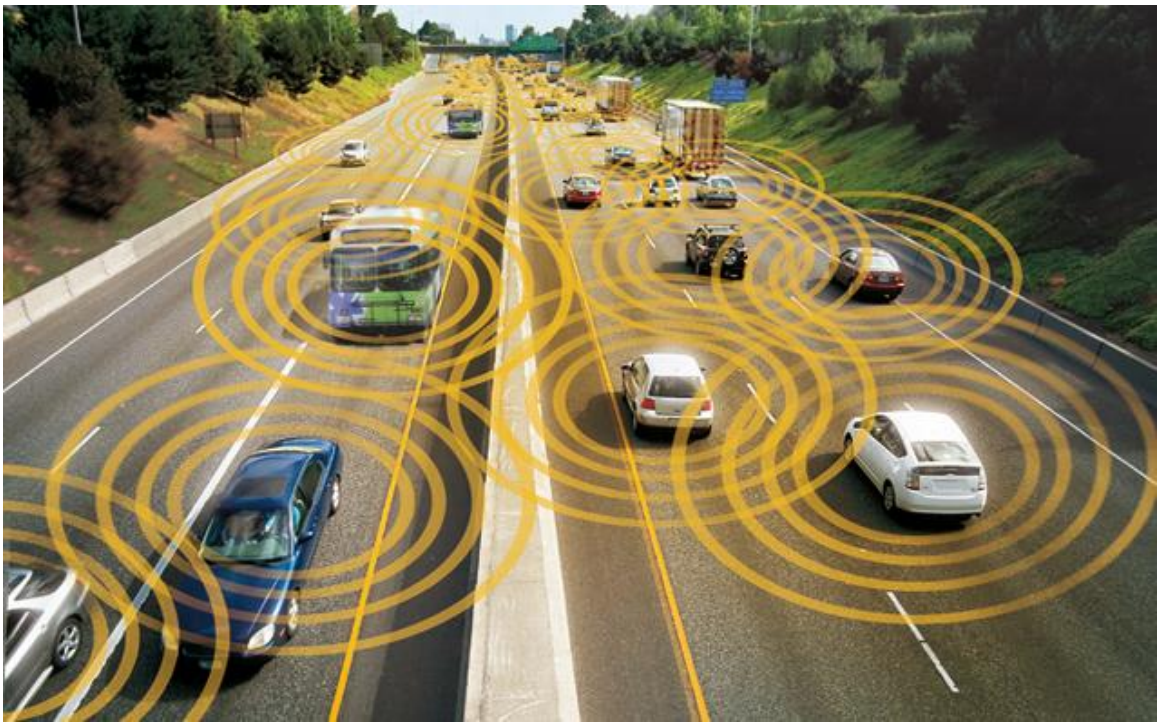
Wireless communication in automotive environment (WCAE)



Project within Pre-study project

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

The tremendous growth of wireless communication enabled devices contributes significantly to economy of scale. The two dominant wireless technologies are IEEE 802.11(Wi-Fi) and 3G/LTE, where 802.11p is a “profile” of 802.11 for enabling cooperative intelligent transport system (C-ITS). As in many other areas, wireless communication will revolutionize the automotive environment and we are just in the first phases of this revolution. The technology has an enormous potential to save lives, enable safer and much more environmental friendly transport at large, handle cargo more efficiently over different transport modes; the list of benefits can be made very long, where the long term goal is autonomous intelligent vehicles. Last but not least, wireless communication fulfils the requirement from end customers to always be connected to the cloud.

The WCAE pre-study has analysed in what areas continued research is required. This has resulted in a list work packages that shortly can be described as:

- Analysis and characterization of the wireless channel through channel measurement campaigns in demanding scenarios; results are to be used for performance evaluation of C-ITS applications
- Performance evaluation of different wireless technologies through a concept called multipath propagation simulator
- Identification the methodologies needed for tracing customer needs into system and component level
- Finding suitable verifications model for the automotive industry for wireless technologies
- Performing research on the reception performance of co-located antenna systems
- Study of solutions to speed up market introduction of C-ITS
- Fostering the second generation of integrated AUTOSAR compliant wireless communication platform

The result is the work plan in the main project WCAE that started July 2013. The project is planned for Q3 2013 until Q4 2016 with a budget of 71 907 004 MSEK of which 35 947 912 MSEK was applied for from VINNOVA. Volvo Car Corporation was responsible for the WCAE application together with the partners Volvo Technology Corporation, ACTIA Nordic AB, Kapsch TrafficCom, Lund University (LTH), Mecel and SP Sveriges Tekniska Forskningsinstitut.

Chalmers and Smarteq were also taking part in the pre-study.

2. Background

Real-time wireless communication in the automotive environment is a key enabler to avoid accidents and increase road traffic efficiency, thus focusing on the objectives of the FFI program. Vehicles exchange information wirelessly to cooperatively avoid dangerous situations and enhance the overall road traffic situation, i.e., C-ITS. For example, the enormous accident that took place at Tranarpsbron outside Östra Ljungby, Sweden, in January this year could have been avoided or at least the damages could have been minimized if we already had C-ITS in place.

VCC and AB Volvo have signed a Memorandum of Understanding (MoU) with the OEMs within the Car-2-Car Communication Consortium (C2C-CC) to start deployment of C-ITS in 2015, i.e., the race is on among the OEMs. To speed up and increase the penetration of C-ITS equipped vehicles will both give improved safety, efficiency and competitiveness for our OEMs.

Telematics and infotainment are currently solely relying on 2G/3G connections to the vehicle. Fast and reliable Internet access to the vehicle is a strong requirement from end customers. With LTE, really high communication rates and spectrum efficient communication can be obtained. However, the new cellular technology implies requirements on efficient antenna solutions and good signal conditions. Therefore, to really benefit from the LTE system, a fixed installation in the vehicle using an external antenna unit is a must. The FFI project ETTE was the first project elaborating with LTE for vehicles; but in rural areas 2G and 3G will be the preferred technologies. Therefore, all three generations of the cellular systems need to be supported in the vehicle, C-ITS solutions based on 802.11p have to be integrated, and all wireless solutions used in the vehicle must co-exist.

In order to meet tomorrow's demands on the connected vehicle, we need to know if we are designing and building the right thing (validation) and if we are designing and building it right (verification) from a system perspective. To some degree, validation and verification are already performed at, e.g., chipset level for 2G/3G/LTE and 802.11. There are, however, no requirements on the overall system installed in the vehicle that can be broken down to a component level, which is needed during the design phase. Further, in C-ITS applications based on 802.11p; there is a need for compliance assessment for the whole protocol stack including triggering conditions in hazardous situations when installed in the vehicle. This needs to be further investigated.

The partners have been or are involved in a number of research projects that provided important background information and support to the pre-study and will continue to do so in WCAE (see fig 1).

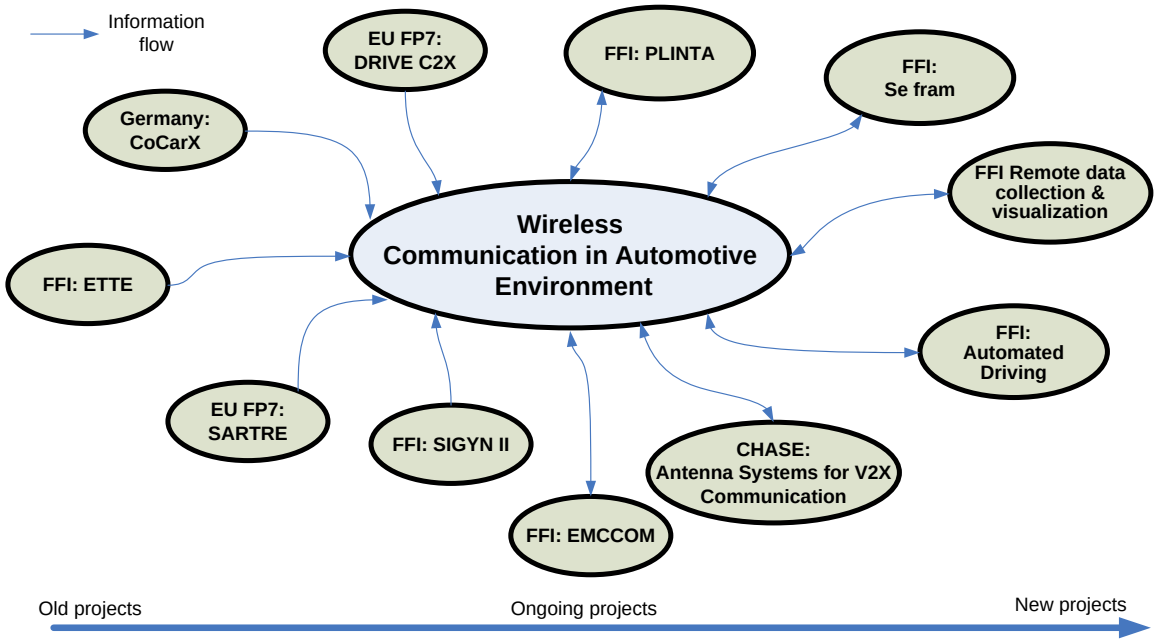

Fig 1. Research projects where partners have been or are involved that have generated important background information.

3. Objective

The main objective of the pre-study was to identify research and innovation needs regarding emerging and existing wireless communication technologies suitable for the vehicular environment supporting the following five identified application areas:

- safety
- efficiency
- telematics
- infotainment
- manufacturing and after-market.

The pre-study resulted in the WCAE application to the FFI program in Q2 2013 and that was approved 2013-05-27.

4. Project realization

The WCAE pre-study addressed aspects that need answers before large-scale deployment of fully integrated wireless communication technologies can become reality in vehicles and its full potential can be explored. The focus herein is the wireless technologies 3G/LTE, Wi-Fi, and 802.11p , enabling a plethora of new services and applications in the following areas: road traffic safety, road traffic efficiency, telematics, infotainment, manufacturing, and after-market.

The partners in the pre-study contributed from their current work and future work plans to create a joint project. Each partner's background for their contribution can very briefly be described as in the following:

- VCC is working on its next electrical architectural platform called SPA. This platform is planned to span a time period that needs to integrate the Connected Car. The result from the pre-study and later on the project WCAE will be transferred to second and the third car programs on the SPA platform.
- Volvo Technology is working on an ITS platform which is going to merge the result of WCAE into a next generation platform for ITS and telematics on-board platform.
- ACTIA is developing, manufacturing and supplying Telematics control units to the vehicle industry (car, truck and special vehicle). The result from the pre-study and later on the project WCAE will be used to developing the future Telematics control units.
- Kapsch is active within development of aftermarket, retrofit and embedded units for V2X safety and efficiency applications. Currently Kapsch has supplied aftermarket devices for radio communication within several research and innovation projects. Kapsch has also strong expertise within standardization for V2X communication. Results from the pre-study and WCAE will be of use for development of new generations of the V2X product portfolio.
- LTH is working on both fundamental physical layer research and networking aspects of V2X communication, including LTE as well as IEEE 802.11p. The results will be used to create an understanding of how to design robust and reliable wireless systems for realistic vehicular environments and will serve as a guide for future research directions in the area.
- Mecel is among other things developing SW for Connectivity modules in the Automotive Industry. The result from WCAE will be used in development of next generation connectivity modules. Mecel also aims at an increased understanding on WiFi capabilities and suitable SW architectures for this in cars.
- SP is working in several projects with new communication technology designed for multipath environments. Drive tests and test environments is a specific area where SP provide knowledge and technology to the industry.

There are on-going discussions to setup collaboration between BMW and the Swedish projects WCAE (this application), CHASE Antenna Systems for V2X Communication (CHASE V2X) and the German project CONVERGE

Two partners contributed with ideas and proposals for urgent work that in the end not were included in the final WCAE project.

- CTH is active in fundamental and applied research on the 802.11 family as well as on LTE, LTE advanced, and future cellular systems. The intention was that the project should benefit from these prior and concurrent activities. At the same time, the project results should have given input to the direction Chalmers' future research.
- Smarteq is developing, manufacturing and supplying Antennas and RF-cables. The result from this ETTE project will be used to develop the next generation Antenna systems for vehicles. Also to get an understanding for limitations and opportunities when combining the needed antenna system/s on vehicles.

The reason not to include Chalmers and Smarteq was the need to limit the scope of WCAE. The work proposed by Chalmers included possibilities in evolving communication system standards that currently are under research and standardization, e.g. "5G". This is of interest for future vehicle platforms but not for research and innovation necessary to be able to implement current systems. It was also decided that WCAE shall not include antenna development. Since this is the main work for Smarteq they decided to not take active part in WCAE. Both organizations are involved in supporting projects e.g. Chase V2x. To some extent, as a result of pre-study WCAE, preparation of new FFI-projects related to Chalmers interest has started."

A number of high-level research questions that has to be addressed in a project were raised in the pre-study:

- How are end user requirements broken down to component level for wireless technologies to facilitate series production of vehicles with this new functionality?
- How is the performance required by end users guaranteed when integrated in the vehicle?
- How do several co-located antenna systems influence each other?
- How do new C-ITS applications perform in different scenarios such as urban and in road trains?
- How can the penetration rate of C-ITS equipped vehicles increase faster?
- Is it possible to provide satisfactory HMI to C-ITS applications without distracting the driver to much?

When these questions were addressed during the pre-study expected results from other project (see fig 1) were discussed to avoid duplicated work.

Everything boils down to that the Swedish automotive industry want to offer the safest and most environmental friendly vehicles in the world to our customers, while providing seamless high-speed Internet access for a pleasant journey.

5. Results and deliverables

The result and deliverable of the WCAE pre-study is the WCAE project plan (see fig 2). The work packages are:

WP1 Requirements and design verification methods. The whole process from customer requirements to final verification of the complete vehicle will be investigated and structured. This will include specifications and verification methods for suppliers.

WP2 System design. The structure of the integration of the communication system in the vehicle electronic is one goal but a second goal is to find how advanced communication systems can be integrated into vehicles already in production or on the road.

WP3 Dissemination and demonstration.

The work package tasks are shown in fig 2.

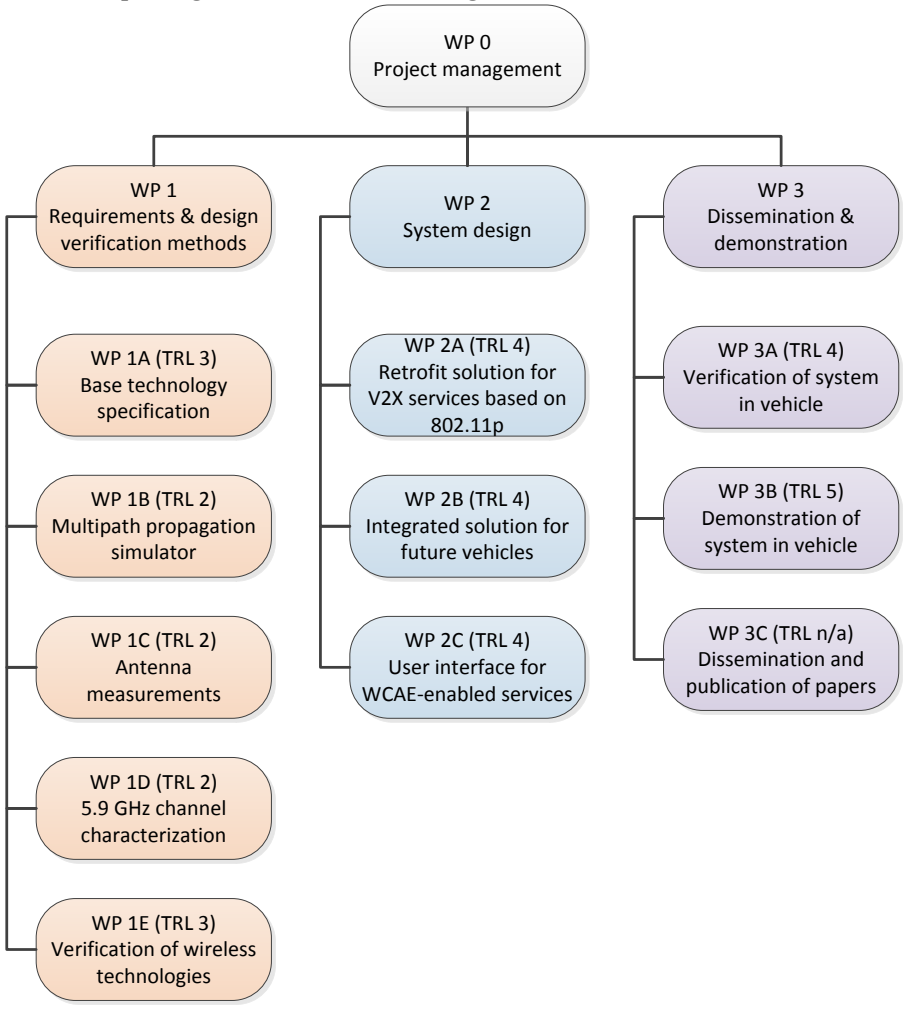

Fig 2. The work packages in the WCAE project plan.

The expected deliverables in WCAE are planned to be:

- A real-time radio channel emulator for lab-bench modem and system (application) tests.
- A radio channel and simulation model for C-ITS in important safety-critical scenarios. This includes urban intersections and road trains with different vehicle types involved and allows for simulations using different antenna arrangements.
- Reference channels and contributions to test cases for performance assessment and requirement specification between OEMs.
- Feasibility of the MPS technique for vehicles.
- Application of channel models in the MPS.
- Verification methods for external communication on complete vehicles.
- Methods to develop the set of specifications needed for a vehicle communication system covering the chain from the end customer to the complete vehicle, including systems and component levels.
- Specifications and measurement methods for vehicle installed communications systems based on customer expectations and communication systems standards.
- Specifications and measurement methods for communication systems coexistence.
- Methods for numerical modelling of complex antenna systems on vehicles.
- First prototype of a retrofit solution for C-ITS applications enabling road traffic safety and road traffic efficiency.
- Second generation of vehicle integrated wireless communication node.
- A flexible and efficient process for adapting the user interface to future requirements and new WCAE-enabled functionality.

More details are available in the WCAE application (WCAE – Wireless Communication in Automotive Environment, Vinnova 2013-01285).

5.1 Delivery to FFI-goals

The pre-study project and later on the WCAE project focus on developing a wireless network access architecture for vehicles including existing and emerging wireless technologies. Focus will also be to develop design and verification methods for wireless communication in the automotive environment. With this focus WCAE project fulfills 3 out of the 5 overall targets of the FFI Vehicle Development program. Since the pre-study is a part of the complete WCAE project the fulfillment of goals are copied from the WCAE application:

- Electrical architecture: OK
- Model based function development: N/A
- Software development: OK
- MIL, SIL and HIL: OK
- Hierarchy development tools: N/A

The fulfillment of the overall FFI goals is judge to be:

Targets	Contributions
How well the project satisfies the targets defined within transport, energy and environmental policy	Improved
The ability of industry to operate knowledge-based production in Sweden in a competitive way	Strengthen
Contribute towards a vehicle industry in Sweden that continues to be competitive	Strengthen
Undertake development initiatives of relevance to industry	Improved
Lead to industrial technology and competence development	Improved
Contribute towards secure employment, growth and stronger R&D operations	Strengthen
Contribute towards actual improvements being made to production at participating companies	Strengthen
Strengthen research environments in selected, prioritized research areas in the field of production technology	Neutral
Support environments for innovation and collaboration	Strengthen
Strive to ensure that new knowledge is developed and implemented, and that existing knowledge is implemented in industrial applications	Strengthen
Rationalize the application of R&D results so that actual production improvements are implemented in participating companies	Neutral
Improve the quality of technical production training	Neutral
Reinforce collaboration between the vehicle industry on the one hand and the Swedish Road Administration, universities, colleges and research institutes on the other	Strengthen
Strive to secure national supplies of competence and to establish R&D with competitive strength on an international level	Improved

6. Dissemination and publications

No publications were planned for the pre-study.

7. Conclusions and future research and innovation

The work with the pre-study showed that knowledge about advanced communication will be crucial for the Swedish vehicle industry. In a few years most new vehicles will be equipped with systems for new warning systems and for internet. The functionality of these systems will improve and contribute to safety and efficiency and also provide infotainment.

A quickly growing market is also an opportunity for suppliers.

Early research and demonstration is necessary and will be provided for in ongoing projects and the main project WCAE developed in this prestudy.

8. Participating parties and contact person

The participating companies and organizations where

- Volvo Car Corporation, Mikael Nilsson (556074-3089)
- Volvo Technology Corporation, Karin Sjöberg (556542-4321)
- ACTIA Nordic AB, Lennart Strandberg (556350-7028)
- Chalmers University, Erik Ström (556479-559)
- Kapsch TrafficCom AB, Adam Tengblad (556042-6289)
- Lund University, Fredrik Tufvesson (202100-3211)
- Mecel, Anders Elisasson (556258-8896)
- Smarteq Wireless AB, Mattias Hellberg (556128-5437)
- SP Sveriges Tekniska Forskningsinstitut, Jan Welinder (556464-6874)