Cooperative Traffic ICT

Strategic Research Agenda

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Executive Summary

Today, two major global man made phenomena are influencing our lives at an increasing pace. First, we are facing the deepest recession since the World War II. Secondly, global warming forces us to take environment into account in a number of our daily activities. These challenges will have deep impacts on human thinking, behaviour and societies worldwide. Transport systems make no exception to this. One very promising solution to the challenges is Cooperative Traffic. The idea of cooperation within a transport system originates from the concept of cooperative driving supporting the concept of automated highways, where vehicles are receiving input signals from the road environment – either from a road surface or road side.

While cooperative driving is making use of data provided both by vehicles' sensor systems and infrastructure data collection systems, the concept of cooperative traffic takes a more holistic view on traffic. Cooperative traffic system is making use of data led operations starting from data collection, transforming it to information and sharing the information at all levels of travel and transport decision making. This means that we have to understand the transport system as a stratified entity of decision making where both the quality and quantity of travelling and transporting are influenced by societal and individuals' values and extending to a single manoeuvre at the wheel. All these levels can be regulated and supported by timely and rich information on travel costs, impacts and choices as well as information influencing the situational awareness of a driver on the road. The cooperative aspect is embedded in the capability of different actors either passively or actively to acquire data and share it with other parts and players of the traffic system.

The Cooperative Traffic research area is structured hierarchically into four different interacting levels:

(i) The highest level represents an approach to study cooperative traffic where the focus is on societal goals aimed at by transport policies and influencing by the values of travellers and hauliers. These have deep-going impacts on our travel such as the pricing of travel and finding alternative solutions to travel. So this level is associated with the travel decisions such as how much we use a private car and the choice of a travel mode or substituting a journey to something else like working at home or using energy efficient travel modes.

(ii) The second level called "Strategic behaviour" is already based on a positive decision to undertake a trip. The issue is related to the planning of the trip such when to make a trip and how to do it. These kinds of decisions could be supported by a number of different measures associated with the availability of travel information and available services along the route or at the destination.

(iii) The third level is directly linked to the situation where the traveller is already on the move. Currently a number of services and assistance functions can be foreseen to make the trip both safer and more comfortable.

(iv) The last level is related to actual travel behaviour on the road and especially at the wheel or control of the vehicle in use. Many of this level support functions are associated with sustainable travel behaviour such as driving safely and economically.

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1. Introduction

1.1 Need for solutions supporting sustainable traffic

Today, two major global man made phenomena are influencing our lives at an increasing pace. First, we are facing the deepest recession since the World War II. Secondly, global warming forces us to take environment into account in a number of our daily activities. These challenges will have deep impacts on human thinking, behaviour and societies worldwide. Transport systems make no exception to this. We are witnessing the automotive sector's restructuring, and somewhat later, we are bound to change our travel behaviour and habits as well.

The past decades in transport systems have witnessed a strong growth in building infrastructures, continuously increasing traffic exposure, non-optimised transport management systems and the dominance of combustion engine technology resulting in a huge number of traffic accidents and harmful emissions. High technology in transport sector has mainly meant more effective and safer motor vehicles satisfying the need of more segmented populations of consumers. Even though during the past years motor vehicles have become also more fuel efficient, the enhanced economy has been outperformed both by the industry itself when introducing heavier and higher performance vehicles but above all, the rapid growth of motorised population in emerging economies.

In the European Union alone, traffic congestion had some years ago a price tag of €50 billion per year or 0.5% of Community GDP, and by 2010 this figure is forecasted to be ca. 1% of EU GDP. The number of cars per one thousand capita has increased from 232 in 1975 close to 500 today. The total traffic exposure of road vehicles has tripled in the last 30 years and, during the last decade, the volume of road freight grew by 35% contributing to 7 500 km or 10% of the network being affected by traffic jams daily.

Without the exception of vehicle technology, traffic sector has remained a low-tech area. This concerns above all the manner in which consumers are supported in their daily travel, choice of travel mode and traffic operations as a whole.

Information and communication technology (ICT) is penetrating practically all business verticals currently. In the transport sector, the deployment of ICT and Intelligent Vehicle Safety Systems (IVSS) in Europe has been the era of developing *sensing* capabilities both of vehicles and traffic monitoring systems to perceive anomalies and hazards in the environment and to improve the fluency of traffic for less costs and cleaner environment. Mainly this has been R&D on camera (video, FIR- and NIR) and radio radar technologies (77 & 24 GHz) – recently also laser scanning to sense the environment and objects in the vehicle path, monitoring and prediction of the vehicle trajectory and driver behaviour, monitoring road segments and traffic flow from fixed installations. The pursuit has been to develop applications for driver assistance and systems for the road authorities for maintenance and traffic management operations. The trend has been in terms of methodology to use sensor data fusion to provide as full understanding as possible of the environment.

The problem is here that enhanced sensing technologies have been mainly used for more stand-alone intelligent vehicles and to a lesser degree to support the whole traffic system. The beneficiaries have been a small proportion of the premium car segment drivers.

1.2 Cooperative driving

The solution to the afore-mentioned challenges and the programme scope is *Cooperative Traffic*. The idea of cooperation within a transport system originates from the concept of *cooperative driving* supporting the concept of *automated highways*, where vehicles are receiving input signals from the road environment – either from a road surface or road side. First documented ideas of automated highway were presented already in 1960 by General Motors. In their vision, the car’s front wheels are automatically positioned by responding to signals picked up by tuned coils mounted on front of the car.

Today, the aim of cooperative driving solutions is to support foresighted driving and an early detection of hazards. This is realised by means of a wireless communication based systems that extend the drivers’ field of view and warns of potentially dangerous situations ahead. Consequently, the aim of these approaches is to provide drivers with the opportunity early to adapt the vehicle speed and also increase headways between vehicles leading to a higher situational awareness of an unforeseen danger.

The main expected application areas are as follows:

- Traffic information exchange between vehicles and background systems,
- Traffic management to utilise the road network capacity to its full extent and to harmonise traffic flow,
- Holistic demand management,
- Early hazard warning system,
- Driver support in merging traffic and
- Platoon diving.

Furthermore, in even a more distant future are cooperative systems for multiple vehicles such as is the case with intersection scenarios. First studies also on this area have been conducted.

Cooperative driving concept in Europe was first promoted and addressed in the EURECA project of the EC PROMETHEUS Programme (1987-1994). Therein, the activities focused first on bi-directional roadside-vehicle communication to be followed by first vehicle to vehicle communication studies. Ever since, the focus of European automotive industry turned to stand-alone vehicle safety systems such as ESP, launched by Bosch in 1995 and later different ADAS applications initiated by Adaptive Cruise Control (ACC) in 2000. Meanwhile in USA and Japan the activities on cooperative driving continued. Not until a few years ago, after realising the need for earlier driver support than what ADAS can provide, OEMs and suppliers “rediscovered” the cooperative driving concept that is also reflected in the later of Calls 6 FP and today, in the 7 FP Calls.

In Japan and Korea, a broad range of cooperative systems have been tested – even though our information of them in Europe is scant. For instance operative platooning has been demonstrated as well as intersection cooperative systems.

Recently, a number of research projects have been carried out and are underway several on vehicle-to-vehicle communications in Europe, Japan and USA. So far, some prototype applications such as the recently demonstrated by PReVENT sub-project WILLWARN (Wireless Local Danger Warning) and INTERSAFE prototype systems are not yet providing mature solutions for commercial use [9].

Today, commonly agreed standards for V2V and V2I communication in Europe are under preparation by the ETSI Technical Committee ITS and the Car2Car Communication Consortium (C2C-CC) that was established to promote the idea of common European standards for C2X communication was instrumental in initiating them. The C2C-CC is a non-profit organisation initiated by European vehicle manufacturers, which is open for suppliers, research organisations and other partners. The Car2Car Communication Consortium is dedicated to the objective of further increasing road traffic safety and efficiency by means of inter-vehicle communications.

Standardisation received a considerable push forward through the allocation of a dedicated frequency band for vehicle safety communication in Europe. 30 MHz have been reserved between 5,875 and 5.905 GHz for exclusive use for communication of safety relevant information. This frequency allocation is quite in line with the frequency band that has been reserved in the USA for dedicated short range communication (DSRC), allowing to use the same chip set and building on the IEEE standard 802.11p, which will generate scale effects and making equipment cheaper, when deployment starts. In addition to the 35 MHz reserved for vehicle safety communication only additional 40 MHz have been reserved between 5.855 and 5.875 GHz and 5.905 and 5.925 GHZ for traffic related applications but there is no exclusive use of this for C2X communication.

As standardisation issues also development work is moving forward quickly. Both CALM (an ISO activity) and the Car2Car Communication Consortium (C2C-CC) by European car manufacturers have developed architectures and protocols that are mostly complementary, but also partly overlapping. Harmonisation activities are ongoing with the European Commission funded support action COMeSafety being the main driver and two EC funded projects deeply involved in this process. CVIS (www.cvisproject.org) is supporting the basic CALM protocols and SAFESPOT which utilise some of the features provided by C2C-CC. These projects are co-operating both on architecture and on technical aspects in order to find interoperability. Another EC funded project, PRE-DRIVE C2X, has taken up the harmonisation work done by COMeSafety and is developing together with this project the system prototype for future field operational tests of the common European architecture described by COMeSafety .

Cooperative driving in Europe has also taken off, since during the past year in EU area only, some 30 projects focusing on this topic have been launched.

1.3 Cooperative traffic

While cooperative driving is making use of data provided both by vehicles' sensor systems and infrastructure data collection systems, the concept of cooperative traffic takes a more holistic view on traffic. *Cooperative traffic system is making use of data led operations starting from data collection, transforming it to information and sharing the information at all levels of travel and transport decision making.*

This means that we have to understand the transport system as a stratified entity of decision making where both the quality and quantity of travelling and transporting are influenced by societal and individuals' values and extending to a single manoeuvre at the wheel. All these levels can be regulated and supported by timely and rich information on travel costs, impacts and choices as well as information influencing the situational awareness of a driver on the road. *The cooperative aspect is embedded in the capability of different actors either passively or actively to acquire data and share it with other parts and players of the traffic system.*

Elementary forms of cooperative traffic are today represented by various traffic management (sub-) systems techniques employing variable message sings (VMS) widely used for the past twenty years on European roads. The main purpose of the traffic management systems has been to both improve the efficiency and safety of the road network by harmonising traffic flow and regulating individual driver behaviour. Following types of traffic management sub-systems have been deployed:

- Speed control / section traffic control (traffic related or weather related),
- Incident management,
- Hazard warning / Congestion warning / Queue warning,
- Ramp control,
- Network traffic control including rerouting,
- Lane control,
- Reversible lane control,
- Tunnel traffic control and
- Bridge traffic control.

The wide use of the systems is explained by the systems' effects as verified in numerous studied. The systems have a capability of optimising the road capacity by 10-40% and reducing injury accidents by 10-40% depending on the system and location characteristics. The deployment of the systems has concentrated on corridors and links with high traffic volumes, which have frequently incidents and where the impacts of the systems are expected to be the highest. Long tunnels and bridges are typically equipped with traffic management systems of their own with often dedicated traffic management centres or rooms.

Traffic management systems are usually controlled on the basis of real time data provided by monitoring systems. Typical data required include, e.g., cross-section traffic data (speed, volume and occupancy), cross-section road surface condition data (dry/wet/snow/ice), cross-section weather data (wind/gusts, precipitation), automatic incident detection, and travel time data. Operators at traffic management centres operate and supervise the systems based on traffic management plans usually developed for typically recurring situations and scenarios and verifying the status of the road network in their responsibility via CCTV cameras. Traffic management centres are usually operated by the respective road operator or the police.

The systems were earlier on only local systems aiming to optimise traffic flow or reduce accidents at a critical spot or on a critical link based on dedicated monitoring systems. The next phase was in tactical traffic management aiming to optimise the traffic on corridors, and lately the trend is moving to incorporate also strategic management optimising the operation of a larger road network and long international corridors. In the most densely populated central European regions, cross-border traffic management has been also deployed. The traffic management systems have also at the same time been increasingly integrated with traffic information systems and services, which support the operation and effectiveness of traffic management and control systems.

The traffic management solutions have been mostly based on quite mature technologies and solutions. European R&D Programmes have not really included major projects since the mid 1990's. The main developments concerning traffic management plans, centre operations, harmonisation of VMS and system evaluation have since then taken place within the so-called Euro-regional projects supported by the TEN-T programme of the European Union. Currently, all these projects have been integrated into a huge seven-year and three-phase EasyWay action involving 23 European countries. The total budget of the deployment- rather than research-oriented action is 1,500 million Euro in 2007-2013. [12]

This concise review of traffic management with extensive data collection as a corner stone for cooperative traffic clearly shows two things: (i) there is a lot of potential to enhance traffic system efficiency in terms of accident reduction and fluency of traffic flow and (ii) there is huge potential to develop traffic management systems more intelligent and serve more stakeholders than drivers only.

Cooperative traffic serves more than traffic management needs and on-site information of travellers and goods only. The Cooperative Traffic programme structures the research field as follows (Figure 1).

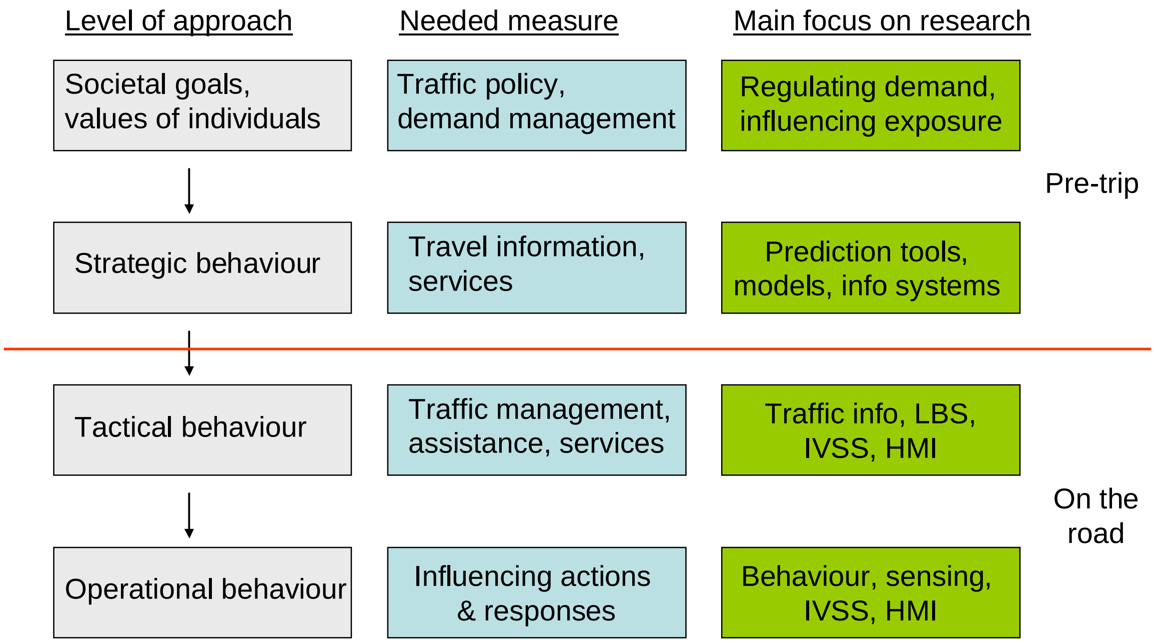

Figure 1. *Cooperative traffic research frame of reference.*

According to the model in Fig. 1, the research area is structured hierarchically into four different interacting levels:

(i) The highest level represents an approach to study cooperative traffic where the focus is on societal goals aimed at by transport policies and influencing by the values of travellers and hauliers. These have deep-going impacts on our travel such as the pricing of travel and finding alternative solutions to travel. So this level is associated to the travel decisions such as how much we use a private car and the choice of a travel mode or substituting a journey to something else like working at home or using energy efficient travel modes.

(ii) The second level called "Strategic behaviour" is already based on a positive decision to undertake a trip. The issue is related to the planning of the trip such when to make a trip and how to do it. These kinds of decisions could be supported by a number of different measures associated with the availability of travel information and available services along the route or at the destination.

(iii) The third level is directly linked to the situation where the traveller is already on the move. Currently a number of services and assistance functions can be foreseen to make the trip both safer and more comfortable.

(iv) The last level is related to actual travel behaviour on the road and especially at the wheel or control of the vehicle in use. Many of this level support functions are associated with sustainable travel behaviour such as driving safely and economically.

The challenge for the industry and the society at large is to deliver the next generation of ubiquitous and converged systems, networks and service infrastructures for communication, computing and media facilitating the decision making of societies and individual travellers. Such new communication infrastructures will permit the emergence of a large variety of technologies, services and business models capable of dynamic and seamless end-to-end connection with multiplicity of devices, networks, providers and service domains. This ubiquitous traffic, transport and travel infrastructure combines in a unique and comprehensive manner the various travel and transport modes, their drivers and passengers as well as their cargo ending up in cooperative traffic.

Concerning the utilization of aftermarket and nomadic devices such as smart phones and navigators used in cooperative traffic, the issue has been to some extent about finding or agreeing on open interface solutions when connecting mobile terminals to vehicle systems as well as how to equip road users outside vehicles with such devices to facilitate their safe participation in cooperative traffic. On the other hand, the problem has also been to some extent creating service concepts for operators and service providers to make money out the functions assisting drivers and other road users. Currently, however, increasing numbers of independently functioning aftermarket telematic devices are entering the market. These devices either provide road users with traffic information and functions or would be capable of doing so in a moving vehicle. As a good example of such mobile devices is given by portable navigators and smart phones, which are affordable and have a capacity to serve travelers in a number of ways in addition to assisting in navigation or serving as mobile phones only.

1.4 Technology in use in transport is underdeveloped

Wireless and wired networks now provide ubiquitous capabilities to connect sensors to inexpensive storage and computing facilities. We are living, travelling and transporting in an instrumented world. Our vehicles and vessels are equipped typically with tens or hundreds of sensors and microprocessors. Electronics is already today forming more than one fourth of the value of a new ordinary family car. Data gets processed by onboard computers to improve energy efficiency and safety. Instructions are given to actuators with millisecond latencies from the triggering event – but only within the in-vehicle boundaries. Interconnections between vehicles and infrastructure have not developed much since the first railway semaphore on the London and Croydon Railway in 1842.

Only some transport information systems process the captured data to develop a deeper system-wide insight into the real-time events. In some systems this data is already used successfully for time-based decision making and improving optimisation of operations for service levels, energy usage and available capacity. Typically this has been easier for single mode, more closed transport than for the transport with more heterogeneous infrastructure and vehicles. An example of an industry which would be able to capture significant benefits out of instrumentation, interconnections and computing capabilities is railway operations as shown in railway operations optimisation in the Netherlands with an ILOG solution.

We claim that overall in transport we have leveraged only marginally the potential of instrumentation, interconnections and computing capabilities and even then strictly within the boundaries of the specific transport mode. Holistic multimodal transport management is just an emerging topic.

Information infrastructure and network management in use in transport - right through from strategic planning to real-time information creation capability and real-time intervention capability - are underdeveloped technologies in comparison to available technology; although millions of vehicles on the roads are full of advanced technology. Deployment of advanced methods and systems has clearly been slower for transport infrastructure and public transport than for in-vehicle systems. Very little of our capability for capturing data, for interconnecting sensors, meters and applications and for processing data for insight, decision making and information utility is used for network optimization, demand management schemes and enhancing the use of more environmentally friendly and energy efficient transport solutions. In the meantime the traffic volumes, the energy consumption in transport, the use of natural resources and the emissions to environment are outpacing the adoption of effective intervening solutions thus making the gap to required progress grow rather than close.

Making scarcity tangible

Scarcity of natural resources is moving up in government, company and individual decision making priorities. We are adopting a view about a world as a relatively closed system from mankind's point of view as illustrated in Figure 1. The scarcity has various implications to the need for transport solutions. We discuss this implication from infrastructure, energy efficiency and environmental friendliness perspectives.

Infrastructure. Increased demand in transport has historically been resolved by constructing more infrastructures. Construction of new infrastructure is now more and more often not an option due to various reasons e.g. avoiding destruction of constructed urban infrastructure, unacceptability of claiming unbuilt land for roads, avoidance of increased load on other parts of the network caused by removing some bottlenecks, and simply the high costs of the feasible infrastructure solutions.

Energy efficiency. Although the end of oil-based economy has been postponed, variations in supply and prices due to political or environmental reasons have raised importance of better understanding and management of natural resources. Emerging economies, increasing wealth and the still questionable sustainability of biofuel production in large scale urge for enhancing use of more energy efficient transport solutions.

Environmental friendliness. European Commission has stated following: "Under the Kyoto Protocol, the European Union is committed to reducing greenhouse gas emissions by 8% from its 1990 level during 2008-2012. However, if current trends continue emissions will in fact rise. One principal factor causing this rise is increased volumes of road traffic." More energy efficient power trains, alternative fuels, low mass materials and structures will not give the necessary results on the timescales required. Systemic and not only technical solutions are clearly needed if we are to achieve the rapid resolution demanded.

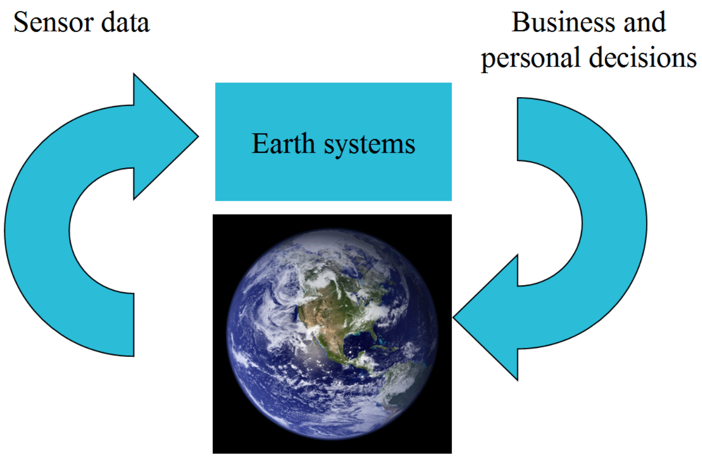

Figure 2. *Resource consumption loops must start to close – earth is a closed system (IBM Research, 2009).*

Real-world-aware systems in traffic and transport

Alignment of constraints and demand will require changes in the behaviour of governments, companies and individuals. It is now becoming widely accepted that we need better methods and systems for managing use of infrastructure and natural resources and emissions to nature. For this we would need new kind of real-world-aware information and communication solutions. Figure 2 illustrates conceptually the flows, where real-time data is captured, transformed, analysed and processed for time-based decision making and information utility. In this world we could make more environmentally aware decisions. It would also enable new information based innovation and businesses.

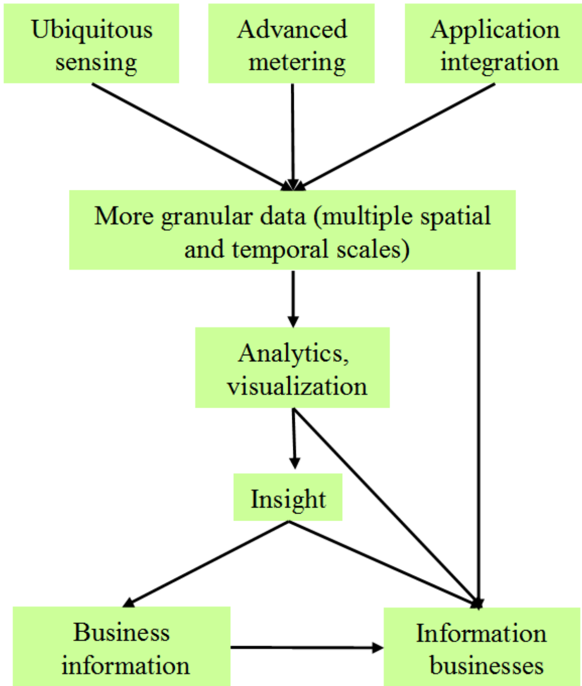

Figure 3. *Conceptual description of information flows in real-world-aware information systems (R.P Williams, 2009).*

Today most of transport system solutions are focused on transactions. Research and operational systems have shown that we can predict traffic flows and effectively influence demand patterns. Cities like Singapore and Stockholm have proven that information systems have a key role in implementing transport policies and reaching set targets.

We should move focus to managing multimodal transport systems from strategic, tactical and operational demand management perspectives:

1. Use instrumentation and simulation of the multimodal traffic that measures performance indicators of interest including carbon, fatalities, congestion, and revenue.
2. Integrate this with real-time (operational) prediction and establish a closed loop between the users and the information through mobility and location-based services
3. Derive insights for tactical and strategic use from the data (observed and predicted)
4. Optimize strategic and tactical charging policies and routing policies as well as optimize decisions for performance indicators of carbon, fatalities, congestion and revenue
5. Study the influence that information, charging and incentives have on behaviour and account for the behavioural modelling and simulation to help with the optimization.

Holistic demand management becomes critical with discussed assumptions on time-scale and magnitude of environmental, infrastructure and energy efficiency challenge. Mastering demand management would require transport management systems which are: (1) integrated, (2) multimodal, (3) system-wide, (4) real-time, (5) dynamic and (6) continuous. These attributes should apply to systems used for (1) strategic planning, (2) performance management and (3) customer management in transport.

Functionality of the demand management systems should extend to areas like policy/process modelling/simulation, impact analysis/simulation, policy testing and deployment, incentive and tariff management, real-time performance management, real-time prediction, incident handling, dynamic capacity reallocation and dynamic redirection of traffic flows. Note that holistic demand management includes traffic management as its integral part. Key objective for demand management should be enhancing use of more environmentally friendly and energy efficient transport solutions.

1. Holistic demand management

Enhancing use of more environmentally friendly and energy efficient transport solutions becomes key objective.

Research needed about integrated, multimodal, system-wide and continuous solutions for:

- policy/process modelling/simulation
- impact analysis/simulation
- policy testing and simulation
- incentive and tariff management
- operations performance management
- real-time prediction
- incident handling
- dynamic capacity reallocation
- dynamic rerouting.

2. Multi-modal decision support

•Provide comparable levels of information and tools for all transportation modes.
•Extensive two-way integration needed.
•Models for predicting travel patterns help in developing efficient decision support tools.
•Examples of solutions: integrated personal transportation account, personal transport scheduler/optimizer, multimodal payment methods.

3. Traveller information

• Location based, mode aware and context sensitive services.
•Replace static information with dynamic and proactive information.
•Automation on top of integration.
•Dynamic handling of transitions between modes.

4. Value-added services

• Safe, secure and transparent information utility as an enabler for a business and community applications.
•Gain is driven by sharing of linked data.
•Services must be ubiquitous and personalised.

Figure 4. *The context of real-world-aware transport systems.*

Multi-modal decision support should bring all modes of transport to comparable levels in terms of information and tools. Extensive two-way integration would be needed to enable functionality like integrated personal transport accounts, personal schedulers/optimizers (GHG, energy, cost, time, predictability) and multimodal payment methods. Models for predicting travel behaviour could help in improving the understanding of demand patterns and in developing efficient decision support tools.

Traveller information should to be location-based, mode aware and context sensitive. Static information should be replaced by dynamic and proactive information services. Integration should be followed by automation. Information should be comprehensive and user experience consistent independent of the mode of transport. Transit from one mode of transport should be handled dynamically.

Emergence of value added services could be accelerated by realizing that multiple clients exist for the various insights which real-time information creation can provide. Two-way information utilities which could be opened for community applications and social networks would accelerate the creation and capture of value embedded in the data. Information utility which is safe, secure and transparent and can manage authenticity of data would deliver us more ubiquitous and personalized data. Information utility's main objective should be enabling, encouraging and increasing sharing of data to increase both global and personal gain on real-world data. An important objective would be the enablement of information utility businesses. Various commercial services would be able to leverage the information utility for running transactional business e.g. parking, car-pools, pay as you drive insurance, condition based maintenance, mileage based lease, performance based refuelling, disabled/young/elderly driver support, special transport, security services, advertising and entertainment.

Note that all the functions and services above are based on a comprehensive information infrastructure, the quality and coverage of which also determine the quality and thereby the value of the functions and services to their users.

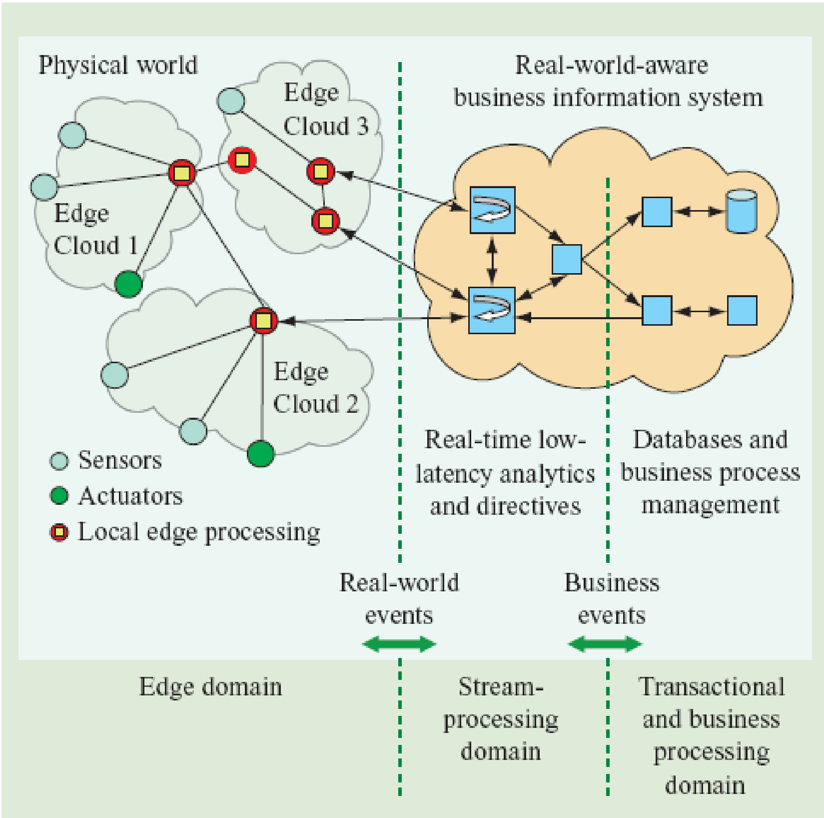

Figure 5. *Topology of real-world aware systems (C.-H. Chen-Ritzo et al., 2009).*

Advanced transport systems could be structured around the topology described in Figure 5. Mobile vehicles and vessels with multitude of sensors, actuators and local processing have plenty of capability within their strictly defined cloud edges. Connecting the mobile clouds with vehicle to vehicle communication with each other and with vehicle to infrastructure communication with the stationary infrastructure clouds is primarily the foundational edge domain research challenge. The standard data format and standard messages for these interconnections should support exchanges of raw data (e.g. speed and location) or processed data (e.g. destination and estimated time of arrival) to allow different information utility based personalized services.

In business information systems for each transport mode there is plenty need for research to make the systems fulfill the concepts of real-world-awareness, but the major research contribution is needed to create the multimodal integrated business information systems for transport.

Assuming that technology is abundant, but transfer of technology to solutions and implementations is not, we should increase focus on questions related to public and commercial applications and use of advanced solutions as described in figure 5. As we are suggesting moving focus from technology innovation to service innovation, we should taken into account that successful service innovation is found in projects with a strong integration with the service providing organization and the external users of the services resulting in their strong commitment to the service in question. Thus we should require this from all our service innovation projects and measure them with criteria like use of authentic user data and number of external users involved designing, testing and piloting the solutions.

We propose increasing focus in transfering research results into public and commercial implementations and use:

Transfer of technology and solutions to field
- Pilot implementations together with client organisations and real users
- Building up the momentum for full scale operational implementations

A holistic approach will benefit from widely recognised strong Finnish research areas like mobile technology, communication technology and service engineering.
- Research in areas like sensor driven data and positinioning could become a new global contribution.

Early operational implementations
- Needed to create opportunities for experience building and learning both in client and delivery organisations
- We need to come up with solutions to the managerial and operational obstacles.
- Business models and governance also need to be seen as test and learning objects.

Figure 6. *Shift from technology innovation to service innovation.*

2. Programme vision

Cooperative traffic programme promotes sustainable traffic by making use of extensive information sharing based on novel technologies and services developed for different levels of a transport system.

The societal driver for the cooperative traffic programme is an urgent need to accelerate the deployment of sustainable traffic aiming eventually at accident- and emission-free mobility. Transport systems are today managed all but an optimal manner. The business driver for more intelligent traffic systems is to develop and offer novel technologies and services to various stakeholders in the system ranging from traffic authorities to individual road users. It is easy to see ample space for novel solutions using information technologies based on a new way of acquiring and handling the data traffic system generates.

Current traffic services and driver support functions address single situations and problems, while promoting sustainable traffic calls for a more holistic approach. The cooperative traffic programme adopts a view where the transport eco-system is structured in separate interacting levels (see Figure 1), and these levels are addressed through dedicated projects. Only in this way, it is possible to meet the programme vision of promoting the sustainability of the whole transport system.

In transport, the vehicles – especially passenger cars - have made a closed system accessible only for the manufacturer, their service and maintenance facilities and nominated licensed partners. That is still the case today, since the data related to the vehicle body control, power train and safety critical systems are mainly proprietary and not open for other than vehicle control uses. However, vehicles are gradually communicating to an increasing degree with the outside world when portable devices are emerging in vehicles with dedicated physical and application interfaces. Car radios, mobile phones, navigation devices and other electronic on-board units (OBU, e.g. for toll collection) have established the early steps of today's in-vehicle system roadmaps. Furthermore, vehicles may serve as sensor or data sources that can be used to serve both individual travellers as well as road operators.

The main ITS systems and applications, with real-time context aware reasoning, cover the various needs of commercial and private vehicle drivers or even some communities with general interests, taking into consideration their demands, needs and current willingness for information and entertainment, by highly sophisticated content and context sensing methods. Moreover, the future ITS, is not limited to single user communication or personal devices, but additionally extends to high-tech in-car platforms, intelligent infrastructure, more generally to users insteacd of just vehicles, and thereby user-to-user and user-to-infrastructure communication, by all the means of future ubiquitous ICT.

However, the new development will bring along issues such as reliability, safety/security, liability, legal constraints, usability, and commercial aspects in the form of OEM expenses and product retail pricing, communication infrastructures and customer values.

Portable and handheld components of the telematic structures and modules have been brought inside the vehicles to establish add-on functions of the built-in vehicle infrastructure. Together these fixed and nomadic building blocks support the consumption of a wide variety of applications and services for safety, security, information and entertainment. The HMI may well be implemented using text, audio, video, voice, voice recognition, tactile and cognitive communication and response. This collection of functionalities and hardware relies on the wireless connectivity with the outside world. This connectivity network forms the new boundary in the coming era. Portable and handheld devices also extend the cooperative traffic outside automobiles, to pedestrians, bicyclists, snow mobiles, etc.

Short-range, cellular, broadband and/or high speed communications are stepping inside the vehicles. DSRC, cellular, WiFi and WiMAX devices and communication links will enhance the world experienced inside the private and public as well as the commercial vehicles.

The CT programme needs - in addition to personal mobility - to address the efficiency of logistics operations both nationally and globally through development of new optimization and prediction models and methodologies. Efficient planning reduces also environmental impact of transport and enables e.g. better and more flexible customer service levels. We are now having many of the building blocks for more connected vehicles and transport system overall.

3. Programme mission

The cooperative traffic programme develops cutting-edge technology and service solutions for different levels of the traffic system by bringing together major players nationally and internationally and raising the Finnish traffic ICT sector competitiveness to a new level.

The Finnish industry – with its strengths in sensor and communication technologies, devices, networks and services – is well placed in the European and even in the world-wide competition to define and develop systems and service infrastructures for the coming years. These will generate new economic opportunities with new classes of networked applications, whilst reducing operational expenditures. The current internet, mobile, fixed and broadcasting devices and networks and the related software service infrastructure need to progress accordingly in order to enable another wave of growth in the on-line economy and society.

Currently, the commercial ITS product range consist of several specific or even tailored solutions, while expanding large-scale problems call for complete and highly scalable ITS platforms. Thus, the focus of Finnish ITS R&D should be targeted from to comprehensive traffic control and management system serving all road users and operators. In addition, private consumption of traffic related data and other ITS related content is rapidly increasing in car environment. The rising interest towards more sophisticated applications and simultaneous requirements to make traffic sustainable allows several novel business opportunities, including the ITS systems, but even more potentially new personalized services for the players in the market.

About the Finnish ITS R&D, the state-of-the-art consists of the world-class research competence, profound know-how and strong experience about various traffic systems and applications. In addition, the Finnish R&D community and participating companies cover the all needed capabilities to develop various types of ITS. Thus, the ultimate challenge is to obtain the leading position in given application areas of cooperative traffic in the world.

4. Objectives

The programme overall *objective is to develop technologies, services and functions for more efficient traffic system operation and functioning as well as raise Finnish ICT industry in transport sector applications to a high international level and in given areas to world elite*.

To realise the overall objective, several more specific objectives need to be first defined and later met. These are listed as follows:

1. Create an active collaboration network between companies and research organizations nationally and internationally.

2. Address traffic system as structured whole consisting of different levels and identify the research and development needs on these levels.

3. Develop services, functions and technologies needed to support sustainable traffic system on its different levels.

4. Identify and build the needed research testing tools and sites for the services and functions validation.

5. Study business models for the deployment of developed novel services and technologies.

6. Create large-scale pilots for the cooperative traffic eco-system.

7. Disseminate the project results effectively to all stakeholders concerned.

To realize the objectives set above, the programme partners need to create projects and participate only through the project work. Participants can vary from technology vendors to content providers. Furthermore, this may include also joint ventures, marketing efforts and strong partnership between participants.

The project activities may vary considerably and range from new R&D focusing on single sensor technologies supporting driver behaviour, new communication techniques, sensor data fusion, new HMI as a well as novel software solutions or novel ways of applying existing software tools. Piloting and testing may comprise of living lab-type of an approach to formal testing following the principles of experimental design.

To direct the CT research, the objectives need to be transformed to focused themes and subjects on the on each level of Figure 1. The projects can involve technologies and services focusing on various user groups, professional or non-professional ITS, the type of transport, the level of necessity or the level of public or private involvement. Although, the focus of the SRA will be set to the road transport and related traffic interfaces, other transport forms and their characteristics need to be considered according to the levels shown in Figure 1. Other modes, means and areas of transport addressed can be railroad, sea and air transport, customs and safety regulations, incident management, pollution and congestion management, fluency of transport and fleet management, and several ICT related topics such as telematics or access networks (Figure 7.).

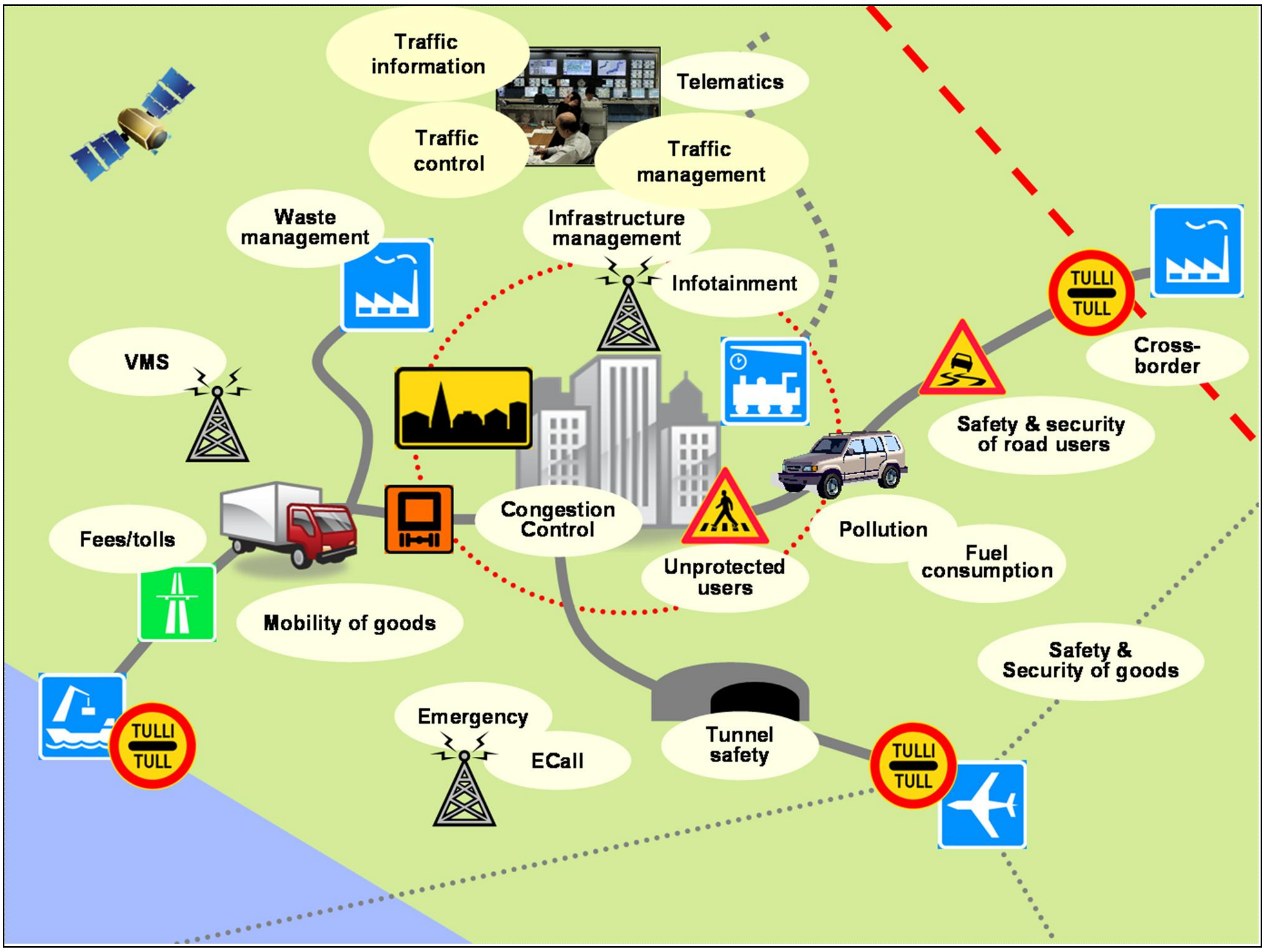

Figure 7. *Cooperative Traffic ICT – Example topics on different levels of research.*

Another focus of research is to look at it from the perspective of different user groups. Moreover, it will be important to notice that the requirements set by private road users and professional drivers are in many cases very different. In the future, cooperative traffic should meet the requirements of all users, alleviate the problems of today's road traffic and offer new solutions such as:

- Efficient mobility of goods in all environments, including urban environments as well as border traffic between different countries. This requires compatible logistics information systems, developed navigation systems, real-time routing, Electronic Fee Collection etc.
- Safety and security of freight and transport, including surveillance and tracking of goods, transport of dangerous goods, sensors in the infrastructure and in the car, ADAS (Adaptive Driver Assistance System), ACC (Automatic Cruise Control), in-car networking and systems for making night time driving safer.
- Context-aware information to all road users, including information about weather and road conditions, traffic disorders, commercials and travel information.
- Safety and security systems for private road users, such as ACC, ADAS, systems to observe the driver's behaviour and alertness, context-aware and driver's profile observing warnings and information, parking aid, sensors in the car and infrastructure, vehicle-to-vehicle, vehicle-to-infrastructure and in-car communication. In addition, innovations for vulnerable road users are considered.
- Infotainment and office applications.
- Multimodal travelling services that aim to increase using public transport.

In the domain of Cooperative Traffic ICT there are various stakeholders with direct and indirect impacts on the global systems (Figure 8). From the services viewpoint the value chain starts from the service creation and provision which are integrated by the service aggregation actors. The infrastructure plays an important aspect in the value chain since the road, traffic and communication infrastructures are the backbone of the Cooperative Traffic. The public authorities are responsible for the road infrastructure and the (telecom) network operators for communication networks. Terminal and Vehicle manufacturers (a.k.a. OEM) with their league of suppliers (a.k.a. Tier1) provide the common factor for the driver, i.e. consumer for services, the consumer device (access terminal) and the car (vehicle).

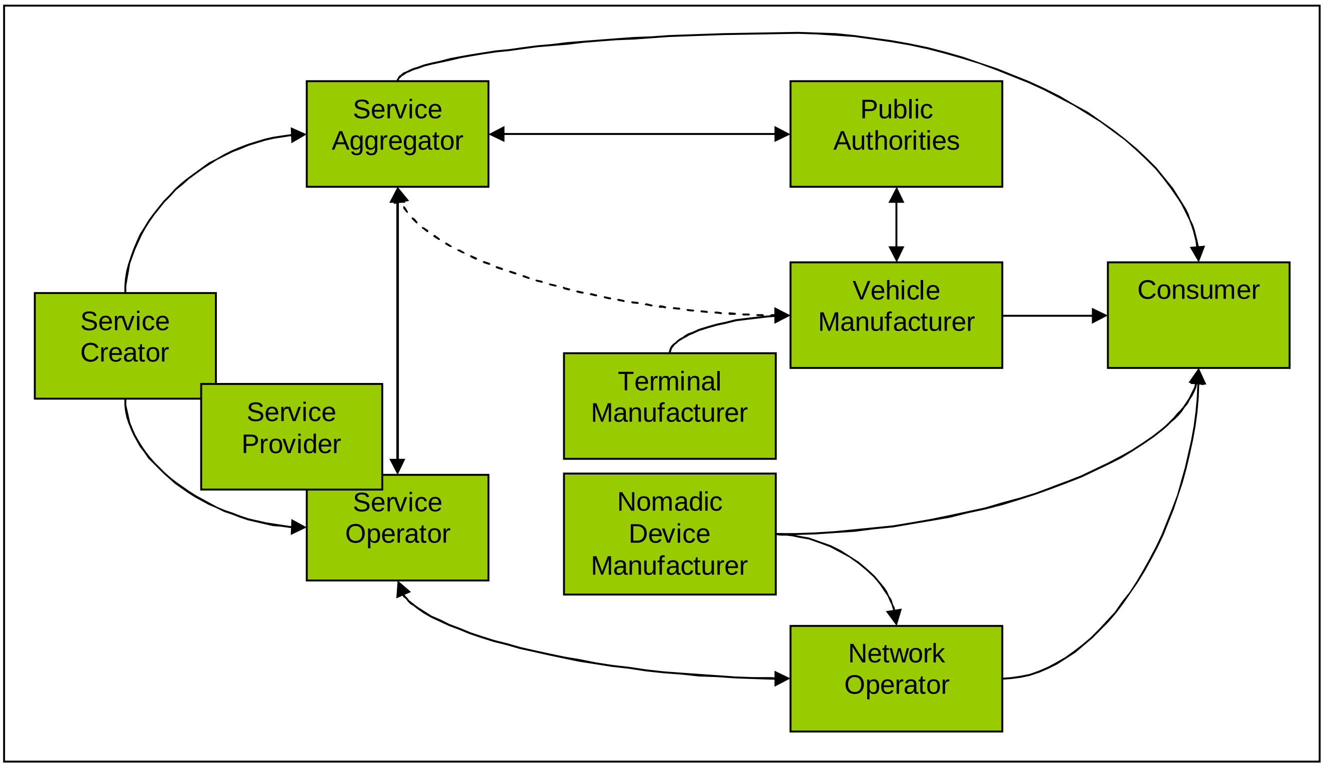

Figure 8. *Stakeholders in the Cooperative Traffic ICT value chain.*

5. Research themes

To reach the mission R&D efforts need to be focused on four different levels as shown in Figure 1.

The work is divided under five research themes. Purpose of the five themes is to provide a structure, which encourages thinking about the research projects in the lines of the idea of web of cooperative traffic services. Instead of thinking within the boundaries of single technology or process, we need think about systems wide integration of them to create a web of services and businesses for the benefit of users. Furthermore, the activities within these themes can be phased to research oriented technology development, applied R&D work towards applications, verification and validation in pilots, and business related activities during market entries. These activities in different areas may occur in a different timescale. At the same time some theme area activities might be in application phase and some activities might be in technology phase.

We have divided our activities as follows:

I. Sensors,
II. Devices,
III. Systems,
IV. Users,
V. Business models

The objectives these five research themes are described below:

I. Sensors
- Sensing equipment (both in-vehicle, mobile and infrastructure)
- New technology enablers for radiometric surroundings monitoring , concepts of new applications and exploring data integration possibilities enabled by radiometric data gathering
- Sensors and algorithms for driver behaviour analysis
- Context awareness requires sensor systems for gathering the necessary information of a driver and vehicle state and driving environment

II. Devices
- In-vehicle information and map/GIS information fusion
- “Next generation” navigators
- Driver and vehicle identification and authorization applications
- Tools and systems for diagnostics fault tolerance
- Instrumented vehicles with prototype implementations

III. Systems
- Customer and community-based information production and exchange
- Designing ontology for the Vehicle Systems/ITS domain
- Real-time optimization and management methods
- Methods for handling and correcting geographical data
- Data collection with reusable, annotated semantic history storages
- Exchanging and integration of information of various sources
- Perception system for special conditions
- Develop the sophisticated information processing methods
- System pilots in global environments, pilot and test sites in Finland

IV. Users
- Adaptive HMI
- Enhanced traveling experience solutions for customers (one point service, with all the necessary information, with profiles and preferences, with all modes)
- Context-based information delivery for transport and travelers
- Modeling various behaviors and their interactions with agent-driven platforms
- Annotating and collecting driver behavior patterns
- Designing ontology for the “Driver Behavior” domain

V. Business models
- User segmentation
- Product and service platforms
- Business processes from client and provider perspectives
- Service management
- Institutional prerequisites and limitations
- Ecosystem development
- Pilot projects to proof test the business models

6. Relevance

In Finland, we have a globally competitive traffic system know-how and excellent competence applicable to all sectors of ITS. To date, no one has created a comprehensive Intelligent Transport System as a commercial service product. Japan appears to be most advanced in the business, but even they are at early stage of deployment in the field of ITS.

Automotive industry with €800 billion turnover is globally the largest segment in manufacturing. Current global vehicle fleet totals some 800 million, and the annual new vehicle market is about 70 million units. The current EU27 vehicle fleet is around 200 million vehicles with an annual renewal rate of 8%; approximately 16 million vehicles annually. The ITS service market makes use of the fact that electronics and software are expected to represent 80–90% of vehicle innovations through 2010. The motor vehicle is becoming a connected entity interacting with other vehicles and the entire traffic system over communication networks.

The automotive industry companies enhance their competitive position by investing in the development of vehicle specific embedded systems. This will offer new possibilities to Finnish companies involved in the business. The industry has vehicle-to-vehicle and vehicle-to-infrastructure communication systems on its R&D agenda, but the scale of this activity is relatively small compared with the vehicle specific systems. The most omitted area is the collection and use of the data available from various sources to manage the traffic flow and impact on the demand of traffic service. The omitted area is however the most essential in terms of constructing the key functionality for traffic control and management. The use of ICT technology is revolutionizing the automotive industry (i.e. in-vehicle, external & home connectivity). Mobile device integration and public telematics are seen the most potential technologies to transform in-vehicle communications in the coming 5 to 10 years. Public telematics are driven by governments for improving traffic flows, congestion, toll collection etc. As the life cycle of a vehicle is very long compared to consumer electronics, the automotive industry has started to develop in-vehicle platforms that can be updated or individualised as new features and connections are launched. This will open opportunities for additional consumer focused telematics services. [1]

Car manufacturers roughly double the amount of outsourced development by 2015 (from €28 billion to €54 billion), high growth especially for module fabrication by suppliers (from €303 billion to €505 billion) and area of growth for subcontracted manufacturers and assembly specialists. Europe will still be the core market for automotive suppliers. [2]

There are a number of topics within the Intelligent Transport Systems in the need of R&D activities. All these systems and applications relate to:

1. Environmental sensing
2. Communication (V2V, V2I / I2V)
3. Human Machine Interaction (HMI)
4. Traffic management (sub-)systems
5. Traffic modeling
6. Traffic information systems
7. Rescue systems
8. Actuation systems and
9. Sustainable travel technologies and services (safety and energy efficiency)
10. Training.

Traffic exposure has been continuously increasing which creates undesired effects such as congestion, air pollution and negative health effects (fluency of travelling, safety & security, environment). This is due both to individual traveling, and commercial transports. Optimization (and, hence, total decrease) of commercial transports in real-life cases is possible although one of the most difficult challenges to solve. Development of better heuristic solution strategies together with more realistic models and real-time optimization with uncertain information are the main challenges for research. Other important challenges are accurate geographical data and integrated problems that combine strategic, tactical and operational planning.

Road safety is a huge social problem of international dimensions. More than 1.2 million people are killed on the world's roads annually. The European Union (EU) has set the goal of halving the number of people killed between 2000 and 2010. In the year 2000, road accidents killed over 40 000 people in the European Union and injured more than 1.7 million. [5] Similar efforts are being made by the Finnish Ministry of Transport and Communications. Nationally the target of road fatalities by the year 2010 has been set to 250. After six years, however, the road safety figures remain pessimistic.

During the last 12 months 379 people have died in traffic accidents. [9] Economically, the impact of road accidents represented the sum of 220 M€ claims paid by Finnish Insurance companies for bodily injuries in 2005. The annual lost in the European economic growth is €80 billion due to automobile accidents and in the EU productivity lost is €2-4 billion due to traffic congestion. Cost of the accidents in the US exceeds $230 billion in 2005.

Today's accidents are mostly attributable to human driving errors of different characteristics. For instance, the Ministry of Transport and Communications Finland in the Road Safety 2006-2010 report indicates that, "Figures from accident investigation boards have shown that the principal cause of head-on collisions on public roads is vehicle handling error in 36% of cases, error of observation or anticipation in 19% of cases, and poor positioning in 15% of cases. Falling asleep accounted for 12% of head-on collisions, and suicide for 10%". [5] This is, in 92 out of 100 head-on collisions the human driver has been responsible for the accident. Thus, both efficient solutions related to the driver's skills, behaviour, and alertness, as well as technological assistance for risky situations is needed. This is specifically true as the number of cars is increasing, and the number of old drivers will be rapidly increasing in most countries.

Market drivers for cooperative traffic (i.e. cooperative travel and transport) technology and service implementations from private vehicle and driver viewpoint are emergency and breakdown services, location-based and location-aware services, navigation with real-time traffic information and route planning services and numerous value-added services.

Drive for an ecological and sustainable transport system is growing worldwide. Today the industry has presented a wide set of powerful and affordable technology for ITS, but also the development trend is to achieve more environmental friendly transport solutions. We are harnessing the capability of technology to contribute to well being of society and individuals. To succeed in this we are creating a collaboration environment encouraging innovation and take-up of new ecological and intelligent technologies ensuring that Finnish industry continues to play an important role in the global scene.

Intelligent vehicle is based on four extensions: increased use of embedded systems, data mining from a variety of vehicle sensors, communication with external systems and Human Machine Interface (HMI). HMI is gaining importance to manage all the information flow to the driver. Intelligent infrastructure should match the vehicle modules with a wider array of infrastructure sensors, communication links and back-office systems in ensuring the availability of traffic, travel and transport information.

Regarding the climate change we need to fight to achieve lower emission vehicles and transport system. Individuals are facing – and in this we have a great role to play – informed choices regarding huge or tiny decisions related to travel and transport. The energy efficiency and alternative fuels is the other path together with telematics solutions ensuring environmental friendly and ecological transport solutions. In transport economy the challenges are with the ever-growing congestion of road and street infrastructure. Within ITS, safety and security are the key drivers. Safety of road infrastructure and safety of vehicles together form the building blocks to have significant impact in travel and transport. Security of data and monetary value transfers with secure communication networks in relation with commercial services are the corner stones of ITS. [10].

European Commission is pushing for larger impetus to achieve a sustainable intelligent transport system. In this scope, EC is providing a framework for ecological and intelligent transport system through emphasis on economic growth, innovation, solutions with minimum negative environmental impact, sustainable movement of goods and people, and safety. EC has several instruments to achieve their target, namely resources for research (including demonstrations), funding and legislation (including Commission Communications, recommendation, directive and regulation).

7. Future traffic as a co-operative system

The Cooperative Traffic ICT can be split toward two application domains as presented earlier, namely *Cooperative Travel ICT* and *Cooperative Transport ICT*. The third dimension is naturally the Driver with the task of *Driving*. The fourth dimension is the *road and street infrastructure*, i.e. the national road administrations and local cities and towns.

The third dimension *Driving*, however, should not be separated from the scope of the two application domains; the driver and the task are integral parts of the two application domains and the characteristics of the task are directly tide to the vehicle, thus either on Travel or Transport. The driver utilises the common in-vehicle infrastructure components independently whether the environment is private or commercial. The drivers' task whether in a private vehicle or in a commercial (i.e. public transport and/or heavy goods vehicle) is to operate the vehicle safely, and, at the same instance, the driver should be capable to receive and access relevant and personalised information according to his/her interests and tasks in a safe manner.

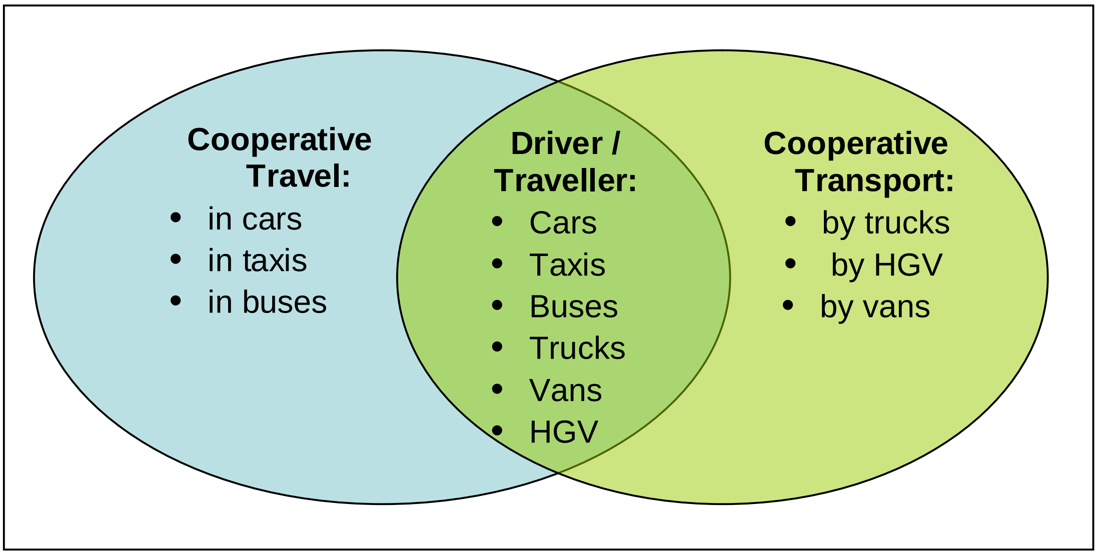

Figure 9. Cooperative transport has drivers and travellers as their common nominator.

The fourth dimension, the *road and street infrastructure*, play the utmost important role in the Cooperative Traffic ICT. The major stakeholders in the ICT SHOK are the commercial companies. However, in the Cooperative Traffic ICT, the national and local administrations own the traffic infrastructure. There are already several administrations (e.g. national, regional and local) that have openly expressed their interest in participation in and collaboration with the Cooperative Traffic ICT companies; they are also willing to provide the test and pilot traffic environment for deployment of Cooperative Traffic ICT solutions.

For **the Cooperative Travel ICT** the leading principle is "*when I'm on the move, I need services, information and entertainment related to my interests and actual location*". Devices, vehicles and infrastructures are intended to be context aware and capable of providing the needed information for the driver seamlessly and on time.

The vehicles in this application domain are cars, taxis and buses whether on the move on roads & streets or parked in the parking areas or in home garage. People are referred in this domain as drivers of the vehicles and travelling in the vehicles. The required communication infrastructures are as follows:

- In-vehicle connectivity between driver personal equipment (mobile phones, mp3 or video players, etc.), third party devices (e.g. navigators), and in-vehicle information systems,
- Mutual vehicle to vehicle information exchange connectivity, Car2Car communication,
- Road & street infrastructure connection between the vehicles and the intelligent road-side equipment, Car2Infrastructure communication
- Services & Infotainment connectivity between drivers and information servers,
- Connectivity between the vehicles and the driver's home or office systems.

In-vehicle connectivity enables the driver with his nomadic devices to connect seamlessly over short-range (Bluetooth) or local broadband (WiFi/WiMAX) network with the vehicle equipped with embedded connectivity solution containing the in-vehicle access gateway and server. In this application domain a set of new intelligent sensors, sensor fusion and applications like EmFit, printed electronics, acceleration, road friction, intelligent tyre are implemented. The domain contains also e.g. vehicle environment perception and monitoring systems and applications, image processing, camera systems, optics as well as modelling, simulation and testing of complex (vehicle) systems. As an integral part of this domain are modules like in-vehicle information and map/GIS information fusion for ADAS and adaptive HMI for safe presentation of information to the driver, context-awareness, nomadic device integration and other intelligent interaction of various devices. In order to proceed with the module and component implementation the technology partnerships and open standards (e.g. Flex Ray protocol, Automotive Open System Architecture AUTOSAR) encourage the introduction of plug-and-play modules.

Vehicle to vehicle (V2V) connectivity enables the in-vehicle systems to communicate securely and connect over dedicated short-range (DSRC, C2C) or local broadband (WiFi/WiMAX) network with the vehicle equipped with interworking embedded connectivity solution containing the in-vehicle access gateway and server.

Road and street infrastructure connectivity enables the vehicle with embedded capability to connect seamlessly over short-range (DSRC), broadband (WiFi/WiMAX) or high speed access network with the external services networks containing the road-side communication equipment, data servers and service provider networks. For safety, security & diagnostics services the vehicle (and the driver) requires identification and authorization applications in order to protect the vehicle, travellers and also goods (in the Cooperative Transport ICT).

Services and infotainment connectivity enables the driver with his nomadic device to connect seamlessly over cellular (GPRS/WCDMA), broadband (WiFi/WiMAX) or high speed access network with the external services networks containing the mobile and wireless communication network equipment, data servers and service provider networks.

Home connectivity enables the driver with his nomadic device and the vehicle's embedded connectivity to connect seamlessly over a high speed access network with the home system and multimedia network structure containing the home server, digital TV, music equipment, air conditioning/heating system, stove and oven, etc.

For **the Cooperative Transport ICT** the leading principle is "*when I'm transporting my cargo around, I need services and information related to my transport task and cargo*".

The vehicles in this application domain are trucks and other heavy goods vehicles (HGV) and emergency vehicles whether on the move on roads and streets or managing their tasks at the location and their cargo in the terminal facilities, at the airports, harbours and ports or in the company garage or depot. People are referred in this domain as professionals driving the vehicles and handling the cargo. The required communication infrastructure is largely corresponding with the Cooperative Travel ICT:

- In-vehicle connectivity between the driver, nomadic device and in-vehicle systems,
- Vehicle to vehicle connectivity between the vehicles,
- Road & street infrastructure connectivity between the vehicles and road-side equipment,
- Services & Information connectivity between the driver and the access points and service providers,
- Office, Cargo Terminal and Public Safety Answering Point (PSAP) connectivity between the driver/vehicle and company DSS systems as well as cargo documents and authorities.

*In-vehicle connectivity***,** *Vehicle to vehicle (V2V) connectivity***,** *Road and street infrastructure connectivity* and *Service and information connectivity* are very similar and comparable with the corresponding domains described in the Cooperative Travel ICT.

Office, Cargo Terminal and PSAP connectivity enables the driver with his nomadic device and the vehicle with embedded connectivity capability to connect seamlessly over short-range (DSRC/Bluetooth), cellular (GPRS/WCDMA), broadband (WiFi/WiMAX) or high speed access network with the office and terminal facility systems and PSAP access network containing but not limited the connectivity servers, gateways as well as information management and DSS including the cargo documents and connections with the required authorities, such as customs services. It remains unclear whether Terrestrial Trunked Radio (TETRA) system would play any significant role in any other application domains than in the PSAP-to-Vehicle (and vice versa) communications of emergency vehicles due to its limited bandwidth.

Connectivity is combined with optimization of commercial transport operations, which contains the largest known potential for improving the efficiency and productivity in companies both nationally and globally. The currently available optimization tools have several deficiencies and the number of companies applying sophisticated optimization tools is still very limited. Therefore, the existing business opportunities are very remarkable both from the viewpoint of software and end-user companies and public sector.

8. Envisaged outputs

Short, medium and long term targets

The focus area will produce outputs based on short, medium and long term targets. The short term targets will be defined to deliver business applicable results after the first year of focus area operation, while the medium and long term targets will be tuned to produce results later. Thus the research process will yield directly applicable results such as demonstrators and pre-commercial pilots each year, but allows simultaneous more theoretical research and generation of radical disruptive innovations.

The steering board of the focus area will process the targets annually and refocus them if necessary.

Short term targets

When: 2009-

What:
- Perception system for special conditions
- Sensing equipment (both in-vehicle, mobile and infrastructure)
- Exchanging and integration of information of various sources
- Interaction of third party devices to the vehicle
- Driver and vehicle identification and authorization applications
- Instrumented vehicles with prototype implementations
- “Next generation” navigators
- Context-based information delivery for transport and travelers
- Designing ontology for the “Vehicle Systems” domain
- Data collection with reusable, annotated semantic history storages
- Solutions to enhance use of real timetime and predictive data
- Open acrchitecture for service platforms
- Mobile payment for multimodal transportation
- Business models for location-based services

Resources:
- Existing technologies and platforms for information integration

New skills & competences:
- New industry collaboration models (based on Cooperative Traffic ICT work)
- Usability experiences and competences
- Experiences from international research collaboration

Medium term targets

When: 2012-

What:
- Sensors and algorithms for driver behaviour analysis
- In-vehicle information and map/GIS information fusion
- Secure V2V, V2I communications solutions
- Customer and community-based information production and exchange
- Enhanced traveling experience solutions for customers
- Pilot and test sites in Finland
- Designing ontology for the “Driver Behavior” domain
- Commercial experiments
- Demand modelling
- Optimisation methods and models
- Technology to support demand management
- Strategic and operatinal decision support tools
- Platforms for collaborative solutions and social media
- Traffic information utilities

Resources:

New sensor and information integration technologies
Analytics and optimisation methodology
Business process modelling and simulation technology

New skills & competences:

New industry networks and business models
Consumer and community based piloting and innovation models
New software engineering approaches and methods for distributed computing solutions
Understanding new information integration possibilities brought by sensor data fusion
New business ideas coming from new entrepreneurers enabled by traffic information utitilies and social media

Long term targets

When: 2015-

What:

Real-time optimization and management methods
Adaptive HMI
System pilots in global environments
New technology enablers for radiometric surroundings monitoring
Concepts of new applications and exploring data integration possibilities enabled by radiometric data gathering
Component based intelligent transportation solutions serving private, commercial and governmental needs
Globally competitive services based on concurrent competitive technology

Resources:

Integrated transport/traveler, vehicle and environmental context systems
Enhanced and seamlessly integrated personal, vehicle, environmental and commercial context information collection and integration solutions
Global best practices, technologies and research partners

New skills & competences:

New software engineering solutions for customer based personalization and seamless mobility
New process optimization and innovation approaches and methods for the industry
New simulation, testing and diagnostics methods and tools for highly complex systems
Capability of applying emerging miniaturized hardware technologies to radiometric monitoring
New business management skills and models for leading-edge services

High level work plan

In higher level, the progress map is divided to three parts which are partially running parallel (see. Figure 10). Each step takes approx. 3 years and enables smooth handover between the work streams taking also into account dependency between results of the previous work flow. Some main points concerning work plan:

- The context awareness requires sensor systems for gathering the necessary information of a driver and vehicle state and driving environment. In this step, the sensor providers and service providers are needed to work together for enabling exhaustive information availability

- Create the mid-term pilot and demonstration sites in Finland and develop the sophisticated information processing methods. The stakeholders interested in test site development should be contributed as well as road service providers.
- Generate intelligent traffic products and services which are evaluated in the Finnish test platforms and commercialised globally.

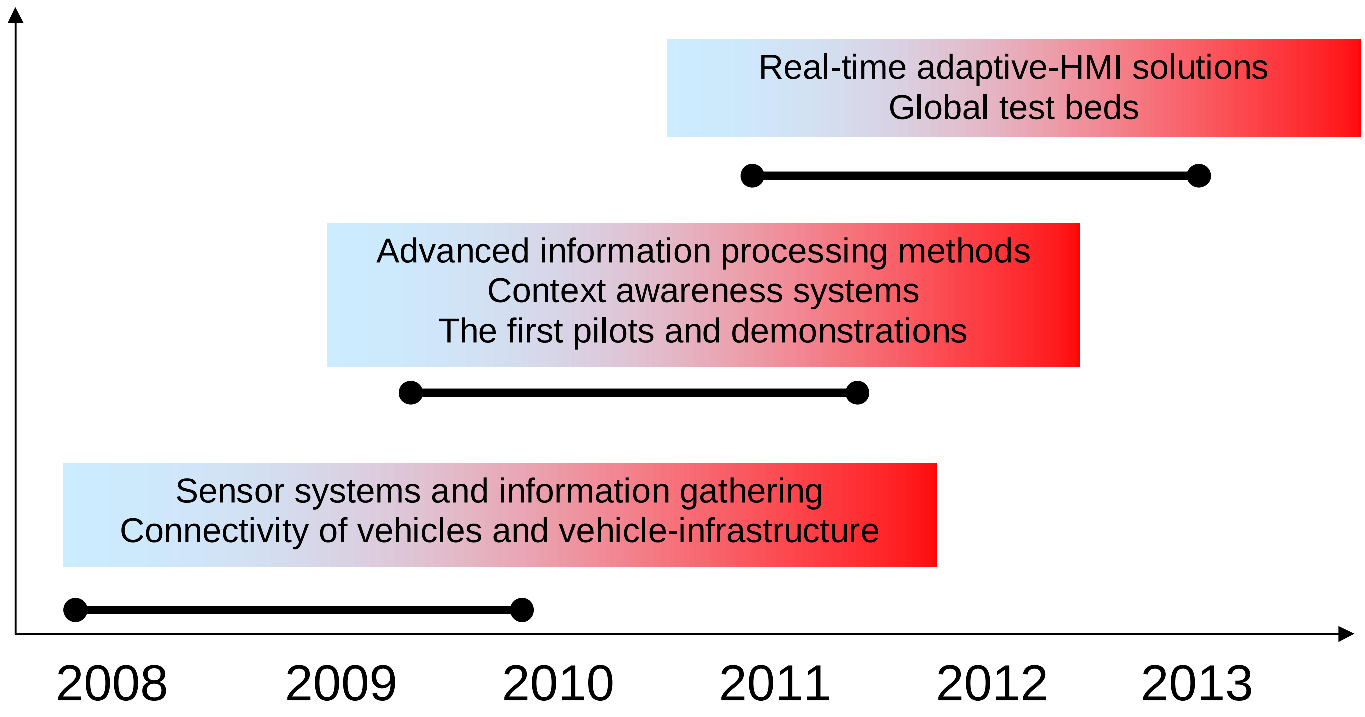

Figure 10. Time schedule of activities.

9. Potential Impact

In overall, this SHOK focus area will have four major impacts.

- Finland by providing large-scale traffic services testing platforms paves way to novel traffic prediction and holistic management technologies and services to travellers to be adopted also in other countries addressing sustainable travel challenges.

- Concerning traffic safety, this program will provide telematic products which will improve driving experience and allowing a driver to focus primarily attention for surrounding traffic. The intention is to reduce traffic accidents 40 %, getting Finland closer to the EU-25's "zero-accident" policy.

- The co-operative systems enables environment friendly driving which also helps Finland to meet the CO2 emission reduction with 5,2% before 2012 according to the KIOTO agreement. Traffic causes 12 % of the annual carbon dioxide emissions in Europe. The telematic product can improve traffic flow e.g. in urban intersections and advising drivers to avoid congestion thus, enabling even 15 % reduction for harmful emission gases.

- SHOK opens opportunities for the Finnish enterprises to penetrate to the global €800 billion automotive and transport sector markets

For achieving the scope of the work programme, is to create a global cooperative transport and mobility concept to be tested, evaluated and demonstrated in Finland. Successful demonstrations help Finnish stakeholders to take the first step and fix their positions in the international markets. This requires getting together all the relevant stakeholders in transport and mobility industry in order to strengthen the exportation incomes in the transport sector. The strong national reference case is the best way of marketing Finnish expertise in this area for selling sensor, modular sub-systems, applications and individual components abroad.

National cooperative travel and mobility system would add to the growth of related industries and increase international market shares of Finnish industries. Furthermore, a successful reference case would make Finnish enterprises desired partners in transport ICT and breed spin-offs in the area. Other expected benefits would be to make national enterprises and R&D sector the leader in cutting-edge technologies associated with transport ICT – not only in mobile communication.

Further crucial impact of the programme, is the forum for Finnish enterprises to network in national level and globally with automotive sector. Today the automotive industry buys bigger and modular parts not just a single sensor from their suppliers. For achieving position as a automotive industry supplier, contacts to the other suppliers is more and more important since a single company can rarely produce a whole system (e.g. dashboard unit). The national R&D programmes hosted by the Ministry of Transport and Communications like Tetra, Fits, Navi and Aino have activated both private and public sector to work together in the field. About 100 companies and enterprises have taken part in the projects during the past 15 years in Finland. (The biggest actual forum is ITS Finland, which has today some 50 members representing both private and public sector which provides good basis for national level networking.

Finnish universities and research organisations have participated in a number of EU projects concerning traffic ICT, intelligent vehicle technologies and transportation systems development overall. Transfer of this know-how to Finnish companies and to benefit Finnish economy will be beneficial.

The Cooperative Traffic ICT SRA has a good basis to grow and continue the ITS R&D activities in Finland. It is important to activate the potential partners to take their share of the enormous global market.

10. Dissemination, Continuation and Exploitation

The focus area will use the following means to cover the action required by the topic:

- director level communications among business community will be used to spread the results
- expert workshops on key findings of the focus area will be organized
- research organizations and universities will use the focus area to build up internationally acknowledged research teams, increase the volume of knowledge transfer in terms of top researcher exchange and enhance the contents of academic education offered
- scientific and business articles will be published, the focus area participants are encouraged to present the results in pre-selected conferences
- demonstration and test sites will be constructed to present the results for ecosystem stakeholders and press

11. Cross project cooperation

The Cooperative Traffic ICT program has interface to other programs in ICT SHOK: Device and Interoperability Ecosystem, Flexible Services, and Future Internet.

The closest relation is to Device and Interoperability Ecosystem program, which considers local, networked and heterogeneous smart environments where different kind of contextual and user information can be accumulated and used for new purposes, and for eventually services and businesses. The technology developed in Device and Interoperability Ecosystem program can be exploited to develop new end user services for ITS.

The Flexible Services program considers the transition to a service oriented economy and networked business. The end user services for ITS will exploit information maintained and generated by several different actors in the field and in particular the end-user services need to be based on municipal services. This calls for models and methodologies for networked business and collaborative services.

The Future Internet program considers the ubiquity, scalability, availability, reliability and dependability issues related to future information networks. Many of these aspects are driven by mobility which is an essential characteristics of ITS, thus the innovations from this program can also be exploited when developing the ITS services.

Tekes has now included ITS as a theme in ongoing technology programmes like Vamos, Ubicom and Safety and security for implementing products and services to traffic sector markets. The service enablers like smart phones, open telematics platforms and wireless broadband IP-network as well as RFID technology have been identified to offer a great business potential in ITS field.

The Cooperative Traffic ICT activity has also interfaces to national R&D programs. Especially, the Ubicom is closely related. This program emphasizes the embedded system aspect in ICT and many of the ITS end-user services are based on embedded systems or information generated by different kind of embedded systems. The technology and innovations developed in Ubicom program can be exploited in Cooperative Traffic ICT to create new networked business in the field.

The Cooperative Traffic ICT activity has a close relation to ÄLLI R&D programme by Ministry of Transport and Communications. The target of the ÄLLI program is to catalyse and accelerate the networking between the municipal sector and Ministry of Transport and Communications Administrative Sector in order to pave ground to the services that are at the program focus. The ÄLLI programme has the similar goal as Cooperative Traffic ICT, generating and facilitating services for the end users, but ÄLLI programme concentrates on developing the municipal services to support the development of commercial services for end users. The Cooperative Traffic ICT, on the other had, focuses on developing end-user services based on the municipal services.

Also there are currently several ITS projects going on in the EU and many Finnish companies and research organisations are actively involved with the development work. In order to reach the world elite in developing ITS services and products, cross project cooperation is crucial as well as up-to-date knowledge of projects and ITS development going in Europe and rest of the world. Thus, while making the Cooperative Traffic ICT SRA especially European Commission’s Framework Programme 5, 6 and 7 projects and project guidelines have been studied and taken into account. Also ERTRAC (European Road Transport Research Advisory Council) SRA, EUCAR (European Council for Automotive R&D) SRA and CLEPA (European Association of Automotive Suppliers) SRA have been considered and compared to the Cooperative Traffic ICT SRA.

A major issue is the deployment of the systems. On the European level, this means that Cooperative Traffic has to liaise also with key deployment actions. Two essential ones are the EasyWay action deploying European ITS services relevant for the road operators, and the eSafety Forum (probably renamed as the eMobility Forum within a few months) accelerating the deployment of intelligent vehicle systems in Europe. Both of these are also linked to the EU ITS Action Plan published in late 2008 and the related Directive curretly in preparation. All of these have recognised the potential of cooperative systems.

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