DRIVing implementation and Evaluation of C2X communication technology in Europe

DRIVE C2X

Accelerate cooperative mobility

Deliverable D22.1

DRIVE C2X methodology framework (abstract)

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SEVENTH FRAMEWORK PROGRAMME

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Executive summary

This deliverable presents the DRIVE C2X methodology for testing and studying the impacts of a number of cooperative functions and services before their market introduction. The aim of cooperative driving applications is to support foresighted driving and early detection of hazards. This is realised by means of a communication-based system that extends the drivers' horizon and warns of potentially dangerous situations ahead. Consequently, the aim of these approaches is to provide drivers with the opportunity to adapt the vehicle speed and also increase headways between vehicles leading to a higher situational awareness of an unforeseen danger.

At present there is a general understanding of the benefits of cooperative systems, but so far they have been tried out in small scale experiments mostly on closed test tracks. Yet, there is no proof of these benefits with many communicating vehicles used by ordinary people in varying conditions on roads.

Communication systems and their components are now mature enough to be brought to large-scale field operational tests.

Most of the functions in this project are based on the PRE-DRIVE C2X project. It created a sound basis for Europe-wide field operational tests of vehicular communication technology. Together with the COMeSafety support action, PRE-DRIVE C2X has agreed on a system specification, which lays the basis for the ongoing standardisation activities in ETSI TC ITS. Based on this, the PRE-DRIVE C2X project developed state-of-the-art system prototypes to be tested in real life conditions and that can be replicated in sufficient numbers. These prototypes are close enough to future production systems to ensure that the results of the envisaged field tests are valid and contribute to the fast deployment of cooperative systems in Europe.

Furthermore, PRE-DRIVE C2X has validated the tools and methods necessary for testing and evaluation of cooperative systems in field operational tests.

DRIVE C2X identified four major objectives:

1. Create and harmonise a Europe-wide testing environment for cooperative systems,
2. Coordinate the tests carried out in parallel throughout the DRIVE C2X community,
3. Evaluate cooperative systems and
4. Promote cooperative driving.

This deliverable presents the DRIVE C2X overall methodology all the way from the selection of functions to impacts assessment of the road tests. Furthermore, the report is a public deliverable and consequently written in "a stand-alone" mode to provide a complete picture to the reader of the purpose of Field Operational Tests (FOT) and the testing procedures of DRIVE C2X in sufficient detail.

The first Chapter "Introduction" leads the reader to the rationale and context of this project and previous work which the current project is based on.

Chapter 2 "DRIVE C2X concept" first presents the objectives of the work in detail and moves on to the architecture of the DRIVE C2X system and then features the application areas. This part shows the project's connection to standards for cooperative communication technologies used and also the relation to the other FOTs.

Chapter 3 "Field Operational Tests overall concept and scope" features the requirements set for FOTs as well defines the basic concepts that have relevance to the project work. Furthermore, DRIVE C2X relation to major other FOTs is shown.

Chapter 4 "DRIVE C2X FOT methodology" makes the core of this report. Here, the whole methodology is described. It is noteworthy that since the whole methodology is written down practically five months after the project start, all details of all methods are not yet in place. This applies e.g. to the precise number of test vehicles, test sites, testing procedures and analysis methods. The upcoming functional tests early 2012 determine to a large extent the details of testing. However, the framework of the methodology can be presented already at this stage. The complete methodology will be presented at month 18 after the pilot tests have been completed.

Chapter 5 "Conclusions" presents the conclusions of the methodology to be applied to FOTs. It also shows the constraints of the testing. This applies to what can be concluded from the tests and how usable the results will be for the needs of various stakeholders of the project.

The origin of Field Operational Tests stems from the needs to assess the impacts of various road traffic safety measures on driver behaviour and safety. The first large-scale FOTs were carried out in the USA and the Nordic Countries in the late 1980's and the early 1990's. The topics of these tests ranged from assessing the impacts of new type of road markings, different types of tyres and ISA (Intelligent Speed Adaptation) and in-vehicle terminals on driver behaviour and risk taking. These pioneering activities also included extensive development of measurement methodology and methods.

The first attempt to realise cooperative systems in PROMETHEUS in the 1980's failed due to the unavailability of suitable communication technology. Serious research efforts in this area were started in Europe in the beginning of this century. Projects such as PReVENT-WILLWARN, Network on Wheels (NoW) and SAFESPOT have produced research prototypes, which showed that communication-based safety and efficiency applications are not only technically viable but may also provide considerable benefits. In order to guide this work and ensure that the projects follow the same technological direction, the COMeSafety Support Action was initiated by the members of the CAR2CAR Communication Consortium. COMeSafety did not only harmonise the activities, but pursued various projects dealing with C2X communication technology. The most significant achievement of this initiative was to provide a commonly agreed architecture description for a European cooperative driving system.

PRE-DRIVE C2X followed the COMeSafety architecture description, refined it and realised a system prototype based on it. So, PRE-DRIVE C2X advanced COMeSafety work beyond the status of a pure research system and being robust enough to sustain a year-long field operational trial. In order to show the performance of this system, PRE-DRIVE C2X also analyzed various applications of vehicular communication technology developed in the numerous research projects concerning effectiveness and suitability for a Europe-wide roll-out. Furthermore, a cooperative systems prototype was realised.

The task of DRIVE C2X is not only to show that the function selection done by PRE-DRIVE C2X is valid from an European point of view, but that the cooperative systems prototype developed by PRE-DRIVE C2X based on the COMeSafety architecture description is functioning as expected and ready for roll out in European member states.

For the data collection, DRIVE C2X is following a two-pronged approach. First, DRIVE C2X is aggregating the data that is generated by the national FOTs during normal national operations. These data provide the basis for the assessments carried out in DRIVE C2X, but naturally it can only give a rough indication of the impacts cooperative systems will have. These data will be assessed for validity, and where possible the results will be scaled up for whole Europe. In parallel, DRIVE C2X will conduct tests on DRIVE C2X specific functions, which have been selected aiming at maximum effectiveness and are expected to yield equal benefit to all member states. By doing this, it is ensured that at the end of DRIVE C2X a number of verified applications of cooperative system technology have been tested and impacts proven and quantified. These are accompanied by applications whose benefits in given European member states have been shown. This gives system

developers the possibility to design a common system taking into account the particularities of the European member state in which a given vehicle is serving most of its life.

The DRIVE C2X system enhances the system architecture that was developed in the predecessor project PRE-DRIVE C2X. The system consists of software and hardware components and relies on the enhanced reference specification. Furthermore, the system includes vehicles as well as road-side communication equipment and backend communication infrastructure. The DRIVE C2X system uses state-of-the-art technology for cooperative systems and complies with current communication standards.

More precisely, there is a need to have enough properly organised large-scale Field Operational Tests in European conditions to provide reliable and unbiased insight into:

- Usability of the systems, effects on and benefits to ordinary users, the society and stakeholders.
- Long-term user acceptance and willingness to pay for such systems and different functions.
- Long-term impacts of assistance functions on driver behaviour and "behaviour compensation",, the over-reliance on assistance functions and the possibly following decreased vigilance.
- Technical performance of the systems and services in real-life long enduring large-scale use.
- Real-life performance of different business models for operation and provision of intelligent vehicle safety systems and services.

Methodologically, FOTs can be realised in a number of ways. Several DRIVE C2X partners participated in the 1st Call FOT *FESTA* that put a lot of effort on the methodological issues of later large-scale FOTs such as the work proposed here.

The consortium envisions two major approaches that are needed in any given serious FOT approach:

1. Tests in daily traffic with sophisticated measurement methods but with less controlled conditions, e.g. non-experimental driving to accumulate data and have an insight of long-term impacts.
2. Tests in closed-circuits or on roads with little traffic in well controlled conditions to get deeper in the behavioural dynamics of drivers and to establish causal relationships.

DRIVE C2X has two technology areas. They are car-to-car communication (C2C) and car-to-infrastructure communication (C2I). Both technology areas are subject to road tests in this project. Nine functions were selected for the full impact assessment. These are:

Traffic safety-related functions:

1. *Road works warning*: vehicles approaching road works are warned in due course before they reach the road works zone. The function is applicable both to stationary road works and moving road works found typically on motorways.
2. *Traffic jam ahead warning*: the driver is warned when approaching the end of a traffic jam to avoid running into the last vehicle in the queue.
3. *Car breakdown warning*: approaching vehicles are warned before reaching a broken down vehicle to avoid running into that vehicle or endangering people in the vicinity.
4. *Weather warning*: information about bad weather conditions ahead is communicated to oncoming vehicles to avoid entering areas with adverse weather conditions at excessive speed.

5. *Emergency electronic brake light*: in case of a hard braking manoeuvre following vehicles are warned to avoid rear end collisions and backing up.
6. *Approaching emergency vehicle warning*: approaching emergency vehicles warn surrounding drivers about their presence to ensure that they can proceed quickly even in very heavy traffic.
7. *Post crash warning*: in the event of an accident oncoming vehicles are warned to ensure that drivers slow down and do not run into the vehicles involved in the accident.

Traffic efficiency related functions:

1. *In-vehicle signage & regulatory and contextual speed limit*: traffic sign information such as "ban on passing" is communicated to the vehicles and indicated in the instrument cluster or the head unit. Information on fixed and variable speed limits as well as the recommended optimal speed is communicated to the vehicles and indicated in the instrument cluster or the head unit. This application does in particular address variable message signs.
2. *Green-light optimal speed advisory*: signal phases of traffic lights are communicated to vehicles in order to inform the drivers about the optimal speed to pass traffic lights at green.

Functions pre-validation was carried out to anticipate the need for vehicles and observations for the actual road tests. Functions cannot all be tested in the same way but need a different approach. In this, pre-validations provide valuable information.

Comprehensive knowledge of impacts of DRIVE C2X functions will be provided on different levels, ranging from individual user behaviour to the transport system and society level in Europe. The specific impacts in target areas (safety, environment, efficiency, mobility) are based on changes in driver behaviour. Therefore, the measures focus on driving and travelling behaviour. For each impact area, the most effective measures compatible with the indicators and criteria will be applied. Furthermore, the target area specific impact estimates create the basis for regional and Europe-wide impact estimates.

The methodology for impact assessment is based on the FESTA methodology and follows directly from the evaluation framework developed in WP42. The methodology is first tested in the piloting phase, before applying it to all functions in the project.

It is necessary to scale up impacts to the level at which stakeholders can make decisions. Even large FOTs with thousands of vehicles only represent a tiny percentage of the traffic exposure and of the traffic composition at any given time. The extrapolation of the results at the test site level to higher levels requires both methodological development as well as a coupling with computer models with high-quality data sources.

This deliverable presents the methodology for the road tests as it stands about five months since project start. So far all the functions to be tested have been selected, and pre-validation was carried out to provide input for the actual test planning. Furthermore, the process from the DRIVE c2x system level to functions, target scenarios and test scenarios was identified. Also the technical test plan was created. What still needs to be done in setting up the complete methodology is to define all the research questions, hypotheses and performance indicators. After that, the actual test design process can start. The tested functions need different designs, and this process has just started. This deliverable will be updated after the piloting phase has been completed. The complete DRIVE C2X methodology will be presented after the pilot tests have been completed and all iterations to the testing methodology have been done.

The greatest challenge in creating the methodology is to harmonise the test sites in terms of test design, testing procedure overall and HMI across test sites. All these have an impact on the final

results. Finally, long-term testing needs also to be planned and agreed throughout the testing community. Even though we are entering large-scale field trials, the results from these tests are still indicative due to the lack of sufficient penetration of cooperative vehicles and needed interaction. However, the results combined with the systematic collection of user experiences and opinions will yield a picture that warrants taking decisions on the continuation of cooperative driving systems.