacons and the in-vehicle device. Furthermore, bundle 2 suffers from a very high negative effect on travel time, which greatly reduces the societal benefit of this bundle. This negative effect is due to a reduction in speeding, induced by the intelligent speed advice function of the bundle

An underlying reason for the low benefit-cost ratio of bundles 1 and 2 is that they aim to improve safety, and on motorways the potential for safety benefits is low, simply because the level of safety is very high compared to other road types. Thus, negative side effects on speed, even when modest in relative sense, will easily dominate.

There are several ways in which one can attempt to address this low benefit-cost ratio, for example by combining several bundles. Here the Road Authority can choose to either wait for some other services to develop, and then attempt to use the deployed platform, or he can stimulate innovation (and keep some level of control) by taking the initiative to invest, in the expectation that future services will remedy the benefit-cost deficit. An option that would deserve more scrutiny is to deploy cooperative services not just on the motorway but also on other roads. This may significantly increase benefits, in particular of safety-oriented functions. Especially for services based on cellular communications the additional cost is low.

This section concludes with some remarks on the significance of these calculations. It is important to realize that although an effort has been made to come up with valid figures, both the monetary costs and the societal impacts of cooperative services are uncertain. For example, it is not altogether clear at what rate the cost of cellular communication should be priced. Many users may have a flat-rate bundle, but of course this does not mean that the true cost is independent of the amount of data exchange. Impacts are uncertain because there is very little ex-post analysis of cooperative systems, and sometimes even of the existing roadside systems. Furthermore there are methodological problems in combining different outcomes from different literature sources (sometimes they do not even agree on the direction of the effect) and in deriving into the impact of a bundle from the impacts of its constituting functions. The COBRA analysis has taken the conservative approach that the cooperative bundle will have the same impact as the existing roadside system that it replaces. It is however conceivable that the impact of the cooperative service will be higher because it is more personalized and has more direct and continuous access to the driver. It should also be noted that some more indirect societal effects (e.g. on travel patterns or employment) have not been assessed.

4 Legal Aspects

This section begins with a summary of relevant legal aspects in the deployment of cooperative systems. The Appendix in Section 9 provides more detailed information (although still a quick scan). Sections 4.2 and 4.3 present a legal perspective on the bundles. Bundle 3 is treated separately from Bundles 1 and 2. Due to the more safety relevant nature of these bundles and, possibly, associated enforcement issues bundles 1 and 2 have additional legal issues that need to be contended with in comparison to Bundle 3.

It should be noted that this legal overview is only indicative in nature. Legal issues related to specific applications/services may relate to other areas of law, may differ between jurisdictions and may be dependent not only on functionality, but also on technical and organizational embedding (and therefore may only be (fully) assessed if their functionality and technical and organizational embedding are sufficiently clear).

4.1 Introduction to Legal Aspects in Cooperative Systems

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

Another relevant parameter in relation to Road Authorities positioning towards cooperative systems may be that of the (potential) legal implications of deployment. For example, one potential benefit of cooperative systems flows from the assumption that these systems may be a substitute for conventional ways of communicating with road users (through VMS and conventional road signs). However, what may be the legal boundaries and constraints in this context. For example, what is the legal status of a speed limit displayed in the vehicle. Can this be a substitute for conventional road signage?

In this section, relevant legal domains will be explored to identify legal implications of the deployment of COBRA-applications. Relevant traffic law aspects will be discussed especially focusing on the legal framework for the use of road signs. Paragraphs 4.1.2 and 4.1.3 will cover civil liability and data protection/privacy issues.

4.1.1 Cooperative systems from a traffic law perspective

Legal questions surrounding the possible implementation of cooperative systems from a traffic law perspective include

- Whether there are restrictions on the deployment of cooperative systems flowing from existing regulations on the use of nomadic devices?
- Whether obligations or prohibitions to be communicated to the road user via an in-vehicle display can be enforced?
- Whether the current (international) legal framework on road signs allows cooperative systems to be a substitute for conventional methods of communicating to road users

The following paragraphs address these issues.

Differences in legislation for nomadic devices exist over European countries [11]. All countries (except Sweden) have adopted specific regulations on mobile phones. Legislation for other device classes (Personal Navigation Devices (PNDs), music players and TV/video players) reveals a heterogeneous situation. The result is that some countries have legislation that intervenes highly in the use of different devices (use of hands free-equipment or mounting location requirements) to states that hardly stipulate any concrete requirements. In addition, in many countries, different regulations apply for the use of specific devices. All in all, existing legislation for nomadic devices does not seem to obstruct the deployment of COBRA-services through nomadic devices.

There are several international conventions and agreements aiming at harmonizing the meaning and use of road signs in order to facilitate safe and efficient cross border traffic. However, differences may still exist due to the non-exhaustive nature of these documents and the possibilities for signatories to make reservations upon ratification.

The implications of the existing legal framework on the implementation of cooperative systems are as follows:

1) Regulatory road signs (i.e. signs intended to inform road-users of special obligations, restrictions or prohibitions with which they must comply) must be in conformity with the current regulatory framework in order to be legally enforceable. *The fact that the current regulatory framework does not provide for obligations or prohibitions to be communicated to the road user via an in-vehicle display obstructs their enforceability.* Furthermore, if it is chosen to aim at enforceability, this kind of technology will raise a number of specific questions on an operational level that need to be addressed. How long should a message be presented in-vehicle? What happens to new information, and what is its priority? Does old information disappear immediately, or does it remain on the screen in a “miniature” form? What happens if the older information is more important or safety-critical, and the new information is less so? Further, this would immediately raise issues of legal evidence. How can it be proven that a speed limit or other obligation was indeed correctly communicated through in-vehicle signage?

2) The above mentioned however, does not mean that information communicated via in-vehicle displays in all cases is without legal relevance. Apart from specific legal obligations such as to give way or to refrain from exceeding the speed limit Dutch traffic law (like most other jurisdictions) includes also a generally formulated statutory provision stipulating that every driver shall conduct himself in such a way as not to endanger traffic (see art. 5 Wegenverkeerswet, Road Traffic Act, hereafter WVW). Furthermore, cooperative systems may have a possible ‘intensifying’ effect on liability of the driver. The availability of a local dynamic event warning-system, warning the driver for dangers that would otherwise be

outside his scope of perception, may also ‘create’ a higher duty of care for the driver because he/she is provided with more information than a driver without such a system and therefore is better capable to take appropriate action to avoid accidents. However, this would require that such a system does not suffer from a substantial percentage of false alarms and that it can be proven (on the balance of probabilities) that the driver of the equipped vehicle ignored a warning. In most cases, this will require some form of data logging.

3) Apart from the fact that it would require legislative changes to ‘upgrade’ in-vehicle display messages to enforceable regulatory signs (see under point 1 above), *this may only serve as a feasible alternative for physical road signs if all vehicles would be equipped for such cooperative functionality*. Introducing mandatory or prohibitive signs in-vehicle would also imply the drafting of requirements for in-vehicle equipment and its implementation in the existing vehicle-type approval and periodic inspection frameworks. This, should that technical solution be chosen, must be established at the European level.

4) One could ask whether in relation to messages communicated to road users other than mandatory or prohibitive signs (for example curvature warning signs or warning signs relating to degraded road surface conditions) COBRA-applications may have more potential to be a viable alternative for road side signage. It seems however, that for several reasons this potential should not be overestimated.

   a. Current (international) regulations on road design and the use of road signs may obstruct this.

   b. Road authorities have a general duty to design roads in a way that they are safe to use (which may require road signage). A breach of this duty of care may lead to liability if accidents occur (primarily based on art. 6:174 Burgerlijk Wetboek, Dutch Civil Code, hereafter BW; see next paragraph). Road authorities owe this duty of care not only towards equipped drivers but also towards non-equipped drivers.

Safety-relevant applications such as bundle 1 applications, should therefore basically be regarded as a complementary service and not as a substitute for road signage that is needed to provide safe roads to all drivers.

4.1.2 Cooperative systems and liability

The implementation of cooperative systems may raise questions in the domain of civil liability. In a recent study cooperative systems were, next to ‘highly and fully automated driving’ identified as ‘liability sensitive’.[9] Cooperative systems are complex systems incorporating many parties, responsibilities and competences. These growing technical interdependencies between vehicles and between vehicles and the infrastructure may lead to specific ‘performance vulnerabilities’. Malfunctions may result from e.g. failure of the roadside equipment, a failure in communication between the roadside equipment and the vehicle, inaccuracy of the messages sent, a failure in the telecommunication systems or the damage may also be caused by a defect of the in-vehicle equipment/components. This also makes the liability situation potentially complex. Applications and services based on cooperative systems may consist of different service components provided by different partners which might be accompanied by unclear distribution of responsibilities and absence of agreements on service ownership. Increasing complexity in the chain of delivery of cooperative systems therefore leads to more complex situations where liability is an important issue to address.

In relation to COBRA-applications, liability issues may specifically come up in relation to safety-relevant application such as hazard warning systems. Particularly in cases where no warning was given although there was indeed a hazardous situation. This may result in claims that accidents may be (co-)attributed to flaws in the system. The extent to which NRA’s may be held liable for such flaws will (inter alia) depend on the role of the NRA in the deployment of the system/delivering the service and the applicable liability regime (road managers’ liability for public roads is governed by national law; therefore, relevant liability regimes may differ between countries).

Under Dutch law the public authority responsible for a public road is liable if someone suffers damage because the road is not according to “the standards which, in the given circumstances, may be set for it and thereby constitutes a danger” (art. 6:174 BW). The key question is of course what standards in the context of art 6:174 BW may be set for cooperative systems as a functional element of the infrastructure. Basically the liability standard of art. 6:174 BW refers to a ‘users expectations test’.

False negatives, or the failure to provide a warning when one should have been provided, introduces a situation in which liability of the Road Authority may be relevant . If for example the information to be provided is correct, but it does not reach the driver due to a technical fault in the infrastructure provided by the road operator, it could be argued that the road operator would be held liable for the technical fault in the messaging apparatus.

The applicable liability rules and (therefore) the extent to which NRA’s may be held liable for flaws will also depend on the role of the Road Authority in ‘delivering the service’. For example, the strict liability for public roads will not be applicable if the involvement of public authorities in the deployment of cooperative systems is restricted to providing information to the industry. In that case liability of the Road Authority (or other public bodies that may be involved) should be judged on the basis of the general fault-based liability rule of art. 6:162 BW or, if there is a contractual relationship (for example between the public authority and digital map builder), on the basis of contract law.

4.1.3 Cooperative systems and data protection and privacy

For (almost) all applications /services, unresolved issues in privacy and data protection may be a concern. Applications and services may be based on the collection, processing and exchange of a wide variety of data, both from public and private sources. Their deployment may also rely on the use of geo-localisation technologies, such as satellite-positioning. As such, cooperative systems constitute a "(personal) data-intensive area" and raise a number of privacy and data protection issues that should be carefully addressed. The principles formulated in the relevant European Directives (which Member States are obliged to implement in their national law regimes) however do not provide specified conditions under which data processing is permissible. This leaves considerable margins of appreciation, also in relation to the design and operation of cooperative systems. Privacy aspects should be considered early in the design of applications and the architecture of the systems. These issues relate to the data collected, to the interoperability of systems, and to the security of the data.

In a recent study on ITS & Personal Data protection – discussing a set of 10 applications including cooperative systems - it was concluded that the concepts and principles laid down in directive, 95/46/EC have proven to be a stable and useful legal basis for personal data protection in the EU. The national legal implementations and practice of data protection have nevertheless led to a fragmentation in the application of personal data protection across the European Union. It was also observed that developments in the area of computing, internet, mobile communications, social media and their widespread use by consumers pose new challenges for personal data protection. Based on a review of relevant legislation, case law, opinions of data protection authorities and other stakeholders the following high-level observations and recommendations in relation to cooperative systems were made:[10, p. 106]

- In the initial stages of deployment, the use of cooperative applications should be based on *explicit and informed consent*. This consent should allow opt-out of all cooperative interactions, and further be specific for distinguished applications.
- For the exchange of messages and management of the ad-hoc networks short-lived pseudonyms should be used to avoid traceability of individual vehicles. It is noted that this requirement, combined with communication needs and requirements on authenticity and integrity of data that are safety-critical, leads to technical/economical issues that have not been solved completely as of today.
- Exchanged data relating to an individual vehicle, its environment or the driver shall be minimised in view of the applications used / consented to.
- Where data relating to individual and identifiable vehicles are processed (either by systems in other vehicles or in the cooperative roadside infrastructure), these data should be deleted immediately after they are no longer needed for the specified purpose. This would not

necessarily apply to aggregated/statistical data that can be derived from the raw data exchanged if they do not include any information that can be related to an individual vehicle

Whether personal data protection is an issue in relation to COBRA-systems depends on how the service is implemented. Privacy issues arise if the individual or vehicle can be identified, directly or indirectly, based on the information from the driver or vehicle to an information processor (for example a traffic control centre or a service provider). If data collection is solely based on loop data (i.e. collection through stationary sensors that measure vehicle flux and or speed without any possible identification of the vehicle), no privacy issues will arise, If COBRA-services are based on the collection of Floating Car Data (FCD) or other personal data provided by vehicle drivers (i.e. data that can, directly or indirectly, be linked to an individual user or vehicle) in order to generate personalized information, then privacy is an issue [10, p.94-102].

Privacy issues can be addressed via a variety of avenues including applying a privacy impact assessment, applying privacy enhancing technologies ('privacy by design' includes anonymisation, data minimisation and deletion of data immediately after initial processing) and requesting explicit consent from the driver for data processing. Preferably guidance for design and operation should be provided through internationally agreed guidelines, standards or templates.[10, p. 119-121]

4.2 Bundle 3 Analysis

As presented in Section 2.1, Bundle 3, "Travel Information and Dynamic Route Guidance" contains the functions Traffic information and recommended itinerary, multi-modal travel information and truck parking information and guidance. This bundle provides information that also has as a secondary objective to improve traffic flow over the network. Information is provided to drivers; no regulatory information (i.e. information containing legal obligations or prohibitions for road users) is provided. Bundle 3 provides all of the primary information functions of DRIPs, based on analysis of the DRIPs and roadside DRIPs and GRIPs.

Because the data provision only relates to traffic and travel information, this bundle is not safety-critical nor does it place requirements on drivers to follow the information provided. Therefore, these applications do not trigger enforcement issues. Liability issues as described in Section 4.1.2 can be limited for the Road Authority.

Whether data protection and privacy is an issue depends on how the service is implemented. Privacy issues arise if the individual or vehicle can be identified, based on the information from the driver or vehicle to the information provider. If data collection is solely based on loop data, no privacy issues will arise, If COBRA-services are based on the collection of Floating Car Data (FCD) or other personal data provided by vehicle drivers in order to generate personalized information, then privacy is an issue In this case, measures must be taken to ensure data protection and privacy.

From a privacy perspective, a "thick client" is preferred. Thick clients do not rely on a central processing server because the processing is done locally on the user system, and the server is accessed primarily for storage purposes. For that reason, thick clients often are not well-suited for public environments. To maintain a thick client, IT needs to maintain all systems for software deployment and upgrades, rather than just maintaining the applications on the server. Additionally, thick clients often require operating specific applications, again posing more work and limitations for deployment. The trade-off is a more robust and local computing environment [8].

A practical matter concerns seamless cross-border functioning of the Bundle. This is primarily a subject for standardization and international cooperation. However, it may be concluded that harmonization through legislative intervention on a European level is needed, including agreements on the display to be established.

4.3 Bundles 1 and 2 Analysis

Section 2.1 provided a brief description of bundles 1 and 2. It established that the bundles provide warnings and information that also concern 'regulatory signs' (i.e. signs intended to inform of special obligations, restrictions or prohibitions with which they must comply). Due to the more safety relevant nature of these bundles and, possibly, associated enforcement issues, bundles 1 and 2 raise additional legal issues that need to be addressed, when compared to Bundle 3. These concern conformity with current regulation in relation to road signs, enforceability and liability issues.

Introducing mandatory and prohibitive signs in-vehicle would also imply the drafting of requirements for in-vehicle equipment, its implementation in the existing vehicle-type approval and periodic inspection frameworks. This, should that technical solution be chosen, must be established at the European level.

Furthermore, assuming that the cooperative systems of bundles 1 and 2 replace mandatory and prohibitive signs would require that obligations or prohibitions communicated via in vehicle-displays are enforceable. Because the current legal framework relating to traffic signs does not provide for in-vehicle presentation, this will require legislative intervention. If such legislative intervention would be undertaken, details such as the following need to be addressed:

- What is displayed? Is the display exactly the same as the road sign, but smaller?
- What is the physical size of the information displayed?
- What is the layout of the display?

Enforcement requires a sufficient level of proof that signage was shown in vehicle. This inter alia introduces the need to certify the service provided by cooperative systems. Quality standards need to be developed, and certification criteria and a certification process need to be developed. For enforcement purposes, logging of the in-vehicle display and perhaps other information may be required. This is different from the current situation, in which just passing a road sign means that the driver is obligated to have seen the sign and to obey the legal obligations or prohibitions they contain. In the absence of roadside equipment, one needs to prove that the sign was displayed in the vehicle, which means that access to the display or a log of the display is necessary. Questions of who, and under which conditions may access these data need to be addressed and a process for accessing the logged display needs to be established.

Accessing logged information is a sensitive privacy issue. It looks like “Big Brother” is watching, which may decrease acceptance of cooperative systems in the area of regulatory signage, if signs are replaced.

It should also be noted in this context that cooperative systems may also have their own specific ‘performance vulnerabilities’. For example, communication through cellular networks may be impaired by atmospheric or other conditions. Furthermore, providing regulatory signage in-vehicle introduces potential risk in the chain of delivery. The chain may contain several links, overseen by several parties. The longer the chain and the more complex the organization for delivery, the higher the risk that the information does not reach the driver’s display. Certification of service provision needs to address the chain of delivery. Cellular involves at least the service provider and the antennae provider. Liability issues need to be considered to address situations in which false negatives and false positives are given. A false negative in the case of a lane closure or a lower speed limit means that there *should* have been a message provided on the in-vehicle display stating that a lane was closed or that the speed limit was reduced, but no message was provided. This means that the driver was not warned that a lane is closed or that the speed limit is lowered. This introduces repercussions for the safety of the driver not getting the message and others that could be affected by this situation, and also for the enforcement of the lack of signage. A false positive concerns the case in which a driver got the wrong message, e.g. the speed was lowered when it actually was not. This particular example does not lead to enforcement problems, but the driver with the false positive message may introduce a risk on the road for him or herself as well as other drivers.

One could ask whether in relation to messages communicated through in-vehicle displays that do not relate to legal obligations (for example curvature warning signs or warning signs relating to degraded road surface conditions) in-vehicle signage may have more potential to be a viable alternative for road side signage. This potential should not be overestimated. Road authorities have a general duty to design roads in a way that they are safe to use (which may require road signage). A breach of this duty of care may lead to liability if accidents occur. Road authorities owe this duty of care not only towards equipped drivers but also towards non-equipped drivers. In-vehicle signage applications should therefore basically be regarded as a complementary service and not as a substitute for road signage that is needed to provide safe roads to all drivers.

More room for ‘differentiation’ between equipped and non-equipped road users exists where new services are provided. This is because in relation to new services, there are no established service expectations of non-equipped road users. One could classify this as Greenfield-services.

Another liability implication may be the possible 'intensifying' effect on liability of the driver. The availability of a local dynamic event warning-system, warning the driver for dangers that would otherwise be outside his scope of perception, may also 'create' a higher duty of care for the driver because he/she is provided with more information than a driver without such a system and therefore is better capable to take appropriate action to avoid accidents. However, this would require that such a system does not suffer from a substantial percentage of false alarms and that it can be proven (on the balance of probabilities) that the driver of the equipped vehicle ignored a warning. In most cases, this will require some form of data logging.

Cooperative systems might also raise liability questions in relation to the position of the Road Authorities, particularly in cases of false misses(i.e. where no warning was given although there was indeed a hazardous situation (primarily bundle 1). This may result in claims that accidents may be (co-) attributed to flaws in the system. The circumstances of the case (such as the inherent limitations of the system and whether these inherent limitations are known to the public), as well as the characteristics of the applicable liability regime will eventually be decisive for answering these questions.

Under Dutch law a lack of warnings may render the road 'defective' (for example, the lack of warnings for a dangerous, 'hidden' curve). In this context, the everyday driver that will also have its moments of lowered attention and carelessness will be the standard to judge the required safety level. However, the sole fact that warnings are lacking where they were preferred is not sufficient to imply the defectiveness of the road. This is especially true as the local circumstances were such that they should have motivated the driver to be more careful, also without the warning. This would apply if COBRA-applications could only be regarded an another means of communicating with the road user. However, COBRA- applications also hold the potential to be able to warn drivers more dynamically than is possible with currently available means. It could be argued that the road operator would be held liable for the technical fault in the messaging apparatus, on the ground that by introducing such a system, the operator was inviting motorists to rely on it, in the expectation that it would be functioning correctly.

However, even if this analysis is correct, the claimant is still left with the task of proving that the fault in the messaging system was causative of the accident. This could be problematic; if the fault meant that the intended warning message was not displayed at all, one could argue that the motorist was, nevertheless, in no worse a position than he often is, namely, of having to drive without advance warning aids, in reliance on his own observation, skills and judgment. On the other hand, in a situation, such as a motorway, where visual aids are commonplace, one could argue that the motorist is induced to place reliance upon them. In that case, the absence of a warning could be interpreted as an indication that there was nothing about which motorists needed to be warned. In other words, no news is good news!

4.4 Conclusions

The chapter investigated legal aspects that arise with the deployment of cooperative systems. The legal aspects concern the conformity with current legal frameworks in relation to road signs, enforceability, liability implications and data protection and privacy. Differences exist between bundle 3 and bundles 1 and 2 in several of these aspects.

Bundle 3 requires addressing privacy aspects should location information of drivers via FCD be used in providing a personalized service. Practically (and not a legal issue), attention to how the information can effectively be presented in such a way consistent with Human-Machine Interface (HMI) guidelines should be paid.

Bundles 1 and 2 require substantive efforts to deploy cooperative systems, especially if the goal is to eventually replace conventional road signage. Should it be the goal, replacement of conventional road signage is a long-term goal, given the required actions at the national and European levels and the business aspects that need to be addressed. If bundles 1 and 2 are meant to supplement the conventional road signage, Road Authorities still must address some legal aspects.

Based on the legal aspects identified for bundles 1 and 2, the steps to be taken in order to deploy bundles 1 and 2 with the goal of replacing conventional road signage are indicated below:

Steps to legally facilitate implementation of cooperative systems involving legal obligations and prohibitions (regulatory signage)

1) Develop Technical specs and standards for in-vehicle equipment and communication technologies at EU-level
    a. Address privacy issues: "privacy by design"
2) If CS are to replace conventional signage, the enabling technology should be made mandatory vehicle equipment (factory fitted or retro-fit)
3) Implement (provide for) in-vehicle road signage in national and international (Vienna convention) law on road signs
4) Address enforcement issues in relation of in-vehicle signage
    a. Address Privacy issues due to logging. In-vehicle data may be necessary.
5) Address Liability issues in chain of delivery.
    a. Address false negatives, false positives

5 Migration Paths

5.1 Introduction

A framework was developed in order to provide a structure for developing the recommendations and roadmap. The framework asks the question, how do Road Authorities move from current situation to the new situation in which cooperative systems are deployed?

Figure 27 illustrates generically the possible movement from using existing roadside system services for traffic management (left column of the figure) to providing these services in-vehicle using cooperative systems (right column in the figure). Shaded boxes in the figure mean that the service in the column is provided. The box labeled "1" in the existing roadside system services is shaded (meaning roadside systems are in use) and shows no movement to provision of services in vehicle. This box represents the situation that an existing roadside system services might not be able to be provided via cooperative systems, at least right now. The shaded box labeled "2" is connected by an arrow to a shaded box that falls in both the existing roadside systems and the in-vehicle columns. This describes the possibility that some but not all of an existing roadside system service can be provided in-vehicle. Some existing roadside infrastructure is still required, at this time. The shaded box labeled "3" illustrates the situation that an existing roadside system service can be completely provided in-vehicle, without the required use of an existing roadside system. Finally, the box labeled "4" is not shaded. This represents a greenfield situation, one in which little or no existing roadside infrastructure is present. Migration path 4 represents the situation in which the stage of using existing roadside infrastructure is skipped and the service is provided in-vehicle. This service might be one that is not offered anywhere on the motorway network.

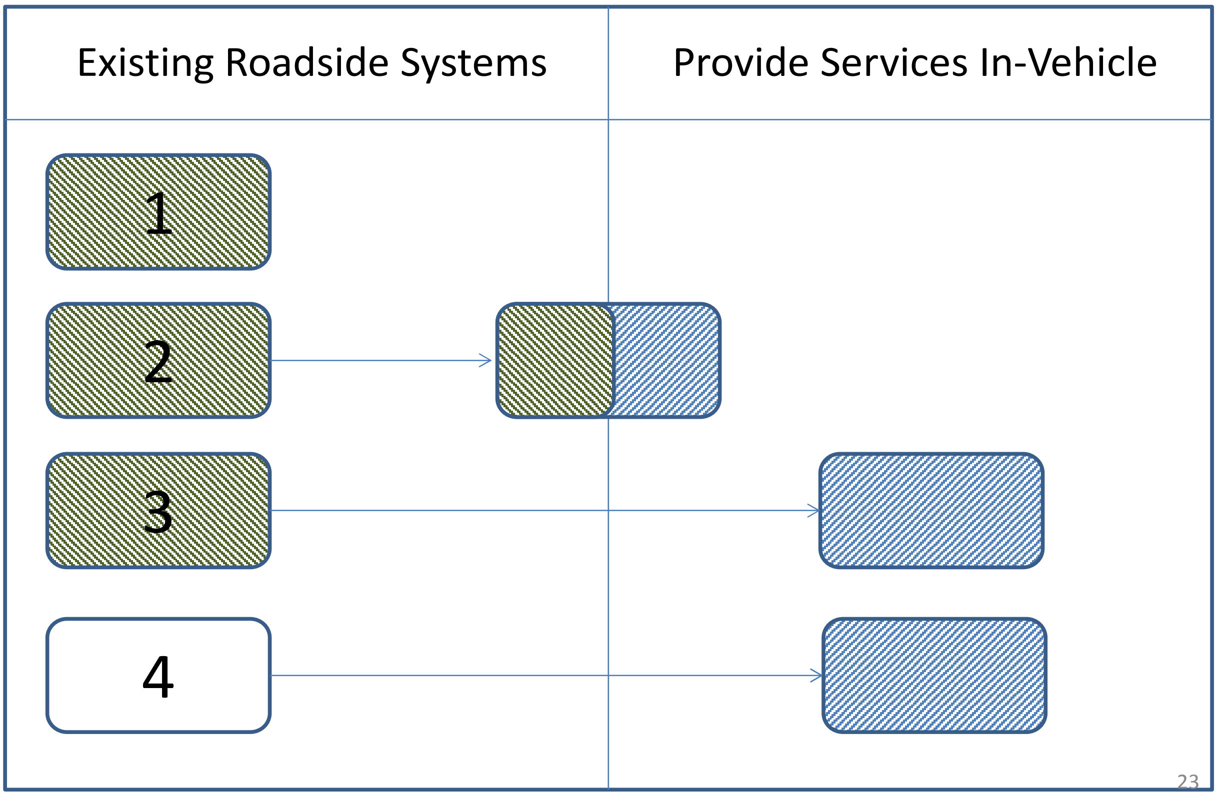

Figure 27: Defining the Migration Path: Framework for Recommendations and Roadmap

The analysis in Chapter 4 indicates that bundles 1 and 2 are quite different from bundle 3. The migration path for these bundles therefore differs from that of bundle 3. Therefore, they will be treated separately here as well.

The Migration paths show what Road Authorities need to do, and in which sequence, in order to deploy the bundles of cooperative systems investigated in the COBRA study. The Migration path integrates business model considerations, findings based on calculations made using the COBRA tool and legal aspects, presented in Chapters 3 and 4.

Figure 28 shows the Migration path for Bundle 3. Figure 29 shows the Migration path for bundles 1 and 2. Actions in four categories are identified, as indicated on the vertical axes in Figure 28 and Figure 29. These criteria were developed in an Internal Consortium Workshop on 7 March, 2013. The criteria are:

- Actions with **partners in deployment** (in green): Road Authorities must make initial choices of the services to deploy, how to deploy them and with whom. The partners in deployment depend on the choice of *role* that the Road Authority wants to play, and the b*usiness model* to use in deployment.
- Actions to **deploy cooperative systems** (in light blue): These actions concern planning when to start deployment of cooperative systems, phase out existing systems and the actual deployment, in relation to other actions when to deploy cooperative systems.
- Actions to address **legal issues** (in dark blue): These aspects include traffic law conformity issues (including enforceability), liability, and data protection and privacy aspects; and
- Actions to address **Standardization and other issues at the European level** (in orange): These aspects include issues such as requirements for in-vehicle equipment.

The horizontal axis the figures represents time at a rather rough scale. The time scale for bundle 3 (2020, assuming cellular technology) and bundles 1 and 2 (2040) indicate that the issues in deployment of bundles 1 and 2 require addressing more significant issues than bundle 3. The relative position from left to right within and between categories roughly indicate that the action on the left must precede the action to the right.

5.2 Migration Path bundle 3

Bundle 3 provides the primary information functions of DRIPs. As mentioned in Section 4.2, Bundle 3 has no enforcement issues. Liability issues as described in Section 4.1.2 can be limited for the Road Authority. DRIPs are also not safety-critical. As a result, the Migration Path for bundle 3 is significantly simpler than for bundles 1 and 2.

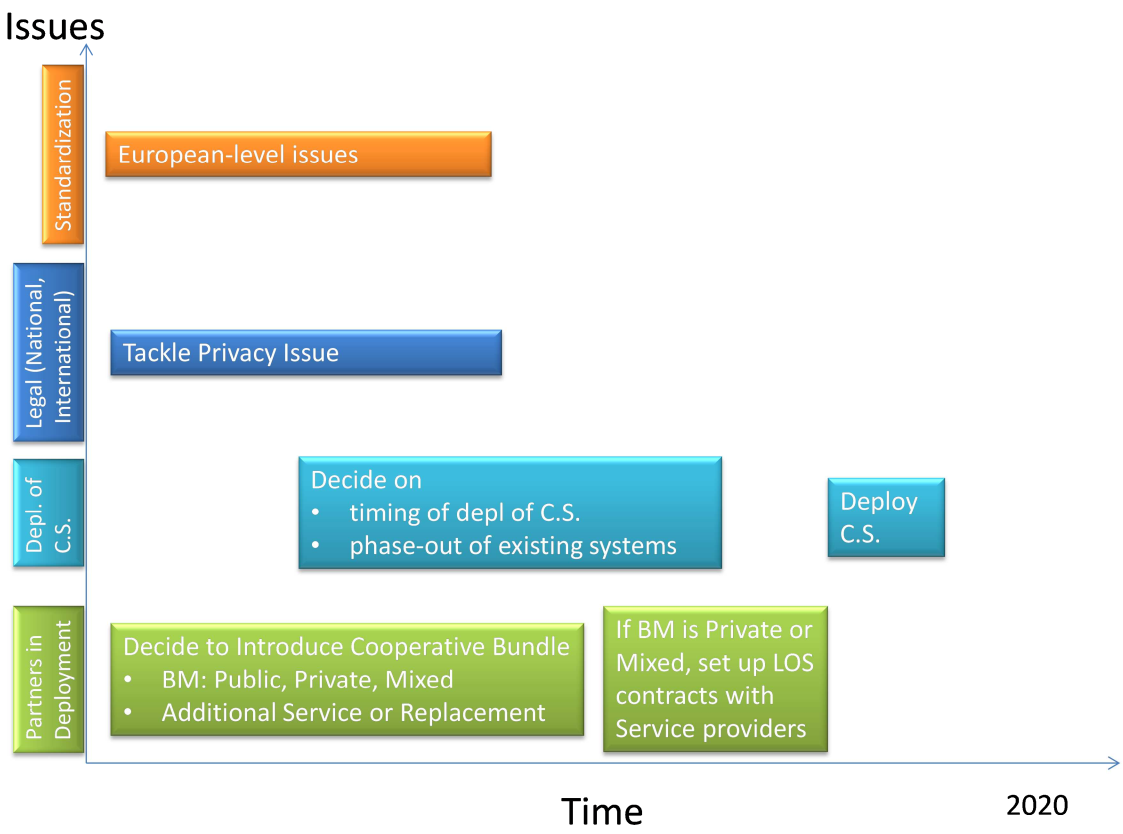

Figure 28: Migration Path for bundle 3 (C.S. = "cooperative systems")

To deploy bundle 3, the Road Authority needs to start three actions first:

- Decide to implement cooperative systems and with which business model;
- Address a possible privacy issue; and
- Address European-level issues.

The Road Authority needs to decide which business model to pursue, Public, Private, or Mixed. This choice determines which stakeholders will become partners in deployment. This decision will have implications for level of complexity in deployment, as described in Section 3.1.3. The Road Authority also needs to decide if the goal is to supplement the current infrastructure with the in-vehicle information, or whether replacement of the existing infrastructure is the goal. If the business model chosen is either Private or Mixed, then the Road Authority has a follow-up action to develop Level-of-Service (LOS) contracts with the service providers and partners in the chain of delivery.

An important legal issue that may have to be addressed is privacy, when personalized information is provided, as discussed in Section 4.2.

The Road Authority will also need to address standardization issues at the European level. Agreements on the display need to be established, in conjunction with seamless cross-border functioning of the bundle. Some level of legal intervention will (most probably) be required.

The deployment of cooperative systems and the removal of existing roadside infrastructure affect the cash flow of the Road Authority. DRIPs provide a large societal benefit. Reducing the existing DRIPS infrastructure aggressively, while the equipment rate of vehicles lags, has a severe negative impact on societal benefits. Therefore, the sequence of deployment of cooperative systems and phasing out of existing roadside equipment must be carefully considered by the Road Authority.

5.3 Migration Path bundles 1 and 2

Bundles 1 and 2 present information that is shown on obligatory and regulatory signs. The legal repercussions are significantly larger than for Bundle 3.

Figure 29 illustrates the migration path for Road Authorities in the situation that they have existing road infrastructure.

Due to legal issues that need to be addressed, the in-vehicle deployment of bundles 1 and 2 should be initially provided as an additional service. A high (but unknown) equipment rate is necessary before all regulatory and signs can be removed from the roadside. Several conditions must be satisfied before the road signs can be removed, all of which take time to address, whether cellular or wireless beacon technology is chosen.

The Road Authority needs to start three actions first:

- Decide to implement cooperative systems and with which business model;
- Decide on the timing of the deployment of cooperative systems, and address political issues regarding road safety;
- Address important legal issues; and
- Address European-level issues.

Similar to bundle 3, The Road Authority must decide which business model to use for bundles 1 and 2. If the business model is Private or Mixed, third parties will provide services. If third parties will provide (parts of the) services, a certification process for quality and reliability of the service providers' applications must be established at the European level. If replacement of regulatory road signage is the goal, then EC regulations must require every vehicle to be equipped from a certain date.

From a legal perspective, liability and data protection issues need careful consideration. To ensure enforceability and/or if replacement of regulatory road signage is the goal, then legislative interventions will be needed to implement in-vehicle signage in the existing legal framework on road signs (including the Vienna Convention on Road Signs and Signals) as well as making the required technology standard factory equipment through the EC whole vehicle type-approval framework.

Part of the choice of business model will require the choice of technology (cellular or wireless beacons). Such a choice will require further study, taking into account robust technology choices, developments elsewhere in Europe and the timing of the deployment. The COBRA tool does not allow the choice of using more than one technology, but this certainly should be considered. Careful study at the country level should consider which parts of the network to equip and when. Choices include whether to equip parts of the network that are not yet equipped, or to equip hotspots where presumably existing infrastructure (eventually) will be replaced. The former will have different benefits from the latter, in terms of costs and benefits. The former will deliver benefits by equipping a previously unequipped location, although the benefits may be marginally lower than newly equipping a hotspot. The latter will provide marginally little to no benefit, as existing systems already provide services, unless the bundle of services provides more benefits than what is currently provided by existing roadside infrastructure. Infrastructure savings may be able to be generated when existing infrastructure is (partially) removed. Partial phase out of existing *warning* systems may be possible if political and legal obligations regarding equity and road safety are sufficiently met. Aspects of these criteria are usually not quantified, but concern political choices.

The existing road infrastructure can be completely removed only when virtually 100% of vehicles are equipped with in-vehicle systems. This requires European regulations that every vehicle be equipped. Equipment must be made mandatory at the European level. The phase-out of existing roadside infrastructure can be started before all vehicles are equipped with the required in-vehicle equipment. However, the removal of all the relevant existing roadside equipment can only take place when the virtual 100% equipment level has been reached. Initially, bundles 1 and 2 should only be provided as an additional service.

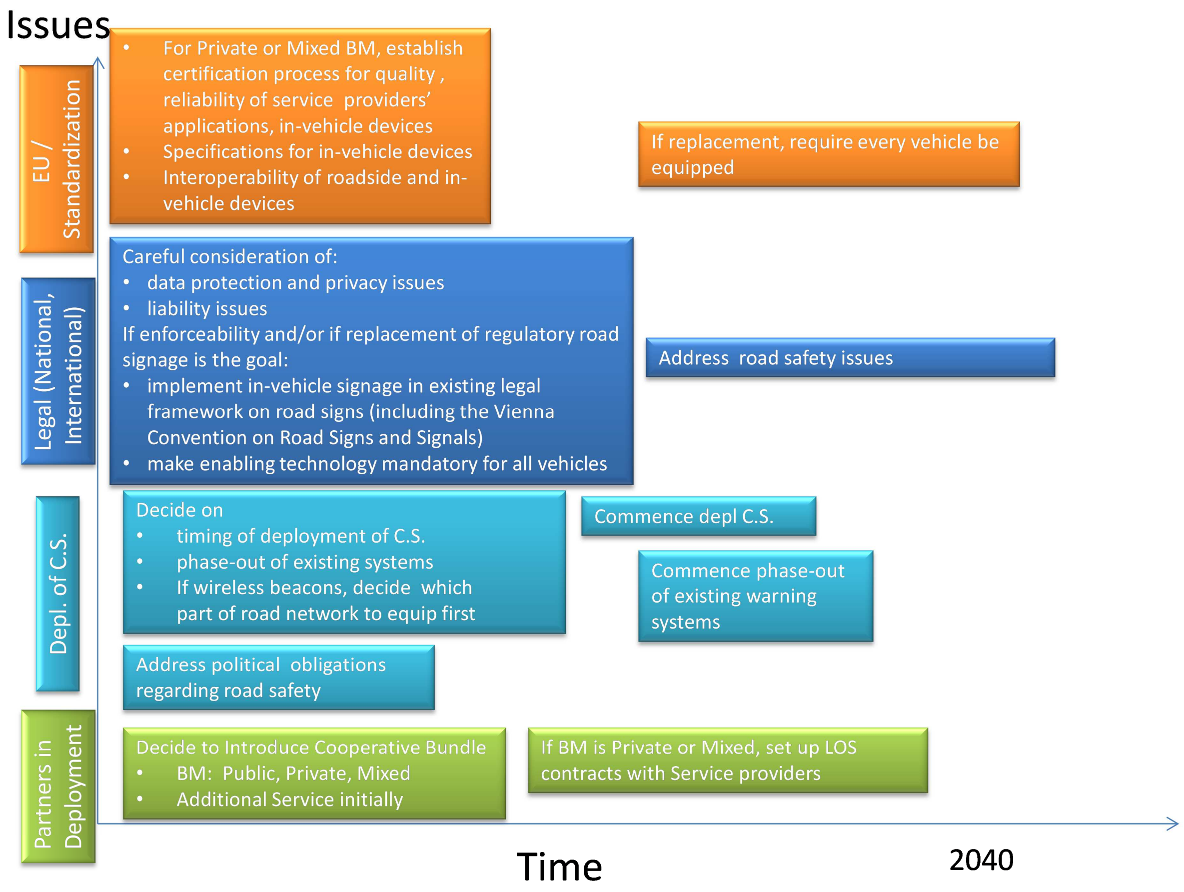

Figure 29: Migration Path for bundles 1 and 2

5.4 Conclusions

Road Authorities must address different types of issues when considering the deployment of Cooperative Services. Some issues are hurdles or preconditions that can prevent the deployment of Cooperative Services, such as legal aspects. Some concern fundamental examination of the role the Road Authority wants to play in traffic management and fulfilling its mandate. Still others have to do with the complexity of financial issues (planning cash flows) and the chain of deployment. The phasing out of existing infrastructure requires significant and careful analysis of the specific situation in each country. It also depends on how the Road Authority is funded. This affects the ability of Road Authorities to make these decisions autonomously. Also, what mandate do they have? Must they provide information to every road user, or provide minimum service?

At this point in time, safety relevant applications such as bundles 1 and 2 should be regarded as a complementary service and not as a substitute for road signage that is needed to provide safe roads to all drivers.

The migration paths above illustrate the strategic steps that need to be taken in order to deploy cooperative systems in a European Country. The European Commission and other key stakeholders are also working on deployment of cooperative systems. The report, “Defining the required infrastructure supporting Co-operative Systems (SMART 2010/0063)” [5] defined challenges for key stakeholders in order to foster the innovation of cooperative systems, where “key stakeholders” refers to those organizations that must invest. Of the twelve challenges, the first ten are directly related to the steps defined above. The twelve challenges are:

1. Define a cooperation agreement within the Key stakeholders group
2. Agree on Day-1 applications

3. Agree on roles and responsibilities
4. Agree on applied standards / a hybrid communication concept
5. Define hot spot areas, corridors and regions
6. Agree on information management procedures
7. Agree on service levels and quality issues incl. conformance testing
8. Identify business models and benefit/cost ratios
9. Agree on legal terms
10. Agree on a detailed project plan on deployment incl. respective investments
11. Identify remaining R&D needs
12. Agree on marketing activities

6 Conclusions and Recommendations

The Chapter first presents conclusions of the COBRA project, then recommendations for further development of the COBRA model and for further research.

6.1 Conclusions

The analyses carried out in the COBRA project revealed a complex picture. Road Authorities must address different types of issues when considering the deployment of Cooperative Services. Some issues are hurdles or preconditions that can prevent the deployment of Cooperative Services, such as legal aspects. Some concern fundamental examination of the role the Road Authority wants to play in traffic management and fulfilling its mandate. Still others have to do with the complexity of financial issues (planning cash flows) and the chain of deployment. The phasing out of existing infrastructure requires significant and careful analysis of the specific situation in each country. This Section of the report summarizes these issues, and discusses the migration paths.

The Benefit-Cost Ratio of deploying cooperative systems is often higher and even much higher than one. Making use of Smart phones and retro-fit units can lead to a relatively quick equipment rate of drivers (vehicles). They are relatively inexpensive, also given the high penetration of Smart phones in Europe. Smart phone issues such as reliability, accuracy and time-criticality prevent the current technology from being used for safety-critical applications. Future cellular technologies are promising and may meet requirements for reliability, accuracy and time-criticality for safety applications.

The societal cost-benefit case is positive for bundle 3. The business cases for the Road Authority for deployment of bundle 3 are positive in each of the three business models analyzed in detail, mainly because of the large potential for cost savings assuming that it is acceptable to remove some of the existing roadside system, that is, the signs (DRIPs) that display traffic and travel information.

For bundles 1 and 2, the costs far outweigh the benefits on the societal level in both the cellular and wireless beacon implementations. However, the Road Authority has a positive business case in all three business models. In the two wireless beacons business models analyzed, the Road Authority would be facing significant initial investment.

The Benefit-Cost Ratio is highly sensitive to CAPEX and OPEX in-vehicle costs, which are multiplied by a percentage of the total number of vehicles equipped, and to the deployment of wireless beacons, which are expensive at this moment. The Road Authority business model does not include the in-vehicle costs; these costs are for users or for vehicle manufacturers. In spite of these in-vehicle costs not being part of the Road Authority's business model, whether a user must pay these costs raises equity issues, as described in Chapter 3. The costs of the wireless beacons influence the Road Authority's business model. Thus, reduction or controlling of these costs work to improve the Benefit-Cost Ratio and the business model.

The Road Authority faces many choices in deciding how to deploy cooperative systems. Some are non-financial, such as the role of the Road Authority in traffic management, the complexity of the chain of delivery of services, policy goals on road safety, environment or congestion, or even less traffic-related goals on innovation, industry development or employment. Other choices are financial, such as the business model. The financial and non-financial choices are interdependent, for example, the choice of a business model implicitly leads to a specific role.

The business model analyses in Chapter 3 show that there are many levers to play with in influencing the business model calculations. These levers can for example affect a scenario in which wireless beacons are deployed: the business case can be made positive. In investigating a plan for deployment, detailed calculations are necessary. The exact results will depend on the existing infrastructure within a specific country. The introduction of cooperative systems using an aggressive vs modest reduction of existing roadside infrastructure has a major impact on the business case. A reduction of existing infrastructure that is too aggressive can lead to a loss of benefits.

A "good" choice of a business model by a Road Authority requires positive business cases for all actors involved in deploying the Cooperative Service. Taking this perspective to the opposite extreme, a Road Authority that chooses the business case that is very positive but means that other actors needed to deliver the service have negative business cases, chooses a path that will doom the deployment of cooperative systems. Simply said: a great business case for the Road Authority may mean a very unattractive business case for another partner. A good choice of business model and Case requires the simultaneous examination of the business models and cases of all the actors needed in deploying cooperative systems.

The migration paths reveal actions that the Road Authority can take before making the decision to deploy cooperative systems. The Road Authority can investigate the financial and non-financial issues mentioned above. It can investigate which cooperative systems provide services would be most relevant to its goals. It can determine what role it will choose to play in deployment. It can explore paths for deployment that result, both in financial and non-financial terms.

In financial terms, Road Authorities that have already invested significantly in existing roadside infrastructure face a more difficult challenge in justifying the investment in cooperative system infrastructure. These Road Authorities will need to build a case for an "in-vehicle service" requiring short and medium term investment and thus an increase in costs with potentially little benefit in the short term above that which has been achieved from the existing road side infrastructure. This may make it difficult to raise funds for these types of services. A careful analysis of investment in new infrastructure and possible reduction in the existing roadside infrastructure over time is required to build the case.

Calculating impacts using the COBRA tool reveal that motorways are often already relatively safe and have a relatively high traffic efficiency. In comparison to other road types, motorways have smaller gains to realize. To achieve higher impacts on a broader geographic scale, and simultaneously to reduce costs, Road Authorities can look for synergies in deployment with other Road Authorities at the provincial and urban levels to achieve impacts on more than one type of road. The synergy is to use applications on a common platform, or even common applications, thus realizing shared costs.

The decision to deploy cooperative systems requires looking at the international context. This project, COBRA, is a good example, given the funding of this project by five Road Authorities in ERA-NET Mobility. Decisions about services and technology lead to greater efficiency, performance and seamless cross-border functionality when carried out at using a larger (international) perspective. Initiatives along these lines already exist and should expand to achieve widespread deployment.

6.2 Recommendations for further development of the COBRA tool

6.2.1 Details of the basis of assessments

The current version of the tool includes an 'output' page which is a self-contained summary of the analysis, which can be printed on two A3 sheets. A series of graphs compare two scenarios and a table provides a record of how the scenarios have been defined and the values which have been set for any parameters which are open to users to vary.

During the workshop which demonstrated the tool, some Road Authorities indicated that a more detailed record would be required. Since then, an early version has been created which prints the key cost data, country data and a list of assumptions for the chosen scenarios.

The methodology, and sources for the impact assessment are currently contained in COBRA Deliverables D2 [2] and D3 [6] respectively, but could also be integrated into the tool in a future version. This would require adding further details to the tool, and developing a mechanism for updating the impact assessment values and any methodological changes.

6.2.2 Hyperlinks

The tool currently contains references and links to the sources of information in cells adjacent to the data. On seeing the tool demonstrated, some Road Authorities requested that the tool be enhanced to provide links from the data cells in the worksheets to the relevant background information on assumptions and definitions. This was not possible within the resources of the current project, so it was agreed that this would be proposed as a possible future enhancement of the tool.

6.2.3 Do something vs do-nothing scenario

The current approach in the tool is to consider the relative difference in costs and benefits. The "do nothing scenario" was not included, because it is complicated by the extent to which existing systems are deployed. It is currently assumed that the impacts of the co-operative systems overlap 1:1 with existing systems. This is likely to be a simplification (e.g. VMS have many different functions); however, existing systems were out of the scope of the impact assessment. Another simplification was that sensors were not included in the tool, which again complicates the "do nothing scenario". Further work would be required in a future version to expand the scope to account for existing sensors, and also to define functions and impacts of existing systems, alongside the overlap with the impacts of the co-operative systems.

6.3 Recommendations for further research

In addition to the next steps to be taken in deploying cooperative systems as described in the Migration Paths and Conclusions above, Road Authorities can take actions to improve their knowledge of the impacts of cooperative systems and pilot cooperative systems in the time of austerity

6.3.1 Impact Assessment

The decision support tool uses the current state of the art in cooperative systems (technologies, impacts and costs-benefits). In order to process the benefits and assess the impacts (COBRA WP3) of currently known and considered cooperative functionalities, 40 preceding projects were used, either Field Operational Tests or simulation studies. Both methods of analysis have their limitations in terms of accuracy of estimates. In the case of field operational trials, the geographical and regional effects as well as the duration of the respective trial will have an influence on the results, making it difficult to extrapolate specific estimates to a general (i.e. country specific) value. In terms of simulations, the limitations result in greater complexity and/or inherent systematic errors, due to high variations in results, input factors, simulation tools, etc. Both sets of limitations may introduce a bias in the final results. The methodology within COBRA for the impact assessment is entirely based on the findings from the literature. No additional simulations or Field Operational Tests were carried out to validate or support the results.

The COBRA project also chose to assess the impacts of a bundle of services, instead of single services. That is, the service "Local Dynamic Event Warnings" consists of the services Hazardous location notification, road works warning, traffic jam ahead warning and post-crash warning (eCall). The "bundle" approach is logical as it is expected that services will be introduces in bundles [5]. Literature studies revealed impacts only for individual services and not for bundles, in particular these bundles.

This approach comes with its own limitations and challenges, notably:

1. Finding the optimum combination of different impact values deduced from different studies to reach one single value per indicator;
2. Establishing the best method of combining different functions within one bundle to one single impact per bundle;

The difficulties ranged from reported positive and negative estimates per indicator, to a large variety of values within different studies. How the conclusion and final values were estimated is a crucial point in assessing the overall impact of a function and bundle.

Based on the literature review and the assessments performed, a set of conclusions and recommendations can be made:

- The literature review revealed a lack of impact assessment results, possibly due to the novelty of cooperative systems. eIMPACT, CODIA, SEiSS and EasyWay are among the major projects that focus on the impact assessment of stand-alone and cooperative systems. More results are expected soon for a limited number of systems, e.g. Drive C2X project.

- There are few studies, which evaluate the positive effects that a cooperative technology can contribute to an existing roadside system. Further research activities have to focus on the difference between roadside (e.g. variable message signs) and cooperative systems (e.g. in-vehicle speed signage) regarding user behavior and impacts.

- The functions that have been studied were analyzed mostly by means of simulations. The reliability and accuracy of results coming from these types of evaluations are usually less trustworthy than from Field Operational Tests. Most projects, in which simulations were used, revealed high variations in results, or even estimates, which were considered unrealistic.

- Further considerations towards a more generalized methodology are needed for the extrapolation of results from Field Operational Tests carried out on a small geographical segment to generalized figures, e.g. per national member state or country specific values.

- The methodology for an impact assessment should be described in depth in order to allow for a conclusive and clear analysis. The majority of studies reviewed did not provide a clear methodology and documentation on how their respective estimates were deduced.

- Only a few projects address the full range of conditions and influencing factors in which the functions would be deployed. As it is expected that cooperative systems will be available across Europe, a deployment scenario for the purpose of an impact assessment should cover a wide range of conditions, e.g. road geometry, traffic and weather conditions, etc.

- There is little research regarding the reaction of drivers towards cooperative systems and the behavioral changes that result. Therefore, it is difficult to assess results from multiple studies, each with its own scenario and conditions.

- Further assessments require consideration of all constraints and assumptions that yield an impact to be reported.

6.3.2 Piloting, in conjunction with austerity measures

Deployment of cooperative systems provide the opportunity to maintain the benefits provided by existing roadside infrastructure while reaping benefits from infrastructure savings. In this time of austerity measures, innovation and austerity can go hand-in-hand.

As mentioned above, the impacts of cooperative systems deployed in addition to existing roadside infrastructure are unknown. Pilots of cooperative systems can be deployed to gain evidence on these differences, as well as other open questions related directly to the decision on deployment of cooperative systems. Information gained during a pilot could improve the COBRA tool based on the new knowledge.

Such a pilot could be used to provide answers to the following questions:

Questions about Driver Behavior:

- What is the compliance of drivers with respect to (specific) existing road signage?
- How do drivers drive differently when additional information is provided in-vehicle? How does this behavior vary over time (short- vs long-term behavioral changes)? Do speeds change, does the cooperative system affect route choice, etc?
- If the frequency of road signage is decreased (once every 8 kilometers instead of once every 2 kilometers), what effect does it have on specific driver behavior parameters?
- How does driver behavior change when in-vehicle services are provided, when the frequency of road signage is decreased?

Questions about Driver Acceptance, Experience:

- Do drivers accept a reduction in existing road signage?
- Does acceptance depend on the provision of in-vehicle services, in the face of reduced road signage?
- What is the drivers experience of reduced road signage, with and without in-vehicle services?
- Do drivers miss information, subjectively and objectively?

Overall societal goals

- What are the impacts of equipping 10%, 20% and 50% of drivers with in-vehicle services? How do the impact change when road signage is decreased?

Carrying out a pilot provides an opportunity to experiment with different business models. For example, a pilot with an information provider could be set up to test out one of the Private or Mixed business models where the Road Authority takes on a different role.

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8 Glossary

4G	4th generation of cellular communications networks
ANPR	Automatic Number Plate Recognition
App	Application used to deliver a service
BABW	Besluit Administratieve Bepalingen Wegverkeer, Decision Administrative Regulations Road Traffic
BW	Burgerlijk Wetboek, Dutch Civil Code
BCR	Benefit Cost Ratio
BM	Business Model
CAPEX	Capital costs of equipment to support a service
CBA	Cost Benefit Analysis
Cellular network	Communications platform to support long range communications e.g. mobile phone
eCall	Emergency Call service in which a vehicle involved in an accident makes an automatic call to the emergency services
FCD	Floating Car Data
GDP	Gross Domestic Product
ISA	Intelligent Speed Adaptation
ITS	Intelligent Transport System
Managed motorways	An integrated set of traffic management systems to improve traffic flow and road capacity; in the UK they primarily involve variable speed limits and hard shoulder running.
NRA	National Road Authority
OEM	Original Equipment Manufacturer (e.g. vehicle manufacturer)
OPEX	Operational costs of running or using a service
Payback year	The first year in which the cumulative benefits of a service exceed the cumulative costs invested in it
Penetration rate	Proportion of vehicles which are equipped to participate in a service
PND	Personal Navigation Device
Queue protection	Automatic traffic management system used to detect sudden traffic disruption and warn traffic approaching the scene to protect vehicles at the back of the queue from rear-end collisions
RVV	Reglement Verkeersregels en Verkeerstekens (Dutch Traffic Code)
Sensor costs	Capital and operational costs of acquiring data for ITS e.g. through loop detectors, CCTV, weather detectors
Smartphone	Mobile telephone used to deliver a variety of other services to users, via Apps
Unintended impact	Dis-benefits occurring as a result of the cooperative system. In calculating the benefit: cost ratio in the tool, these are treated as if they were additional

	costs
Value web	A value web depicts the flows of services, money and non-monetised value between the main stakeholders involved in a service (whether as providers or users).
VMS	Variable Message Sign to display a number of messages, and which can be switched on or off as required; various types of sign are available involving different technologies and costs and performing different functions. When considering the savings from removing VMS, users of the tool will need to specify the types, costs and level of deployment to fulfil the function which is being investigated.
Wireless beacon	Communications beacon to support short range communications between vehicles and the roadside. It is assumed that each beacon has a range of 300 metres.
WVW	Wegenverkeerswet, Road Traffic Act, The Netherlands

9 Appendix: Legal Aspects: A Quick Scan

This section gives an overview of relevant legal aspects in the deployment of cooperative systems. It should be noted that this legal quick scan is only indicative in nature. Legal issues related to specific applications/services may relate to other areas of law, may differ between jurisdictions and may be dependent not only on functionality, but also on technical and organizational embedding (and therefore may only be (fully) assessed if their functionality and technical and organizational embedding are sufficiently clear).

9.1 Introduction

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, thus contributing to road operators' objectives. The COBRA project aims to help Road Authorities to position themselves to realise the potential offered by developments in cooperative systems. It does so primarily by providing insights into the costs and benefits of investments, both from a societal perspective and a business case perspective.

Another relevant parameter in relation to Road Authorities positioning towards cooperative systems may be that of the (potential) legal implications of deployment . For example, one potential benefit of cooperative systems flows from the assumption that these systems may be a substitute for conventional ways of communicating with road users (through VMS and conventional road signs). However, what may be the legal boundaries and constraints in this context. For example, what is the legal status of a speed limit displayed in the vehicle. Can this be a substitute for conventional road signage?

In this section, relevant legal domains will be explored to identify legal implications of the deployment of COBRA-applications. Relevant road traffic law aspects will be discussed especially focusing on the legal framework for the use of road signs. Paragraphs 9.3 and 9.4 will cover civil liability and data protection/privacy issues.

9.2 Cooperative Systems from a traffic law perspective

Are there any restrictions on the deployment of cooperative systems flowing from the existing regulation on the use of nomadic devices?

A recent study on regulation of nomadic devices [11] revealed that a diversity in the countries' legislative approaches exist. Although all countries (except Sweden) have adopted specific regulations on mobile phones, with regards to other device classes (Personal Navitation Devices (PNDs), music players and TV/video players), the picture is rather non-homogeneous: Some countries address the use of these devices through both specific and/or general regulations; however, in other countries there is no legislation applicable to the use of any devices other than mobile phones. Also concerning the level of detail of applicable regulations (i.e. to what extent the use of a certain device is restricted), the results indicate that the picture in the countries is rather variable; ranging from countries intervening highly in the use of the different devices to states that hardly stipulate any concrete requirements. In addition, in many countries, different regulations apply for the use of a specific device (e.g. for PNDs: ranging from regulations addressing the driver's field of view to regulations prohibiting additional PND functions). All in all, existing legislation for nomadic devices does not seem to obstruct the deployment of COBRA-services through nomadic devices.

To what extent do current laws allow cooperative systems to be a substitute for conventional methods of communicating to road users?

Apart from increased safety and traffic efficiency, a potential benefit of cooperative systems for Road Authorities lies in the potential of these systems to provide a functional substitute for conventional methods to communicate with road users , i.e. through VMS and road side road signs leading to cost savings as a result of a decrease in the number of traditional, physical road side signage or equipment.
For example, in theory it is conceivable that in-vehicle signage may serve a substitute for road side road signs relating to legal obligations such as speed limits, allowing for example for more flexible, more dynamically tuned speed limits. However, it to what extent this may be legally feasible. For example, what is the legal status of a speed limit displayed in the vehicle. Can this be a substitute for conventional road signage? How can enforcement be carried out? This question first of all relates to existing laws and regulations concerning the use of road signs.

International legal framework on road signs

On an international level there is a long history of attempts to harmonize the meaning and the use of traffic signs. This resulted in several international conventions and agreements dealing with this topic: the two Vienna Conventions from 1968 on Road Signs and Signals and on Road Traffic, (which both have a global scope), the European Agreements supplementing them (, and the Protocol on Road Markings, additional to the European Agreement supplementing the Convention on Road Signs and Signals. [12]

The aim of these legal instruments is to facilitate cross-border transport through harmonized rules and road signs. For example, the Vienna Conventions on Road Signs and Signals obliges the Contracting Parties to accept the system of road signs, signals and symbols and road markings described in the convention and undertake to adopt it as soon as possible (art. 3).

In cases where variable message signs are used, the inscriptions and symbols reproduced on them must also conform to the system of signs and signals prescribed in this Convention. The red colour of the symbol of a sign and its border shall not be changed (art. 8). Noteworthy is also the art 3 (b) with stipulates that “with a view to improving traffic control techniques, and having regard to the usefulness of carrying out experiments before proposing amendments to this Convention, it shall be open to Contracting Parties to derogate from the provisions of this Convention, for experimental purposes and temporarily, on certain sections of road.” The formulation makes clear that derogations may only be temporarily.

Although the harmonizing effect of these treaties and agreements is clear, national differences may still exist due to the non-exhaustive nature of these documents and the possibilities for signatories to make reservations upon ratification. The Netherlands – ratifying these international conventions and agreements in 2007 – made quite a large number of reservations.[13] One such reservation relates to the use of variable message signs. Contrary to art. 8 of the Vienna Convention on Road Signs The Netherlands uses maximum speed limit signs on VMS without a red coloured ring.

The Dutch legal framework for the use of road signs

Dutch road traffic law is characterized by a closed system of traffic signs and road signs containing obligations, prohibitions and warnings. The underlying rationale of this system (as well as of the international conventions and agreements mentioned above) is to provide road users with a uniform, coherent, and easy to understand system of traffic signs.

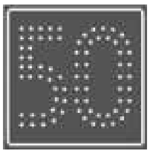
Road users must obey road signs that contain obligations or prohibitions (art. 62 Reglement Verkeersregels en Verkeerstekens, the Dutch Traffic Code; hereafter ‘RVV’). Traffic signs may be displayed via variable message signs (‘elektronisch signaleringsbord’) (art. 64a RVV).

Road signs include (art. 3 Besluit Administratieve Bepalingen Wegverkeer, the Decision Administrative Regulations Road Traffic, hereafter ‘BABW’):
a. traffic signs;
b. traffic lights;
c. road surface road signs.

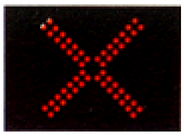
Traffic signs containing legal obligations, prohibitions, or advised speeds must be in conformity with the signs included in the RVV (Annex I, Chapter A-H).

Examples:

Maximum speed



Maximum speed on a variable message sign



Closed road lane

The same applies to traffic signs that indicate danger. (Annex I, Chapter J).

Examples:

Traffic queue

Traffic queue on VMS

Dangerous curve

Traffic lights ahead

Traffic signs containing other information for road users must, as far as no specific model is being prescribed in the RVV, be placed on a rectangular sign, on which the letters, numbers or symbols are placed in a blue field. Deviations are subject to the approval of the Minister of Transport. (art. 4 BABW)

Road surface road signs containing obligations or prohibitions must be in conformity with the RVV. Other road surface road signs may be used for the purpose of guiding traffic, to remind road users of the local speed limit, or to indicate other relevant conditions (art. 6 BABW). Other road surface road signs than laid down in the BABW may not be used (art. 7 BABW).

Implications of the existing legal framework for the implementation of cooperative systems

This more or less closed system for the use of road signs seems to have several implications for the implementation of cooperative systems:

1) Regulatory road signs (i.e. signs intended to inform road-users of special obligations, restrictions or prohibitions with which they must comply) must be in conformity with above described traffic regulations. This means that obligations or prohibitions communicated to the road user via an in-vehicle display are not legally enforceable. Although there is no legal definition of 'road sign' or 'variable message sign' in the above mentioned traffic regulations, it flows from the legal system that in-vehicle displays cannot be qualified as such. For example technical regulations provide for minimum size and height of traffic signs.[14] It would therefore require legislative changes to 'upgrade' in-vehicle display messages to the

equivalent of regulatory road signs. In theory, it is possible, through legislative intervention, to 'upgrade' regulatory road signs that are communicated through in-vehicle displays to be legally binding (and therefore enforceable) road signs. Such an upgrade in fact happened in the Netherlands in relation to road signs communicated through VMS (art. 64a RVV). However , this kind of technology will raise additional and specific questions on an operational level in this domain that need to be addressed. How long should a message be presented in-vehicle? What happens to new information, and what is its priority? Does old information disappear immediately, or does it remain on the screen in a "miniature" form? What happens if the older information is more important or safety-critical, and the new information is less so? Further, this would immediately raise issues of legal evidence. How can it be proven that a speed limit or other obligation was indeed correctly communicated through in-vehicle signage

2) The above mentioned however, does not mean that information communicated via in-vehicle displays in all cases is without legal relevance. Apart from specific legal obligations such as to give way or to refrain from exciding the speed limit Dutch traffic law (like most other jurisdictions) includes also a generally formulated statutory provision stipulating that every driver shall conduct himself in such a way as not to endanger traffic (see art. 5 Wegenverkeerswet, Road Traffic Act, hereafter WVW). Furthermore, cooperative systems may have a possible 'intensifying' effect on liability of the driver (see also paragraph 4). The availability of a local dynamic event warning-system, warning the driver for dangers that would otherwise be outside his scope of perception, may also 'create' a higher duty of care for the driver because he/she is provided with more information than a driver without such a system and therefore is better capable to take appropriate action to avoid accidents. However, this would require that such a system does not suffer from a substantial percentage of false alarms and that it can be proven (on the balance of probabilities) that the driver of the equipped vehicle ignored a warning. In most cases, this will require some form of data logging.

3) Apart from the fact that it would require legislative changes to 'upgrade' in-vehicle display messages to enforceable regulatory signs (see under point 1), this may only serve as a feasible alternative for physical road signs if all vehicles would be equipped for such cooperative functionality. Introducing mandatory or prohibitive signs in-vehicle would also imply the drafting of requirements for in-vehicle equipment and its implementation in the existing vehicle-type approval and periodic inspection frameworks. This, should that technical solution be chosen, must be established at the European level

4) One could ask whether in relation to messages communicated to road users other than legally enforceable obligations (for example curvature warning signs or warning signs relating to degraded road surface conditions) COBRA-applications may have more potential to be a viable alternative for road side signage. It seems however, that for several reasons this potential should not be overestimated.

   a. Current (international or national) regulations on road design and the use of road signs may obstruct this.

   b. Road Authorities have a general duty to design roads in a way that they are safe to use (which may require road signage). A breach of this duty of care may lead to liability if accidents occur2 (based on art. 6:174 Burgerlijk Wetboek, Civil Code, hereafter BW; see next paragraph). Road Authorities owe this duty of care not only towards equipped drivers but also towards non-equipped drivers.

[2] This may even include criminal liability (see LJN: BY5595). In a recent court case the municipality Stichtse Vecht was sentenced to pay a fine of € 22.500, - for negligently killing a motorcyclist and her passenger by way of not sufficiently repairing a degraded stretch of road.

Safety-relevant applications such as Bundle 1 applications, should therefore basically be regarded as a complementary service and not as a substitute for road signage that is needed to provide safe roads to all drivers.

9.3 Cooperative Systems and liability

The implementation of cooperative systems may raise questions in the domain of civil liability. In a recent study cooperative systems were, next to ‘highly and fully automated driving’ identified as ‘liability sensitive’. [9] Cooperative Systems are complex systems incorporating many parties, responsibilities and competences. These growing technical interdependencies between vehicles and between vehicles and the infrastructure may lead to system failure. Damages may result from e.g. failure of the roadside equipment, a failure in communication between the roadside equipment and the vehicle, inaccuracy of the messages sent, a failure in the telecommunication systems or the damage may also be caused by a defect of the in-vehicle equipment/components. This also makes the liability situation complex. Applications and services based on cooperative systems may consist of different service components provided by different partners which might be accompanied by unclear distribution of responsibilities and absence of agreements on service ownership.

In relation to COBRA-applications, liability issues may especially come up in relation to safety-relevant application such as hazard warning systems. Particularly in cases where no warning was given although there was indeed a hazardous situation. This may result in claims that accidents may be (co-)attributed to flaws in the system. In this paragraph we will focus on the extent to which NRA’s be held liable for flaws in the functioning of cooperative systems, for example in cases of a single-vehicle accident.

Road managers’ liability for public roads is governed by national law. Therefore, relevant liability regimes may differ between countries. Liability for the safety of roads is mainly liability of public bodies because roads are owned by the state or by local governments.

Dutch law, in contrast to most other jurisdictions in Europe [16], provides for a specific (strict) liability rule for public roads. Art. 6:174 of the Dutch Civil Code stipulates that the public authority responsible for a public road is liable if someone suffers damage because the road is not according to “the standards which, in the given circumstances, may be set for it and thereby constitutes a danger”.

A public road in the sense of art. 6:174 BW does not only include the foundation and surface of the road, but also their accessories such as traffic lights, VMS, safety barriers, etc. [15, p. 15-16]. Therefore, infrastructure components of infrastructure-supported cooperative systems will fall under the scope of this liability. Foreign objects on the road (e.g. oil) are not part of the construction and therefore do not cause liability under this article. Furthermore, there is no liability based on art. 6:174 BW, if there had been no liability under the general rules of liability, had the road manager known of the defect at the time it had arisen. So, art. 6:174 BW only denies the possessor the defense that he was unaware of the defect. Only if the defect was caused at such a time that the possessor, had he known of the defect, still could not have prevented the damage, is there a defense. This somewhat cryptic defense may be relevant in relation to cooperative systems, e.g. in a case of deliberate disruption by a third party (hacking by terrorists).

Art. 6:174 BW is a strict liability, meaning that road managers can be held liable irrespective of fault (i.e. insufficient maintenance, etc.). If a bridge collapses because of a construction defect caused by a fault of the architect, then the public body responsible for the road will still be liable. Also if sections of roads or tunnels are privately operated, the liability of art. 6:174 BW still rests on the public authority that can be identified to be formally in charge of proper maintenance of the road. To the outside world this public body remains legally responsible for any damages that may be caused by a ‘defective’ road. The same mechanism applies to the situation that maintenance is being outsourced .[15, p.17]

As was stated earlier, the public authority responsible for a public road is liable if someone suffers damage because the road is not according to “the standards which, in the given circumstances, may be set for it and thereby constitutes a danger”.

The key question is of course what standards in the context of art 6:174 BW may be set for cooperative systems as a functional element of the infrastructure. Basically the liability standard of art. 6:174 BW refers to a 'users expectations test'.

Under circumstances, a lack of warnings may render the road 'defective' (for example, the lack of warnings for a dangerous, 'hidden' curve).[15, p. 28] In this context, the everyday driver that will also have its moments of lowered attention and carelessness will be the standard to judge the required safety level (see for example HR 20 maart 1992, NJ 1993, 547). However, the sole fact that warnings are lacking where they were preferred is not sufficient to imply the defectiveness of the road (see for example Hof Den Haag 20 mei 1999, NJ 2000, 77). This is especially true as the local circumstances were such that they should have motivated the driver to be more careful, also without the warning (see for example HR 26 september 2003, NJ 2003, 660). In essence it largely boils down to balancing the costs of taking precautionary actions in the form of warnings (or other measures) and the likelihood that accidents will occur.

This may be illustrated with the decision of the Dutch Supreme Court in the 'bus sluice-case' (Hoge Raad, 20 maart 1992, NJ 1993, 547). The municipality of Diemen, a small town near Amsterdam, decided to make a construction on a bus-lane in order to prevent other traffic to use this lane. Buses were able to easily pass this construction, but drivers of motor cars who tried to cross the obstacle drove their cars through a gap because of the narrower wheelbase. Within a short period of time some forty cars had landed in the gap. One of the victims, a taxi driver, sued the Municipality of Diemen, alleging that the way the bus sluice had been constructed was unlawful. Although Diemen had taken a lot of safety measures, such as warning-signs, the Dutch Supreme Court decided that these measures were not sufficient and that Diemen therefore had breached its duty of care. This decision was not surprising given that almost forty drivers did not react properly to these warnings and drove into the gap. This case not only illustrates that manufacturers/Road Authorities need to take account of the everyday driver that is not always as careful as we expect a model driver to be, it also makes clear that warnings cannot be used as a simple safeguard against liability claims if they have proven to insufficiently effective.

But how should we assess the safety road users are entitled to expect from COBRA-services? As far as these COBRA-services would be nothing else than another medium to communicate messages otherwise displayed on road signs, for the COBRA-service user, basically, nothing would change, except for the possibility of new types of functional breakdowns of the system 3 (see however the comments made in relation to the duty of care owed to non equipped drivers in previous paragraph under bulletpoint 4). However, cooperative systems also hold the potential to be able to warn drivers more dynamically than is possible with currently available means. Would such additional services render Road Authorities potentially liable for any missed warning?

What is for example the position where the information provided is correct in itself, but it does not reach the driver because of some technical fault in the infrastructure provided by the road operator. It could be argued that the road operator would be held liable for the technical fault in the messaging apparatus, on the ground that by introducing such a system, the operator was inviting motorists to rely on it, in the expectation that it would be functioning correctly.

Even if this analysis is correct, the claimant is still left with the task of proving that the fault in the messaging system was causative of the accident.4 This could be problematic; if the fault meant that the intended warning message was not displayed at all, one could argue that the motorist was, nevertheless, in no worse a position than he often is, namely, of having to drive without advance warning aids, in reliance on his own observation, skills and judgment. On the other hand, in a situation, such as a motorway, where visual aids are commonplace, one could argue that the motorist is induced to place reliance upon them. In that case, the absence of a warning could be interpreted as an indication that there was nothing about which motorists needed to be warned. In other words, no news is good news!

Due to the restricted scope of art. 6:174 BW, art. 6:162 BW (the general fault based rule of liability) may also be a relevant ground for liability of road managers. For example, the strict liability for public

[3] For example break downs in data communication between infrastructure and vehicles.

[4] For the road manager's liability to be established, apart from a 'defect' in the road, the requirement of a causal link between the 'defect' and the damage must be fulfilled. This means that the alleged failure of the cooperative system should also be regarded the legal cause of the accident. Because in practice, the requirements of defectiveness and causal link between defectiveness of the road and damage are often hard to differentiate from each other it will often come down to the same discussion.

roads will not be applicable if the involvement of public authorities in the deployment of cooperative systems is restricted to providing information to the industry. In that case liability of the Road Authority (or other public bodies that may be involved) should be judged on the basis of the general fault-based liability rule of art. 6:162 BW or, if there is a contractual relationship (for example between the public authority and digital map builder), on the basis of contract law.

Some BM's provide for a (commercial) service provider to make the COBRA-service available to the road user. Service providers may be confronted with tortious liability claims if they fail to provide a 'safe' service. However, in the sole capacity of service provider, the liability exposure of this Actor is more likely to be determined by contract with the 'service purchaser'.

9.4 Cooperative Systems and data protection and privacy

"Cooperative Systems form a special category of concern as it is an application area with a potential to completely change road transport as we know it today and would – on a longer term – affect all vehicles and all vehicle trips. Given the challenges it involves concerning privacy, it requires coordination and further elaboration on a European level involving at least the automotive industry and road operators." [10, p. 103]

For (almost) all applications /services, unresolved issues in privacy and data protection may be a concern. Applications and services are based on the collection, processing and exchange of a wide variety of data, both from public and private sources. Their deployment may also rely on the use of geo-localisation technologies, such as satellite-positioning. As such, cooperative systems constitute a "(personal) data-intensive area" and raise a number of privacy and data protection issues that should be carefully addressed. The principles formulated in the relevant European Directives (which Member States are obliged to implement in their national law regimes) however do not provide specified conditions under which data processing is permissible. This leaves considerable margins of judgement, also in relation to the design and operation of cooperative systems. Privacy aspects should be considered early in the design of applications and the architecture of the systems. These issues relate to the data collected, to the interoperability of systems, and to the security of the data.
This paragraph will shortly describe the legal framework and analyse and evaluate the most important messages from recent reports on this issue in relation to cooperative systems.

Data protection laws first developed on a national level. In 1995 European legislation was introduced in this domain: Directive 95/46/EC on the protection of individuals with regard to the processing of personal and on the free movement of such data. This was followed by other legislation including the Directive 2002/58/EC concerning the processing of personal data and the protection of privacy in the electronic communications sector (Directive on privacy and electronic communications). In the field of ITS reference can also be made to the ITS Directive (Directive 2010/EU). Article 10 of this Directive addresses rules on privacy, security and re-use of information. The article reiterates the principles of personal data protection from the data protection directive and emphasises that: 1) Member states shall ensure that personal data are protected against misuse, unlawful access, alteration and loss; 2) The use of anonymous data / anonymisation as one of the principles of enhancing individuals' privacy should be encouraged. 3)In particular where special categories of personal data are involved, Member States shall also ensure that the provisions on consent to the processing of such personal data are respected.

The key objectives of Directive 95/46/EC are reflected in article 1 of the Directive:
1) In accordance with this Directive, Member States shall protect the fundamental rights and freedoms of natural persons, and in particular their right to privacy with respect to the processing of personal data.
2) Member States shall neither restrict nor prohibit the free flow of personal data between Member States for reasons connected with the protection afforded under paragraph 1.

Article 2 provides the following definition of 'personal data': Any information relating to an identified or identifiable natural person (the data subject). Identifiable means one can be identified, directly or indirectly, in particular by reference to an identification number or to one or more factors specific to his/her physical, physiological, mental, economic, cultural or social identity. This definition includes any information that can be used to uniquely identify or locate a single person or that can be used with other sources to uniquely identify a single individual. The identification mostly depends on the particular circumstances and the applied means, but in principle a person can be identified directly by name or indirectly by a telephone number, a car registration number, an ID associated to a smart card (e-ticketing in public transport), a contract for a telematics on board unit. In certain conditions, even a dynamic IP address (if the processing of IP addresses is carried out with the purpose of identifying the users of a computer) should be considered as personal data.

The fact that data fall under the definition of personal data does not mean that every gathering, processing or storage of these data is forbidden. It only means that the principles laid down in the Directive have to be applied.5

Article 6 lists a number of principles concerning data quality. Member States shall provide that personal data:

a) is processed fairly and lawfully;
b) collected for specified, explicit and legitimate purposes and not further processed in a way incompatible with those purposes;
c) adequate, relevant and not excessive in relation to the purposes for which they are collected and/or further processed;
d) accurate and, where necessary, kept up-to-date. Inaccurate data to be erased or rectified; and
e) kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the data were collected or for which they are further processed. Member States shall lay down appropriate safeguards for personal data stored for longer periods for historical, statistical or scientific use.

The 'controller' is responsible for compliance in the above respects. 6

Article 7 lists a number of criteria for the legitimacy of personal data processing. Member states shall provide that personal data may be processed only if:

a) the data subject has unambiguously given his consent;
b) processing is necessary for the performance of a contract to which the data subject is a party;
c) processing is necessary for compliance with a legal obligation to which the controller is subject;
d) processing is necessary in order to protect the vital interests of the data subject;
e) processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller or in a third party to whom the data are disclosed; and
f) processing is necessary for the purposes of the legitimate interests pursued by the controller or by the third party or parties to whom the data are disclosed, except where such interests are overridden by the interests for fundamental rights and freedom of the data subject, such as data relating to racial or ethnic origin; political opinion; religious or philosophical beliefs; trade union membership; and health or sex life.

For the sector of electronic communications, Directive 2002/58 (E-Privacy directive) complements the Directive 95/46/EC. Directive 95/46/EC is lex generalis which applies to the processing of personal data unless Directive 2002/58 – the lex specialis – determines otherwise (See for a detailed description and analyses of the complex relation between these two Directives [18]). Directive 2002/58 introduces traffic data (any data processed for the purpose of the conveyance of a

[5] Article 5 provides that the Member States shall, within the limits of the provisions of the Directive, to determine more precisely the conditions under which the processing of personal data is lawful, but within the limits of the provisions in this chapter of the EU Directive.

[6] The controller is defined in article 2 as 'The natural or legal person, public authority, agency or any other body which alone or jointly with others, determines the purposes and means of the processing of personal data; where the purposes and means of processing are determined by national or Community laws or regulations, the controller or the specific criteria for his nomination may be designated by national or Community law'.

communication on an electronic communications network or for the billing thereof) and location data (any data processed in an electronic communications network, indicating the geographic position of the terminal equipment of a user of a publicly available electronic communications service) as distinct types of data and provides extra protection in order to guarantee confidentiality, prompt anonymisation, and consent.

For example, article 9 of Directive 2002/58 states that location data other than traffic data “relating to users or subscribers of public communications networks or publicly available electronic communications services ”may only be processed if the data are made anonymous, or with the consent of the users or subscribers of the service to the extend and for the duration necessary for the provision of a value added service. Furthermore, paragraph 2 of article 9 states that, if there is consent by the users, there has to remain the ability for the user to refuse the processing temporarily. In addition, the processing has to be limited to the duration necessary to provide the service. In other words, unnecessary processing of location data (other than traffic data) is prohibited, unless provided for by art. 15 of Directive 2002/58. This article mainly relates to the use of traffic and location data by public authorities for purposes of safeguarding national security and law enforcement. It allows member States to pass legislation to allow access of public authorities to such data and to mandate data retention, without consent of data subjects.

In a recent study on ITS & Personal Data protection – discussing a set of 10 applications including cooperative systems - it was concluded that the concepts and principles layed down in directive, 95/46/EC have proven to be a stable and useful legal basis for personal data protection in the EU. The national legal implementations and practice of data protection have nevertheless led to a fragmentation in the application of personal data protection across the European Union. It was also observed that developments in the area of computing, internet, mobile communications, social media and their widespread use by consumers pose new challenges for personal data protection. Based on a review of relevant legislation, case law, opinions of data protection authorities and other stakeholders the following high-level observations and recommendations in relation to cooperative systems were made:[10, p. 106]

- In the initial stages of deployment, the use of cooperative applications should be based on explicit and informed consent. This consent should allow opt-out of all cooperative interactions, and further be specific for distinguished applications.
- For the exchange of messages and management of the ad-hoc networks short-lived pseudonyms should be used to avoid traceability of individual vehicles. It is noted that this requirement, combined with communication needs and requirements on authenticity and integrity of data that are safety-critical, leads to technical/economical issues that have not been solved completely as of today.
- Exchanged data relating to an individual vehicle, its environment or the driver shall be minimised in view of the applications used / consented to.
- Where data relating to individual and identifiable vehicles are processed (either by systems in other vehicles or in the cooperative roadside infrastructure), these data should be deleted immediately after they are no longer needed for the specified purpose. This would not necessarily apply to aggregated/statistical data that can be derived from the raw data exchanged if they do not include any information that can be related to an individual vehicle

Whether personal data protection is an issue in relation to COBRA-systems depends on how the service is implemented. Privacy issues arise if the individual or vehicle can be identified, based on the information from the driver or vehicle to the information provider. If the information provided to drivers in-vehicle is based on loop data and not personalized, eg, no information is provided by the driver in generation of the in-vehicle information, no privacy issues arise. If the information provided in-vehicle is based on Floating Car Data (FCD) or other information provided by the vehicle driver in order to generate personalized information, then privacy is an issue.

Privacy issues can be addressed via a variety of avenues including applying a privacy impact assessment, applying privacy enhancing technologies (‘privacy by design’ includes anonymisation, data minimisation and deletion of data immediately after initial processing) and requesting explicit consent from the driver for data processing. Preferably guidance for design and operation should be provided through internationally agreed guidelines, standards or templates. [10, p. 119-121]. The extend to which ITS-applications have been covered by for example opinions of national data protection supervisors, the Art. 29 WP or European Data Protection Supervisor differs substantially. Some areas/application such as eCall are well covere, others only partially and most applications are not covered at all [10, p. 115].