European Commission

Smart Cities
Stakeholder Platform

Cooperative Intelligent Transport Systems and Services

Key to Innovation Integrated Solution

Cooperative Intelligent Transport Systems and Services (C-ITS)

Document information	
Prepared by:	Karl-Oskar Proskawetz (ITS /D)
Edited by:	Stefan Klug, Bernd Beckert (Fraunhofer ISI/D)
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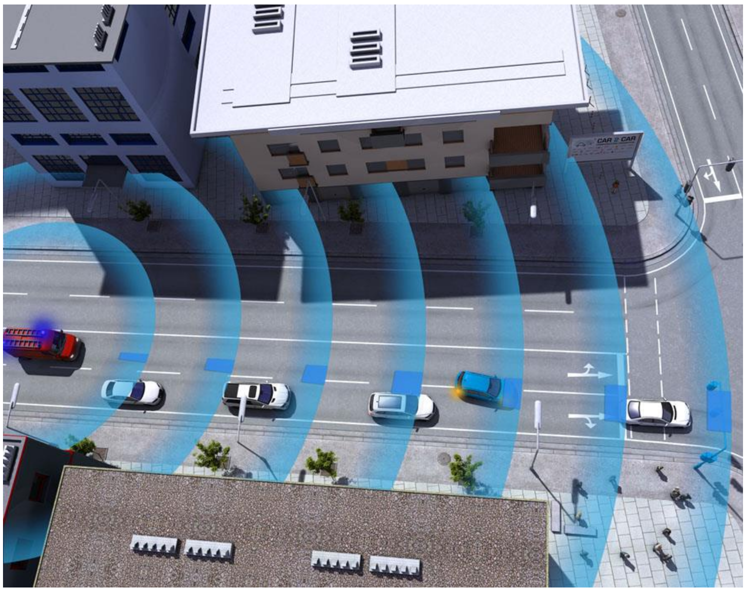
ABSTRACT

Modern vehicles equipped with driver assistance systems can “feel” (by sensors), “see” (by cameras) and – in future – “speak” (by communication systems). The new technology of cooperative Intelligent Transport Systems and Services (C-ITS) enables communication between vehicles and traffic infrastructure. It is based on the principle that cooperative parties (ITS stations, i.e. in vehicles, road side units) exchange information among each other in terms of standardised message sets. The receiving ITS station analyses the incoming data and makes use of them, resulting in a self-organisation principle on local level. Services and applications being subject to competition between companies cover up-to-date traffic information, improved road safety by avoiding accidents and reducing injury severity, increased efficiency by supporting a consistent traffic flow, foresighted driving and enhanced driving comfort. By involving public transport, bicyclists and pedestrians, intermodal and environmental capabilities, autonomous driving and further functions will be addressed in a second step when C-ITS has reached a sufficient market penetration.

Based on an European Mandate M/453, the minimum set of standards for C-ITS is developed and will essentially be finalised in 2013. The vehicle manufacturers have announced to start Day One deployment of C-ITS in Europe based on ITS G5 technology beginning in 2015. Some front runners of road operators and road authorities aim on strengthening this voluntary deployment process by investing in cooperative Road Side Units on infrastructure side.

C-ITS applications are manifold and may not all be implemented at the same time. Instead, a phase model will be applied. For cities in the first phase, applications related to traffic lights are of primary interest. The technology enables the transparent prioritisation of public transport (bus, tram) and of emergency vehicles at intersections. Signal phase and timing information support “green driving” of all vehicles and safe and comfortable crossing of intersections even by blind and visually impaired pedestrians. Collecting probe vehicle data from all C-ITS users provides a detailed up-to-date picture of the traffic situation and improves traffic control and intermodal traffic management. Energy and emission savings result from facilitating a consistent traffic flow, reducing the number of accidents as well as traffic caused by searching suitable parking areas. Furthermore local information on P&R and public transport offers could contribute to a modal shift towards environmental friendly transport modes.



Picture 1: Cooperative intersection scenario with emergency vehicle and traffic lights (Source: CAR 2 CAR Communication Consortium).

INTRODUCTION

The Key Innovations (KIs) are a key output of the Smart Cities Stakeholder Platform. The Platform promotes innovation and is part of the Smart Cities and Communities European Innovation Partnership of the European Union. It aims to accelerate the development and market deployment of energy efficiency and low-carbon technology applications in the urban environment. The emphasis will be on their integration, which is a key challenge particularly for Smart Cities' technologies. The Platform aims to bring together technology providers, financiers and specialists in implementing smart city strategies at local level.

The expert Working Groups of the Platform on Energy Efficiency and Buildings, Energy Supply and Networks, ICT, as well as Mobility and Transport select from the spectrum of Solution Proposals (SPs) submitted by stakeholders[1] the *most promising and fundamental* solutions to accelerate the development of smart cities. The focus is on specific promising innovations, considered pillars or technical leapfrogs for integrated solutions in smart cities, thus promising, but standalone solutions, will not be developed into key innovation files and toolkits.

Regardless, if an SP will be part or not of a key innovation document, all solution proposals will be published in the Platform and linked to city profiles. The Platform is not an evaluation body and is open to all relevant smart solutions, large or small scale for cities and their inhabitants.

The aim is to promote through the preparation of a detailed document, a guide for cities on the performance of the innovation, including in some cases wider impacts on city life (such as change of behaviour, environment, social inclusion etc.). For each innovation, this key innovation document will describe the methodology to deploy it, including the technical requirements and the necessary framework conditions, such as existing infrastructures, technical expertise, regulatory requirements as well as the financial costs involved. The document aims to promote the adoption of the key technology and to identify barriers to deployment to assist relevant authorities in developing solutions to remove them. The document will list the technology providers as well as information of a number of potential financial sources by the EU and other bodies which have supplied information to the platform.

The information in the Key Innovation documents will become an integral part of the recommendations of the Smart City 10 Year Rolling Agenda document the Platform will draft for the European Commission. This document will highlight identified actions at European level required to promote the adoption of key innovations, such as the removal of regulatory barriers or recommendations on the focus of the Horizon 2020.

It is important to stress that this document is not a set of technical proposals or a full evaluation of the innovation, but aims to assist the cities to identify potential solutions and understand their context and implementation needs. It does not exempt or substitute a detailed cost/benefit analysis and implementation plans for cities that wish to introduce the innovation. The Stakeholder Platform cannot take any responsibility for inaccuracies or missing information or specific problems in the implementation of the proposed Key Innovations or other Solution Proposals.

[1] Solution proposals are published on the web site: www.eu-smartcities.eu/ solution-proposals

Description of a Key Innovation

A key objective of the Smart Cities Stakeholder Platform is to identify Key Innovations (KIs) for the development of Smart Cities. The selection of an SP as KI is based on the following criteria: **applicability, simplicity, affordability**, **usability,** the extent to which it addresses technology integration and if the potential impact is significant. Selected SPs will then be enhanced by the Platform's technical Working Groups (WGs) to develop KIs, adding the following aspects:

- Premises for the technology development and up-take (e.g. problems, what the technology is intended to achieve, other unforeseen benefits for the smart cities);
- Potential integration with other technologies and sectors, including use of ICT;
- If necessary, enhancing the information from the SP on the urban environment in which the technology can be applied;
- Key pre-requisites for the applicability of the key innovation, such as the required enabling environment;
- Instruments and market conditions needed to reach commercial viability.[2]

KIs will be completed by the technical WGs in collaboration with the Finance WG. This group will analyse the financial needs of the KI as well as their financial viability and bankability. The members of the WG will provide information on funding sources. The result will be published as a Key Innovation Toolkit.

The Toolkits thus provide practical solutions that can create an enabling environment for the application and replication of key innovations in a smart city.

[2] This includes a description of the main EU support instruments, such as the Risk Sharing Financing Facility

1. Presentation of the Key Innovation

Submitted to the platform at date (Innovation maturity)	Body(ies) submitting the proposal(s):	IP right holders:	Problem addressed	City (ies)	Parties or stakeholders involved:
1. Car2Car and Car2Infrastructure Communication					
6 August 2012 (Pilot Project)	Karl-Oskar Proskawetz **ITS Niedersachsen** (www.its-nds.de)	research organisations /companies	Improvement of road safety and efficiency	Frankfurt, Helmond,	Automotive industry, road authorities, road operators
2. Hybrid cooperative ITS - Combining ITS G5 and cellular communication enables comprehensive services for intermodal and sustainable mobility					
6 August 2012 (Pilot Project)	Karl-Oskar Proskawetz **ITS Niedersachsen** (www.its-nds.de)	research organisations /companies	Enhancing the application of cooperative ITS	Frankfurt, Helmond, …	Automotive industry, road authorities, road operators
3. DITCM: Dutch Integrated Testsite Cooperative Mobility					
20 Sept 2012 (Pilot Project)	Joelle van den Broek **TNO** Netherlands	research organisations /companies	Towards a Smart Mobility Roadmap	Eindhoven , Helmond	Industry, local and national governments, knowledge representative, mobility platform
4. TBIs functions and applications at the city level					
13 Sept 2012 (Pilot Project)	EL Faouzi Nour-Eddin, **IFSTTAR**		Role of test-beds Innovation Incubators for fostering global Intelligent transportation systems deployment	Stuttgart	Automotive industry, , road operators, Research institutes, ITS association, Drivers' association, Solutions providers
5. Cooperative Adaptive Traffic Control for urban ecoDriving					
28 Sept 2012 (Pilot Project, e.g. EU Freilot, eCoMove, DriveC2X)	Roberto Baldessari **NEC Europe**	Many, depending on the detailed algorithm	Optimising vehicle speed and traffic light phase		Automotive or after-market equipment suppliers, traffic light controllers suppliers

6. Application of V2I for Virtual DMS, proximity actuator and travel-time capture					
24 Sept 2012 (Pilot Project)	Jose Carlos Riveira-Martinez **Schneider Electric**	/	V2I on-board information		Traffic authorities, on-board equipment sellers,Telco, ITS solutions providers
7. Real-time Expert-Adaptive Traffic Regulation					
24 Sept 2012 (Best Practice)	Jose Carlos Riveira-Martinez **Schneider Electric**	Schneider	City Congestion Management		Municipality Mobility Agency, ITS solutions provider

1.1 Description of the innovation and rationale for selection

The SPs have been selected based on the following evaluation grid:

	Evaluation Criteria (Score: 1 to 5)	Weight
1. Impact over GHG emissions		25%
1,1	CO2 reduction,	
1,2	Increasing share of renewables,	
1,3	Increasing energy efficiency	
2. Economic issues/ cost-benefit-ratio		25%
2,1	Affordability (mobility costs for end users)	
2,2	Economic viability (period for return of capital)	
3. Smartness of Innovation		25%
3,1	Innovative nature/ progress to the state-of-the-art	
3,2	Integration into the urban transport system, handling existing (infra-) structures	
4. Potential for market uptake and replication/ customers experience		25%
4,1	Potential for scale-up and replication	
4,2	Barriers to market entry (e.g. vendor lock-in or non-interoperable protocols and rules)	
4,3	stakeholders involvement/ consumers attractiveness (e.g. user-friendliness of the technology)	
Total Score		

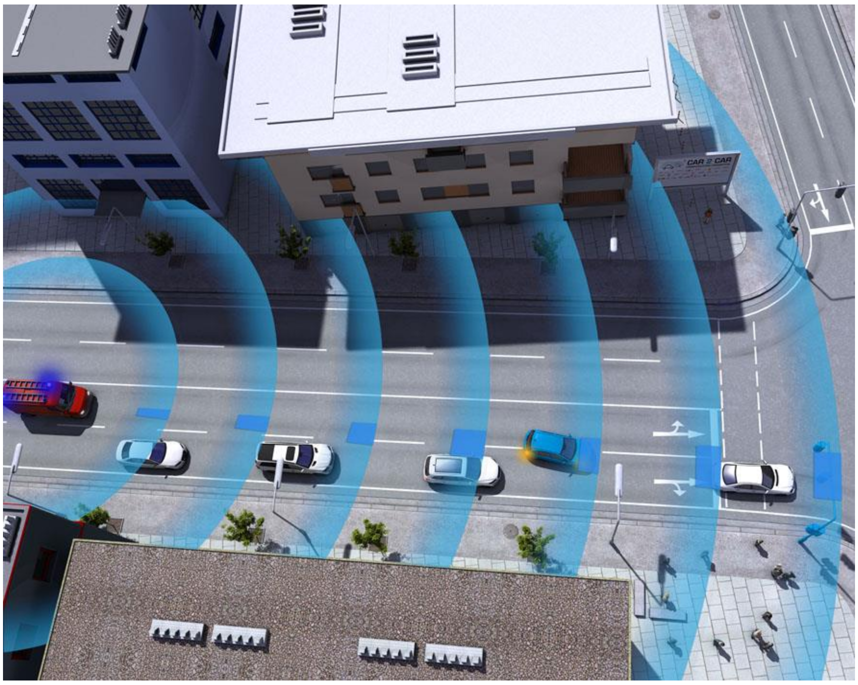
The evaluation result for each of the criteria was as follows (scale = 1 (lowest effect) to 5 (highest effect)):

criteria	SP#1	SP#2	SP#3	SP#4	SP#5	SP#6	SP#7
1	2,08	2,08	2,67	2,67	2,67	2,08	2,83
2	2,92	2,92	4	4	4	2,92	3,33
3	3,67	3,67	4	4	4	3,67	4,17
4	3,78	3,78	2,67	2,67	2,67	3,78	3,89
total	**3,11**	**3,11**	**3,33**	**3,33**	**3,33**	**3,11**	**3,56**

Modern vehicles equipped with driver assistance systems can “feel” (e.g. by sensors), can “see” (e.g. by cameras) and in future can “speak” (e.g. by communication systems). The new technology of Cooperative Intelligent Transport Systems and Services (C-ITS) enables these communication processes of vehicles among each other (V2V) and with traffic infrastructure (V2I). It is based on the principle that all cooperative parties (ITS stations, e.g. in vehicles, road side units) (locally) exchange information in an ad hoc network using ITS G5 wireless communication. Every receiver evaluates the data received and considers the information for its data analysis, resulting in strategic warning, tactical advices and information provided to the driver. While vehicles provide data for example about their position, speed and driving direction or event-driven information, such as a defect, road side units deliver data about for example current speed limits, the signal phases and timing of traffic lights or information about diversion. The analysing receivers integrate those data to a complete picture of the local traffic situation and generate information and warnings directly relevant for the individual driver. Via a Human Machine Interface (HMI), he receives for example information about road works blocking his route or is warned in case of a potential situation, for instance if a vehicle in front of him brakes hard suddenly.

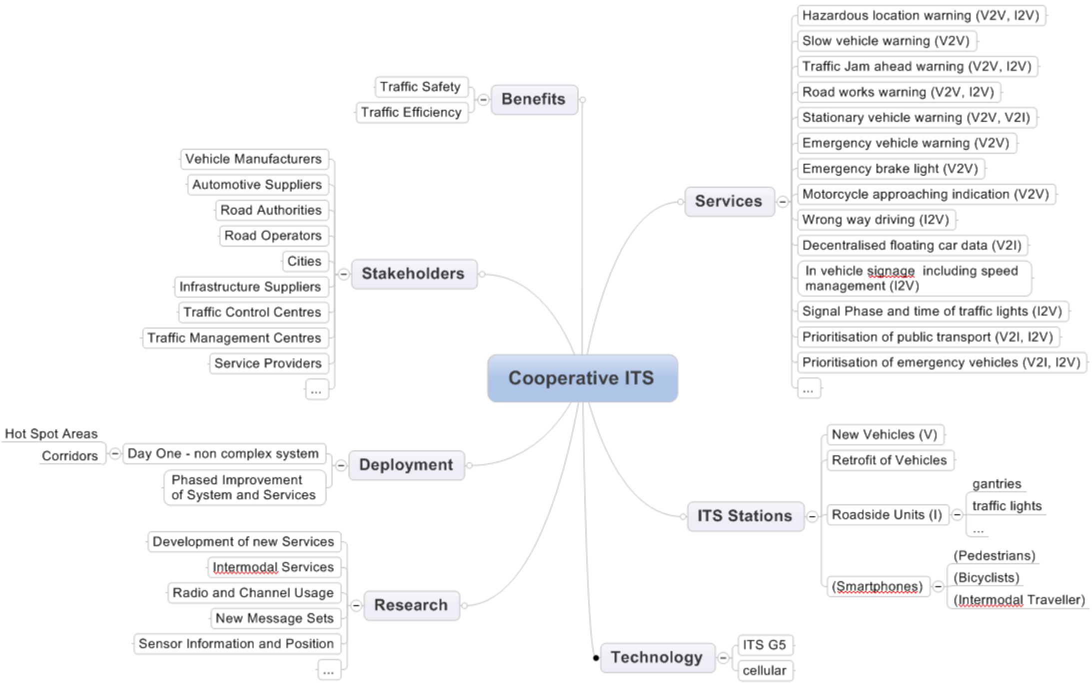
As a synergy between driver assistance systems and cooperative systems, hazardous locations like black ice, slippery roads or aqua planning detected by the or an individual vehicle can directly be announced to other approaching drivers. Meanwhile an important characteristic of cooperative systems is that an autonomous intervention by the drivers assistance system like an emergency brake might be implemented at a later phase of deployment, but not at the time when C-ITS enters the market. The driver always accounts for the way he reacts on the information and warning received.

The local, ad hoc low latency communication based on ITS G5 is designed for improving road safety and traffic efficiency aiming at accident free traffic flow in future. Furthermore ITS G5 and cellular communication can provide pre- and on-trip information supporting foresighted and comfortable travelling as well as commercial services with high quality level increasing driving comfort. The principle of self-organisation in an ad-hoc network enables flexible, robust and fail-safe architectures as well as new services and improved service qualities. Regional traffic management centres, fleet management centres and service providers as well as centralised or decentralised traffic control can be part of the cooperative systems network.



Picture 1: Cooperative intersection scenario with emergency vehicle and traffic lights (Source: CAR 2 CAR Communication Consortium).

Based on the cooperative data received, cities will be enabled to capture the up-to-date status of traffic situations as basis for organising traffic control and traffic management local and city wide easily. By the permanent information on type, position, speed and direction of vehicles in consistent intervals a fruitful basis for analysing the real-time traffic density or disruption is laid. These traffic conditions can be directly and locally influenced by traffic management centres in terms of changing temporary speed limits or advice diversions which are delivered via cooperative traffic infrastructure equipped with road side units. Applications of special interest for urban areas are the transparent prioritisation of public transport and emergency vehicles at traffic lights. That means that an approach of an emergency vehicle is not only registered by cooperative traffic lights, but communicated to all drivers which will be enabled to build a rescue lane in a quick and safe manner. Information about signal phases and timing of cooperative traffic lights support adaptive “green waves”, smoothing traffic flows, platooning of vehicles for increasing road capacities. Including further service providers into the wireless network helps reducing efforts for finding a parking place or a charging station for electrical vehicles, for example if points of interest like car parks, charging stations, P&R facilities are announced to the driver. Even vulnerable road users like pedestrians and bicyclists might be involved in the cooperative network in future. First national projects supporting the mobility of blind and visually impaired persons show the potential of the cooperative technology: Special applications on mobile devices can exchange data with cooperative traffic lights and inform the end-user about signal phases and intersection topology haptic and acoustically.



Picture B1.2: Mind Map of most important facts on cooperative Intelligent Transport Systems and Services (C-ITS)
(Source: ITS Niedersachsen).

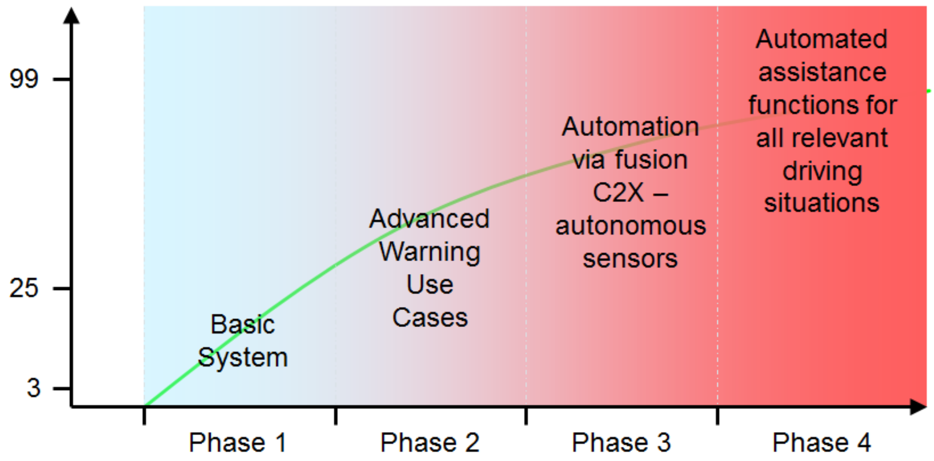
1.2 Deployment status

Based on the European mandate M/453[3], the standardisation organisations ETSI and CEN have been requested to develop the minimum set of standards determining the interoperability of C-ITS during the past years. For Day One deployment – the first phase in which cooperative systems enter the market – it has to be ensured that vehicles and traffic infrastructure are speaking ‚the same language’, meaning that message sets, performance requirements and security and privacy aspects have to be defined as guideline for individuals systems produced by different manufacturers and in different countries. Most of the standards required for deployment are being finalised in 2013. Some missing standards will be released during 2013. The most important ETSI and CEN standards will be published as European Norms in a second step.

[3] Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of information and communication technologies to support the interoperability of co-operative systems for intelligent transport in the European Community. Brussels, 6 Oct 2009 (http://ec.europa.eu/enterprise/sectors/ict/files/standardisation_mandate_en.pdf)

On 10 October 2012, a press information announced that vehicle manufacturers within the CAR 2 CAR Communication Consortium are signing a Memorandum of Understanding on European deployment of cooperative ITS starting in 2015. They declared that they will regard commonly defined message formats, performance requirements, security and privacy principles when it comes to develop their individual C-ITS solution to be built in vehicles from 2015 on. Retrofitting of old vehicles is under discussion for faster pushing the penetration rate of Day One systems. Within the informal “Amsterdam Group” four European “umbrella” organisations [4] aim at a harmonised and integrated implementation of cooperative ITS and jointly develop a deployment plan for cooperative systems in Europe.

Currently functional and regional “hot spots” are discussed for starting deployment in Europe. Regional hot spots address cities and their urban hinterland. To push the penetration rate of cooperative systems after market introduction, there is a need for investing in upgrading local traffic lights, road infrastructure and vehicles mainly used for inland traffic. Complementing functional hot spots address specific functions / applications which can be enabled fast and with (comparable) low investments but high benefit / cost ratio. The functional hot spot approach is also discussed for corridors connecting the regional hot spot areas and for offering early user benefit in the entire road network.



Picture B1.3: Phased approach for deployment of cooperative Intelligent Transport Systems and Services (C-ITS) (Source: Car2Car Communication Consortium).

An ELSA or R&D / demonstration framework might be helpful for fostering Day One deployment in Europe, for providing a co-funding and a legal framework which supports the cooperation of different stakeholders required. In addition, R&D projects need to develop further system and service innovations to be deployed during the next phases.

The cooperative system and dedicated functions have been tested and demonstrated in many European cities. Cities being involved in most important field operational tests are listed below (the list makes no claim to be complete).

- Frankfurt / Main (Rhine-Main area, Germany)
  National large scale field operational Test by the simTD project (see www.simtd.de);

  The simTD project (2008-2013) in its first phase defined the overall cooperative architecture and the system design, the implementation, integration and test of individual sub-systems as well as the experimental design. Then the cooperative infrastructure on motorways, rural roads, urban

[4] ASECAP – the European professional association of operators of toll road infrastructures, CEDR – the European organisation for the national road administrations, POLIS – the network of European cities and regions working together to develop innovative technologies and policies for local transport – and CAR 2 CAR Communication Consortium.

roads, related traffic control and management centres and vehicle fleets of more than 100 test vehicles were implemented. The third project phase focused on the large-scale field operational trial under real conditions, its documentation, analysis and evaluation.

- Paris (France)
  national field operational Test by the SCORE@F project (see www.scoref.fr);

  SCORE@F project (2010-2013) focused on cooperative V2V and V2I services increasing the safety and comfort for passenger cars and long-distance lorry drivers. The test field comprised special test tracks, motorways including tunnels and urban roads in the southwest of Paris. Project results were fed in standardisation at the European Standardisation Organisations ETSI and CEN.

- Tampere (Finland), Gothenburg (Sweden), Helmond (Netherlands), Frankfurt (Germany), Yvelines (France), Brennero (Italy), Vigo (Spain)

  European field operational Test by the DRIVE C2X project (see www.drive-c2x.eu);

  The European DRIVE C2X project (2010-2013) laid the foundation for rolling out cooperative systems in Europe, leading to safer, more economical and more ecological driving. It focused on communication among vehicles (C2C) as well as between vehicles and roadside and backend infrastructure system (C2I). Thereby it also enabled commercial services based on C2X communication data to private and commercial customers. Beside testing and demonstration, it brought together all stakeholders involved, prepared an implementation roadmap, contributed significantly to the European ITS standardisation and provided the necessary certainty for a decision towards market introduction by investigating socio-economic and business-economic aspects of cooperative driving.

- Braunschweig (Germany)
  Application Platform Intelligent Mobility (AIM)
  (see http://www.dlr.de/fs/desktopdefault.aspx/tabid-6422/10597_read-23684/);

  In the framework of AIM, building up project independent cooperative ITS infrastructure covering the Braunschweig city was started in 2010 on urban roads and urban motorways. By end of 2012 it comprised 30 road side units for ITS G5, six road side units for W-LAN for the inclusion of pedestrians and cyclists in cooperative scenarios and GSM/UMTS[5] connection for infrastructure / vehicles. By end of 2015 at least 60 road side units will be in operation for the next 15 years. The service oriented architecture (SOA) and 23 basic services were designed to meet project-specific demands covering mobility research, different transportation modes and intermodality.

- Vienna (Austria)
  Cooperative Mobility Demonstration during the ITS World Congress 2012, national Testfeld Telematik project (see www.testfeld-telematik.at);

  The Testfeld Telematik project (2011-2013) established a telematics testing field for cooperative services aiming at the mutual exchange of real-time information between vehicles and infrastructure to raise safety, efficiency and environmentally friendly mobility. It was of particular importance that the passenger transfer to public transport was made attractive and simple, which was achieved by comprehensive co-modal traffic information for all means of transportation. About 3.000 drivers tested cooperative services for 12 months on the main test route that has a length of about 45 km and is located in the area of the motorway intersection A2/A23-A4-S1.

- Madrid (Spain)
  Cooperative Road Information Pilot project mVia, Adaptive Traffic Control (15% of city intersections).

[5] = Cellular communication media

The mVia project implemented travel time calculation and dynamic VMS with use of on-board equipment and data capture (including ODB connection) on a 40km northbound freeway corridor. Servers already processed the geo-referenced information and served data for driver's notifications. Additionally Madrid is intensively using adaptive traffic lights regulation, aiming at providing smooth adaptation of traffic plans to changes in traffic conditions. By now, nearly 350 intersections of the 2.200 have been working in adaptive mode for the last ten years, implementing a near closed-loop regulation.

1.3 Technical feasibility and viability

Present status:

The basic technology of cooperative ITS has been developed and improved during the past decade. Its technical feasibility and the benefits of cooperative services have been demonstrated in various national and European research projects like Coopers, CVIS, SafeSpot, eCoMove and FREILOT. Specific technological and organisational issues have been addressed in further projects and resulting best practice solutions have been demonstrated in several European cities.

During the ITS World Congress 2012 in Vienna, experts and the public audience could experience the benefits of C-ITS in a cooperative mobility demonstration under real life conditions on public roads involving cooperative vehicles, cooperative road side units and the Viennese traffic management centre.

Emerging solution for smart cities:

Several large scale field operational tests (FOTs) like simTD (Germany), SCORE@F (France) and DRIVE C2X (Europe) proved the system stability and performance. The FOTs generated user and stakeholder experiences and provided data for impact and cost benefit analysis.

In January 2013, new European projects like COMPASS4D (www.compass4d.eu) with city pilots focusing on energy efficient intersections have started. Within COMPASS4D seven European cities (Bordeaux, Copenhagen, Eindhoven-Helmond, Newcastle, Thessaloniki, Verona and Vigo) are willing to further invest in road safety, energy efficiency and congestion reducing measures based on cooperative ITS during the next three years.

For supporting the European deployment of cooperative ITS starting in 2015, a tri-national driven corridor project Vienna – Munich – Frankfurt – Rotterdam and further national projects are currently discussed and developed.

1.4 Financial analysis

This section presents an initial financial evaluation, based on the estimations of the solution providers.

The vehicle manufacturers have to invest in the development of Day One cooperative systems and their implementation in the vehicles. Road authorities and road operators need to invest in road side units (e.g. traffic lights, gantries) and build up know-how for developing optimised services, processes and backbone infrastructure. Deployment of cooperative ITS will follow a phased approach starting in 2015 with not too complex devices and a set of Day One applications offering early user-benefits already at low penetration rates. The next deployment and migration phase might be initiated after three to seven years depending on the innovation and lifecycles of vehicles and infrastructure components. With increasing penetration rates, further cooperative use-cases / applications become feasible and further stakeholders might be involved.

The cost/benefit analyses of cooperative ITS needs to take into account national / European economies as well as the business economic aspects for each of the stakeholders involved.

The Amsterdam Group (see section 1.2) is developing a joint European road map, a general roll-out plan and related fundamental investment planning. Harmonised results are expected to be available by mid/end of 2013.

Example for adaptive traffic light regulation use case:

Estimated reduction of stops/delays provided by Adaptive Traffic Control systems provide mean benefits of 3% reduction in travel times, being equivalent to two minutes per driving hour at rush period. Additionally, informing drivers at ciritcal decision points, for example before they enter a congested road segment, can divert traffic to alternative routes, avoide mean jam durations already being effective at estimated 10% penetration of involved vehicles.

In case of equipping all new vehicles with cooperative ITS devices, it takes about two years to reach a 10% penetration. Concentrating promotion and deployment of cooperative ITS on selected European agglomerations and connecting them by cooperative corridors could speed-up the time for exceeding the minimum 3% penetration threshold for supporting the Day One use cases with quality acceptable from driver’s (end-user) view-point. Coordinated investment in cooperative roadside infrastructure significantly improves the benefits for drivers and road operation with respect to traffic flow and capacity already during early stage of deployment.

For taking advantage of cooperative ITS, cities need to invest in deployment of cooperative traffic lights and roadside units and integration of cooperative ITS services like traffic data collection, traffic data analysis, traffic control and traffic management. Based on the performed national and European projects costs for the additional roadside infrastructure are estimated to the amount of about EUR 4.000 – 6.000 per ITS G5 hotspot. For a complete new acquisition of a roadside unit, costs of about EUR 20.000 – 50.000 are expected depending on the infrastructure prerequisites. Integration of cooperative services in traffic control centres and traffic management centres will require additional investments, operational and maintenance costs as well as costs for advanced training of the employees.

Risks for the cost / benefit ratio may arise from uncoordinated activities not involving all stakeholders being relevant for cooperative ITS. The risks might arise from uncoordinated development and standardisation, but also from proprietary deployment of cooperative ITS hard- and software for vehicles and cooperative infrastructure in European regions, cities and corridors. Other risks might arise from insufficient public budgets on national, county and city level for financing investments, maintenance and continuous operation of cooperative ITS as well as research and development activities for enhancement of new services.

1.5 Suitable city context

Within the Amsterdam group the cities are represented by the POLIS network (European cities and regions networking for innovative transport solutions).

Cities investing in Day One deployment of cooperative ITS should have a sufficient high inland traffic volume. These cities need to invest in cooperative Road Side Units (e.g. traffic lights, gantries) at least at the main road network. In addition, the traffic control processes, traffic management processes and backbone infrastructure should be adapted and know-how has to be build-up for developing and making use of optimised services and processes. Cross-linking between the traffic control and management of the city and the traffic management on motorways nearby enables further improvement in case of accidents, road works and temporal detours.

For enabling a coordinated initial investment in cooperative infrastructure and cooperative vehicles a close cooperation with the automotive industry is required. The cities have to invest in building-up the cooperative infrastructure while the automotive industry has to promote and to sell cooperative vehicles especially in these cites / regions. Depending on the services and mode of transport further stakeholders might be involved.

The cooperative ITS technology offers flexible solutions independent of the city sizes and mode of transport. For initiating the further development of cooperative ITS with respect to the specific needs of the cities, the cities or their association need to discuss their needs and required functions with other stakeholders aiming at joint R&D activities and field operational tests.

2. EXPECTED IMPACTS

2.1 Energy supplied or savings expected

Cooperative ITS offers a high potential for avoiding high traffic density by shifting motorised traffic to more appropriate modes and to improve the processes, safety and efficiency of all modes of transportation. C-ITS aims at an accident free traffic flow. Foresighted driving, passing traffic lights in adaptive "green waves", smoothing traffic flows, and reduced efforts for finding a parking place contribute to save energy and fuel, reduce emissions and noise. Platooning of vehicles, harmonised traffic flows and improved merging processes at bottle necks increase road capacities. The cooperative ITS technology supports the improvement of individual traffic as well as public transport, transport of goods and further transportation modes.

This is directly related to savings in energy.

Example for adaptive traffic light regulation use case:

A first estimation of effects on reduced delays and stops caused by adaptive traffic light regulation can be calculated as 0,02 litres/vehicle/day for a mean trip of 5 km. Considering mean traffic volumes of 10.000 vehicles/day, the adaptive regulation effects in typical city centre areas with total fuel saving of estimated 3 million litres/year for the city.

Example for green driving in a sub-urban road networks:

Within the German FAMOS R&D project, the energy savings of foresighted driving have been investigated and demonstrated for a passenger car Golf 1.4l 90kW TSI and DSG. Compared to today's normal driving, the highly accepted driving profile "comfort" resulted in 9,3% energy savings and a 1,9% longer travel time. The "eco" mode even enabled 12,6% energy savings while extending the travel time to 3,1%. However due to extreme freewheeling the driver acceptance was significant lower compared to the comfort mode. Further energy savings can be assumed from following vehicles even if they are not equipped with the technology.

2.2 Expected impact on GHG emissions

As indicated in 2.1, fuel consumption reductions can be directly estimated as limiting GHG emissions. Cooperative feedback to drivers and adaptive techniques in traffic control is providing smoothest circulation, lesser delays and stops, diversion of traffic flows in response to automatically detected incidents and timely notifications to drivers, both on V2V and V2I communications capabilities.

GHG emissions include also direct air-quality improvement in highly dense city centres by proportionally reducing most toxic concentrations of NOx, SOx and PM2.5 concentrations.

Extending the calculation example included in 2.1, the reductions of emissions can be estimated as follows:

A reduction of 3 million liters/year in our example city due to adaptive traffic regulation is equivalent to 7500 CO2eq.

2.3 Interfaces with other technologies/ transport modes

For making optimal use of the cooperative ITS technology, interfaces and information exchange between the different modes of transport need to be established e.g. between traffic management centre and public transport management centre or traffic information via selected communication media. Furthermore internal stakeholder processes like operation and maintenance of road infrastructure need to become integrated.

On automotive side, autonomous driving and advanced driver assistance systems are driving forces closely related to the further development of cooperative ITS. The high sophisticated solutions require reliable, precise sensors like cameras, radars or laser scanners, as well as accurate positioning solutions (based on satellite navigation and transponder technologies) and detailed digital maps.

For involving vulnerable road users in cooperative ITS, smartphone technology has proven as universal device for sophisticated mobility services. Special designed applications can improve safe and comfortable (intermodal) mobility even of blind and impaired pedestrians.

2.4 Waste generation

For reducing the costs of the cooperative ITS devices, they will become integrated stepwise in today's antenna systems and electronic control units of vehicles, of roadside units / traffic lights / gantries as well as of smartphones for enabling cooperative services. On midterm the high integration of cooperative ITS is expected to limit the additional waste generation to a small / negligible quantity.

2.5 Wider potential benefits for cities

Capturing an up-to-date data basis of the current local / city-wide traffic situations enables better traffic information, traffic control, traffic management and transport planning. Services related to intermodal transport chains will also benefit from the improved data bases which could support the modal shift and strengthen the use of public transport means. Especially electrical vehicles will benefit from the foresighted driving support and optimised charging station management. The knowledge about mobility patterns even might support future smart-grid applications.

Cooperative ITS and related assistance systems provide a huge potential for developing high quality services and for adapting them also to the needs of elder and/or handicapped people.

Reduction of GHG, particularly NOx, SOx and PM, is expected to provide beneficial consequences on air-quality measurements, by means of realigning actual values to objectives. Benefits on general mobility, health issues and associated hours lost in congestions are also indirect benefits for the whole citizenship.

Cooperative ITS offers the largest benefits for cities in collecting traffic data, providing mobility information and optimising traffic flows at and between intersections and roundabouts taking into account all modes of mobility (e.g. vehicles, public transport, emergency vehicles, bicyclists and pedestrians). This offers the opportunity for upgrade of cooperative traffic lights and further road side units as well as necessary backbone systems in cities by focusing on promoting selected modes of mobility and environmental aspects with respect to the size of cities like:

- Public transport (bus and tram) could be fostered using cooperative ITS in all vehicles and related traffic lights, e.g. for prioritisation of public transport modes, as well as collecting passenger and other data.

Emergency vehicles such as police cars, fire brigades and ambulances could use cooperative ITS in all vehicles. In case of operation, the emergency vehicles can warn other traffic participants and request prioritisation at traffic lights.

Blind and visually impaired persons could be assisted by cooperative traffic lights.

Cities can use cooperative ITS with a focus on reducing their CO_2, NO_x and particle emission footprint by optimising modal split, traffic flow, parking or vehicle fleets.

2.6 Other expected impacts

The concept and development of cooperative ITS making traffic safer and more efficient has been mainly driven by the European vehicle manufacturers so far. The design of cooperative ITS allows competition between the vehicle manufacturers driving further innovation.

With respect to the infrastructure related stakeholders (e.g. authorities and operators) competition is not a very strong driving force. Meeting environmental requirements and tightened requirements for enabling sustainable mobility could be an additional driving force for stakeholders especially related to the infrastructure.

Last but not least, cooperative ITS innovations will strengthen the competitiveness of the European industry and improve the living quality within European cities.

Deployment on other roads

Deployment of cooperative ITS on motorways can focus on cooperative RSUs at existing gantries for section control, traffic measuring facilities, emergency telephones and additional points of interest like parking areas. Furthermore backbone systems and processes need to be upgraded for making use of the cooperative ITS opportunities.

Deployment of cooperative ITS on rural roads can focus on safety in critical areas. On rural roads cooperative applications and functions could be based mainly on local vehicle-to-vehicle communication, complemented by traffic information provided via cellular or broadcast communication networks.

3. ADDITIONAL REQUIREMENTS ON DEPLOYMENT

This section presents the requirements for wider deployment of the innovation. It indicates any potential barriers or risks facing wider deployment or replication elsewhere.

3.1 Governance and regulation

This section discusses any identified necessary governance and regulatory prerequisites for the innovation to be introduced.

Especially strategies, architectures, services and processes related to road authorities, road operators, cities and automotive industry need to be commonly developed, tested and standardised European-wide for visualising the benefits towards sustainable mobility enabled by cooperative ITS. Deployment of cooperative ITS in Europe needs to build-up on standards and profiles commonly agreed by all (investing) stakeholders. The legal framework should be harmonised where necessary for enabling minimum performance and quality as well as transparent responsibilities and liabilities cross-border and seamless in all road networks.

3.2 Stakeholders to involve

This section identifies the different stakeholder that need to be mobilised to successfully introduce the technology in the urban area, such as households, specific professional bodies, corporations, specific authorities (transport authority), etc,

Stakeholder	**Role/ how to be involved** **(Main aspects)**
Mayors/ politicians	Road-Safety/mobility regulations of cities, budgets for infrastructure and operation
City administration	Planning, implementation of e.g. traffic lights and RSUs, traffic control, mobility management, infrastructure operation and management, provision of traffic information and Infrastructure-2-Vehicle services
Transport ministries	Safety/mobility regulations for the overall road network, budgets for infrastructure and operation
Road authorities	Planning, implementation of e.g. RSUs, infrastructure operation and management
Road operators	Traffic management and infrastructure operation, provision of traffic information and Infrastructure-2-Car services
Automotive industry	Implementation of on-board equipment, HMI, Car-2-Car services, in-vehicle signage of Infrastructure-2-Car services, provision of Car-2-Car and Car-2-Infrastructure data
Service and content providers	Data aggregation, data enrichment and data / service distribution
Car drivers/ inhabitants	Final users, consumers, providers of cooperative information
Financial institutions	

For making cooperative ITS happen, different stakeholders need to cooperate. Depending on the cooperative services, different roles and responsibilities can be identified and have been standardised by CEN for selected Day One services. The realisation of a cooperative service requires that all related roles are taken by actors. However the allocation of the roles to actors and their resulting responsibilities might depend on the selected option for implementation and the underlying business model.

3.3 Supporting infrastructure required

Today traffic control and traffic management in Europe rely on dedicated heterogeneous sensor and backbone networks, and hard- and software solutions ensuring high availability and integrity (e.g. traffic signalling and control in cities, section control on motorways). Migration towards cooperative ITS requires European wide standardised interfaces, protocols and message sets for seamless exchange (sharing) of information between the sub-networks and the cooperative vehicles. Due to opening the former closed sub-networks for exchanging cooperative information, safety aspects become important for ensuring tamper proof and fail-safe operation. Furthermore privacy requirements need to be met for ensuring the confidence of the cooperative users.

As prerequisite of pre-existing infrastructures collaborative and adaptive technologies rely on highly capable communications networks, considering transparency among technologies, and combining both private and public networks for PAN/LAN/WAN, 3G/4G and others.

Processing computer infrastructures are also required, considering specific capture and dissemination platforms. Area coverage probably requires local communication nodes (RSUs) and distributed processing. Public/private clouds are nowadays a promising infrastructure option.

3.4 Alignment of administrative levels involved

Implementation of KI's in cities will be supported by funding mechanisms and other (policy) incentives at different administrative levels: city, national and EU. However, some initial interviews on the challenges that cities face during the roll out of sustainable mobility projects indicate that the supporting frameworks at the city, national and EU-level are not always optimal aligned. This is especially evidenced by the preliminary evaluation of several urban electro-mobility initiatives.

City officials indicate that successful implementation of sustainable mobility initiatives requires a highly flexible tailor-made approach; especially through cooperation with local key-stakeholders. This approach involves flexibility of implementation trajectories regarding: timing of roll-out, adjusting overall project size, as well as the possibility to involve (new) public and/or private partners. In contrast, national and EU administration levels typically aim to develop longer term policy frameworks that need to be uniform and shaped in a verifiable format, thereby limiting flexibility. The challenge for future incentivizing frameworks is to bridge the gap between the need for local flexibility and the aim for long term uniform and verifiable policies at the higher administrative levels.

4. Potential Funding Sources

The Finance Group of the Stakeholder Platform has prepared documents on funding models and the use of EU Funding instruments, either from the EU budget or from the European Investment Bank. The documents are freely downloadable from the Stakeholder Platform's website.

- For funding models please refer to the **"Financing models for Smart Cities"** guidance document.
- For EU supported funding instruments please refer to the guidance document on **"Using EU Funding mechanisms for Smart Cities"**.

This section presents specific recommendations for financing models and potential sources suitable for this KI**"**.

4.1 Financing models suitable for the innovation

No specific information yet available.

This innovation has several components, which can only be funded by public authorities, such as intelligent systems for emergency vehicles and the required signalisation infrastructure.

The system can also have private applications, in terms of traffic data for example. Access to this data could be charged. Business models need to be designed for the different markets.

4.2 Specific sources of funding for the KI

No specific information yet available.

List of abbreviations:

Car2X, V2X	Car-to-X, Vehicle-to-X (Communication and data exchange between vehicles and any other cooperative entity)
CEN	Comité Européen de Normalisation , European Committee for Standardisation
C2C, Car2Car, V2V	Car-to-Car, Vehicle-to-Vehicle (Communication and data exchange among vehicles)
C2I, Car2I, I2Car, V2I, I2V	Car-to-Infrastructure, Infrastructure-to-Car, Vehicle-to-Infrastructure, Infrastructure-to-Vehicle (Communication and data exchange between vehicles and infrastructure RSUs)
C-ITS	Cooperative ITS
ITS	Intelligent Transport Systems and Services
ITS G5	Ad hoc communication using the allocated European frequency bands 5.875 MHz to 5.905 MHz (and reserved frequency bands)
ETSI	European Telecommunications Standards Institute
ODB	Open Database
RSU, ITS Station	Road Side Units
VMS	Variable Message Signs
W-LAN	Wireless Local Area Network

Smart Cities and Communities

Smart Cities Stakeholder Platform

…brings together people, industry and authorities from across Europe to make our cities more energy efficient, better to live in and growth-friendly.

…is about developing concrete innovative solutions for cities through tailored innovations.

…facilitates the exchange of knowledge and best solutions across smart cities in Europe.