

## C-ITS implementation issues: barriers and possible solutions

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### Abstract

Cooperative ITS for road traffic offer potentials regarding road safety and traffic efficiency that go significantly beyond what can be achieved with isolated vehicle and infrastructure systems. However, besides functional and technical aspects there are legal and institutional, financial, political and culture barriers that need to be addressed and must be overcome in order to successfully deploy cooperative services on a broad level throughout Europe. This paper contains an analysis of identified barriers and their possible solutions on the basis of the eCoMove project and several research projects that deal with to C-ITS implementation.

**Keywords:** cooperative ITS, deployment, barriers, solutions, eCoMove

### Introduction

This paper discusses issues that are expected to play a role in the implementation of cooperative systems such as the ones developed in the eCoMove project [1]. Also, it addresses several opportunities to deal with barriers that have been identified for different stakeholders. The content of this paper has been taken from eCoMove-deliverable D6.5 [2].

A barrier to implementation can be defined as: “anything that substantially reduces the probability of adoption of the technologies and applications developed within the eCoMove project”. A first step in the process of identifying barriers to implementation was to review projects already completed for barriers that were mentioned there. This led to the identification of several general barriers that many innovative projects in the area of intelligent transport systems are dealing with. Also, project partners were asked to provide barriers they have perceived in the project or are afraid of when contemplating real-world implementation (rather than in a testing environment). Examples of barriers gathered were presented to stakeholders in the combined eCoMove-ecoDriver stakeholder workshop, which was held in Dublin on June 4, 2013.

### Barriers encountered or expected for eCoMove

Several categories of barriers to implementation can be distinguished. In the eCoMove project they have been grouped in four categories:

1. Legal and institutional barriers
2. Financial barriers
3. Political and cultural barriers
4. Practical and technical barriers

***Legal and institutional barriers***

Legal and institutional barriers occur when legislation or organisations slow down or make impossible the implementation of applications, core technologies etc. For example, an organisation refuses to grant access to their equipment or data, or a law forbids the adaptation of existing technology. Privacy issues also fall in this category.

***Financial barriers***

Financial barriers occur when there is no party that can or wants to cover the costs of further development, implementation and operation. Also, in the case of cooperative systems, with many stakeholders involved, it can concern the effort needed to bring together the necessary funds.

***Political and cultural barriers***

Innovative technologies and applications can take some getting used to. If there is no political support, financial, legal or organisation barriers may occur. Cultural barriers have to do with the end users: are they accepting of the new technologies and applications? Will they purchase and/or use them? Or ignore or even lobby against them?

***Practical and technical barriers***

Practical and technical barriers are likely to occur with innovative technology and applications. Bugs are likely to occur and may be hard to resolve. People may lack the skills and expertise to deal with the innovations.

***Legal and institutional barriers***

- Privacy may be an issue when floating vehicle data are used (position, speed, etc.).
- Safety: can it be shown/guaranteed that the system has no negative impact on traffic safety?
- Security: is there sufficient protection against hacking into the system?
- Liability (“The system does not result in the reduction that was promised”; “Who is responsible in case of system malfunctioning?”).
- Vendor-locking; access to (road-side and/or in-vehicle) equipment or data needed for successful operation may not be granted.
- The cooperative aspect is new in procurement in local governments (projects were always either in-vehicle or infrastructure based projects).

***Financial barriers***

- A sustainable business plan that is positive for all stakeholders involved is not yet in place.
- (Innovative) business models for cooperative systems need to be defined (who pays for OBUs, RSUs, maintenance).
- The application is expected to cost more than private customers or fleet owners are willing to pay.
- Customers are not willing to pay more than a very small amount until they know the system and its potential benefits very well.

***Political and cultural barriers***

- Benefits and costs are not known with sufficient accuracy; effects known were obtained under varying condition and thus difficult to compare.
- There is uncertainty about user acceptance and penetration rates.

- There is uncertainty about the impact on total network performance.
- It is unclear what added value cooperative systems have (when compared with stand-alone systems).
- The business case is not clear.
- The relevant stakeholders (e.g. OEMs, road operators, municipalities) will not implement communication devices (in vehicles, road-side) when no benefits can be shown yet.
- Energy-efficiency and emissions, or eco-driving, are not a priority to authorities, fleet owners or car drivers.
- Drivers may refuse to drive more energy-efficiently if this increases their travel time.
- The application requires intensive cooperation between public and private stakeholders (who initiates/feels responsible?).
- Specific organizational/operational processes that do not align well with cooperative mobility.
- Conservative stakeholders, especially the end-users (e.g. road authority).
- Constraints set by road authorities, daily operation (that is not to be interfered with) and installed base pose limitations to field tests.
- Unawareness about existence of cooperative systems and/or misunderstanding of the implications (e.g. 'I don't want to replace all my systems' – which may not be needed).
- Uncertainty about the continuity of service (in time and space): Will the system work in another city or country? Will it keep working?
- The uncertainty regarding the compliance of future users especially when looking at the issue of social pressure and the fact that in some cases the system use might lead to an increase in time.
- Worries about possible driver distraction from using the system.
- Systems may not be suited to driving styles or vehicle types in some regions.
- Cities do not have enough knowledge about cooperative systems / intelligent transport systems and their benefits.

### ***Practical and technical barriers***

- Good quality live traffic and travel data is often not available, or very costly, or requires significant efforts to obtain and process.
  - Live traffic data for the ecoStrategic Model (Helmond) was difficult to access and process, and varied in quality
  - Live traffic data is difficult to obtain in most cities (there is more experience with motorway data).
- The eCoMove system is complex with many components, applications and core technologies interacting with each other. This led to difficulties with the interpretation of data and messages in several chains of linked components, applications and core technologies (which were often implemented by different partners).
- Many parties are involved - who is ultimately involved in and/or responsible for exploitation of cooperative services?
- Unclear how eCoMove applications fit in /can be made interoperable with legacy systems.
- No up to date map data.
- Lacking map data, e.g. no accurate altitude (or slope) data
- Out-dated legacy systems.

- Vendor-locking; it is hard to work with another vendor's equipment (e.g. traffic controller, vehicle data). In this category, this refers to technical problems that may arise from this.
- Lack of interoperability.
- Worries about the adequacy of the current V2X communication standards (in projects conditions are "more ideal" than in the real world). The requirements on CAM content will put requirements on vehicle positioning that require advanced sensors and could make a simple and inexpensive implementation unfeasible.
- Interpretation of I2V messages (e.g. SLAM, TSPDM and ITM) proved challenging, especially due to TLC variability.
- Time synchronization of ITS stations and the accuracy is not defined, which will lead to interpretation errors of all time stamped information.
- Positioning inaccuracies may prevent lane-level positioning (e.g. required for GLOSA and SLAM) and cause inaccuracies in driver advice. This may especially be a problem in cities and tunnels.
- Differences in map data between ITS stations may be as problematic as having no map data at all. It is not feasible to solve this by creating "one map for all" – instead, different ITS stations should be expected to have different maps, and V2X communication is required to be map agnostic. This way of thinking is not common yet.
- eCoMove solutions are expected to only be feasible in combination with other solutions, and it is unknown when those will be available.

### **Opportunities to deal with barriers**

For some of the barriers mentioned above, solutions are available (and in some cases, are already applied). Several examples, specific to eCoMove, are listed below. Not all barriers are discussed; some barriers are already addressed in general (e.g. privacy issues with the use of floating vehicle data).

#### ***Legal and institutional***

*Possible solution: Memoranda of Understanding to speed up complex decision processes*

Stakeholders can work together to accelerate implementation. For example, within the Car2Car Communication Consortium (C2C-CC), a MoU was signed by 10 OEMs. Green light optimal speed advice is the one energy efficiency application on the list of cooperative applications to be first implemented in 2015. Another example relevant to cooperative systems is The Amsterdam group, which includes members of C2C-CC, road operators and members of city councils. There is also a MoU set up by this group and they have also defined day one applications (the same as C2C-CC).

Similarly, stakeholders in a region may work together to ensure access to (road-side and/or in-vehicle) equipment or data needed for operation of applications. Memoranda of Understanding or service level agreements could be used to make the cooperation more formal.

#### ***Financial***

*Possible solution: Promoting the financial benefits of eCoMove applications*

Customers need to know how they benefit from purchasing and using the system. Well informed customers, who have knowledge about the benefits and/or the costs, are more likely to buy applications and use them. Some of this information is available from tests in the

project, but more information can become available from field operational test and pilot projects.

*Possible solution: Define and adopt a breakthrough business plan*

Stakeholders can investigate, define and detail a business plan that will include all stakeholders involved and will provide combined offering of services for free and premium services, while premium services are accessible only if free services are adopted.

The investigation can be based on a number of novel and breakthrough business plan strategies that already proved able to start up an ignition effect in the market introduction in other fields.

*Possible solution: Smart procurement / investment schemes*

For road side units, a large part of the costs consists of installation costs. These costs could be reduced by procurement of “cooperative system ready equipment”. Cooperative RSUs could be procured in yearly renewal schemes of road authorities. Also, the eCoMove functionalities could be combined with other services to improve the business case.

***Political and cultural***

*Possible solution: Further testing, in real-world situations, of applications and publication of results to wide audience*

eCoMove is an R&D project. A logical next step would be to further test some applications in field operational tests (or incorporate eCoMove applications in running FOTs). Some applications may be ready for pilot tests. Besides showing that technically, the applications work, such tests can be used to investigate compliance of drivers to the advices under various conditions. Further tests will thus generate proof of the benefits (and costs) of applications and will help to show how these application help to make traffic and transport more sustainable.

*Possible solution: Marketing strategies*

Many drivers are unfamiliar with the type of support that the eCoMove system can provide, and as a consequence are not ready to purchase the system. Marketing campaigns can help to make drivers (and other stakeholders, such as employers, transport firms, car dealerships, policy makers) aware of the potential and ease of use of eCoMove functionalities. For this, attractive and instructive illustrations and movies need to be used. This was illustrated by the fact that respondents showed a higher interest in the applications in the second of two eCoMove on-line surveys – with the second survey showing video sequences of the driving simulator studies rather than simple (non-animated) illustrations of the applications as were shown in the first survey.

*Possible solution: Massive public awareness campaign to create the ground for market demand*

In parallel to extensive field operational tests and targeted marketing strategies, a massive public awareness campaign, addressing all major media, can create the ground for a so-called avalanche effect in the market demand. In addition, it can create a change in drivers’ mind-sets, removing pre-conceptual barriers such as: “I need to be in the city centre before 9:00h, the more I speed up and overtake, the faster I’ll be there”. Stakeholders already familiar with the applications could be asked to act as “ambassador” of the system, and end user groups such as IRU, FIA and national counterparts could be asked to participate.

*Possible solution: Training*

This concerns for instance training of drivers as to what they can contribute to energy efficient driving, as well as training drivers how to use the applications etc.. Different goal strategies can be explored, e.g. emphasising fuel savings, or CO<sub>2</sub> reduction, or service & maintenance savings. A distinction should be made between private (car) drivers and professional drivers (of cars, but most of all trucks where fuel savings are very important for transport firms).

Training needs to include the following aspects:

- The reason why one would eco-drive
- A vision of eco-driving and its goals
- The skills that are needed
- The incentives (fuel or cost savings, CO<sub>2</sub> reduction, etc.)

Once eco-driving systems are widely distributed on the market, driving schools could be encouraged or legally obliged to insert in their training programmes specific sessions to learn how to use these new systems.

*Practical and technical*

*Possible solution: reduce complexity when needed after completion of high level architecture (HLA)*

If the HLA shows that system is very complex with many interfaces and many developing partners, it may be best to reduce complexity already at that stage and not to wait until the integration and verification stage. This reduces the workload both in technical terms and in terms of planning of integration and verification activities.

When the complexity cannot be reduced (any further), more time needs to be reserved for integration and testing.

*Possible solution: Standardisation*

For instance, standardisation of time stamps used (to avoid time synchronisation problems), standardisation of traffic data exchanges (formats and understanding of the formats). Minimal requirements should be defined and verified.

Also, it should be realised that standardisation does not solve all problems. Even when it is possible to, for instance, exchange data in a standardised way, stakeholders still have to come to an agreement about sharing data (which might create barriers in all other categories).

*Possible solution: common APIs*

A common API was defined for the map in eCoMove. Thus, the actual map implementation was hidden. This concept works if the maps are not substantially different and when map agnostic location references are used to describe locations (cfr. OpenLR/Agora/ULR/...). Together with standardisation it is a possible solution to vendor locking.

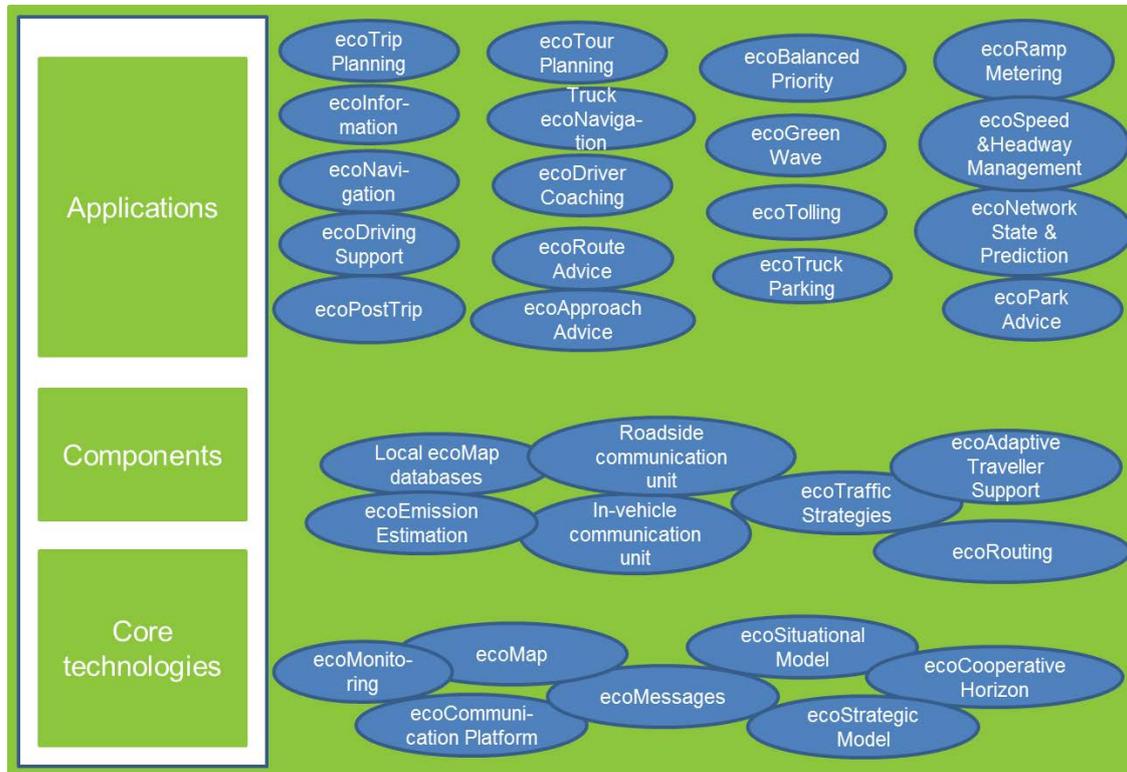
In addition, it would be good to investigate possibilities for Open Data approaches in the context of maps and floating vehicle data.

**Strategies to accelerate implementation**

The results of the eCoMove applications are promising. To achieve the expected benefits in the near future, the various elements of the eCoMove systems need to be implemented as soon as possible. The question is then: when are each of the elements of the eCoMove system ready for implementation?

It proved very difficult to put all elements in a roadmap, as is a customary way of showing when innovative applications and technologies are expected to be implemented. The main reason for this was the complexity of the system: the large number of core technologies,

components and applications that make up the eCoMove system (see Figure 6), and the fact that many of the applications depend on other elements of the system (e.g. an application uses the ecoMap, as well as ecoMessages and road-side and in-vehicle communication units). For a single application, it was therefore already hard to give a projection for when implementation would be feasible. For the entire eCoMove system, it would have resulted in a series of roadmaps with high uncertainties as to when the needed combinations of core technologies, components and applications could be available.



**Figure 1: The many elements of the eCoMove system**

It was decided to focus instead on general deployment needs, and what paths to implementation can be envisaged. Part of that is the identification of strategies to accelerate deployment. The following paragraphs discuss such strategies.

### ***Cooperate, in every sense of the word***

The implementations in the eCoMove project made clear that for every application, the input from multiple partners was needed. This is obviously also the case for future large scale implementation of (parts of) the eCoMove system. Partners are convinced that cooperation will bring benefits. Therefore, efforts should be made (and supported/financed) to bring stakeholders together, to discuss common needs and goals, and possible paths to implementation. When cooperation has been decided on, the roles and responsibilities of the stakeholders involved need to be clearly defined so that situations where stakeholders are waiting for other stakeholders to “do something” are avoided. Memoranda of Understanding and Service Level Agreements can be used to document agreements between partners.

Cooperation will also be needed between system elements – i.e. there needs to be interoperability. Common APIs, standardised messages, and map agnostic location referencing can help developers make progress more quickly. Projects like eCoMove have

helped and can continue to help by providing input to standardisation activities and by re-using, as much as possible, existing and well-functioning technologies and components.

### ***Work towards a sustainable business case***

Even though it is very difficult to say when all of the eCoMove system elements can be implemented, it is obviously not necessary to implement the whole system all at once. Single applications or small sets of applications may be implemented, starting with simpler architectures and working towards more complex applications with greater benefits. Applications that share core technologies and/or components can be implemented in combination, or combinations with e.g. safety applications can be sought.

A sustainable business case also needs transparent figures about costs and benefits. Some figures have been provided by the eCoMove project, but subsequent field operational tests and pilots will generate more figures (e.g. on usage and compliance in real-world situations, and on the balance between effects on energy use and travel times) that can be used to reinforce the business case of cooperative systems and services for energy efficient mobility.

### ***Start where the necessary ingredients are available***

Some locations are more suitable for innovative systems such as eCoMove because they already have system elements in place that are needed for implementation of specific applications. For instance, the eCoMove core technologies and applications use large amounts of data, and the effort involved in obtaining and processing (live) traffic data, either from road-side sources or from vehicles, should not be underestimated. If there are (interoperable) legacy systems to build on, that is also an advantage. It should be checked that these systems are robust enough to keep working properly when new functionalities or applications are added to them. Finally, current digital maps offer much of the information needed for systems such as eCoMove. However, the exact attributes offered may differ between regions.

In the end, if stakeholders are not willing to invest time and money in the implementation, it is not likely to succeed. Stakeholders can be motivated in different ways, and it is useful to list all benefits of the system so that different stakeholders can find out if the system can help with what motivates them. eCoMove showed impacts in several areas and the concepts applied will in some cases even help address several problems at once (e.g. emissions-delays-fuel costs).

### ***Disseminate & educate***

The more people know and understand about the eCoMove applications and their benefits, the better. Most stakeholders, as well as the future users, are not yet aware of the potential of the eCoMove applications, and will thus not go looking for them (or will be hesitant about them when they are offered to them). The eCoMove project has generated concepts, architectures, and test results, as well as illustrations and movies of the applications developed. These can all be used to tell stakeholders about systems and services for energy efficient mobility. Once the systems are market-ready, marketing is needed to show potential users what applications are available, and driver training can help them make better use of them.

### **Deployment path and needs**

As stated in the previous section, there is no need to implement everything immediately. The best paths to deployment depend on when the core technologies, components and applications are available and mature enough. The following general deployment needs were identified:

***Live traffic data***

Floating Vehicle Data / probe data from vehicles are needed. Data are available from many sources, but are not necessarily accessible and/or used by current traffic management applications. The ITS action plan and directive [3] tackle this to some extent, as well as the INSPIRE directive [4], and working groups can also address this issue.

***Map attributes covering environmental aspects***

As a first step, static eco-attributes need to be included in digital maps. This concerns for instance slope and curve radius. Subsequently, dynamic eco-attributes could be added to digital maps, e.g. traffic light states and dynamic speed limits. It should be noted that the ADAS maps cost are higher than the costs of the “normal” map dataset used for regular navigation.

***Standardised (eco)Messages***

Cooperative systems need standardised messages so that communication can be effective (all messages are interpreted correctly and can be used to generate effective advices or actions). eCoMove applications use existing (standardised) messages but some specific eco-messages were introduced in the project. If these messages are likely to be used in various other implementations in the future, they should evolve into standardised eco-messages so that other parties may use them too.

***Penetration rates***

The eCoMove applications will not have the desired impact at very low penetration rates. Penetration rates (road-side units and on-board units) need to reach certain levels for optimal operation. The optimal level depends on the application: some applications already show substantial impacts at relatively low levels of penetration of on-board units (e.g. 10%), although (in the case of V2I communication) only in areas where the infrastructure equipment rate is high. Other applications show ever increasing impacts with increasing penetration rates (but may have lower benefit-cost ratios at higher penetration rates). For some applications, it could be useful to start with, or limit the use of the system to specific fleets, such as public transport and/or emergency vehicles, or heavy goods vehicles.

Some considerations with respect to penetration rates are:

- Road-side units (RSUs):
  - Cooperative road side ITS needs routers for communication; existing road side units may need to be upgraded.
  - Attractive use cases need to be defined; e.g.:
    - Detection (especially for urban areas not yet using road side detection or looking to replace it or increase the spacing between detectors),
    - Back office solutions, for non-time critical use cases.
- On-board units (OBUs):
  - Cooperative ITS in the vehicles can be expected to run on different platforms – smartphone, navigation system, embedded, or hybrid forms.

Robustness of applications needs to be improved, so that small changes in the vehicle, the map (e.g. geometry or signs) or the road infrastructure (e.g. loop detectors paved over) do not lead to problems with the application or significant reduction of the effect.

***Expectations w.r.t. development paths***

Given the variety in applications and local situations/problems, it is expected that each of the stakeholders involved (but perhaps most importantly road authorities and OEMs) will find their own platform and development path. Given that in the past many stakeholders, especially cities, were inclined to develop their own solutions and interfaces, it is very important that all stakeholders aim to make their systems interoperable and/or compatible.

**Conclusions**

The barriers discussed above need to be taken into account in the further development and deployment of the system or elements thereof. When not addressed, these barriers can lead to delays in the implementation or result in few users purchasing and actively using the system.

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