TEAM

Tomorrow's Elastic Adaptive Mobility

D1.0 TEAM users, stakeholders and use cases

Part B State of the art and use cases of basic technologies

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1.4	27.05.2013	Latest changes, more clarifiying
1.5	28.05.2013	Finalisation

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1 Basic technologies

In this Part A of Deliverable D1.0, the work of the sub-project EMPOWER regarding the basic technologies is outlined. This includes a report on the current state of the art of basic technologies used in TEAM and describes a possible development beyond the current state. For each basic technology, possible use cases for theses developments beyond the state of the art are described. Another section describes the stakeholders of basic technologies and the technological challenges and risks they see for each of these basic technologies.

1.1 Introduction to basic technologies

One of the cornerstones of TEAM is the development of basic technologies to support the applications. In the sub-project EMPOWER several components will be developed such as communication convergence, positioning accuracy, mapping, privacy and security. In this sense, the sub-project will provide the basic building blocks for the TEAM system.

The work is organized in a matrix format. The horizontal perspective comprises the different ITS subsystems where these technologies will be integrated, which are the vehicle, roadside, central and personal subsystems. The vertical perspective comprises the different technologies to be developed, which were divided in the beginning of the project in four TECH groups:

- Communication technologies (Responsible: Intel)
- Local Dynamic Map++ (LDM++) and Automotive Cloud (Nokia/FhG)
- Cooperative Positioning (Delphi)
- Security and Privacy (Fokus)

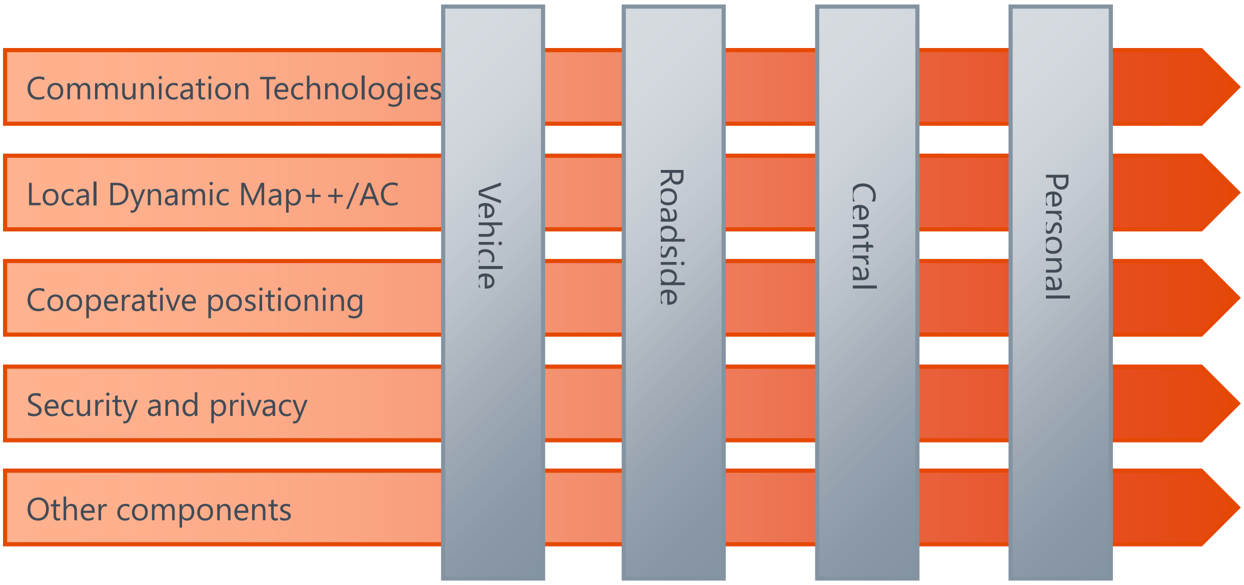

Figure 1.1: Matrix showing work organisation

All technology enablers developed in EMPOWER will be integrated and used by TEAM applications to be developed in the DIALOG and FLEX sub-projects, as shown in the figure below. Furthermore the whole TEAM system will be tested, evaluated and demonstrated in the sub-project EVALUATION.

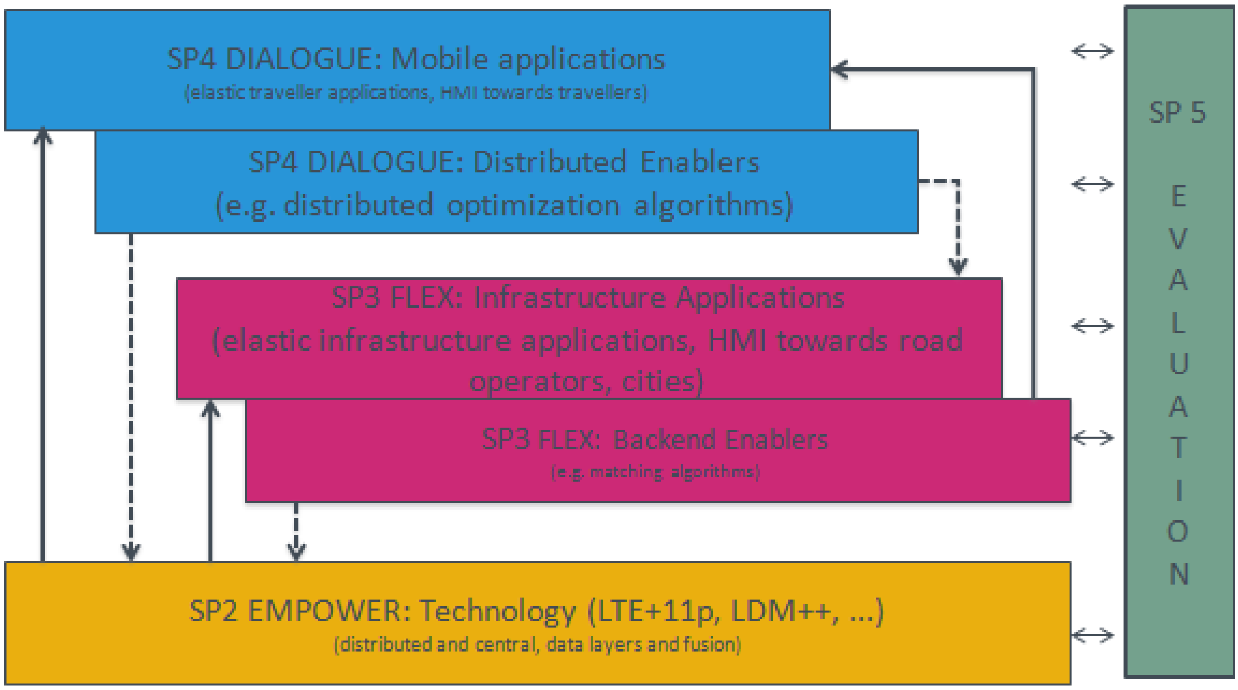

Figure 1.2: Description of sub-project interaction

The remaining of this chapter follows the TECH groups division. An update of the state of the art is given, including a high level description of the objectives for development beyond state of the art in TEAM. Furthermore all the use cases for each main technology are described, followed by use cases not directly connected to any of these topics. Lastly the stakeholders for the basic technologies are listed.

1.2 State of the art and beyond

The goal of this section is to provide an overview of the SoA and of the planned TEAM innovations in some technologies that have been identified as core in the context of the TEAM project.

This section has been organized reflecting the structure of the TECH groups, and also adding another thematic area, gamification and community building (Uni Genoa), which is another fundamental aspect of the TEAM applications that will be developed in SP3 and SP4. The structure of every subsection is the following, in order to provide a proper coverage of the field:

- Introduction/relevance of the field to TEAM

- State of the art
- Expected progress beyond SoA
- Guidelines for TEAM

The final subsection draws the overall conclusions on the work done.

1.2.1 Communication technologies for ITS: V2X and LTE

Long and short-range communications in Intelligent Traffic Systems (ITS) play a central role for the deployment of related applications and services. These applications and services embedded in a mobility context establish very stringent requirements regarding diverse aspects of safety, reliability and security, among others, which due to the very dynamic environment and usage context pose high demands on the underlying communication technologies. In general, the employed technologies must offer flexible adaptive coverage from several meters to several thousand meters, they must support environments shared by multiple overlapping wireless networks, and must offer real-time and non-real-time reliable unicast, multicast, broadcast and geocast data distribution. Further, ITS environments are characterized by a large number of heterogeneous participants, thus yielding the following communication relationships: Vehicle-2-Infrastructure (V2I), Vehicle-2-Vehicle (V2V), Vehicle-2-Pedestrian (V2P) and Pedestrian-2-Pedestrian (P2P).

Heterogeneous traffic actors need to be supported by proper infrastructure, spanning a wide range of hardware devices, each with their particular technological requirements regarding communications, power consumption and processing power: Roadside Units (RSU) for the fixed traffic infrastructure, On-board Units (OBU) for vehicles and smartphones for pedestrians. For this reason, there is a clear need for hybrid networks comprising mobile (2G, 3G, 4G) and short-range ad-hoc networks, like ETSI ITS-G5 [CM3]. Long Term Evolution (LTE) shows in this regard the potential to cover many of the above V2X needs depending on the particular use case, however coverage and compatibility to existing and future ITS technologies will be decisive for acceptance and widespread use of it.

TEAM will employ, adapt, combine and advance some of the available technologies in novel ways in order to cope with challenges established by Intelligent Traffic Systems. The project concentrates basically on future-oriented technologies dealing with long-range (LTE) and short-range (IEEE 802.11p) [CM4] communications, combined with standards and protocols like GeoNetworking [CM5], CALM [CM6-8] and IEEE 1609 [CM9], among others.

1.2.1.1 State of the art

TEAM applications are based on both short-range (local-area) and long-range (wide-area) wireless communication technologies. The most prominent representative of short-range wireless communications are vehicular ad-hoc networks, like ETSI ITS-G5 based on IEEE 802.11p. For long-range communications, cellular networks such as 2G, 3G and LTE are potential candidates. Previous research projects such as GeoNet, PRE-DRIVE C2X [CM10], SAFESPOT [CM11], and CVIS [CM12] have developed and demonstrated ETSI ITS-G5 and ETSI GeoNetworking technologies for vehicular applications. In 2008, the EC allocated dedicated frequencies (5875–5905 MHz) for traffic safety and efficiency applications. The ongoing European project DRIVE C2X is about to conduct field operational tests (FOTs) to validate the technology under real-world conditions. National FOTs like simTD [CM13] in Germany are contributing to this European effort. Preliminary experimental data indicates that short-range technologies such as 802.11p and GeoNetworking are now mature and allow vehicles to exchange data within a small distance (1-2 km) in real-time (10-100 ms). Nevertheless, it remains challenging to employ these technologies for large geographic areas, e.g. tens of square kilometres. 2G and 3G cellular networks provide long-range communication and have been evaluated in research projects such as PRE-DRIVE C2X and simTD. The general conclusion was that these technologies were not able to meet all stringent requirements for latency of ITS applications. Furthermore, ITS applications using 2G and 3G technologies also face challenges regarding bandwidth requirements and scalability. However, these limitations will likely change when LTE (Long Term Evolution) will be deployed.

Long-Term Evolution (LTE)

Key technical characteristics of LTE: LTE is being marketed by many operators around the world as '4G', but this is not strictly true. As per the ITU classification, LTE is in fact an evolution of IMT-2000 technology and hence comes under the 3G categorisation with WCDMA, HSPA, HSPA+ and other technologies mentioned previously. The ITU concluded that IMT-Advanced and WiMAX2 should be defined as '4G' technologies. For all of this, many mobile operators have announced that LTE is '4G' and so the marketing machine has started an irreversible branding of LTE.

LTE is likely to impact the mobile industry in two major ways. First, it is set to deliver practical data rates that are in excess of 20Mbps, and early signs are that it can deliver this throughput. The company TeliaSonera [CM14] launched the first commercial LTE network in Sweden at the end of 2009 and has reported average rates of 25Mbps and peak rates in excess of 50Mbps. Second, and perhaps most importantly, LTE is expected to be a technology that will be implemented by more than 200 operators worldwide in five years.

There are two variants to LTE technology, namely FDD (Frequency Division Duplex) and TDD (Time Division Duplex) . The latter variant is being deployed in 2.5GHz spectrum band. The future of TD-LTE - and more specifically the availability and affordability of TD-LTE devices - is dependent upon the adoption of the network technology in being China and India which will drive TD-LTE global economies of scale. Chipset manufacturers are developing multi-mode FDD/TDD chipsets to facilitate interoperability and regional roaming capabilities [CM1].

Coverage: LTE coverage today is low, both in terms of the number of markets that have live LTE network deployments, and in terms of the LTE coverage offered within those markets by the operators that have launched (just over 100 LTE networks commercially deployed to date, covering around 5% of global population - large cities mainly). The timing of LTE deployments depends in part on the availability of 'digital dividend' spectrum, which is in low frequency bands, and hence is suitable for good rural coverage. However, LTE at the moment is still in its infancy and so network build-out is slow and relatively expensive. Over time, LTE deployment is likely to follow the same pattern as 2G and HSPA service roll out, with growing adoption creating economies of scale for suppliers of network equipment and device components, driven by increasing scale and adoption. As LTE scale grows, costs fall, making the service more accessible to more of the customer base, which in turn drives further adoption, and hence, greater coverage on more networks; 4G LTE is expected to represent 10% of global connections in five years [CM1]. ITS requires a full LTE coverage, otherwise there will be no complete availability of applications and services. Some analysts expect 100 per cent LTE coverage in 2015 already.

Bandwidth and Latency: LTE has theoretical peak download rates of 170Mbps, and early network deployments are delivering data rates between 10Mbps and 50Mbps. These rates are generally in excess of those available on current consumer fixed line services using DSL and cable modem technologies as well as wireless 3G HSDPA/HSUPA.

Low latency has been designed into LTE from the outset. A radio latency of less than 10ms is the requirement, which makes LTE an ideal technology for voice services and video telephony. Latencies of less than 50ms might be seen in real networks. It should be noted that the Voice over LTE standard uses a different mechanism to previous radio technologies – instead of using circuit-switched technology for voice, Voice over LTE specifies that voice calls are delivered via a technology called IMS, with the service definition having been completed by GSMA [CM1].

Regarding LTE operating performances, it is possible to collect a complete view through the results of The LTE/SAE Trial Initiative (LSTI) [CM15]. It was an open initiative founded in May 2007 and driven by vendors and operators; it successfully concluded its work in January 2011. LSTI co-ordinated industry-wide interoperability testing of standards compliant equipment from different vendor pairs, stimulating early feedback into the standard. In 2009 LSTI demonstrated LTE capabilities and advantages in near-commercial conditions. Friendly users tested mobile broadband applications, using pre-commercial form factor terminals in several field trials. In January 2011, LSTI concluded its work and presented preliminary outcomes at the Mobile World Congress 2011.

LSTI trials confirm that in ideal radio conditions Measured Round Trip Times on 32Byte messages fall below 15ms; these performances are not so different from that one published by other sources such as EASY-C research project (with some laboratory measures below 10ms). The priority of C2X related applications and services regarding round trip delay, e.g. a guaranteed QoS, needs to be debated.

Regarding throughput, LSTI registered that measured performances meet or exceed the field trial expectations of at least 100 Mbps for downlink and 30-50 Mbps for uplink in both FDD and TDD systems. Cell Capacity has been estimated with an average value equal to 40 Mbps on 20 MHz channels even considering realistic interference conditions [CM2].

Spectrum Consideration: The two primary spectrum bands for LTE are the 'digital dividend' at 700MHz or 800MHz (dependent upon market) and the IMT-extension band (2.5-2.6GHz). Digital dividend spectrum is being freed by the move from analogue to digital broadcast signals for television. Since the analogue to digital switchover is an on-going process in many markets around the world, the timing of the availability of this band varies across markets. 2.6GHz spectrum is open in most markets and so has a good degree of alignment in licensing, notably in Europe. This spectrum is also being licensed around the world at the moment with varying timelines.

There are multiple bands for LTE defined by ITU-R [CM16], which provides more than 10 frequency bands being not very well harmonized globally (Figure 1.3).

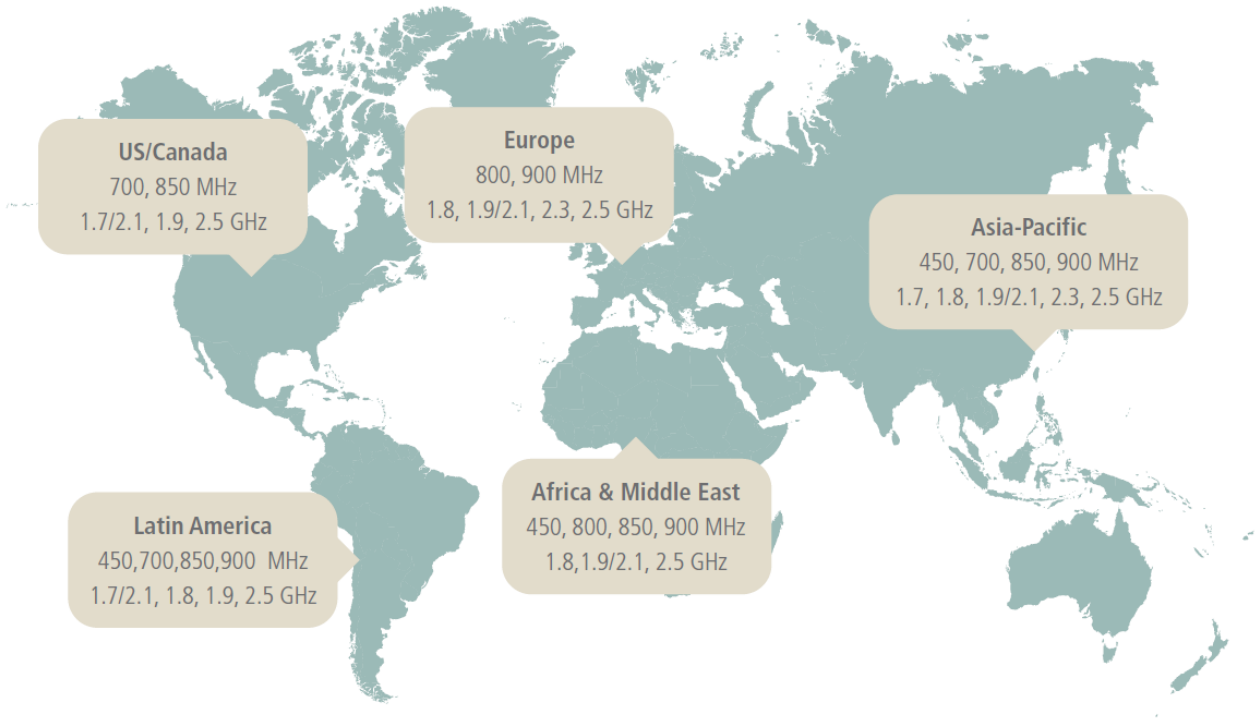

Figure 1.3: Worldwide LTE spectrum availability [CM1]

Vehicular Communication Systems

Vehicular Communication Systems are an emerging type of networks in which vehicles and roadside units are the communicating nodes; providing each other with information, such as safety warnings and traffic information. As a cooperative approach, vehicular communication systems can be more effective in avoiding accidents and traffic congestions than if each vehicle tries to solve these problems individually.

Generally vehicular networks are considered to contain two types of nodes; vehicles and roadside stations. Both can be developed/ implemented as Dedicated Short Range Communications (DSRC) devices. DSRC works in 5.9GHz band with a bandwidth of 75 MHz and an approximate range of 1000m. Please note that DSRC in this context is not the DSRC system defined by the European CEN operating in the 5.8GHz area. The network should support both private data communications and public (mainly safety) communications but higher priority is given to public communications. Vehicular communications is usually developed as part of Intelligent Transport Systems (ITS). ITS seeks to achieve safety and productivity through intelligent transportation which integrates communication between mobile and fixed nodes. To this end ITS heavily relies on wired and wireless communications.

Motivation

The main motivation for vehicular communication systems is safety and eliminating the excessive cost of traffic collisions. According to the World Health Organization (WHO), road accidents annually cause approximately 1.2 million deaths worldwide; one fourth of all deaths caused by injury. Also about 50 million persons are injured in traffic accidents. If preventive measures are not taken road death is likely to become the third-leading cause of death in 2020 from ninth place in 1990. [CM1]

However the deaths caused by car crashes are in principle avoidable. The US Department of Transport states that 21,000 of the annual 43,000 road accident deaths in the US are caused by roadway departures and intersection-related incidents. This number can be significantly lowered by deploying local warning systems through vehicular communications. Departing vehicles can inform other vehicles that they intend to depart the highway and arriving cars at intersections can send warning messages to other cars traversing that intersection. Studies show that in Western Europe a mere 5 km/h decrease in average vehicle speeds could result in 25% decrease in deaths. Policing speed limits will be notably easier and more efficient using communication technologies.

Although the main advantage of vehicular networks is safety improvements, there are several other benefits. Vehicular networks can help in avoiding congestion and finding better routes by processing real time data. This in return saves both time and fuel and has significant economic advantages.

Development

Vehicular communications is mainly motivated by the desire to implement Intelligent Transport Systems (ITS) because of their key benefits in safety and travelling ease. Several ITS institutions operate around the world to bring ITS concepts to real world. In the United States one of the main players is U.S. Department of Transportation (US DoT). The federal DoT promotes ITS through investment in potentially high payoff initiatives. One of these major initiatives, Vehicle Infrastructure Integration (VII), seeks to increase safety by providing vehicle to vehicle and vehicle to roadside units communications through Dedicated Short Range Communications (DSRC).

Intelligent Transportation Society of America (ITSA), which has members from many diverse areas including private companies, universities, and governmental agencies, aims to improve cooperation among public and private sector organizations. ITSA summarizes its mission statement as “vision zero” meaning its goal is to reduce the fatal accidents and delays as much as possible.

Many universities are pursuing research and development of vehicular ad hoc networks. For example, University of California, Berkeley is participating in California Partners for Advanced

Transit and Highways (PATH) along with several other universities in California and elsewhere such as Stanford, UCLA, MIT, Texas A&M etc.

Car manufacturers and communication corporations are also investing in vehicular communications; among them are Kapsch, General Motors, Daimler Chrysler, Ford Motor Company, Siemens, Honda, Toyota, BMW, Mercedes-Benz and Mark IV.

Integrated automobile devices like OnStar have begun to make a presence on U.S. markets, with automobile manufacturers like GM offering them as options on their vehicles. Third party companies use these devices to offer services such as directions and emergency assistance to their customers. Although these devices may add an extra level of safety and peace of mind, they do not offer drivers the freedom to communicate with each other.

Technical specifications

Two categories of draft standards provide outlines for vehicular networks. These standards constitute a category of IEEE standards for a special mode of operation of IEEE 802.11 for vehicular networks called Wireless Access in Vehicular Environments (WAVE). 802.11p is an extension to 802.11 Wireless LAN medium access layer (MAC) and physical layer (PHY) specification. With revision 2012 of IEEE Std 802.11, the 11p amendment was directly integrated into the Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. 802.11p aims to provide specifications needed for MAC and PHY layers for specific needs of vehicular networks. IEEE 1609 is a family of standards which deals with issues such as management, security and multi-channel operation of the network on top of IEEE 802.11p:

- **1609.1** - Resource Manager: This standard provides a resource manager for WAVE, allowing communication between remote applications and vehicles.
- **1609.2** - Security Services for Applications and Management Messages
- **1609.3** - Networking Services: This standard addresses network layer issues in WAVE.
- **1609.4** - Multi-channel Operation: This standard deals with communications through multiple channels.

The current state of these standards is trial-use. A vehicular communication networks which complies with the above standards supports both vehicular on-board units (OBU) and roadside units (RSU). RSU acts similarly to a wireless LAN access point and can provide communications with infrastructure. Also, if required, RSU must be able to allocate channels to OBUs. There is a third type of communicating nodes called Public Safety OBU (PSOBU) which is a vehicle with capabilities of providing services normally offered by RSU. These units are mainly utilized in police cars, fire trucks, and ambulances in emergency situations.

As mentioned before DSRC provides several channels (seven 10 MHz channels in North America) for communications. Standards divide the channels into two categories: a control channel and service channels. Control channel is reserved for broadcasting and coordinating communications which generally takes place in other channels. Although DSRC devices are allowed to switch to a service channel, they must continuously monitor the control channel. There is no scanning and association as there is in normal 802.11. All such operations are done via a beacon sent by RSUs in the control channel. While OBUs and RSUs are allowed to broadcast messages in the control channels, only RSUs can send beacon messages.

In North America DSRC devices operate over seven 10 MHz channels. Two of the channels are used solely for public safety applications, which mean that they can only be used for communications of message with a certain priority or higher.

Although 802.11p and 1609 drafts specify baselines for developing vehicular networks, many issues are not addressed yet and more research is required.

802.11p [CM4]

IEEE 802.11p is an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE). It defines enhancements to 802.11 (the basis of products marketed as Wi-Fi) required to support Intelligent Transportation Systems (ITS) applications. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure in the licensed ITS band of 5.9 GHz (5.85-5.925 GHz). IEEE 1609 is a higher layer standard based on the IEEE 802.11p.

802.11p will be used as the groundwork for Dedicated Short Range Communications (DSRC), a U.S. Department of Transportation project based on the ISO Communications, Air-interface, Long and Medium range (CALM) architecture standard looking at vehicle-based communication networks, particularly for applications such as toll collection, vehicle safety services, and commerce transactions via cars. The ultimate vision is a nationwide network that enables communications between vehicles and roadside access points or other vehicles. This work builds on its predecessor ASTM E2213-03.

In Europe, 802.11p is used as a basis for the ITS-G5 standard, supporting the Geonetworking protocol for vehicle to vehicle and vehicle to infrastructure communication. ITS-G5 and Geonetworking are being standardized by ETSI ITS.

ETSI TC ITS [CM3]

The European Commission has issued a Mandate (M453) to European industry and governments to develop a minimum set of standards needed to ensure the functionality and interoperability of these new communication technologies, and enable connected vehicles to communicate intelligently with traffic management and control infrastructure throughout Europe.

This Mandate is directed to ETSI (the European Telecommunication Standards Institute) and CEN (the European Standards Committee), that between them have already published many of the required standards.

The completion of these standards will open the way for a harmonized pan-European deployment of C-ITS in cities and on the highway network, enabling cooperative intelligent roadside systems to communicate with equipped cars, trucks, emergency services and public transport vehicles. Through the joint statement the infrastructure suppliers invite public authorities at national, regional and city levels to work with them to ensure that the respective products and services fulfil their needs and goals concerning interoperability and functionality.

The ETSI TC ITS stack covers the full communication stack up to application layer, as shown in Figure 1.4.

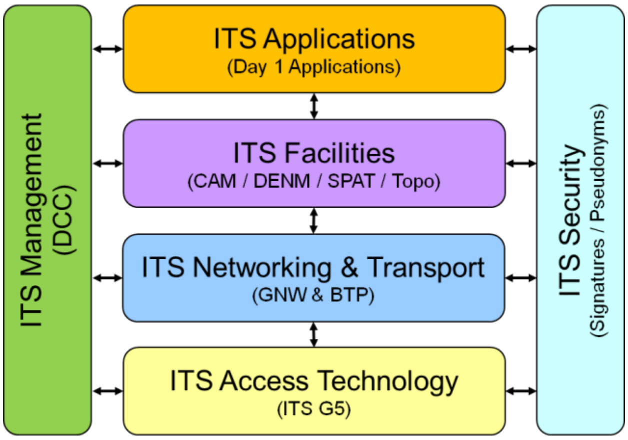

Figure 1.4: ETSI TC ITS Stack

GeoNetworking Protocol

ETSI produces standards for ICT, including fixed and/or mobile radio, and Internet technologies. ETSI is recognized by the European Union as a European Standards Organization. ETSI published several specifications to define different aspects of the ITS systems such as Road Transport and Traffic Telematics, Geonetworking and ITS Applications.

The Geonetworking protocol layer is a network layer protocol that provides packet routing in an ad hoc network. It makes use of geographical position information for packet transport. Geonetworking supports the communication among individual ITS stations as well as the distribution of packets in geographical areas. Geonetworking can be executed over different ITS access technologies for short-range wireless technologies, such as ITS-G5 and infrared. The ITS access technologies have many technical commonalities, but also differences among themselves. In order to reuse the Geonetworking protocol specification for multiple ITS access technologies, the specification is separated into media-independent and media-dependent functionalities. Media-independent functionalities are those, which are common to all ITS access technologies for short-range wireless communication to be used for Geonetworking. The media-dependent functionalities extend the media-independent functionality for a specific ITS access technology. Therefore, the Geonetworking protocol specification consists of the standard for media-independent functionality and at least one standard for each media-dependent functionality.

ETSI defines the Geonetworking in ETSI TS 102 636 family of documents [CM5]. The core of the Geonetworking protocol layer is defined by the ETSI TS 102 636-4-1 standard [CM5], in the document titled "Geographical Addressing and Forwarding for Point-to-Point and Point-to-Multipoint communications; Sub-part 1: Media-Independent Functionality".

Communications, Air-interface, Long and Medium range (CALM) [CM6-8]

Communications access for land mobiles (CALM) is an initiative by the ISO TC 204/Working Group 16 to define a set of wireless communication protocols and air interfaces for a variety of communication scenarios spanning multiple modes of communications and multiple methods of transmissions in Intelligent Transportation System (ITS). The CALM architecture is based on a IPv6 convergence layer that decouples applications from the communication infrastructure. A standardized set of air interface protocols is provided for the best use of resources available for short, medium and long-range, safety critical communications, using one or more of several media, with multipoint (mesh) transfer.

CALM enables the following communication modes:

- Vehicle-to-Infrastructure (V2I): communication initiated by either roadside or vehicle (e.g. petrol forecourt or toll booth)

- Vehicle-to-Vehicle (V2V): peer to peer ad-hoc networking amongst fast moving objects following the idea of MANET's/VANET's.
- Infrastructure-to-Infrastructure (I2I): point-to-point connection where conventional cabling is undesirable (e.g. using lamp posts or street signs to relay signals)

Methods of transmission used by CALM may be based on one or more of the following communication media:

- Infrared
- GSM (2G, 3G cellular telephone communication technology)
- DSRC 5.8-5.9 GHz (legacy systems)
- Various evolutions of the IEEE 802.11 standard including WAVE (IEEE P1609.3/D23) [CM17], M5 (ISO 21215) [CM18-19], 802.11p
- WiMAX, IEEE 802.16e [CM20]
- MM-wave (63 GHz)
- Satellite
- Bluetooth
- RFID

The CALM architecture provides an abstraction layer for vehicle applications, managing communication for multiple concurrent sessions spanning all communications modes, and all methods of transmission.

1.2.1.2 Proposed progress beyond state of the art

LTE provides significant improvements with regard to latency and bandwidth. Moreover LTE is currently deployed in most parts of Europe and brings broadband coverage to almost all regions. Since LTE promises wide-area connectivity, low latency and high bandwidth, it is a central communication technology enabler for a broad range of mobile applications, including ITS. However, LTE is designed for human-based communication in low-to-medium vehicular deployment scenarios, leading to inefficiency in the transportation of data generated by automotive applications. While technologies such as LTE are attractive for ITS applications, they were not designed for ITS and relevant requirements have not been analysed in this context yet.

Similarly, the common ITS architecture (COMeSafety [CM21]) has not been analysed to be extended for LTE yet. Consequently, a number of research questions arise on the interaction and interdependency between communication infrastructure and the automotive applications. In the context of 3GPP, V2X communication is a form of machine-type communication (MTC) with a specific set of requirements on quality of service and data traffic characteristics. V2X communication is especially challenging for mobile cellular networks due to the frequent transmission of data packets, and the large number of mobile devices and the high mobility scenarios. In this context, several critical issues will be investigated in TEAM.

1. Adaptation for LTE will be designed and developed to make these technologies suitable for ITS applications, including aspects of the mobile network architecture as well as the radio access network (RAN). For example, a possible enhancement is to provide mechanisms for sending information to a target geographic area, the current implementation of which in LTE has many limitations.

2. Specific ITS requirements will be mapped to 3GPP enhancements [CM22] so that future cellular networks will be suitable for ITS applications (e.g. allow vehicles and personal devices to form an ad-hoc network under control of an eNodeB to achieve lower latency and higher scalability).

3. LTE, 802.11p, and GeoNetworking will be combined to make the best out of all these technologies. The ultimate goal is to achieve low latency, wide coverage, and high scalability by using these technologies to complement each other.

4. Personal devices such as smartphones will play an important role in the future (either as nomadic or in-vehicle devices); hence they will be embraced as a key component in the TEAM system architecture.

5. While pursuing forward-looking approach towards future technologies, TEAM will not neglect current and soon-to-be-deployed technologies/services such as eCall [CM23] but it will incorporate them in the TEAM system architecture.

6. The effect of communication delays on distributed algorithms and the impact of congestion on the dynamic ad hoc communication networks are topics that need to be addressed properly.

1.2.1.3 Guidelines for TEAM

Here follows a synthesis of the guidelines suggested for the TEAM developments. More details are provided in the Annex A: ITS Communications for ITS (LTE and V2X short-range communications) - Areas of Research.

- Consider planning and implementing a flexible communication layer able to cope with possible different spectrum allocations in a very flexible manner, e.g. the overlaying applications should deliver services in a reliable way independently of the underlying technology employed.
- Consider a versatile communications unit with a flexible, modular architecture that allows for exchangeability of radio modules.
- Consider OBU und RSU architectures that provide forward-looking adaptability to yet unforeseen technological developments (e.g. changes in spectrum allocation, future hardware, etc.) and use-cases.
- Implement real-time service quality metrics between middleware infrastructure and applications, indicating current quality level of service. Let applications decide and act accordingly.
- Prepare applications to cope with varying service quality conditions, e.g. inform the user of such variations or implement intelligent actions upon service quality degradation like e.g. use of alternative technologies (11p with multi-hopping in an ad-hoc network instead of LTE), adequate and sufficient data buffering, etc.
- TEAM infrastructure should support multiple communication standards and technologies, including legacy, in order to ensure seamless connectivity.
- Consider providing support for IMS (IP Multimedia Subsystem) in TEAM.
- TEAM should consider research of safety features over unreliable or non-certified services (IMS) or technologies. For instance in the use-case of transmission of safety messages over IMS.
- TEAM should look into clean handover mechanisms between different LTE network operators. The question of whether all LTE network providers offer a similar set of services and thus guarantee a given level of reliability for ITS should be investigated, e.g. what's the minimum set of features that's common to most providers.
- Consider the implementation of similar functionality as in project "CoCar-x" (Reflector concept) to enable peer-to-peer connections and ad-hoc networks using regular LTE or cellular networks.
- Consider using IMC functionality integrated in the Reflector concept.

- Rely on literature to find existing solutions related to the use-cases and applications envisioned in TEAM.
- Perform systematic and exhaustive research regarding ITS network deployment including factors such as geographical area, topography, transmission network availability and limitations, application requirements, involved costs, etc.
- Consider an ITS network architecture made up of heterogeneous elements and technologies (3GPP femto-/pico-cells, mobile network macrocell infrastructure, WLAN access, etc.) in order to increase robustness and penetration.
- Consider implementing hybrid data packet routing in heterogeneous networks comprising different technologies and depending on real-time network availability and quality metrics.
- Consider implementing extensions to the current ITS command definitions in order to reduce message traffic in the network and also include more complex use-cases as envisioned in TEAM
- Provide message definitions compliant to ETSI standards.
- TEAM should look at LTE / ITS-G5 integration issues regarding EM interference of closely located radiators and the corresponding hardware.
- EM design considerations apply to OBUs and RSUs as well and have a direct impact to the implementation of the versatile communication unit.

1.2.2 Traffic and dynamic data management: Cloud services and the cloud-based Local Dynamic Map (LDM++)

Having location based data and services accessible in a seamless way and independently of the platform and operating system is a key requirement for cooperative systems, which involve components from distinct ITS stations with different characteristics (vehicle, infrastructure, mobile device). Today's technologies enable these components to be always connected and consequently cloud based services and shared data stores constitute the vector of choice for real-time information exchange as they ensure interoperability and data consistency between remote components of a system. Traffic information aggregated from various sources by Traffic Management Centres however constitutes only one source of dynamic data for a cooperative application. Other types of data like parking availability or weather information relevant for the driver or traveller can be made available by third party service providers. Optimally, this data should be stored and accessed in one and same location for all applications running in a given ITS station to allow proper referencing of the data in relation to the road network. Synchronization mechanisms need to be additionally implemented in order to harmonize the content of LDMs in the different sub-systems.

1.2.2.1 State of the art

Traffic management centres are now available in most major European cities. They operate a variety of traffic information and control systems, integrating information sources such as loop detectors, floating car data, and closed-circuit television CCTV to trigger control actions or to provide traffic information to stakeholders. Traffic Management Systems (TMS) aim at providing an integrated and coordinated solution to steer traffic either at city or highway level. TMS may be designed with primary objective safety, improving traffic throughput [CS6], or at congestion and emission reduction [CS7]. There are several communication standards available [CS1, CS2] to provide information to the end users. Besides TMS, there are also other approaches to handle and manage traffic-related data on a larger scale. Examples include the National Data Warehouse for Traffic Information [CS3] in the Netherlands, or the Mobiliätsdatenmarktplatz [CS4] in Germany.

The approach chosen in TEAM is to use an alternative technology known as Local Dynamic Map (LDM), which has been specified and developed in the EU funded SAFESPOT [CS7] and CVIS [CS8] projects and is considered one of the essential elements of cooperative systems since [CS1]. The LDM concept developed in these projects originally addressed cooperative systems for safety and traffic efficiency applications, serving time critical highly dynamic data needs (e.g. position of surrounding vehicles). The LDM is in essence a data store, which provides a real-time mapping of relevant static, temporary and dynamic infrastructure elements and objects around the system that is maintaining the LDM. In the initial concept, it is constructed from four different layers containing data with different levels of dynamicity, as illustrated in Figure 1. In practice however, the different implementations developed by map makers in the SAFESPOT project consisted either of a single Relational database containing all data or a basis layer with static map data stored in a binary data format (Physical Storage Format or PSF) and a relational database with dynamic data geo-referenced to the static data. The most important aspect was the possibility for an application to access any type of data, from static to highly dynamic, seamlessly via a unified Application Programming Interface (API). The main outcome of the SAFESPOT and CVIS projects has been the specification of this API. In these practical implementations, each data type can be considered as a layer and the data model can be extended as required for new types of applications. While all subsystems have read access to the LDM data store, the updates to dynamic data in the system are managed by a Data Processing and Data Fusion module, which attempts to create useful information out of the streams of data flowing into the system.

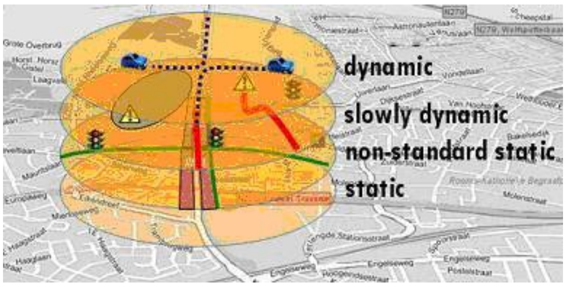

Figure 1.5: Initial 4 layer LDM concept from the SAFESPOT project [CS1].

The LDM is currently in the process of standardization by both ETSI and CEN. ETSI has created a dedicated Task Force STF 448 in May 2012 and CEN has added the LDM to TC 278 with a connection to ISO TC204. The European standardization organisations have been required to work together on the LDM as part of co-operative Intelligent Transport Systems following the European Commission Mandate M/453 published in 2009. Standardisation not only includes data model by layers and protocols but also shared data management including synchronization, data integrity and security.

TEAM will include a n-layer architecture to serve dedicated needs – highly adaptable to the context for which the extended LDM will be employed. The extended LDM, which is referred to as LDM++ in this document, consists of a static and dynamic location-based data store centrally maintained in the cloud and of local extracts in the devices used by the traveller and centred around his position. These real-time database extracts constitute the actual local map component which will be used by the applications. With this approach, local modifications of the map content or addition and update of dynamic data like traffic events will be directly integrated in the central data store thus making it available to all other connected client devices within a short time frame. Related multi-layer incompatibility issues will be addressed (e.g. unified semantic description of layers).

1.2.2.2 Proposed progress beyond state of the art

Despite the advanced state of TMS many immediate issues remain to be resolved when considering the applications described in the project. First, the sheer volume of data, and need for an advanced level of computation, presents a number of key challenges. Paramount amongst these are network models that can be used in a proactive manner to mitigate road incidents, and which can be updated in real time in an efficient manner. Second, smartphones and connected cars are now allowing the definition of new advanced TMS concepts. In particular TEAM makes use of bidirectional communication to enable feedback and control loops in these concepts. Furthermore, the distributed nature of many applications, and the availability of aggregated data, leads to many application-dependent issues that are currently not on the roadmap of traffic centre operators. These include the effect of computational delay, the ability of infrastructure and mobile agents to aggregate information via communications, the choice of distributed vs. centralised communications, and the effect of fleet composition and density of instrumented vehicles, on applications. Central to these issues are the provision of cloud services. Due to the advancement in communication technology (in particular with regard to bandwidth and latency), and data management techniques, the cloud concept now meets the requirements of TEAM. Cloud services and the well-accepted concept of the LDM are relevant to the TEAM project, as they provide the basis for a new solution to enable open and ubiquitous access to traffic and mobility information. Associated with cloud services are QoS issues that are particular for vehicular applications. A concern in this project is therefore to achieve seamless QoS performance and to provide certain levels of robustness with respect to communication failure.

1.2.2.3 Guidelines for TEAM

The approach in TEAM will build on earlier developments made in the SAFESPOT and CVIS projects with 2 main objectives:

1. Establish a layered reference system: A location referencing platform will be created to use as a canvas for services. The canvas incorporates a static map as a reference system shared across all applications and users. Dynamic layers can be added to that shared reference and can be stored persistently. An automotive grade map and an API to manipulate it and perform geo computation will be incorporated. The map will be installed as a component in all systems and applications will use the API to access it. In addition to the geo APIs, APIs to store and share geo referenced objects with other users and applications will be created.
2. Create a hybrid Cloud adapter. A hybrid system that uses map data stored in the system will be implemented together with a smart cache or proxy that can store data and interactions on them in a local „cloud" thereby making the fact that a connection might be temporarily unavailable transparent to applications. The cloud access will be abstracted to access a transparent entity that will defer requests if they cannot be answered locally in a non-blocking way.

1.2.3 Positioning

Positioning accuracy is still a challenge for driver assistance applications. In order to give the driver correct information, it is necessary to have lane level positioning. Several projects and research groups have been working on the issue during the last years, but there is still the need to solve it with mass market receivers.

Cooperative GPS is a new positioning concept that allows vehicles, smartphones and the traffic infrastructure nearby to exchange raw GNSS (Global Navigation Satellite System) data with each other to improve the accuracy of each other's positions. By using this technique, the TEAM applications will be able to assist the drivers with correct and accurate information.

1.2.3.1 State of the art

Positioning technologies have been available for customers for many years, such as GPS (Global Positioning System) from USA that has been available globally without Selective Availability since 2000, with one of the main applications being in-vehicle navigation. Despite this fact, the receivers still lack enough precision for expanding their use for more demanding applications, such as safety. Using regular GPS can provide errors up to 20m, according to official GPS information (www.gps.gov). Many techniques aim at improving accuracy, but many result in a more expensive system, such as RTK (Real-time kinematic positioning). As an example, the problem of lane position is not yet solved and it's very common to see standard navigation devices giving wrong advices to the driver due to lack of GPS precision in dense urban environments or complex road intersections. Many problems have been solved by estimating the position, but when it is necessary to have very low latencies and high precision, this approach is not usable.

There are several approaches under investigation by the scientific community for achieving lane level positioning. For instance, the project CoVeL (co-funded by the European GNSS Agency) developed a precise positioning system based on two innovative algorithms: the relative positioning and the cooperative map matching. CoVeL used GNSS raw data exchange among vehicles and infrastructure (via 802.11p) plus EGNOS and EDAS correction. CoVeL obtained a good level of confidence to achieve lane level position accuracy especially in extra-urban scenarios identifying the most relevant errors for the urban environment.

Another project still ongoing is the German national project Ko-PER which is also developing a relative positioning system. The Ko-PER-system exchanges GPS raw data among vehicles and infrastructure (via 802.11p). Moreover the satellite orbit information is used. This information is available from the navigation data that is sent via broadcast from the GPS satellites. The result is a relative vector pointing from the GPS antenna position of the local vehicle to the GPS antenna position of the cooperating vehicle. Because of the relative consideration between the cooperating vehicles some related GPS error factors can be eliminated. The goal of this approach is to minimize the general error between the cooperating vehicles in order to achieve a better positioning precision. However, the implementation of the relative positioning system is still under development. First results are expected in the next months.

In general, three issues drive discussion in the area of Cooperative Positioning:

1. The availability of physical measurement: to measure information by using a suitable technique, into six categories: location, distance (ranging), angle (ranging), area (ranging/connectivity) and neighbourhood (radio connectivity).
2. The availability of information: to communicate (transmit) individual information to neighbours nodes.
3. Distributed algorithms for positioning: to compute cooperative localization by using some suitable algorithm and available information. Include position computation techniques and localization algorithms.

References [CP1, CP2] are two technical reports for TEAM project where is possible to find an extensive state of the art survey for Cooperative Positioning in vehicular networks, respectively.

1.2.3.2 Proposed progress beyond state of the art

TEAM will use the experience gained in previous projects, such as CoVeL and Ko-PER, and will base its development on GPS raw data exchange between vehicles and infrastructure.

Furthermore, the project aims to take into account the developments of the European Union's Galileo positioning system and have the TEAM system ready for a seamless integration when this GNSS becomes available.

1.2.3.3 Guidelines for TEAM

Here follows a synthesis of the guidelines suggested for the TEAM developments.

- Raw data capable GPS receiver on the TEAM platform to be built
- Perform research regarding the algorithms for relative positioning including geographical area, impact of multipath effects, availability of the cooperative localization messages (CLM)

- Perform research on multipath detection
- Implement the relative positioning system on the TEAM platform
- Data fusion with available local vehicle data (e.g. velocity, yaw-rate)

1.2.4 Gamification, coaching and community building in infomobility

This section addresses the field of serious games and community building solutions and technologies, given their promising ability to engage users in performance improvement and collaboration activities, that look particularly important in the fields covered by TEAM, with particular reference to green/safe driving.

1.2.4.1 State of the art

Recent years have seen the rapid surge of gaming and social networking. The potential of Serious Games – games designed with a primary goal different than pure entertainment [SG1, SG2, SG3] – is relevant, because a large population is familiar with playing games. Through gaming, the learning is applied and practiced within that context (situated cognition) [SG4]. This is particularly promising for a domain like (green/safe) driving, where the user (driver/passenger) is in the field and could exploit this experience to learn.

In the scientific community there is a consensus about the instructional potential of games, mostly because they are considered inspiring and motivating [SG5] [SG6]. Several games are being successfully used in several different application domains (e.g., [SG7] [SG8] [SG9]). [SG 10] discuss their experience in designing a persuasive serious game in a field which is somehow related TEAM, such as power conservation. The paper addresses in particular the points of user assessment and provision of feedback and hints for good performance.

There are some examples also in the domain of mobility, such as Chromaroma [SG11] by the London Underground. The popular term now is gamification, which is the use of game design techniques and mechanics to solve problems and engage audiences [SG12] [SG13]. Typically, gamification applies to real-world processes and behaviour, in order to encourage people to adopt them. Despite the immediate appeal, there are also some concerns about gamification [SG13]. In any case, proper pedagogical mechanisms are necessary in order to make games effective for actual instruction. Thus, a meaningful gamification of a system is a far from trivial challenge [SG14].

The main OEMs have assistant systems to inform drivers about optimal gear changes, and acceleration behaviour and have partially related them to incentives and game-like approaches. Examples are Fiat eco:Drive system [SG15], Ford Fusion and Mercury Milan EcoGuide with the SmartGauge coaching system (including the growing leaves/vines metaphor to show good driver behaviour) [SG16], BMW Eco Pro [SG17], Honda insight Eco Assistant [SG18]. The Chevrolet Volt's dashboard, called Driver Information Center, provides very pleasant real-time feedback on the driver's driving style, which looks particularly suited to behaviour change [SG19]. The system displays a ball that animates and changes colour (e.g., yellow for sudden braking) based on a car's acceleration or deceleration.

Nokia has recently presented the "Routine Driving" infotainment app [SG20], applying gamification to routine driving in order to transform into performance driving, which is driver training focused on developing optimal vehicle handling skills appropriate to the road terrain. The app provides real-time feedback of how well the driver is driving through a role play game interface, named "Driving Miss Daisy". The game features levels based on the player's previous performance. The game provides a final summary of the trip and performance beside occasionally commenting (through primarily audio feedback) on the chauffer's real and actual driving performance. The game monitors smooth and hazardous driving performance. Smooth driving performance includes constant driving speed for a period of time (aka cruise control), driving within speed limit, smooth acceleration and deceleration of the vehicle, and smooth cornering. Hazardous driving includes going over the speed limit, sudden starts and stops, sharp cornering, and erratic lane changes. The current version implements all but the cornering and lane changes. Players are able to compete with themselves by comparing performances over the same route on different days or compete with others through the reporting of their rank among all people that have played the game on the same route. The percentage rank given at end of each drive reflects the position among all scores gained by other drivers on the same route. The app collects driving data such as car speed from OBD, accelerometer readings from the smartphone, altitude from smartphone's GPS, and speed limit of the current road from Nokia's maps API service [SG21]. The game is a HTML5 application that runs inside a Web browser on the smartphone, as the app involves mash-up of data and functionality from the smartphone, the car, and the cloud. The phone is connected to a MirrorLink-enabled head unit via USB. The MirrorLink technology [SG22] is used to deliver the browser-based application running on the smartphone to a car's dashboard

Fiat eco:drive Mobile connects the in-car software and data with a smartphone, allowing an immediate analysis of the driver's performance. This new version also includes functionalities for social networking, as the possibility to share results through Facebook and Twitter, creating the possibility of rewarding the best "eco:drivers" with virtual badges and real prizes. Communities are expected to emerge for various driver categories. All the eco:drive users are part of the "eco:Ville" online community in which the eco:drivers savings are collected. The community is continuously growing, with 87,000 users, who have saved a total of 4,900 tons of CO2 by improving the efficiency of their driving style (as of beginning of 2011).

[SG23] made an interesting study aimed at evaluating the user acceptance of five different persuasive in-car interfaces designed to support a fuel-efficient driving style. [SG24] discusses how to motivate eco-driving through in-car gaming, highlighting the importance of challenging and competitive situations.

The I-GEAR project is studying incentives for drivers, in a game-like environment, for improving traffic conditions by promoting good drivers' behaviours. A preliminary paper, [SG25], focuses on ethics, privacy and trust aspects. [SG26] argues that using social networks for exchanging real time public transport information among travellers (e.g., punctuality, noise levels, schedules, quality of the transport means, etc.) can be very effective. Social networks would provide an easy way of sharing information and also provide a sense of community to the involved travellers. They also propose the concept of a smartphone social application, with a game structure of crowd rating and rewards.

The Sunset project is a 3 year project kicked-off in 2011 [SG27]. Its main goals concern the study of social services that motivate people to travel more sustainably in urban areas; the study of Intelligent distribution of incentives (rewards) to balance system and personal goals; the development of algorithms for calculating personal mobility patterns using information from mobile and infrastructure sensors. The TEAM serious game application, on the other hand, provides a specific service for improving the driver behaviour both in driving (green and safe) and with respect to a proper use of the other collaborative TEAM applications (e.g., co-modal route planning, collaborative parking), in a social gaming environment where various types of good driver behaviours are detected and incentivized both through informative feedback (also concerning negative aspects) and real-world rewards in particular exploiting the TEAM applications themselves, in a virtuous cycle. For instance, the collaborative parking application could provide more/better parking information to drivers that have shown to have a more suited and collaborative drive.

Concerning driver profiling, some solutions have recently been proposed, in particular concerning the field of insurances and fleet management. For instance, MyDrive Solutions have developed black boxes and apps that claim to be able to offer fairer, more personal motor insurance, and can even help to improve driving. They build a driver profile which scores a person's driving according to five categories (consistency, pace, anticipation, calmness, smoothness), before providing a weighted average score, namely the Expert Driver Score [SG28].

Blackbox Telematics offers a similar device and service, the "Green Driving EcoRisk System", which is a GPS/Driver behaviour and performance tracking system, that records in particular excessive acceleration, harsh braking, excessive corning, over speeding, excessive idling and geo-fence alerts. This information is available in "real time" through a server, and is typically used for fleet management [SG29].

Telekom Austria Group M2M, Fela Management AG and G4S Security Systems have entered into a partnership, developing the Eco Driving Solution, that aims at enabling companies to reduce costs by gathering and analysing a broad range of data around both drivers and vehicle fleets [SG30]. The driver is being identified through a card or special RFID key. Driver behaviour analysis relies on data from sophisticated on-board GPRS devices with inbuilt accelerometers and direct connection to the car OBD interface. Driving style parameters like harsh breaking or acceleration, out of hour's usage or idling of the engine is being aggregated, analysed and compared by a central system. The results can be given to drivers as direct feedback and help the fleet manager to determine the need for training. A fleet management tool allows keeping track of all fleet vehicles including location management, time stamps, movement and even engine idle or working status. Geo-Fence Management initiates a warning alert in case the vehicle leaves or enters a specific zone or doesn't keep the time schedule. A special sensor of the on-board GPRS device allows for immediate accident detection. Crash data is being recorded automatically for later event analysis and a battery allows the device to transmit location data for recovery. In case of theft, the OBD interface connection of the on board GPRS device enables remote vehicle immobilization.

The expected added value of the TEAM social gaming application with respect to the above is its real-time driver information and feedback (coaching), the correlation with the other "elastic mobility" TEAM applications (e.g., collaborative parking, collaborative navigation, etc.) and the game-based environment also supporting competitions.

1.2.4.2 Proposed progress beyond state of the art

TEAM will make use of the community spirit that drives social networks. TEAM will establish closed, open, or dynamic (e.g. location- or context-specific) communities and support these with features to share and compare individual driving techniques and styles but also to collaborate. This social aspect will support the soft coaching, e.g. by signalling right actions to improve performance and by rewarding the most eco-efficient driver or community through score, appointments or other mechanisms. But the "traditional" social networking (e.g. Facebook and Twitter) does not look suited for an in-car environment, because of usability issues and type of contents/services.

TEAM will go beyond the state of the art by building a social driving platform, which is quite different from simply producing data/games for Facebook, Twitter, Google+ or LinkedIn. The platform relies on geo-tagging, geo-messaging, transport/car semantics, proximity, ad-hoc mobility gamification, ad-hoc HMI in order not to overload the cognitive functions of the user. This does not mean developing another Facebook, but providing a new enabling platform for a specific context (transport), with a critical mass of users (drivers and travellers), with a great potential for entertainment, learning/coaching and community building. Different to existing solutions like eco:drive Mobile, it enables open communities, not directly related to any OEM. As a limited example of such a huge potential, we can cite Waze [SG31], a social GPS application that provides free navigation and allows the user to become part of the local driving community in his area, joining forces with other drivers nearby to outsmart traffic, save time and improve everyone's daily commute. Waze uses cell phone data. Thus, a major innovation by TEAM is given by the integration and exploitation of the actual vehicle data.

The Nokia "Driving Miss Daisy" app already exploits distributed web-services, also including car data, but the TEAM application will make a much more extensive use of vehicle signals and try to devise vehicle-independent assessment techniques, so to the evaluate the real capabilities of the driver, independent of the actual driven car. The black box solutions recently appeared for driver profiling are very interesting and we will develop a similar approach but for real time analysis and feedback for the driver in a pleasant human interaction environment such as gaming, with the added value of real-time coaching.

Information from the TEAM gaming application may be integrated in existing social networks, such as Facebook as well, for instance by providing for each user an icon showing his driving status or profile.

Finally, a major innovation consists in the virtuous cycle, which intends to incentivize a proper use of the other "elastic mobility" TEAM applications (e.g., collaborative parking, collaborative navigation, etc.) through a comprehensive, gamified social mobility environment.

1.2.4.3 Guidelines for TEAM

Given the games' growing popularity, the idea has emerged of gamifying systems in order to improve the user performance. However, while there are established methods for designing games, design of gameful systems is still not well explored nor motivated nor formalized. Moreover, empirical data about actual effectiveness are not yet available [SG32]. Thus, design of the TEAM serious game and community building system will have to consider a variety of factors trying to empirically achieve a solution able to meet the requirements of users and stakeholders.

The system will need to consider all the TEAM applications that will input values about the user performance and will receive virtual coins (or similar) to be spent. We expect that the overall system architecture will need to aggregate several modules, including:

- A user/friendship management system (for which state of the art open source solutions may be integrated and adapted, such as ELGG [SG33])
- A credibility management system (for which the ITS 2.0 solution by the Telecom Italia TEAM partner could be a proper starting point)
- A user profiling and assessment module able to quantitatively assess in real-time the driver performance, with respect to some particular targets, such as green and safe driving. There are modules already developed for this, that will need to be improved for a real-time performance and considering the differences among the different vehicles.
- A driver coaching module able to give the driver formative feedback in real-time about his performance, which is a new module, to be developed from scratch.
- A mapping system able to aggregate and manage highly dynamic information layers. For this, the TEAM map module (Nokia/Navteq will be fundamental)
- A collaboration management system for managing collaboration.
- An appealing Human-Machine Interaction consistent with the other TEAM applications.
- The actual serious game logic and modules.

1.2.5 Privacy and Security in ITS

Ensuring privacy and security is of high importance for acceptance and success of new technologies. The main focus in this area is not only to enhance security and privacy solution, but rather to adapt innovations that will be achieved in TEAM and maintain a high level of privacy and security for all kinds of ITS communications.

1.2.5.1 State of the art

Securing communications and preserving the privacy of users has always been a major topic in communications systems. Three primary services are the essential: authentication, integrity and confidentiality. Those refer to security as well to privacy protection and offer basic separation of concerns into the categories of identification of entities, clearance for information modification and access to data. Neither of them can be achieved alone. ITS communication utilises wireless communication links. Therefore it is more exposed to security and privacy threats than conventional wired communications. Furthermore, due to the Adhoc nature of the system, principles from the cellular communications worlds are not directly applicable. Introducing additional communications technologies, e.g. LTE, besides the core technology ITS-G5A, will raise complexity as well. This leads to a multimodal environment, where every possible communications link offers different embedded capabilities and resulting threats and vulnerabilities. Cellular based channels originated in the mobile telephony sector already offer mobile-to-base encrypted communications [PS5]. On the other hand, ITS-G5A based ad-hoc channels are broadcast and unencrypted. A comprehensive approach is required to incorporate those different properties into a generic model. Key factors are the separation into different security and privacy-preserving categories. Those are systems security, communications security and location privacy protection. Each of them targets a special scope. This way it is possible to sort out a lot of cross-scope issues. While the single systems security is the anchor for the communications security between some black boxes, location privacy protection is a basic principle. Storing and processing of location data in a decentralised way or in cloud-based systems seriously affects the privacy of all users. Research projects and standardisation bodies have done some progress on defining the security and privacy baseline for ITS communications. However, they are almost always designed very specific for their special purpose. Even the standards follow this approach and set a limited scope for their applicability. Important contributions to the field are

- the PRE-DRIVE C2X security architecture document [PS1],
- the Threat, Vulnerability and Risk Analysis of ETSI [PS2], and
- the IEEE 1609.2-2006 ITS security standard [PS3].

[PS1] outlines the principle security architecture for ITS-G5A based communications systems without taking special use-cases and applications into account. [PS2] lists threats, vulnerabilities and risks for an ITS-G5A based communications system without GeoNetworking capabilities. Finally [PS3] is an implementation near description of security services and protocols used in the US-American IEEE 1609 stack. The environment for it is therefore different compared to the European systems, but it is very advanced in terms of concrete applicable measures.

In summary, the common state of the art in secure ITS communications consists of:

- Establish a closed user group by providing authentication certificates to valid communication nodes

- Assign authorisation through attributes within the certificates
- Sign and verify all traffic on network layer
- Perform plausibility checks
- Enable privacy protection by frequently changeable pseudonymous certificates

1.2.5.2 Proposed progress beyond state of the art

Current security solutions focus on dedicated communication technologies. For optimal integration of different underlying communication modes (e.g. 802.11p, 2G/3G/LTE, Wi-Fi), an integrated security and privacy protection solution is required. Thus, TEAM will provide a multimodal security solution for ITS, based on recent findings for singular communication technology modes. Moreover, it will integrate different public key infrastructure (PKI) solutions for cross-certification, employing a trust hierarchy for ITS. Furthermore, TEAM will work on adaptive verification strategies which allow a balanced processing effort on bounded devices.

1.2.5.3 Guidelines for TEAM

Starting from the conceptual and technological results of the projects PRE-DRIVE C2X and DRIVE C2X, TEAM will enhance existing security solutions and adapt new requirements resulting from the technological progress in TEAM. While the following objective 1 summarizes the mandatory targets, objective 2 is optional and may be refined during the project.

Objective 1: Preserve security and privacy achievements

State of the art solutions for ITS communications security define a certain level of security and privacy on V2X communications. New communication channels (i.e. LTE) and technologies (i.e. LDM++) introduced with TEAM shall not comprise an excuse to unbend any security goals. In particular, we will define measures to ensure at least that:

- Data integrity and authenticity of incoming and outgoing ITS messages are assured independently from the communication channel.
- Privacy of ITS nodes is protected, not only in ad-hoc communications, but also in backend services and cloud-based technologies.
- Data security and confidentiality is guaranteed for sensitive data, services that are available on payment etc.

Objective 2: Enhance security solutions

The progress on communication technologies targeted in TEAM, may result in new requirements on the existing security solutions. Additionally, the TEAM consortium may decide to improve the state of the art solutions. Potential enhancements may possibly include

- integration of different PKI solutions for cross-certification,
- adaptive verification strategies that allow a balanced processing effort on bounded devices,
- or any other requirement that emerges during project progress.

Technological approach

Considering objective 1, the technological approach must comprise the following steps:

- Review of existing state of the art solutions, e.g. [PS2, PS4]; per network technology, per application etc.
- Identification of threats and the relevant security measures that are most important in the context of TEAM – possibly including a mapping between the TEAM applications and the corresponding security threats and measures that are applicable to each of them.
- Decision upon the adoption of specific security measures that will be implemented in TEAM or/and in future services/deployments.
- Decision upon the development beyond the SoA/ further extension of specific security measures for ITS services and communications.

and must address the following technical aspects:

- Attaching digital signatures and verification of messages independent from the communication channel and entity, e.g. vehicle or (backend) infrastructure.
- Privacy preserving measures, such as changing pseudonyms on individual nodes as well as backend services, especially regarding personal and location data stored in cloud services.
- Encryption of personal and confidential unicast messages.
- Public key infrastructures, employing a trust hierarchy and deploying certificates.
- Integration of existing security mechanisms (e.g. LTE encryption).

1.2.6 Conclusions on the state of the art analysis

At the beginning of the project, SP2 partners agreed in defining working teams for attacking five thematic areas, namely: Communication technologies, Dynamic maps, Positioning, Privacy and security and gamification and community building.

In the communication area, TEAM applications will rely on both short-range (ETSI ITS-G5 based on IEEE 802.11p) and long-range (UMTS and LTE) wireless communication technologies. TEAM will investigate in particular issues related to LTE adaptation (e.g., for sending information to a target geographic area), 3GPP enhancements (e.g., to achieve lower latency and higher scalability), combination of LTE, 802.11p and geonetworking, the effect of communication delays on distributed algorithms.

In the mapping area, key issues will need to be faced in to support the new TEAM applications, providing a significant advancement over the state of the art. First, the sheer volume of data has to be addressed, achieving efficiency and real-time performance. Other factors include: the effect of computational delay, the ability of infrastructure and mobile agents to aggregate information via communications, the choice of distributed vs. centralised communications, and the effect of fleet composition and density of instrumented vehicles, on applications. Vehicular application specific QoS issues (in particular robustness with respect to communication failure) will have to be addressed for the functioning of the TEAM applications in the cloud.

Positioning technologies are commonly used, in particular for navigation. However, the receivers still lack precision for addressing issues typical of new generation applications (e.g., lane-level positioning). The TEAM improvements will focus in particular on exploiting GPS raw data exchange between vehicles and infrastructure, and on guaranteeing readiness and a seamless integration when the Galileo system becomes available.

Gamification and community building solutions look promising in engaging users in performance improvement and collaboration activities. There are already some applications for user profiling (in particular for insurances and commercial fleet management) and for social sharing of travel-related data (e.g., Waze). TEAM will contribute to advance the state of the art by developing a mobile app able to assess and comment on the driver performance in realtime, also supporting virtuous competitions, and by developing an interactive collaborative map where travellers will be able to share various kinds of information, in particular coming from the vehicle. Driver coaching on the collaboration aspects of the TEAM cooperative applications will be another key innovation.

Privacy and security are a great concern for large scale public applications largely relying on exchange of sensitive data. TEAM will devise an integrated security and privacy protection solution for ITS, based on recent findings for singular communication technology modes. The solution will integrate different PKI solutions for cross-certification, employing a trust hierarchy for ITS. Furthermore, TEAM will work on adaptive verification strategies which allow a balanced processing effort on limited-resource devices.

1.3 TEAM main technologies

In the following sections the main technologies to be developed in TEAM will be detailed with use cases. Each TECH group listed and described a set of use cases based on the applications to be developed in the sub-projects FLEX and DIALOGUE. These use cases took also into consideration the main focus for TEAM and the guidelines described in the State of the Art survey.

1.3.1 TEAM TECH Group Positioning

There are a lot of high priced GPS positioning solutions available on the market providing a very accurate positioning precision. One of the goals of the cooperative positioning is to use low-cost GPS hardware and improve the positioning precision with the information that is available via car-to-car communication.

The cooperative positioning system consists of two cooperating modules: the cooperative position module and the LDM++ module. This architecture is depicted in Figure 1.6.

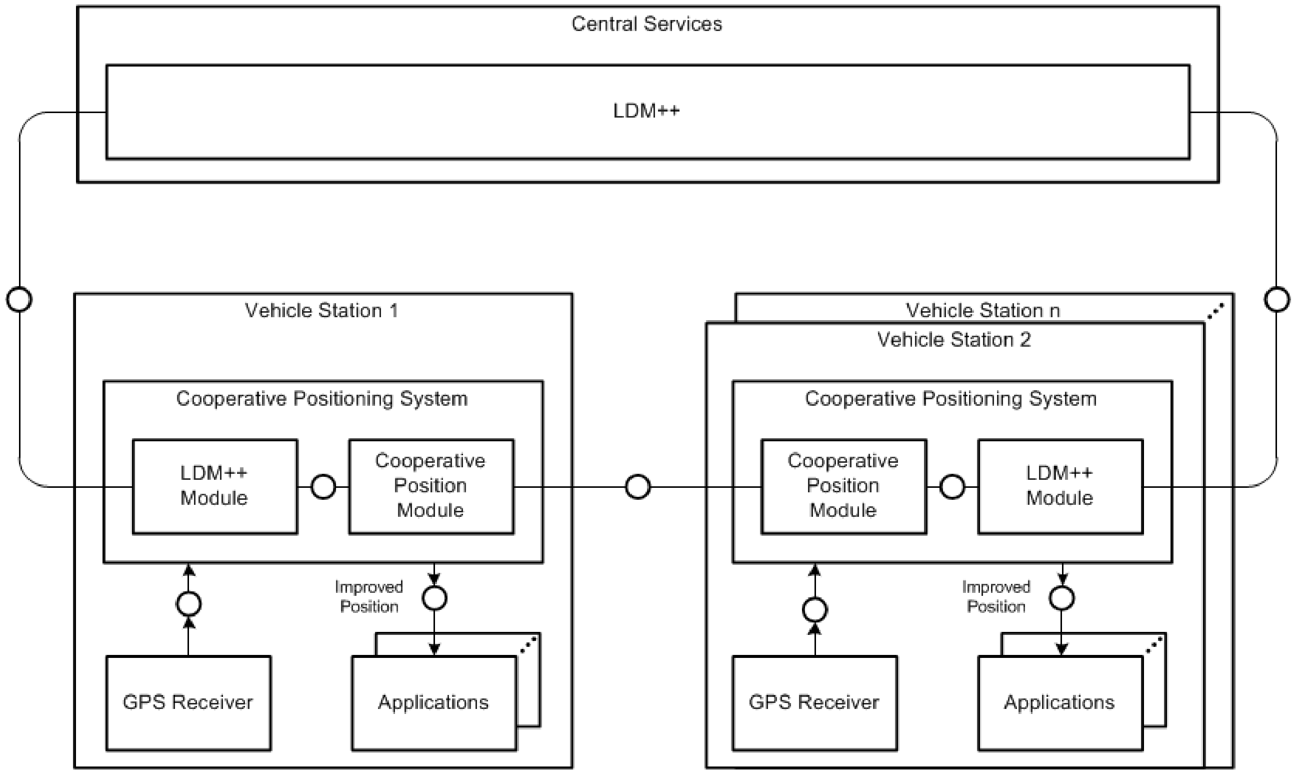

Figure 1.6: Architecture of Cooperative Positioning

The cooperative position module is based on GPS raw data exchange via car-to-car communication. On the local vehicle the GPS receiver provides the ephemeris data from the navigation message that is sent via broadcast from the GPS satellites. This data is needed to calculate the positions of the GPS satellites. The exchanged GPS raw data contains the measurement data (e.g. satellite id, signal strength, pseudorange, etc.) for each satellite in view. The positioning algorithm calculates a relative vector pointing from the GPS antenna position of the local vehicle to the GPS antenna position of the cooperating (remote) vehicle. The cooperative position module provides the relative vector to the LDM++ module. The LDM++ module applies a map-matching algorithm to improve the positioning accuracy. The resulting positioning information is then made available for the applications.

Each vehicle has its own relative coordinate system with the vehicle at the origin. For the evaluation of the cooperative positioning system a GPS reference system is required. The message that is exchanged between the vehicles is called Cooperative Localization Message (CLM). The CLM contains the GPS raw data, and for evaluation purposes it can also contain the data from the GPS reference system. Upon reception of a CLM the local vehicle records the precise absolute positions from both vehicles and the calculated relative vector. The evaluation can be done by adding the relative vector to the absolute GPS position from the reference system. The resulting position shall match with the absolute position of the cooperating (remote) vehicle. At this point the accuracy of the system can be estimated by comparing the estimated absolute position of the remote vehicle with its accurate position.

The GPS raw data antenna and the GPS antenna of the reference system cannot be placed on the same position on the vehicle. Therefore a translation vector is needed to perform a coordinate transformation to map the absolute GPS position of the reference system to the antenna position of the cooperative positioning system. This translation vector is also included in the CLM. The transformation has to be done for both vehicles in order to obtain the precise origin and pointing position of the relative vector. The relative and translation vectors are shown in Figure 1.7.

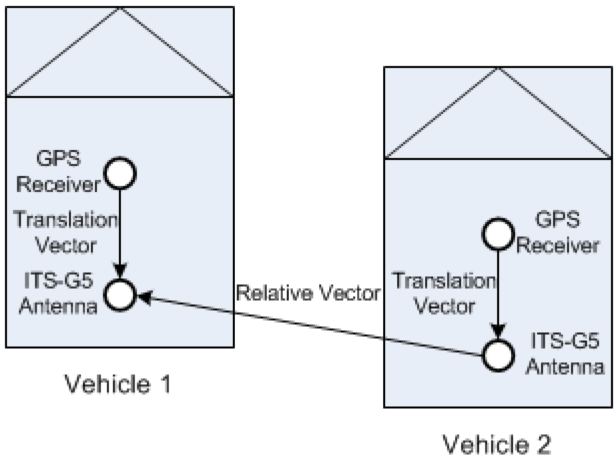

Figure 1.7: Relative and Translation Vectors

There are three use cases related to the cooperative positioning system.

In the first use case the **infrastructure** is utilized to improve the positioning accuracy. The infrastructure (e.g. traffic light, road sign, etc.) is equipped with a raw data GPS receiver and provides the CLM to the approaching vehicles. The precise GPS antenna position on the infrastructure is well-known so that there is no GPS reference system needed. A possible approach is to calculate the absolute position on the infrastructure and exchange this position information via the CLM. The nearby vehicles can calculate a difference vector between the estimated position and the known antenna position and apply this vector to the local absolute position estimation. This approach improves the absolute position of the moving vehicles.

The second use case describes the cooperative positioning with **mobile units**. Each vehicle equipped with a cooperative positioning system calculates a relative vector to the cooperating vehicles.

The third use case describes an approach that employs **parked vehicles** to improve the positioning accuracy of the mobile vehicles. It is assumed that a parked vehicle calculates its own absolute GPS position and that the estimated position will improve over time. The improved absolute position could be exchanged via the CLM. This use case is similar to the first use case with the exception that the precise absolute position of the parked vehicles has to be estimated. This approach should improve the absolute positions of the moving vehicles.

1.3.1.1 Cooperative Position with infrastructure

Overview

Use case name	Cooperative position with infrastructure
Use case short description	Vehicle approaches an area with an ITS roadside unit (e.g. Traffic light, road sign, etc.) and exchanges GNSS data with the infrastructure to improve its position accuracy and obtain lane level accuracy
Component implementing the use case	Cooperative Positioning
Deployment platforms (vehicle/personal/central/road side)	all
Services provided to higher layers	API with relative and/or absolute position information, depending on availability

External actors and components

Actors' short name	Short explanation
Data provider	Roadside unit
Data consumers	Vehicle
Network provider	Short range communication (802.11p)

Use case system requirements

Geographical target relevance area	Area covered by the roadside unit communication range
Expected communication need	High
Expected processing need	High
Demonstration challenges	Implementation of V2I
Localization precision need	Lane level accuracy

Required functional components

Components short name	Short explanation
Communication (V2V, Mobile network)	Communication is needed between vehicle and roadside unit (V2I)
Storage (on car/smartphone) and backbone	None or minimal
Localization / Positioning	Standard off-the-shelf GPS receiver
Clock	

Objectives

Exchange positioning information from the infrastructure to the vehicle in order to increase the position accuracy and reach at least lane level.

Basic functioning

The roadside unit, for being static in a place, knows its position with much higher accuracy. Consequently it could exchange position information with nearby moving vehicles in order to increase their position accuracy in relation to the roadside unit.

This service could be announced via broadcast by the RSU or queried by the vehicle when it reaches communication range. The positioning data is then exchanged using ITS-G5 communication and the vehicle performs the calculations necessary to improve its position accuracy.

The cooperative positioning consists of two collaborative modules. The cooperative position module provides a relative vector from the GPS antenna position of the local vehicle to the GPS antenna position of the cooperating vehicle. This relative vector is used by the LDM++ module. The calculations performed in the LDM++ module include map-matching. The resulting positioning information is then made available to the applications.

Definition of work

- Implementation of communication and data exchange between infrastructure and vehicle
- Implementation of in-vehicle calculations for increasing position accuracy
- Implementation of map matching for lane positioning
- Implementation of interfaces for positioning information for SP3 and SP4 (applications)

Possible Challenges

- Volume of data necessary.
- Processing power needed to perform the calculations.
- Accuracy of map data for map matching.
- Communication range.
- Distortion of communication.

Comments, additional features

None

1.3.1.2 Cooperative position with mobile units

Overview

Use case name	Cooperative position with mobile units
Use case short description	Vehicle approaches another ITS vehicle and exchanges GNSS data to improve both vehicle's position accuracy
Component implementing the use case	Cooperative Positioning
Deployment platforms (vehicle/personal/central/road side)	all
Services provided to higher layers	API with relative and/or absolute position information, depending on availability

External actors and components

Actors' short name	Short explanation
Data provider	Vehicles
Data consumers	Vehicles
Network provider	Short range communication (802.11p)

Use case system requirements

Geographical target relevance	Area covered by vehicle units communication range

area	
Expected communication need	High
Expected processing need	High
Demonstration challenges	Implementation of V2V
Localization precision need	

Required functional components

Components short name	Short explanation
Communication (V2V, Mobile network)	Communication is needed between the two vehicles (V2V)
Storage (on car/smartphone) and backbone	None or minimal
Localization / Positioning	Standard off-the-shelf GPS receiver
Clock	

Objectives

- Exchange positioning information between two vehicles in order to increase the position accuracy.

Basic functioning

- Vehicles exchange position information in order to increase their position accuracy.
- This service could be announced by broadcast or queried when the units reach communication range. The positioning data is then exchanged using ITS-G5 communication and the vehicles perform the calculations necessary to improve their position accuracy.
- The cooperative positioning consists of two collaborative modules. The cooperative position module provides a relative vector from the GPS antenna position of the local vehicle to the GPS

antenna position of the cooperating vehicle. This relative vector is used by the LDM++ module. The calculations performed in the LDM++ module include map-matching. The resulting positioning information is then made available to the applications.

Definition of work

- Implementation of communication and data exchange between the two vehicles
- Implementation of in vehicle calculations for increasing position accuracy
- Implementation of map matching for lane positioning
- Implementation of interfaces for positioning information for SP3 and SP4 (applications)

Possible Challenges

- Volume of data necessary.
- Processing power needed to perform the calculations.
- Accuracy of map data for map matching.
- Communication range.
- Distortion of communication.

Comments, additional features

None

1.3.1.3 Cooperative position with parked vehicles

Overview

Use case name	Cooperative position with parked vehicles
Use case short description	Using parked vehicles to improve positioning

Component implementing the use case	Cooperative Positioning
Deployment platforms (vehicle/personal/central/road side)	all
Services provided to higher layers	API with relative and/or absolute position information, depending on availability

External actors and components

Actors' short name	Short explanation
Data provider	Vehicles
Data consumers	Vehicles
Network provider	Short range communication (802.11p)

Use case system requirements

Geographical target relevance area	Area covered by vehicle units communication range
Expected communication need	Low
Expected processing need	Low
Demonstration challenges	Implementation of V2V
Localization precision need	

Required functional components

Components short name	Short explanation
Communication (V2V, Mobile network)	Communication is needed between the two vehicles (V2V)

Storage (on car/smartphone) and backbone	None or minimal
Localization / Positioning	Standard off-the-shelf GPS receiver
Clock	

Objectives

- Use parked vehicles as beacons to improve positioning of moving vehicles.

Basic functioning

- Parked vehicles know their position accurately. Use this information to anchor moving vehicles.

Definition of work

- Implementation of communication and data exchange between the two vehicles
- Implementation of in vehicle calculations for increasing position accuracy

Possible Challenges

- Volume of data necessary.
- Processing power needed to perform the calculations.
- Accuracy of map data for map matching.
- Communication range.
- Distortion of communication
- Low number of vehicles.
- Energy consumption.

Comments, additional features

None

1.3.2 TEAM TECH Group LDM++ and Automotive Cloud

As described in Section 1.2.2, the LDM++ utilizes the inner structure of the Local Dynamic Map (LDM). This concept will be enhanced with a distributed layered architecture with a map as a basic reference layer.

The following use cases describe the structural organization of data for the LDM++:

- *Storage*: TEAM applications and services are also deployed on personal devices and vehicles. In order to provide a similar concept like the LDM for these devices, a local stub of the LDM++ will be deployed on each device. These stubs are either fully functional or only provide interfaces to a LDM++ instance deployed on a central infrastructure. This implementation will be transparent to the using application or user. In both cases, the LDM++ will also provide a storage space to save data locally.
- *Layered Information*: Data is allocated to different information layers. These layers can have a different scope or time horizon and can also implement different services depending on the type of information for this layer.
- *Annotations*: Almost all data stored in the LDM++ will be referenced to a known location on map. Therefore the LDM++ will also provide map matching facilities. This map matching will also be used to identify real world objects and their representation on a map.
- *Map Matching*: For data which a standard or defined data format is not yet available for, the LDM++ will also be able to store free texts or annotations to objects.

Applications and users will not only use existing data, but will also collect new or modify existing data. The following use cases describe possibilities to modify local data and also distribute updated data to central instances of the LDM++ or near-by LDM++ stubs.

- *Synchronization*: Data which are updated on one device need to be synchronized with other devices in storage and bandwidth efficient way.
- *Broadcasting*: Depending on the type of information, data from the LDM++ may be useful for all devices nearby. Instead of addressed each single device in range, data could be broadcasted within a limited range

- *Push Data*: LDM++ data get constantly updated. Push Data Notifications are a service for users and applications to get notified when there is new data of interest without needing to synchronize their whole data storage all the time.

Two of the most standard functionalities of a map will also be provided by the LDM++ component:

- *Map Rendering*: Visualization is required in order to allow a user to understand stored data. The visualization will be done as part of a HMI component and according to the HMI guidelines in TEAM.
- *Simple Routing*: While applications may implement a routing algorithm with special objectives, the LDM++ will implement a very basic routing on a single layer.

1.3.2.1 Provide Storage for geo referenced data

Overview

Use case name	Geo-referenced data storage
Use case short description	LDM++/AC will provide a synchronized storage for data with geo references
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	all
Services provided to higher layers	Storage API

External actors and components

Actors' short name	Short explanation
Data provider	Components on all deployment platforms

Data consumers	Components on all deployment platforms
Network provider	None required

Use case system requirements

Geographical target relevance area	everywhere
Expected communication need	None
Expected processing need	Medium
Demonstration challenges	None
Localization precision need	None

Required functional components

Components short name	Short explanation
Storage	Holds data for synchronization
Clock	Allows expiration of old data

Objectives

A local storage for fast data access will be provided with each decentralized LDM++/AC stub. This data is annotated with a geo-location.

Basic functioning

Data with information about geo-location and time validity is stored locally. Data is provided by a component, which also provides a geo location stored with the data.

Definition of work

* Design of data storage API

Possible Challenges

* Design API which covers all possible required data access methods
* Space-efficient storage of data

Comments, additional features

None

1.3.2.2 Layered map information

Overview

Use case name	Layered Map Information
Use case short description	LDM++/AC will separate data into different layers
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	all
Services provided to higher layers	layered information with a limited visibility/scope

External actors and components

Actors' short name	Short explanation
Data provider	LDM++/AC stubs, other components and applications
Data consumers	Other components and applications

Network provider	None: data is provided to local components only

Use case system requirements

Geographical target relevance area	all
Expected communication need	Only locally to the vehile/personal device/roadside station
Expected processing need	Medium
Demonstration challenges	None
Localization precision need	Varying, depending on layer

Required functional components

Components short name	Short explanation
Storage	Stores all layer information

Objectives

Due to limitations in bandwidth and processing power on several platforms, the LDM++/AC component shall provide a way to limit the amount and type of data stored and used by other components. This can be accomplished by structuring information into several layers and only using information from relevant layers in processing and transferring.

Basic functioning

Both data providers and data consumers and the LDM++/AC can assign data to an information layer. This layer can be chosen by the type of data (e.g. public transit routes) or type of information the data provides (e.g. safety context, tourist information).

Data of each layer can be accessed by appropriate programming interfaces.

Definition of work

- implement storage layers
- define criteria for layer assignment for unstructured data
- design API for layer based access

Possible Challenges

- Assignment of information to different layers
- Providing information about and access to different layers

Comments, additional features

None

1.3.2.3 Map objects annotations

Overview

Use case name	Map Objects Annotations
Use case short description	Annotate objects stored on LDM++/AC
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	All
Services provided to higher layers	Annotated objects, API

External actors and components

Data provider	LDM++/AC stubs, other components
Data consumers	HMI, other components
Network provider	-

Use case system requirements

Geographical target relevance area	All
Expected communication need	None
Expected processing need	Low
Demonstration challenges	None
Localization precision need	Varying, depending on annotated object

Required functional components

Components short name	Short explanation
Storage	Stores annotations

Objectives

Components and users of LDM++/AC may annotate objects stored on the LDM++/AC. These annotations have more an informational character and are bound to objects and not to fixed geographical positions.

Basic functioning

Components use a defined API to select an object they want to access the annotations of. Annotations can be changed and also searched for.

Definition of work

- Design API for annotation access

Possible Challenges

None

Comments, additional features

None

1.3.2.4 Map matching and geocoding

Overview

Use case name	Map Matching and Geocoding
Use case short description	Points and Addresses can be positioned on the map and matched to road network
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	All
Services provided to higher layers	API

External actors and components

Actors' short name	Short explanation

Data provider	LDM++ storage
Data consumers	all components which utilize map information
Network provider	-

Use case system requirements

Geographical target relevance area	Everywhere
Expected communication need	None/Medium in case map structure data needs to be transfered
Expected processing need	Medium
Demonstration challenges	None
Localization precision need	Varying, depending on the used transport means

Required functional components

Components short name	Short explanation
Storage	Minimum (personal device, vehicle) to large (cloud based)
Communication	Provides data transfer channel

Objectives

Coordinates or Addresses can be matched to the underlying network. Addresses can be converted into Coordinates.

Basic functioning

Different layers can be used for matching (e.g. match to public transit, match to highway only). The map matcher can be configured to accommodate those. This includes a geocoder and reverse geocoder, which calculates a position from a known location and vice versa.

Definition of work

- Determine layers that map matching is needed for
- Define API
- Define format for geo coordinates
- Define system of reference

Possible Challenges

- Requires mapping engine / platform

Comments, additional features

None

1.3.2.5 Automotive cloud data synchronization

Overview

Use case name	Automotive Cloud Data Synchronization
Use case short description	Data is synchronized between local LDM++ storage and automotive cloud
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	all
Services provided to higher layers	Update Notification

External actors and components

Actors' short name	Short explanation
Data provider	LDM++ storage
Data consumers	LDM++ storage
Network provider	Short range communication (802.11p), LTE, wired networks

Use case system requirements

Geographical target relevance area	everywhere
Expected communication need	High
Expected processing need	Medium
Demonstration challenges	None
Localization precision need	None

Required functional components

Components short name	Short explanation
Storage	Minimum (personal device, vehicle) to large (cloud based)
Communication	Provides data transfer channel

Objectives

Data from local data storage and the automotive cloud has to be synchronized.

Basic functioning

On a regular basis, the contents of the local data storage and the automotive cloud are compared to each other and differences are transferred to synchronize both storages.

Definition of work

- Determine differences between local and remote data storage
- Transfer difference data in a bandwidth-efficient way

Possible Challenges

- Compare both data storages with limited processing power
- bandwidth-efficient transfer of data
- conflict resolution when data has been updated on both storages

Comments, additional features

None

1.3.2.6 Local map environment broadcast

Overview

Use case name	Local Map Environment Broadcast
Use case short description	LDM++/AC stubs can broadcast information about their current environment
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	Vehicle, personal, road side

Services provided to higher layers	Information about current environment

External actors and components

Actors' short name	Short explanation
Data provider	LDM++/AC stubs
Data consumers	LDM++/AC stubs on receiving devices
Network provider	V2X communication

Use case system requirements

Geographical target relevance area	All
Expected communication need	Medium to High, depending on amount of data
Expected processing need	Low
Demonstration challenges	None
Localization precision need	Low

Required functional components

Components short name	Short explanation
Communication	Needed to send and receive broadcast messages

Objectives

The LDM++/AC stubs on mobile devices and road side units each have an individual view on the current environment. This view is to be shared with all other devices currently in range.

This updates a local stub and also provides information about nearby TEAM users.

Basic functioning

The local information of a LDM++/AC stub is broadcasted on a regular interval or by request. The information amount and type is limited in respect of available bandwidth and privacy.

Definition of work

- Define subset of information that is broadcasted

Possible Challenges

- How to differentiate two different individual views to send only relevant information

Comments, additional features

None

1.3.2.7 Push data to local LDM++ stub on an event

Overview

Use case name	Event based LDM++ Update
Use case short description	Vehicle enters a particular zone (e.g. a city area). Previously required data is deleted, now relevant data from the city zone is downloaded from the cloud
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	all

Services provided to higher layers	Update Notifications

External actors and components

Actors' short name	Short explanation
Data provider	LDM++ storage
Data consumers	LDM++ storage
Network provider	Short range communication (802.11p), LTE, wired networks

Use case system requirements

Geographical target relevance area	everywhere
Expected communication need	High
Expected processing need	Medium
Demonstration challenges	None
Localization precision need	Varying (area, link, intersection, lane level)

Required functional components

Components short name	Short explanation
Storage	Minimum (personal device, vehicle) to large (cloud based)
Communication	Provides data transfer channel
Localization / Positioning	Is a source for an update triggering event

Objectives

Data from local data storage and the automotive cloud has to be synchronized. This synchronization has to be done once a vehicle or traveller enters or leaves an area which his/her local device has no data for or for which it does not require locally updated data anymore.

Basic functioning

The current position of a traveller is observed on the local devices. Once the traveller reaches a position or will reach such a position with a high enough probability, for which the current map storage has no data, synchronization is started (geo-location event based synchronization).

Synchronization is also triggered once a traveller changes his/her means of transport such that his/her local map storage gets updated information about now important traffic data (modus event based synchronization)

Synchronization may also be triggered from the LDM++/automotive cloud due to new data for the current position of the traveller. Therefor a traveller can decide to publish its position and means of transport to the automotive cloud (update event based synchronization)

Definition of work

- Implementation of position observer
- Implementation of modus detection
- Implementation of Push mechanism for updates

Possible Challenges

- Algorithm for means of travel detection
- Data management – potentially a lot of layers and a lot of data
- Performance of bulk addition/removal of objects
- Assignment of information to different layers
- Providing information about and access to different layers

Comments, additional features

None

1.3.2.8 Map rendering

Overview

Use case name	Map Rendering
Use case short description	API to render a map into an HMI graphics display context.
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	Vehicle, Personal, Central
Services provided to higher layers	API, Visualization Runtime Component

External actors and components

Actors' short name	Short explanation
Data provider	LDM++ storage
Data consumers	HMI
Network provider	-

Use case system requirements

Geographical target relevance area	everywhere
Expected communication need	None

Expected processing need	High
Demonstration challenges	Hardware availability as rendering vector data requires integration work on deployment into automotive hardware
Localization precision need	None

Required functional components

Components short name	Short explanation
Storage	Minimum (personal device, vehicle) to large (cloud based)
Communication	None

Objectives

Map is rendered so application can visualize content on it

Basic functioning

Map data is decoded from LDM++, converted into geometrical objects which are rendered on a graphics display.

Definition of work

- Integrate Rendering Backend
- Define API
- Implement runtime

Possible Challenges

- Integration of existing map rendering capabilities that are quite complex
- Performance of graphics hardware

- Application architecture and user interaction architecture needs to be aligned
- Design of an intuitive layouting of map details

Comments, additional features

None

1.3.2.9 Specific layer routing

Overview

Use case name	Specific Layer Routing
Use case short description	Routing within layer boundaries is implemented as core feature of the LDM++/AC
Component implementing the use case	LDM++/AC
Deployment platforms (vehicle/personal/central/road side)	All
Services provided to higher layers	Routing on a specified layer

External actors and components

Actors' short name	Short explanation
Data provider	LDM++/AC storage, routing requests from other components
Data consumers	other components
Network provider	-

Use case system requirements

Geographical target relevance area	all
Expected communication need	None
Expected processing need	High
Demonstration challenges	None
Localization precision need	Varying, road level to bus stop level

Required functional components

Components short name	Short explanation
Storage	Holds all information required for routing
Routing Algorithms Engine	Provides efficient routing algorithm implementations

Objectives

Basic routing on different layers (public transit, roads) has to be implemented.

Basic functioning

A routing request with a start and destination is fulfilled by using routing algorithms on information provided by a layer.

Definition of work

- Implement routing different types of layers

Possible Challenges

- Layers may be structured differently and thus routing algorithms need to be implemented according to layer specifications.

Comments, additional features

None

1.3.3 TEAM TECH Group Security, Privacy, and Reliability

TEAM basic technologies and applications potentially introduce security and privacy threats. It is the task of the TECH Group Security, Privacy, and Reliability to identify these threats and provide adequate countermeasures. Consequently, all security-related use cases are derived directly or indirectly from application use cases or other basic technologies. They follow the single target of preserving the primary security objectives – integrity, authenticity, and confidentiality – as well as privacy.

After analysing the FLEX and DIALOGUE applications and use cases as well as the TEAM basic technologies, we identified four major categories of required security use cases, which are briefly introduced below together with the related security use cases.

Privacy protecting use cases

Privacy protecting use cases cover all technologies and services that handle sensitive user data. This includes location data in V2X communications, confidential transmission of user data to and from backend systems, as well as storage and access to user profiles. Among others, the following use cases are particularly related to privacy threats:

- *User profile data privacy (SP2_SEC_UPDP)* addresses privacy threats that result from a user profile component for gathering user data and behaviour.
- *Preservation of location privacy (SP2_SEC_PLP)* proposes a pseudonymisation of static identifiers in V2X communications in order to prevent traceability of vehicles and users.
- *Prevent pseudonym linkage (SP2_SEC_PPL)* provides mechanisms to avoid depseudonymification of V2X data on backend systems by linking different pseudonyms of the same vehicle to each other.

Protection of V2X communication channels

Protection of V2X communication channels includes both, security of long-range (LTE) as well as short-range (IEEE 802.11p) communications. It covers integrity and authenticity of broadcast communications and additionally confidentiality of unicast communications:

- *Protection of broadcast V2X communication (SP2_SEC_PBVC)* describes threats to the integrity and authenticity of V2X broadcast communications and offers countermeasures.
- *Protection of unicast V2X communication (SP2_SEC_PUVC)* proposes methods to protect unicast V2X communications that has to be usually confidential.
- *Protection of aggregated V2X data (SP2_SEC_PAVD)* addresses the specific problematic of securely aggregating V2X data and providing it back to vehicles in a trusted way.

Protection of local data and systems

Protection of local data and systems comprises use cases for secure storage of data, secure installation of applications, and trust of user reported incidents:

- *Secure storage of local data* (SP2_SEC_SSLD) provides mechanisms to store confidential data locally in a secure manner.
- *Secure installation of TEAM applications* (SP2_SEC_SITA) addresses threats that rise from deployment of TEAM applications and proposes countermeasures, e.g. integrity checks.
- *Safe interconnection with external applications (SP2_SEC_SIEA)* introduces security measures to integrate external services like social media networks safely into the TEAM platform.
- *Trusted incident reporting (SP2_SEC_TIR)* minimises the rist and impact of malicious incident reporting

Derived security use cases

Derived use cases that are required by other security use cases. This category includes use cases for deployment and management (e.g. revocation) of security credentials:

- *Deployment of security credentials (SP2_SEC_DSC)* proposes a system to provide, deploy, and manage (e.g. revoke) security credentials such as different certificates and key pairs as well as revocation lists.

1.3.3.1 User profile data privacy

Overview

Use case name	User Profile Data Privacy
Use case short name	UPDP
Use case identifier	SP2_SEC_UPDP
Use case short description	The user inserts system personal information such as name, surname, contact info, voluntary information, driving style, home address etc., or information regarding the vehicle such as license plate, colour, fuel type, brand, etc. TEAM has to ensure the privacy, confidentiality and non-interception of the data from unauthorized users and applications.
Precondition	TEAM platform saves "personal data".
Postcondition	TEAM platform has to prevent unauthorized access to the above mentioned data. Even though someone manages to "steal" the data, he or she should be unable to read them.
Normal flow	• Driver inserts to the TEAM platform his/her profile such as personal data and voluntary data e.g. favourites POIs, etc. • TEAM saves the data and encrypts it. • TEAM secures the transmission of data.
Deployment platforms (vehicle/smartphone/ backbone)	All platforms.
Expected frequency of use	High.

External actors and components

Actors' short name	Short explanation
TEAM platform	Database of users.

Network Provider	Internet and Mobile network.
Data recipients	All different providers or applications.

Input and Outputs

Input	Personal data of driver.
Output	Cryptographic personal data.

Required functional components

Components short name	Short explanation
TEAM Core System	Responsible for the security of the personal data.
Communication components (LTE, 802.11p)	Communication is needed between user and web applications.
Cryptographic components (SP2)	Responsible for cryptographic techniques.

Objectives

TEAM has to ensure: (a) that only specific applications could access personal data (authentication), (b) personal data should not be modified without permission (integrity) and (c) personal data should not be readable if sniffed (privacy).

User benefits

User's data is safeguarded concerning privacy and confidentiality, user's data is accessed only from authorized users, applications, etc.

Basic functioning

TEAM has to develop methods for the protection of user's personal data and implement procedures that guarantee the safety of personal data. Even if someone manages to gain access to user's data, there should exist auditing mechanisms which could identify the relevant breach of security either internal or external.

Definition of work

- Implementation of solutions and techniques capable to guarantee the protection of the user's personal data.

Possible Challenges

- TEAM has to implement procedures to avoid possibly internal or external violations.
- TEAM has to consider the different security techniques of the communication providers.
- TEAM send the encrypted user data to the server, within specified time threshold; thus, there is the need for efficient and adequate data encryption vs. time limitations.

Comments, additional features

None

1.3.3.2 Preservation of location privacy

Overview

Use case name	Preservation of location privacy
Use case short name	PLP
Use case identifier	SP2_SEC_PLP
Use case short description	Third parties (including any other ITS-station and backend service providers) should not be able to track the location of a vehicle during a longer period of time (i.e. hours or days). Location privacy

	may be provided through pseudonyms instead of static identifiers.
Precondition	Vehicles broadcast their location data frequently to adjacent ITS-stations and backend systems (i.e. automotive cloud). Short-term (i.e. seconds or minutes) location tracking is required for many use cases.
Postcondition	Vehicles are not traceable during a longer period of time.
Normal flow	Privacy based on pseudonyms: • All public identifiers are exchangeable. • All components using public identifiers register for pseudonym change notifications. • Pseudonym changes are triggered in regular intervals. • On a pseudonym change, registered components are notified and change their public identifiers immediately. • During critical situations components might disable pseudonym changes and freeze the current pseudonym.
Deployment platforms (vehicle/smartphone/ backbone)	This use case affects all vehicle components that publish any static identifiers as well as all backbone components that store any static vehicle identifiers.
Expected frequency of use	Pseudonym changes will only occur in larger intervals, e.g. every 30 minutes.

External actors and components

Actors' short name	Short explanation
V2X data provider	ITS-station/vehicle broadcasting location data
V2X data consumers	Receiving adjacent ITS-stations
Backend service provider	Provider of the backend infrastructure and services for the automotive cloud

Input and Outputs

Input	Registration for pseudonym changes
Output	Pseudonym change notifications

Required functional components

Components short name	Short explanation
none	

Objectives

Anonymise the identity of vehicle in order to preserve the location privacy of drivers and passengers. For short periods (i.e. a few seconds or minutes) location tracking of adjacent vehicles is required by many use cases. But tracking over longer periods (i.e. hours or even days) is never necessary and harms seriously privacy drivers and passengers. As location data is considered to be personal data, this might even be a legal issue.

User benefits

Privacy of users is preserved.

Basic functioning

In regular intervals (e.g. every 30 minutes) all public identifiers of an ITS-station/vehicle should be changed.

In-vehicle: The TEAM in-vehicle security module triggers the pseudonym change. Pseudonyms might be derived from certificates, which are used for other security purposes. All components publishing any static identifiers to any external party (V2X or backend) must be notified and change all identifiers.

Backend: Backend services are not allowed to link different identities of a single vehicle, e.g. by position tracking. If they are aware of any static vehicle identifiers, they must anonymise these.

Definition of work

- Implementation of interfaces for applications in order to register for pseudonym change notifications and to freeze a pseudonym.
- Implementation of pseudonym change mechanisms.

Possible Challenges

- Issues with applications which rely on tracking or static vehicle identities
- Components or backend services that wrongly stick to static identifiers

Comments, additional features

- Proper anonymisation/pseudonymisation on backend services must be verified and possibly enforced.

1.3.3.3 Prevent pseudonym linkage

Overview

Use case name	Prevent pseudonym linkage
Use case short name	PPL
Use case identifier	SP2_SEC_PPL
Use case short description	Aggregating large sets of V2X data on backend services might allow to link different pseudonyms of a single vehicle, e.g. by following the geographical trace. Countermeasures to avoid this linkage will be applied either on the backend service or directly on the vehicle.

Precondition	V2X data is pseudonymised according to SP2_SEC_PLP.
Postcondition	It is not possible to link different pseudonyms of a single vehicle within aggregated V2X data sets.
Normal flow	Option 1: minimise data sets ● Keep the data set minimal (e.g. by not storing V2X data, but using only "live" data) Option 2: silence gaps ● After pseudonym changes aggregation of data is suspended for an adequate period of time. ● This prevents geographic linkage of pseudonyms. Option 3: collaborative pseudonym changes ● Change pseudonyms of multiple vehicles at the same time in certain situations, e.g. at crossroads or traffic lights. ● Requires additional use of silence gaps or (temporally) reduced location accuracy.
Deployment platforms (vehicle/smartphone/ backbone)	Vehicle and/or backend services that aggregate V2X data.
Expected frequency of use	Low. This is limited to pseudonym changes.

External actors and components

Actors' short name	Short explanation
V2X data provider	ITS-station/vehicle broadcasting location data
V2X data aggregator	Backend service that collects and possibly stores V2X data

Input and Outputs

Input	None
Output	None

Required functional components

Components short name	Short explanation
none	

Objectives

Do not allow V2X data aggregating backend systems to bypass privacy enhancing measures.

User benefits

Privacy of users is preserved also on backend systems.

Basic functioning

Apply countermeasures on backend systems (V2X data aggregator) and/or vehicles (V2X data provider) to prevent linkage of pseudonyms. These might be:

- Minimisation of data sets
- Silence gaps
- Collaborative pseudonym sets

Definition of work

- Select the best option depending on how data is aggregated
- Specify algorithms that for that option.
- Implement these algorithms.

Possible Challenges

- This use case gives only first ideas on how to prevent pseudonym linkage. Depending on the actual implementation, this use case might be conflicting with LDM++ based application use cases, since it may temporally restrict accuracy or availability of floating car data

Comments, additional features

None

1.3.3.4 Protection of broadcast V2X communication

Overview

Use case name	Protection of broadcast V2X communication
Use case short name	PBVC
Use case identifier	SP2_SEC_PBVC
Use case short description	Validate integrity and authenticity of incoming V2X broadcast messages on all deployment platforms.
Precondition	Many use cases rely on incoming V2X data, trusting in the authenticity and integrity of the data and its originator. Third parties could possibly inject manipulated V2X data to influence TEAM applications to their advantage.
Postcondition	Recipients of V2X data (including vehicles, road side units, smartphones, and backend systems) are able to validate and possibly discard manipulated data.
Normal flow	All V2X communication participants are equipped with certificates that are signed by a trusted authority. Outgoing V2X data is signed, signature and signed certificates are attached Each receiver may verify the integrity of the data (through the

	signature) and the authenticity of the originator (through the signed certificate). Alternative approach: Secure end-to-end stream V2X data that is streamed from a backend provider (i.e. automotive cloud) may alternatively be sent through a trusted channel, e.g. end-to-end encrypted channel with initial authenticity check.
Deployment platforms (vehicle/smartphone/backbone)	Each deployment platforms that receives or sends V2X data, i.e. all platforms.
Expected frequency of use	Very high, on each time V2X data is sent or received.

External actors and components

Actors' short name	Short explanation
Originator	Sender of V2X data is obliged to provide information (i.e. signatures and certificates) to proof its authenticity and integrity of the data.
Recipient	Receiver of V2X data might verify received data using the attached signatures and certificates.

Input and Outputs

Input	V2X data, signature, originator certificate
Output	Decision on data integrity and originator's authenticity, which may lead to further steps (e.g. discard data on negative verification result)

Required functional components

Components short name	Short explanation
Communication components	On sender side, signatures and certificates must be attached

(LTE, 802.11p)	to message headers. On receiver side, messages must be verified and verification results must be considered for further processing (e.g. drop message on negative result).
Security components (SP2)	Provides security operations, e.g. signing, verification, and possibly encryption/decryption are required. Stores key material and certificates.

Objectives

Achieve security targets of data integrity and authenticity.

User benefits

Preserve secure and reliable platform that allows users to trust on.

Basic functioning

The state of the art approach relies on a public key infrastructure and involves signing outgoing messages as well as verifying incoming messages based on cryptographic signature algorithms, e.g. ECDSA.

In TEAM we might add an alternative approach for backend communication, which is based on trusted end-to-end channels. This might be an secured channel between vehicle and automotive cloud, which ensures data integrity and authenticity if the authenticity of communication partners is verified during connection establishment. All V2X data traversing this channel is considered to be trusted, so that signing and verifying is not required.

Definition of work

- Design and implementation of security components
- Definition of interfaces between security components and network layer
- Integration into network layers on each deployment platform

Possible Challenges

- Integration into multiple different platforms might be costly in terms of time and error-proneness.
- Cryptographic operations might require too much resources (CPU time) for individual platforms.

Comments, additional features

None

1.3.3.5 Protection of unicast V2X communication

Overview

Use case name	Protection of unicast V2X communication
Use case short name	PUVC
Use case identifier	SP2_SEC_PUVC
Use case short description	Guarantee confidentiality of unicast V2X communications, e.g. between vehicles and backend systems. To protect data confidentiality this kind of communication should generally be encrypted between the endpoints.
Precondition	Communication between vehicles and backend systems might be confidential. (This does usually only include unicast communications rather than V2X broadcast communications.)
Postcondition	End-to-end encryption of unicast V2X communication channels preserves confidentiality of user data.
Normal flow	Use end-to-end encryption for each unicast communication, where confidential user data might be involved
Deployment platforms	All

(vehicle/smartphone/ backbone)	
Expected frequency of use	High

External actors and components

Actors' short name	Short explanation
None	

Input and Outputs

Input	Confidential data to be encrypted
Output	Decrypted confidential data

Required functional components

Components short name	Short explanation
LDM++ with cloud	Ensure encryption of confidential communication links.
Vehicle data or phone data provider	Ensure encryption of confidential communication links.
Communication components (LTE, 802.11p)	Ensure encryption of confidential communication links.

Objectives

Preserve security target confidentiality.

User benefits

Keep confidential use data secret.

Basic functioning

- Use common encryption technologies wherever applicable, e.g. https for Web services.

Definition of work

- Identify communication links to protect.
- Use a common encryption technology.

Possible Challenges

- Overlooked communication links.
- Weak hardware

Comments, additional features

There will most probably be no dedicated security software components for this use case, since there are already a lot of common encryption technologies available, which might easily be integrated into the software components, which actually do the communication.

1.3.3.6 Protection of aggregated V2X data

Overview

Use case name	Protection of aggregated V2X data
Use case short name	PAVD
Use case identifier	SP2_SEC_PAVD
Use case short	An ITS node must be able to check the integrity and authenticity of all incoming V2X data, also if this data is provided by aggregating

description	backend services.
Precondition	V2X data is aggregated and distrusted again by backend services.
Postcondition	Vehicles have the ability to check the integrity and authenticity of aggregated V2X data and its providing backend service.
Normal flow	• Incoming V2X data must be verified by backend services, before it is processed further. • Integrity of stored V2X data must be ensured or verified again on further processing. • During redistribution of aggregated data, the receiver (i.e. a vehicle or another backend service) must be able to verify the integrity and authenticity of the aggregated data and its providing backend service, e.g. by verifying the digitally signed data and/or distributing is through a secured channel, e.g. https.
Deployment platforms (vehicle/smartphone/ backbone)	Vehicle (V2X data provider) and backend (V2X data aggregator).
Expected frequency of use	Very high, continuously during the whole process of aggregation and redistribution.

External actors and components

Actors' short name	Short explanation
V2X data provider	ITS-station/vehicle broadcasting location data
V2X data aggregator	Backend service that collects and possibly stores V2X data

Input and Outputs

Input	V2X data, aggregated V2X data
Output	Trusted (aggregated) V2X data

Required functional components

Components short name	Short explanation
none	

Objectives

Ensure integrity and authenticity of aggregated V2X data to the same extend as locally broadcasted V2X data.

User benefits

Security of the system is enhanced.

Basic functioning

Digital signatures and confidential communication channels as well as secure storages (i.e. encrypted) protect the integrity and authenticity of (aggregated) V2X data on transmission to and from backend systems as well as during storage.

Definition of work

- Define storage solution, e.g. encryption
- Define security measure for redistribution, e.g. encrypted channel and/or signed data
- Implement solutions
- Apply security measures on all deployment platforms

Possible Challenges

- The large number of involved components and communication channels increases the possible threats.

Comments, additional features

None

1.3.3.7 Secure storage of local data

Overview

Use case name	Secure storage of local data
Use case short name	SSLD
Use case identifier	SP2_SEC_SSLD
Use case short description	Unauthorised users should not access private data that are stored in TEAM system.
Precondition	The TEAM system stores user-specific private data.
Postcondition	The TEAM system shall not allow unauthorised users to access private data and shall store the private data in a format that is not readable by unauthorised users.
Normal flow	User/application request for private user data. System asks for a combination of user name and password. (a) Validation of user credentials as incorrect; access is denied. (b) Alternatively, unauthorised user access private data files using correct credentials. Unauthorised user is unable to copy local files or unable to read them because of their encryption.
Deployment platforms (vehicle/smartphone/backbone)	Backbone (Automotive Cloud server)
Expected frequency of use	High

External actors and components

Actors' short name	Short explanation
Data provider	Internal data only (TEAM User Profiles database)
Data consumers	e.g. drivers, travellers, traffic management centres
Network provider	Mobile network, internet

Input and Outputs

Input	Any request for access to private local data.
Output	An access blocking message in case of improper credentials or use.

Required functional components

Components short name	Short explanation
LDM++ with cloud	Needed if private local data are stored in automotive cloud.
Vehicle data or phone data provider	No need.
Communication components (LTE, 802.11p)	Communication is needed between user and automotive cloud; otherwise the use case is meaningless.
User profile	User relevant information needed to ensure authorisation to access private data,

Other SP2 component	Interface with the user.
Components from SP3 or SP4	No need.

Objectives

The TEAM system should ensure that stored private user data are immune from external unauthorised access. Even in the case that private data files are accessed; they should be encrypted so as to become unreadable.

User benefits

Secure storage of private user data and immunity to improper use is of high priority for user acceptance of the TEAM application.

Basic functioning

Every user private data record to the TEAM system database should be encrypted.

Any private data request from authorised applications and/or users should be authenticated and limited.

Definition of work

- Implementation of solutions and technologies for suitable data encryption and application/users verification approaches.

Possible Challenges

- Application and/or communication providers could have their own different security algorithms and requirements.

Comments, additional features

None

1.3.3.8 Secure installation of TEAM applications

Overview

Use case name	Secure installation of TEAM applications
Use case short name	SITA
Use case identifier	SP2_SEC_SITA
Use case short description	TEAM platform should be able to check the integrity of an application (digital signature etc.). Then TEAM has to authorize the application, verify it and install it.
Precondition	TEAM platform should allow installation of applications on their environment.
Postcondition	TEAM platform shall not allow installation of unauthorized applications and the exchange of personal data.
Normal flow	• User tries to install an application • TEAM system checks and decides the authorization of the application. • TEAM system checks the authenticity of the application. • The application is installed.
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone, Third party applications.
Expected frequency of use	High - Users often want to have their favourite applications in different platforms.

External actors and components

Actors' short name	Short explanation
Network Provider	Internet and Mobile network e.g. downloading of the application.
External device	User could insert an external device with the installation file of the application.
TEAM platform	Responsible for the application installation.

Input and Outputs

Input	Installation files of the application.
Output	Installed application.

Required functional components

Components short name	Short explanation
Communication components (LTE, 802.11p)	Communication is needed between user and web applications.
TEAM Core System	Responsible for the installation of an application and the connections between TEAM platform and the application.

Objectives

TEAM system through appropriate methods has to ensure the integrity of the installed applications. It includes verification that application code has not been tampered with since its publication. Application source should also be known and authorised.

User benefits

A TEAM user can securely install authorised application in their devices. The security operations during applications installation make the users' feeling safe and increase their trust in TEAM.

Basic functioning

User downloads and installs an application. TEAM security module decides if the desired application is secure for installation on the TEAM platform and informs the user.

Definition of work

- Implementation of solutions and techniques capable to guarantee the protection of the above mentioned security objectives.

Possible Challenges

- TEAM has to check for possible viruses, trojan horses, malware and other type of malicious software.
- TEAM has to consider that installed applications could have their own different security mechanisms.

Comments, additional features

None

1.3.3.9 Safe interconnection with external applications

Overview

Use case name	Safe Interconnection with External Applications
Use case short name	SIEA
Use case identifier	SP2_SEC_SIEA
Use case short description	A TEAM user could be able to safely connect via the TEAM platform with social media and any other WEB 2.0 applications.

Precondition	TEAM gives access of user's information to external WEB 2.0 applications e.g. driver share his location, his thoughts, photos and videos, etc.
Postcondition	The TEAM system shall not allow unauthorized interception of transmissions between TEAM and WEB 2.0 environments.
Normal flow	• User asks connection with external application. • External application is connected with TEAM. • TEAM checks the authenticity of application and integrity of data transmission. • The connection between platform TEAM and application is successful.
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/vehicle-API, backbone (traffic management centre), third party (web applications).
Expected frequency of use	Low

External actors and components

Actors' short name	Short explanation
Driver	Provide input on the desired applications.
Network Provider	Internet and Mobile network.
External Application	Processes the data.

Input and Outputs

Input	Desired data from the user.
Output	Desired data from the user; information regarding traffic, location, etc.

Required functional components

Components short name	Short explanation
Vehicle data	User provides the location or other data regarding vehicle.
Communication components (LTE, 802.11p)	Communication is needed between user and web applications.
User profile	Data regarding the driver such as sex, age, etc.
TEAM platform	User wants to share information regarding traffic jams, dangerous spots, etc.

Objectives

TEAM has to ensure the authenticity of any external interconnected application and the integrity of transmitted data,

User benefits

Safe interconnection of external social media application apart for serving relevant TEAM applications may increase users' approval and may advertise the interconnected TEAM application itself, as well.

Basic functioning

- TEAM has to ensure the privacy, integrity and confidentiality of transmitted data via external applications.

Definition of work

- Implementation of solutions and techniques capable to guarantee the safe interconnection and exchange of data with external applications if required.

Possible Challenges

- TEAM has to conform with the external applications data format and security requirements.

Comments, additional features

None

1.3.3.10 Deployment of security credentials

Overview

Use case name	Deployment of security credentials
Use case short name	DSC
Use case identifier	SP2_SEC_DSC
Use case short description	Crypto algorithms may rely on certificates and/or key material that must be deployed (and possibly revoked later) to vehicles and infrastructure.
Precondition	Many of the security-related use cases will most probably be implemented based on cryptographic algorithms, which rely usually on security credentials, e.g. • Public/private key pairs for sign/verify and encrypt/decrypt operations • Trusted root certificates • Trusted certificates of backend services • Short-lived credentials that must be replaced frequently • Revocation lists to revoke abused certificates
Postcondition	All TEAM platforms are equipped with root certificates as well as signed certificates and key pairs. If required certificates with a short life-time may be renewed frequently over remote connections. Current revocation lists are available to all TEAM platforms.

Normal flow	Different deployment procedures may be required: • Systems are equipped with static security credentials once during system setup • Dynamic deployment during run time via a secured remote connection systems to a backend service • Short time credentials are renewed frequently • Regularly updated revocation lists, allow premature expiry of security credentials
Deployment platforms (vehicle/smartphone/ backbone)	All
Expected frequency of use	Very low. Once during setup and additionally regularly during run time to renew revocation lists and refresh certificates.

External actors and components

Actors' short name	Short explanation
Certificate authority	Trust anchor. Issues certificates and revocation lists,
Node	Any communication node. Must be equipped with certificates and revocation lists.

Input and Outputs

Input	Requests for certificates and revocation lists
Output	Different kinds of certificates, revocation lists, etc.

Required functional components

Components short name	Short explanation

Communication components (LTE, 802.11p)	Communication between nodes and backend services (certificate authority).

Objectives

All communication nodes must be equipped with security credentials in order to apply cryptographic mechanisms, which are required for many security use cases.

User benefits

Users do not directly benefit from this use case, but this use case enables other security use cases that provide huge benefits.

Basic functioning

A backend service (certificate authority) provides all required security credentials and revocation lists remotely. Nodes send requests in order to obtain these. Communication between nodes and certificate authority should be confidential and the nodes must be authorized.

Definition of work

- Implementation of certificate authority backend service.
- Implementation of credential management on nodes.

Possible Challenges

- Availability of remote connection during setup and run time
- Initial deployment, needs individual authorization of each node.

Comments, additional features

None

1.3.3.11 Trusted incident reporting

Overview

Use case name	Trusted incident reporting
Use case short name	TIR
Use case identifier	SP2_SEC_TIR
Use case short description	An integral part of the TEAM platform is incident reporting by users. This constitutes a threat to the integrity of information distributed within TEAM, since malicious users (or groups of users) might potentially report false events with the purpose of influencing the system. This use case summarizes a range of countermeasures that minimise the likelihood and the impact of those attacks.
Precondition	The TEAM platform offers the possibility of incident reporting on various traffic situations, which opens a security vulnerability by reporting false events.
Postcondition	Several security measures minimise the likelihood and impact of malicious incident reporting, which increases the trust in the TEAM platform.
Normal flow	The following security measures shall be applied. In the section “Basic functioning” more details are given. ● Incident reporting restricted to legitimate TEAM users and devices (both must apply) ● Mandatory user registration on the TEAM system ● Mandatory user authentication on reporting device ● Reporting restricted to the current position and time of the used vehicle or personal device ● Limited number of reports per users and devices within a time frame

	• Ensure authenticity and integrity of communication between the reporting device and backend, see SP2_SEC_PUVC, SP2_SEC_PBVC, and SP2_SEC_PAVD
	• Apply plausibility checks on the backend service before processing incoming incident reports, e.g.
	  • Require multiple coincident reports
	  • Compare to information from other sources
	  • Check statistic probabilities of certain events
	  • Estimate trust-level of reporting users and devices based on previous reports of the same user as well as from the same vehicle or personal device
	• Allow affected users and devices to report "false" incidents
	• Distribute trustworthiness of incidents to affected users and devices
	• Suspend users and devices that abuse the TEAM system

Deployment platforms (vehicle/smartphone/ backbone)	This use case affects the vehicle and personal platforms that are used for incident reporting as well as backbone components, which process user reported events.
Expected frequency of use	On transmission and processing of reported incidents

External actors and components

Actors' short name	Short explanation
Reporting user	Registered user of the TEAM platform, who is able to report incidents through his vehicle or personal device.
Reporting device	Vehicle or personal device that was used to report an incident.
Backend service	Central backend component that receives, processes, and

	redistributes reported incidents.
Affected user	Registered user of the TEAM platform, who is affected by a reported event and may be notified through the TEAM system.
Affected device	Vehicle or personal device, which is affected by a reported event and may be notified through the TEAM system.

Input and Outputs

Input	Incident reporting
Output	Trusted incident reporting

Required functional components

Components short name	Short explanation
N/A	

Objectives

Minimise the likelihood and impact of malicious incident reporting in order to increase the trust in the TEAM platform.

User benefits

A trusted and reliable system that increases user acceptance.

Basic functioning

The proposed security measures are briefly explained below.

- **Incident reporting restricted to legitimate TEAM users and devices**
  The TEAM system is not open to unknown entities. Only a legitimate TEAM user may report an incident. Additionally, it is required to use a legitimate TEAM device (i.e. vehicle or

personal device). Consequently, the combination of two known (and potentially trusted) entities is required to issue a report.

- **Mandatory user registration on the TEAM system**
  A registration procedure is required before a user is allowed to report incidents. This procedure shall increases the efforts to create fake user accounts on the one hand and help to identify malicious users on the other hand.
- **Mandatory user authentication on reporting device**
  The user credentials are requested during the incident reporting process in order to avoid third parties from misusing registered user accounts or devices.
- **Reporting restricted to the current position and time of the used vehicle or personal device**
  Creating false reports is complicated by this restriction and forces malicious users to be on site.
- **Limited number of reports per users and devices within a time frame**
  A single user (or device) is restricted to not exceed a reasonable number of reports within a certain time to avoid spamming with malicious reports.
- **Ensure authenticity and integrity of communication between the reporting device and backend, see SP2_SEC_PUVC, SP2_SEC_PBVC, and SP2_SEC_PAVD**
  It is ensured that reports are not manipulated during transmission and that the originating device is a legitimate and trusted TEAM platform.
- **Apply plausibility checks on the backend service before processing incoming incident reports, e.g.**
  - **Require multiple coincident reports**
    The possibility manipulation by a single or a few users is eliminated. At least a certain number of legitimate user accounts and TEAM devices are required.
  - **Compare to information from other sources**
    Information available from other sources (e.g. weather, traffic density, measured data) should be considered in the plausibility check.
  - **Check statistic probabilities of certain events**
    The probability of a certain incident may be calculated by several factors (e.g. daytime, season, location) and influence the acceptance of a report.

  - **Estimate trust-level of reporting users and devices based on previous reports of the same user as well as from the same vehicle or personal device**
    Depending on the number and substance of previous incident reports a reporting user as well as its device are classified to trust-levels. A low-trusted report may then for example require more coincident reports or other positive conditions to be accepted and vice versa.

- **Allow affected users and devices to report "false" incidents**
  Feedback of affected users allows the TEAM system to evaluate the substance of reports retrospectively, which influences the trust level of reporting users and devices for future reports.

- **Distribute trustworthiness of incidents to affected users and devices**
  The trustworthiness of an incident may be specified by the trust-levels of its originators and further facts gathered during the plausibility checks. This value gives the affected users (and devices) evidence about its plausibility and how to further proceed with it.

- **Suspend users and devices that abuse the TEAM system**
  Users, vehicles, and personal devices may be suspended (temporally or permanently) after misuse has plausibly been reported or observed or when falling below a certain trust-level.

Definition of work

Each of the proposed measures has to be reviewed for its relevance and efficiency. Selected measures must be allocated to a component and implemented.

Possible Challenges

Multiple components and subsystems are involved.

Comments, additional features

None

1.3.4 TEAM TECH Group Communication Technology

Based on selected applications proposed by SP4 DIALOGUE and SP3 FLEX, representative use cases related to the required communication infrastructure were extracted and analysed. The use cases relate to particularly challenging situations and conditions where a combination of reliable communications for specific applications featuring high safety requirements and acceptable Quality-of-Service (QoS) must be provided.

1.3.4.1 V2X wireless communication support

Overview

Use case name	V2X wireless communication support
Use case short description	Information exchange between vehicles, infrastructure and backbone to enable various collaborative cruise control mechanisms.
Component implementing the use case	• GNBTPAPI (GeoNetworking Gateway) • (Eco)CAM / DENM / other facility layer protocols (we would need to evaluate what information will be exchanged between) • Map-enabling component (as long as not part of LDM++) • IP Gateway (IP gateway of the vehicle)
Deployment platforms (vehicle/smartphone/backbone)	Vehicles, Infrastructure, Backbone
Services provided to higher layers	• API to obtain incoming data from other vehicles containing information, e.g. about speed, acceleration, emission info, etc. • API to send data to vehicles/infrastructure/backbone containing C-ACC related data.

External actors and components

Actors' short name	Short explanation
Data provider	Traffic management centre aggregating traffic-situation information, controlling traffic-light information, etc.
Data consumers	Vehicles, Infrastructure, Traffic Management Centre
Network provider	Using cellular network for IP communication between vehicles, infrastructure and a traffic management centre.

Use case system requirements

Geographical target relevance area	Everywhere (in case of cellular network problems, V2V technology might help)
Expected communication need	High, since time-critical data will be exchanged
Expected processing need	High, since real-time calculations need to be made when applying collaborative algorithms
Demonstration challenges	Having at least a few vehicles for the convoy Having a few non-convoy vehicles
Localization precision need	varying

Required functional components

Components short name	Short explanation
Communication (V2V, Mobile network)	• Vehicle to vehicle • Vehicle to infrastructure • Vehicle to traffic management centre
Storage (on car/smartphone) and backbone	• Cars should have some short-term storage capabilities to aggregate dynamic traffic situation when applying cruise control algorithms. Could be very basic.

	• Infrastructure should have medium-term storage capabilities to store information about traffic conditions. • Traffic management centres should have long-term traffic capabilities
Localization / Positioning	Positioning is needed with high precision, since the inter-vehicle gap could be less than the vehicle length.
Clock	Time synchronization of all participants in V2V and V2X is a major requirement by all vehicle communication protocols.

Objectives

Collaborative ACC communication support to enable communication between vehicles, infrastructure and management centres, allowing exchange of information required for ACC algorithms.

Basic functioning

All communication and lower-layer support should be transparent for the application. Communication between vehicles containing information about e.g. speed and acceleration should be exchanged on time basis, for example using the ETSI CAM (Cooperative Awareness Message) protocol. Vehicles will receive information about surrounding vehicles and infrastructure and apply algorithms for ACC. Information about "road budget" may be requested from the management centre when entering a new road. Requests regarding the formation of a vehicle convoy could be exchanged either using the ETSI DENM (Descentralized Environmental Notification Message) protocol or a new facility-layer message should be defined.

The leader of a newly formed convoy should send information about the convoy to the monitoring management centre on a regular basis, so that e.g. traffic lights get optimized. Other vehicles should receive information about the convoy either directly from the management centre or from the infrastructure.

Definition of work

- Implementation of interfaces for synchronization for SP3 and SP4 (applications)

- Implementation of synchronization
- Implementation of interfaces to storage providers
- Evaluation of (a) information that needs to be exchanged between participants and (b) mechanisms to form a convoy to see if a new facility-layer protocol will be needed or existing ones could be re-used.
- Define and implement interfaces for 11p and cellular communication
- Implementation of precise positioning

Possible Challenges

- Define message format required for the needs of C-ACC
- Define and meet communication performance requirements of C-ACC

Comments, additional features

None

1.3.4.2 Communication support for safety purposes

Overview

Use case name	Communication support for safety reasons
Use case short name	CSSR
Use case identifier	SP2_CSSR
Use case short description	Notification to all about a vehicle approaching fast
Precondition	Preventable accidents due to major differences in velocity
Postcondition	Vehicles warned about impending danger, life saved and damages avoided

Normal flow	• Vehicle approaches other vehicles • Approaching vehicle informs other nearby vehicles (velocity-pending) • The information includes location, direction and speed. • Other vehicles receive the information and warn driver/rider
Deployment platforms (vehicle/smartphone/ backbone)	Fully vehicle-integrated Working V2V network,
Expected frequency of use	Continuously

External actors and components

Actors' short name	Short explanation
Approaching vehicle	The vehicle which sends the information
Other vehicles	The vehicles which receive the information

Use case system requirements

Geographical target relevance area	Depending on nature of traffic event (e.g. accident, road blockage, etc.). TEAM infrastructure to enable dynamic coverage depending on event gravity.
Expected communication need	High
Expected processing need	Low to moderate
Demonstration challenges	Low to Medium
Localization precision need	Low (typ. GPS)

Input and Outputs

Input	Map, Location, direction, speed, speed limit, V2V-communication
Output	Approximation of the probability of collision

Required functional components

Components short name	Short explanation
LDM++ with cloud	To identify the roads
Vehicle data or phone data provider	Speed is also taken from vehicles e.g. on-board GPS or GPS-enabled devices.
Communication components (LTE, 802.11p)	802.11p to V2V communication
User profile	NA
Other SP2 component	NA
Components from SP3 or SP4	NA

Objectives

The application provides communication facilities that can be used to avoid collisions of vehicles travelling in the same direction (or even vehicles with crossing paths).

User benefits

This application helps drivers/riders to detect fast approaching vehicles in advance to avoid hazardous situations.

Basic functioning

- Vehicle approaches other vehicles
- Fast approaching vehicle informs other nearby vehicles

- The information includes location, direction and speed.
- Other vehicles receive the information and warn driver/rider

Definition of work

- Part of ITS station application software.

Possible Challenges

- Ability to meet latency and safety requirements when using unreliable / non-certified communication facilities like e.g. 4G or legacy 2G/3G

Comments, additional features

Warning may be executed by using a combination of a visual and audio indicator.

1.3.4.3 Geo-casting communication support

Overview

Use case name	Geo-casting communication support
Use case short description	When a vehicle enters a particular geographic area, it is registered to the list of vehicles travelling there. Thanks to this operation it is possible to communicate in geo-cast mode all the significant applicative information related to this area. The system can discover when the vehicle leaves the area and it has to be cancelled from the list
Component implementing the use case	Communication Manager
Deployment platforms (vehicle/smartphone/backbon	Vehicle/smartphone functionalities: geographic position signalling, sending/receiving messages

e)	Backbone functionalities: geographic areas configuration, mobile devices management, sending messages
Services provided to higher layers	API to configure geographic areas API to send messages

External actors and components

Actors' short name	Short explanation
Data provider	Application/service providers (Traffic management centre…)
Data consumers	Drivers and travellers
Network provider	Mobile Network operator must offer to external application the possibility to use some network functionalities such as message sending, cell broadcasting, etc.

Use case system requirements

Geographical target relevance area	Everywhere (in case of cellular network problems, V2V technology might help)
Expected communication need	low
Expected processing need	low
Demonstration challenges	
Localization precision need	Typically 500m but TEAM infrastructure should allow dynamic coverage depending on parameters such as TEAM actor speed, safety requirements, etc.

Required functional components

Components short name	Short explanation
Communication (V2V, Mobile	Communication is needed between vehicle and cloud to

network)	send and receive relevant messages
Storage (on car/smartphone) and backbone	Storage capacity is needed for received messages.
Localization / Positioning	Geo-location, possibly including speed and direction, of individual vehicles is a fundamental requirement for the geo-cast service
Clock	A clock can be required to synchronize the positions collection from vehicles

Objectives

Geo-casting communication support can make available the possibility to distribute applicative messages only to the vehicles that are travelling in well-defined zones.

Basic functioning

1. Pre-operation: the application/service provider can define, through a web interface, a geographic area where it is interested to communicate with vehicles in geo-casting mode.
2. When a vehicle starts, it sends its location/time stamp to the geo-casting communication support service URL.
3. The geo-casting support service identifies the geographic area and registers the vehicle into the vehicle list.
4. Based on the clock used by the system, the vehicle updates its position to the geo-casting communication support service. If the communication support service discovers that the vehicle has left the geographic area, it eliminates the vehicle from the list.
5. When an external application needs to use geo-casting communication support, it provides the message to be sent through the proper API.
6. The geo-casting support service sends the messages to all the vehicles registered within the list working with mobile operator systems.

Definition of work

- Implementation of interfaces to define geographic areas of interest
- Implementation of interfaces to define messages that have to be sent
- Implementation of interfaces towards mobile operators network services

Possible Challenges

- Hand-over between geo-cast cells could present challenges. Suggested approach: use predictive motion information to determine which cells should most probably be addressed by individual moving vehicles and pre-allocate resources accordingly. A simple vehicle motion model might suffice for fast moving vehicles and simple transport network topologies/geometries. Even if a driver uses a navigation system, the path is known a priori in most, yet not all cases.

Comments, additional features

None

1.3.4.4 Seamless mobility between areas covered from different base stations and/or different technologies

Overview

Use case name	Seamless mobility between areas covered from different base stations and/or different technologies
Use case short description	The vehicle shall be capable of moving between areas covered by different base stations that may implement different technologies (e.g. LTE and HSPA) without experiencing any/significant degradation in service delivery.
Component implementing the use case	Communication module (if we refer only to 3GPP technologies, it will be a pure 3GPP module)
Deployment platforms	in vehicle device / smartphone / mobile network

(vehicle/smartphone/backbone)	
Services provided to higher layers	Continuous connectivity Seamless mobility

External actors and components

Actors' short name	Short explanation
Communication module / Device manufacturer	Communication module manufacturers shall produce devices with dual/triple radio modules, capable of supporting the seamless mobility between technologies (e.g. handover, roaming) as described in relevant standards.
Network provider	Mobile Network operator must have the mobile network configured in a way to support seamless mobility (e.g. handover/roaming capable network configuration). Regarding 3GPP technologies, a key aspect is related roaming agreements between operators of different countries (e.g. management of an Italian LTE dongle operating on a German mobile network).

Use case system requirements

Geographical target relevance area	Especially in Base Stations' / cells' border areas, and areas with poor network coverage.
Expected communication need	High
Expected processing need	Low
Demonstration challenges	For 3GPP technologies both device and network shall be properly configured. Mobility between 3GPP and non-3GPP technologies is difficult/ expensive/ requires too much effort.

Localization precision need	Low

Required functional components

Components short name	Short explanation
Communication (Mobile network)	Communication component is needed for the connection between vehicle/smartphone and network infrastructure.
Storage (on car/smartphone) and backbone	NA
Localization / Positioning	NA
Clock	NA

Objectives

Seamless mobility between areas covered from different base stations and/or different technologies allows for the continuous connection of the in-vehicle device/smartphone to the network infrastructure, and through it to the service delivery platform /application servers etc.

Basic functioning

The mobile device (in-vehicle device/smartphone etc.) moves between two areas that are covered by two different base stations of the same or of different technologies at the edge of the cell coverage the communication module receiver identifies the poor coverage of the first base station and starts searching for another base station (providing better coverage) to camp on or to connect to. After network negotiation procedures the device connects to and can be served by the second base station.

For mobility between two cells/base stations that implement 3GPP standardised technologies - the same (e.g. two LTE cells) or different (e.g. HSPA and LTE cells)-, these functions shall be according to the relevant standards.

For mobility between two access points that implement IEEE standardised technologies these functions shall also follow the relevant standards where available.

Definition of work

- For 3GPP based networks:
  - Mobile network planning and proper configuration to achieve seamless mobility
  - End user device shall have a communication module supporting both technologies as well as the standardised protocol stack.
- For non-3GPP technologies, the device shall be properly configured to support reselection of access points – however, this may not be sufficient for seamless mobility in case of an active session.

Possible Challenges

- In case of mobility between different 3GPP technologies (e.g. HSPA and LTE) both the end user device and the network shall be properly configured.
- For mobility between the known non-3GPP technologies, seamless mobility in case of an active session may be problematic, while reselection of access point when the device is in idle mode can be implemented.
- Mobility between 3GPP and non-3GPP technologies (e.g. LTE and Wi-Fi or IEEE 802.11p) is usually difficult to achieve and requires expensive infrastructure and much effort from the mobile operator side.

Comments, additional features

None

1.3.4.5 Information dissemination support

Overview

Use case name	Information dissemination support

Use case short description	Advanced information dissemination using different communication technologies - 11p, cellular (e.g. LTE) - for transparent delivery of information to the target areas.
Component implementing the use case	• Communication Manager on vehicles • Communication Agent in the backbone/TMC (centralized server)
Deployment platforms (vehicle/smartphone/backbone)	Vehicles, Infrastructure, Backbone, Smartphone
Services provided to higher layers	• API to obtain information from vehicles • API to obtain data from service providers • API to obtain data from mobile network operator, road-side units operators • API to forward/disseminate data to a geographical area

External actors and components

Actors' short name	Short explanation
Data (Service) provider	Communication Agent (CA) which offers a multi-technology information dissemination service by creating a bird-eye view of the communication network and vehicles and by providing algorithms for effective and reliable information dissemination
Data (Service) consumers	Vehicles, Infrastructure, Traffic Management Centre, Service Providers
Network provider	The Communication Agent (CA) acts like a multi-technology network aggregator. Data providers use the CA to disseminate information. Information can be disseminated by the CA using mobile network operators' networks or road-side unit operators' networks

Use case system requirements

Geographical target relevance area	Everywhere
Expected communication need	High, since not all vehicles might be equipped with both 11p and cellular technologies
Expected processing need	High, since real-time aggregation and dissemination algorithms need to be applied
Demonstration challenges	Having a couple of vehicles, some equipped with both 11p and cellular, some only with 11p
Localization precision need	< 10m

Required functional components

Components short name	Short explanation
Communication (V2V, Mobile network)	• Vehicle to vehicle • Vehicle to infrastructure • Vehicle over IP • IP
Storage (on car/smartphone) and backbone	• Vehicles should have some basic storage capabilities to temporary store data the needs to be forwarded to other vehicles • Communication Agent in the backbone should have more extended storage capabilities that would be needed for information aggregation
Localization / Positioning	Positioning is needed with high precision, since the inter-vehicle gap could be less than the vehicle length. Precise positioning is required for advances forwarding and

	dissemination mechanisms.
Clock	Time synchronization of all participants in V2V and V2X is a fundamental requirement for all vehicle communication protocols.

Objectives

The Communication Agent offers a multi-technology information dissemination service.

Basic functioning

A centralized unit (e.g. a Communication Agent (CA)) resides in the infrastructure, e.g. in the Traffic Management Centre. It is responsible for periodically receiving and processing information from vehicles gathered through Road-Side-Unit Operators (RSUOs) and Mobile-Network Operators (MNOs). These vehicles send information about themselves, but also about neighboring vehicles equipped only with 11p communication whenever RSU are were not deployed.

The CA also has interfaces towards RSUOs and MNOs to maintain information about coverage and service availability in a geographical area. It is able to resolve reliable ways to disseminate information coming from service providers or directly from the traffic management centres using multi-technological communication. The CA is able to instruct vehicles equipped with certain communication functionalities to relay information to other vehicles, which can lead to improved dissemination reach and network offload. Because of its centralized nature, the CA can provide advanced features, e.g. geo-fencing and real-time statistics, etc.

Definition of work

- Definition and implementation of interfaces towards vehicles
- Definition and implementation of interfaces towards MNOs and RSUOs
- Definition and implementation of interfaces towards Service Providers and within TMC
- Implementation of advanced information dissemination algorithms
- Implementation of synchronization

- Implementation of interfaces to storage providers
- Define and implement interfaces for 11p and cellular communication
- Definition and implementation of dedicated protocols for information dissemination between vehicles (or adapting existing ones: Geo-networking, DENM, etc.)
- Implementation of precise positioning

Possible Challenges

- Close cooperation with MNOs and RSUOs required to obtain information about network coverage and network quality
- Real-time and on-demand processing and aggregation of information, which can impair the performance and scalability

Comments, additional features

None

1.3.5 Additional basic technologies (Sebastian Schwardt)

Enabling technologies developed in TEAM will not be limited to serve selected TEAM applications only. During the identification and collection of use cases for the basic technologies, use cases of technologies were identified, which are not reasoned by a particular application or basic technology. The following list of technologies will be used by several basic technologies and applications:

1.3.5.1 Update functionality

Overview

Use case name	Update system features
Use case short description	The use case implements the functionality to update certain features of the system. The "system" targets mainly

	distributed parts of the system. So for example application (parts) running on ITS Vehicle Stations or Personal Stations (Mobile phones).
Component implementing the use case	Some component of the basic system
Deployment platforms (vehicle/personal/central/road side)	Vehicle ITS Station Personal ITS Station (Smartphone) Central / backend Roadside ITS Station
Services provided to higher layers	Update defined parts of the system

External actors and components

Actors' short name	Short explanation
Data provider	The developer is the "data" provider who wishes to release a new software
Data consumers	The end consumer is the "data" consumer is this particular case.
Network provider	Not applicable.

Use case system requirements

Geographical target relevance area	Not applicable.
Expected communication need	Depends a lot on the implementation. May be very low (if the update is realized in a very smart way assuming the update is a minor one) and could be very high if major parts of the system must be exchanged.

Expected processing need	Varies a lot. The reliability requirements may be very high.
Demonstration challenges	Low: The demonstration does not require a particular setup.
Localization precision need	Not required.

Required functional components

Components short name	Short explanation
Storage	We might require some storage capacity for backup services (e.g. as long the new software is not validated on the platform, the previous version should be stored).
Communication	Yes, to transfer the new software code.

Objectives

It should be possible to update functionalities or components of the TEAM system. In order to make this in a structured way, we wish to have one unified method to implement this. That includes the software code but also some processes (e.g. that the updates component needs to be validated on the platform).

Basic functioning

We assume a software developer wishes to update a software component, which deployed on a TEAM platform (in most cases we will target the distributed platforms as the requirement to implement a common methodology is more important here). The software developer would need to proof that the update is valid and improves the (integrated) system. That might be done with automated tests. The use case includes, that the update is approved. All distributed component have system component that supports the update process. For example it receives the update file and some scripts to install and validate the update. The component runs the update considering specified rules (e.g. that the update is not done while the driver is moving the vehicle etc.). The component monitors the update process and runs the scripts to validate the update. It is able to redraw the system update at any time, if an error occurs.

Definition of work

- An update process needs to be defined, which starts with the update to the documentation of the update, the tests, etc. and ends with the user interaction while updating and definition of validation scripts running on the platform.
- The process must fit to different update needs (from different applications, from incremental updates to major updates, from safety-critical updates to low priority updates.
- The update process must be tested for all concrete update processes.

Possible Challenges

- Some updates might be safety critical.
- It may be challenging to implement one common procedure for various update process.

Comments, additional features

None

1.3.5.2 Review log messages and system status

Overview

Use case name	Review log messages and system status
Use case short description	Even if the system is not a debug modus, logs shall be produced, which give information about the system state, errors etc. It should be able to relevant people to review these logs. Moreover, system operators are able to access the distributed systems and could review its state.
Component implementing the use case	System logging system.

Deployment platforms (vehicle/personal/central/road side)	All platforms.
Services provided to higher layers	The component is a sunk for logs and system states. The applications will use the interface and provide the log messages. These will be managed by the logging component, e.g. for serialization. The component extracts the system state.

External actors and components

Actors' short name	Short explanation
Data provider	The data provider is the component which wishes to store log outputs somewhere (locallay, remotely), where a system operator .can read it
Data consumers	The developer of the relevant application which logged.
Network provider	Will be need, as log messages or files will be transmitted.

Use case system requirements

Geographical target relevance area	Not applicable.
Expected communication need	Rather low as we assume that the system is generally stable.
Expected processing need	Low.
Demonstration challenges	Low.
Localization precision need	No need.

Required functional components

Components short name	Short explanation
Storage	Might be relatively high. There must be a method implemented that defines what happens when the storage capabilities are not (anymore) sufficient.
Communication	Needed if the log messages/files should be transmitted.

Objectives

System developers (or maintainers) should be able to review the proper functioning of deployed software. In case a mistake is detected they should be able to find the reason for that (in order to be able to update the software accordingly). They logs which are produced while running (at least in the moment the system experiences problems) should help here.

Basic functioning

The system operator has been made aware of the problem in the software (e.g. when he/she reviews the state, of when users have experiences problems). Then the operator could access log files. This could be done remotely or directly. The operator may clear log files if needed.

Definition of work

- A general interface to drop any kind of logs need to be implemented on all platforms. Most often required data needs to extracted (e.g. to minimize storage requirements).
- All application or component developers will need to implement the interface by the logging component if they wish to log.
- The logging component needs to serialize the logs from system components, applications etc.
- The operator must be able to access the platform, review the log files, and clear log files.

Possible Challenges

- Storage for logging.

- Integration to all components.

Comments, additional features

Experiences from FOT projects like simTD or DRIVE C2X are available.

1.3.5.3 User profile

Overview

Use case name	User profile maintenance
Use case short description	The use case implements all basic functionalities of the user profiling. Contents of the profile are provided by use cases of SP3 and more importantly from SP4. The use case updates and forgets the contents. It stores the information.
Component implementing the use case	User profile
Deployment platforms (vehicle/personal/central/road side)	Vehicle ITS Station Personal ITS Station (Smartphone) (possibly remote also)
Services provided to higher layers	Maintain the user profile. Higher level components can read the profile, can edit the profile. The component includes a smart update functionality and a forgetting function.

External actors and components

Actors' short name	Short explanation
Data provider	Data provider are higher level applications and enablers especially from SP4. They will provide the contents of the user profile.

Data consumers	The date consumers will be the same as the data providers. All applications enablers etc. which implement personalization features.
Network provider	Eventually, in case the user profile is remote or if the data consumer or data provider are remote. It could be implemented in a way that everything is locally deployed, then no network provider is required.

Use case system requirements

Geographical target relevance area	Not applicable.
Expected communication need	Depends a lot on the implementation: In case every component (profile, data consumer and provider) is deployed on the same platform, no communication need is required. If the components are deployed on multiple platform the communication need is there, still we assume, that the communication need is rather low.
Expected processing need	Low.
Demonstration challenges	Low: The demonstration does not require a particular setup.
Localization precision need	Not required.

Required functional components

Components short name	Short explanation
Storage	We might require some storage capacity for the user profile. It is assumed, that this is rather small.
Communication	See above, expected to be low.

Objectives

The use case described the functionality of one component – the user profile. The user profile is responsible to maintain the user profile information. Higher level application or enablers could interface the component to edit, update and delete information from the user profile. The user profile defines the way to serialize the profile information. It provides rights to applications to edit and remove the content. It defines the schema for the user profile.

Basic functioning

The component addressed with this use case stores the information in a secure way. Application who wish to interface the use profile require rights to read and write the profile. The component takes care, that only this applications read and write who have these rights. Moreover, the component handles if the case when different applications provide different or conflicting information. Here, a application priority list may help in the most simple form. Another possibility or an extra feature is that the component forgets information over time. That means if a user has been identified to be a very aggressive driver some time, it should be able to update this information over time in case his or her behaviour has changed. Generally speaking, it means that the component is able to assess the relevance of a given information.

Definition of work

- The information that should be collected in the user profile shall be collected.
- A schema to store and update the given information shall be defined.
- An interface to other applications and enablers, which wish to interface the user profile must be designed.

Possible Challenges

- None.

Comments, additional features

None.

1.4 Selection of use case to implement

The previous list of use cases for basic technologies has been collected by different groups, each with a specific focus on a single technology and led by an expert for this technology. Each expert group was asked to develop an idea of how to enhance their technology in TEAM beyond the state of the art to the next generation. This resulted in a list of possible enhancements and use cases without any constraints or thoughts about possibility, feasibility or usability and also included enhancements which an application or user may not have a need for.

In parallel, two other work packages WP32 and WP42 designed applications for infrastructure (DIALOGUE) and travellers (FLEX). This list of applications underwent a selection process as described in Part A, Chapter 2 and resulted in a list of eleven applications which will be implemented in TEAM. The work packages WP32 and WP42 also formulated use cases for this reduced list of eleven applications. These use cases from DIALOGUE and FLEX applications can be seen as a lose form of requirements to basic technologies in EMPOWER. While application designers had not yet expressed real requirements from basic technologies, the TECH groups tried to describe everything that would be needed from a technological perspective to implement the applications.

As a result of both approaches, the list of use cases for basic technologies includes use cases that are not needed for users and applications, and misses requirements that are implicit to application designers, but are not yet covered by technology experts.

During the next step in TEAM, both groups, application designers and technology experts, will be asked to define requirements for both applications and technologies and map them onto each other to get a full list of requirements for technologies, applications and users.

1.5 Summary

The EMPOWER sub-project main objective is to develop the enabling technologies to be used by FLEX and DIALOGUE applications. These technologies aim at developing beyond the current state of the art on several topics and creating the basic building blocks needed to achieve the collaboration envisioned by the TEAM system.

The work in this sub-project was divided in four main topics. The first one is communication convergence, which will evaluate how short range communication (802.11p) can be integrated with the latest cellular data communication (LTE) techniques to provide seamless communication to the applications. The second topic is dynamic maps, building from the existing LDM (Local Dynamic Map) concepts and creating an LDM++ with addition of cloud technologies. The third area to be focused is cooperative position, which will investigate different methods for improving both relative and absolute position to reach at least lane level accuracy. The fourth subject includes privacy, security and reliability for the complete system.

In the beginning of the chapter the state of the art is updated for all themes with the addition of the gamification topic. Literature and current projects were examined to determine what the current state of the art is and how TEAM can advance from this point with relevant innovations.

Subsequently a detailed description was provided for use cases for all four technologies. These use cases were developed taking into account the applications needs but also looking into how the technologies should work. The result is a comprehensive description of the enabling technologies to be developed in TEAM and a set of guidelines for the subsequent work.

Lastly the stakeholders' aspect was considered, with focus on the basic technologies. The sub-project wanted to include all relevant stakeholders' needs, by listing their requirements, concerns and characteristics. The TEAM applications were the starting point in order to evaluate the technology challenges for the project.

List of abbreviations and acronyms

Abbreviation	Meaning
(eco)CAM/DENM	Special form of CAM/DENM message for ecological information exchange
11p	See 802.11p
2G	2nd generation mobile communication standard, GSM
3G	3rd generation mobile communication standard, UMTS
3GPP	3rd Generation Partnership Project, unites telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TTA, TTC)
4G	4rd generation mobile communication standard, LTE
802.11p	See IEEE 802.11p
ACC	Adaptive cruise control
ADAS	Advanced driving assistance system
AIDE European project	European project, Adaptive Integrated Driver-vehicle InterfacE, http://www.aide-eu.org
AKTIV	German research iniative, Adaptive and Cooperative Technologies for the Intelligent Traffic, http://www.aktiv-online.org/english/projects.html
API	Application programming interface
Application	Group of eventually distributed functions which cause a system to perform useful tasks which are recognizable to the end user, see Part A, Section 1.2.2
ASTM E2213-03	Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems — 5 GHz Band Dedicated Short Range Communications (DSRC) Medium Access Control (MAC) and Physical Layer (PHY) Specifications
Automotive cloud	Distributed storage and computing systems dedicated to automotive systems
B2B	Business to business
Basic technologies	Fundamental technologies required by applications, refers in TEAM context to technologies developed by EMPOWER, see Part A, Section 1.2.1

Abbreviation	Meaning
C-ITS	Collaborative intelligent transport systems
C2C	Car to Car
C2I	Car to Infrastructure
C2X	Car to Car / Car to Infrastructure
CA (certificate authority)	Certificate authority, certificate issueing entity
CA (communication agent)	Communication agent, see Section 1.3.4.5.
CACC	Collaborative adaptive cruise control, see Part D, Section 1.2.1
CALM	Communications access for land mobiles, http://www.isotc204wg16.org/concept
CAN bus	Controller Area Network bus, vehicle network
CCA	Co-modal coaching with support from avatar
CCTV	Closed Circuit Television
CDM	Collaborative driving and merging
Chromaroma	London based public transport online game, http://www.chromaroma.com/
citylog	CITYLOG European project, http://www.city-log.eu/
CLM	Cooperative Localization Message, see Section 1.3.1
Cloud	Distributed storage and computing systems
CMC	Collaborative pro-active inter-urban monitoring and ad-hoc control
CO2	Carbon dioxide
CODIA	Impact assessment study for cooperative systems, http://www.cvisproject.org/en/links/codia.htm
COMeSafety (2)	European support action, http://www.comesafety.org.
CONAV	Collaborative eco-friendly navigation
COPLAN	Collaborative co-modal route planning
CoVeL	Cooperative Vehicle Localization for Efficient Urban Mobility, http://www.covel-project.eu/
CPTO	Collaborative public transport optimization
CSE	Community services enablers, set of functions allowing to receive, validate and publish a series of contents, generated by a community of users, about mobility issues/conditions
CSI	Collaborative smart intersections for intelligent priority

Abbreviation	Meaning
CVIS	European research project, Cooperative vehicle.infrastructure systems, www.cvisproject.org
Datex 2 / Datex II	DATEX II TS 16157 1-3, Standard for communicating and exchanging traffic information, http://www.datex2.eu/
DC	Collaborative dynamic corridors
DIALOGUE	Sub-project of TEAM, SP4.
DRIVE C2X	European research project, http://www.drive-c2x.eu
DSRC	Dedicated short range communication
EASY-C	German project EASY-C, http://www.easy-c.de/index_en.html
EC	European Commission
eCall	Emergency Call, European initiative intended to bring rapid assistance to motorists involved in a collision anywhere in the European Union. The eCall initiative aims to deploy a device installed in all vehicles that will automatically dial 112
ECDSA	Elliptic Curve Digital Signature Algorithm
Eco Assistant	Driver assistant system for ecological driving.
Eco Pro	BMW assistant system for ecological driving, http://www.bmw.com/com/de/insights/technology/efficientdynamics/phase_1/measures_ecopro.html
eco:Drive	FIAT assistant system for ecological driving, http://www2.fiat.co.uk/ecodrive/
eco:Ville	Online community for FIAT customers using the eco:Drive product, see eco:Drive.
EcoGuide	Ford assistant system for ecological driving.
ecoHMI working group	working group in eCoMove project
eCoMove	European research project, www.ecomove-project.eu/.
EDAS	EGNOS Data Access Service
EFP	Collaborative eco-friendly parking
EGNOS	European Geostationary Navigation Overlay Service
ELGG	Open source social networking engine, http://elgg.org/
EMPOWER	Sub-project SP2 of TEAM
Enabler	Used for data or aggregated data, tools and algorithms to be used by the applications, see Part A, Section 1.2.3

Abbreviation	Meaning
eNodeB	E-UTRAN Node B, hardware part in UMTS networks
ESoP	European Statement of Principleson human machine interface, http://euroalert.net/en/news.aspx?idn=7680
ETIS ITS G5	Set of protocols and parameters for European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band
ETSI	European Telecommunications Standards Institute
ETSI ITS	European Telecommunications Standards Institute Intelligent Transport System
ETSI TS 102 636	Family of documents defining GeoNetworking
European CEN	European Committee for Standardization
EVALUATION	Sub-project SP5 of TEAM
FCD	Floating car data; data and information collected by probe vehicles, typically speed and position
FDD	Frequency Division Duplex, variant of LTE technology
FLEX	Sub-project SP3 of TEAM
FOT	Field Operational Test
G5	Set of protocols and parameters for European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band
GaLA	Games and Learning Alliance, http://www.galanoe.eu/
Galileo	GNSS built by EU and European Space Agency, similar to US-american GPS
Geo-casting	Delivery of information to a group of destinations in a network identified by their geographical locations
GeoNet	GeoNet European Project, http://www.geonet-project.eu/
GeoNetworking	Networking including georouting
GMSA	GSM Association of mobile operators and related companies devoted to supporting the standardising, deployment and promotion of the GSM mobile telephone system
GNBTPAPI	GeoNetworking/BTP API, a software component developed in DRIVE C2X project
GNSS	Global navigation satellite system
GPS	Global Positioning System, a GNSS developed by US Department of

Abbreviation	Meaning
	Defense
GSM	Global System for Mobile Communications, ETSI 2nd generation mobile communication standard
HARDIE Guidelines	Harmonisation of ATT Roadside and Driver Information in Europe Design Guidelines Handbook, DRIVE II Project V2008, Deliverable No. 20
HCI	Human computer interaction
HMI	Human machine interface
HPSA+	High speed packet access, extension to HPSA
HSDPA	High speed downlink access, extension to UMTS, part of HPSA protocol family
HSPA	High speed packet access, extension to UMTS communication technology
HSUPA	High-Speed Uplink Packet Access, extension to UMTS, part of HPSA protocol family
HTML5	Hyper Text Markup Language 5. Markup language for structuring and presenting content for the World Wide Web and a core technology of the Internet
HW	Hardware
I-GEAR	European research project, Incentives and Gaming Environments for Automobile Routing
I2I	Infrastructure to infrastructure communication
I2V	Infrastructure to vehicle communication
ICE	Internal combustion engine
IEEE	Institute of Electrical and Electronics Engineers
IEEE 1609	Higher layer standard based on the IEEE 802.11p
IEEE 802.11p	Approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE)
IMS	IP Multimedia subsystem
IMT-2000	International Mobile Telecommunications-2000. 3G technology comply with IMT-2000.
IMT-Advanced	International Mobile Telecommunications-2000. 4G technology comply with IMT-2000.
INTIME	European research project, Intelligent and efficient travel

Abbreviation	Meaning
	management for European cities, http://www.in-time-project.eu
INVENT	German research initiative, Intelligent traffic and userfriendly technology, http://www.invent-online.de/
IP	Internet protocol
ISO	International Organization for Standardization
ISO TC 204	ISO Technical committee, is responsible for the overall system aspects and infrastructure aspects of intelligent transport systems, http://www.iso.org/iso/iso_technical_committee?commid=54706
iTRETRIS	European research project, Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions, www.ict-itetris.eu/.
ITS	Intelligent Transportation Systems.
ITS 2.0	Product by Telecom Italia.
ITS G5A	Operation of ITS-G5 in European ITS frequency bands dedicated to ITS for safety related applications in the frequency range 5,875 GHz to 5,905 GHz
ITS station	According ETSI EN 302 665, there are four ITS stations: Personal ITS stations, Vehicle ITS stations, Roadside ITS station, and Central ITS station
ITS-g5	Set of protocols and parameters for European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band.
ITSA	Intelligent Transportation Society of America
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union Radiocommunication Sector
Ko-PER	German research project Ko-PER, http://ko-fas.de/deutsch/ko-per---kooperative-perzeption.html.
LDM	Local dynamic map
LDM++	TEAM concept based on the LDM
Local Dynamic Map	Concept developed in the SAFESPOT project. It is a data store located within an ITS station containing information which is relevant to the safe and successful operation of ITS applications.
LOS	Level of service
LSTI	LTE/SAE Trial Initiative alliance founded as a global collaboration

Abbreviation	Meaning
	between vendors and operators with the goal of verifying and promoting the new standard. Scope to ensure the global introduction of the technology as quickly as possible
LTE	Long-term evolution, marketed as 4G LTE. Standard for wireless communication of high-speed data for mobile phones and data terminals.
LTE/SAE Trial Initiative	See LSTI
M453	European Commission Mandate M/453. It invites the statdardisation bodies CEN, CENELEC and ETSI to prepare a coherent set of standards specifications and guidelines to support European Community wide implementation and deployment of Cooperative ITS
MAC	Media access control
MANET	Mobile ad-hoc network
MM-wave	Millimeter wave: Extremely high frequency is the highest radio frequency band, a form of electromagnetic radiation. Upcoming Wi-Fi standard IEEE 802.11ad will run on the 60 GHz band
MNO	Mobile-Network Operators
Mobilitätsdatenmarktplatz	Oline portal to exchange mobility data, http://www.mdm-portal.de
MTC	Machine-type communication
NFC	Near field communication
O/D	Origin/Destination
OBD	On-board diagnostics
OBD2	OBD2 or OBD-II is an improvement over OBD (OBD-I) in capacity and standadisation
OBU	On-board unit
OEM	Original Equipment Manufacturer
OS	Operating System
P2P	Pedestrian to Pedestrian
PC	Personal Computer
PHY	Physical layer according to OSI model
Physical Storage Format	Layout format describing how map data is stored on a physical device
PKI	Public key infrastructure

Abbreviation	Meaning
POI	Point of Interest
PRE-DRIVE C2X	European research project, Preparation for Driving implementation and Evaluation of C-2-X communication technology
PSAP	Public Safety Answering Points
PSF	Physical Storage Format
PSOBU	Public Safety OBU, a vehicle with capabilities of providing services normally offered by RSU
QoS	Quality of Service
RAN	Radio Access Network
RED-like algorithm	Refers to Random early detection algorithm.
REST architecture	Representational State Transfer (REST) architecture, a style of software architecture for distributed systems such as the World Wide Web
RESTful	Applications or services conforming to the REST constraints
RFID	Radio-Frequency Identification
roadside unit	Equivalent to ITS Roadside station.
RSU	Road-Side-Unit, equivalent to ITS Roadside station
RSUO	RSU Operators
S.I.MO.NE	s.i.mo.ne floating car, http://simone.5t.torino.it/
S.I.MO.NE protocol for FCD	s.i.mo.ne floating car data exchange protocol, http://simone.5t.torino.it/
SaaS	Software as a Service
SAFESPOT	EU SAFESPOT project, http://www.safespot-eu.org/
Serious gaming	game designed for a primary purpose other than pure entertainment, main purpose is to train or educate users
SG	Serious Gaming
SG-CB	Serious Gaming and Community Building
SG-CB	Serious gaming and community building
SHF	Stakeholder Forum
Short Range Communication	Generic term for three incompativle different short-range communication standards in Europe, USA and Japan
simTD	German project sichere intelligente mobilität - Testfeld Deutschland, http://www.simtd.de

Abbreviation	Meaning
SIRI	Service Interface for Real Time Information, model for real time public transport data exchange, http://www.kizoom.com/standards/siri/
SP	TEAM sub-project
SP2/SP3/SP4/SP5	TEAM sub-projects EMPOWER/FLEX/DIALOGUE/EVALUATION
SPaT	Signal phases and timing of traffic lights
SPITS	Strategic Platform for Intelligent Traffic Systems, http://www.cvisproject.org/en/news/spits_the_strategic_platform_for_intelligent_traffic_systems.htm
Stakeholder Forum	TEAM initative to exchange with stakeholders of the TEAM project and TEAM technologies.
Sunset	Sunset EU Project, http://sunset-project.eu/
SW	Software
TD-LTE	Synonym for TDD LTE variant
TDD	Time Division Duplex, variant of LTE technology
TEAM	Tomorrows Elasic Adaptive Mobility project, https://www.collaborative-team.eu/
TECH Group	Basic technology group, group of partners within TEAM with special knowledge or interest regarding a basic technology
TMC	Traffic Management Centre
TMC	Traffic Message Channel, technology for delivering traffic and travel information to motor vehicle drivers
TMS	Traffic Management Systems
TPEG UML	Transport Protocol Experts Group Unified Modeling Language, standardized modeling language to describe conceptual content
TSS Aimsun	Transport Simulation Systems Aimsun, integrated transport modelling software
TwinLin	TwinLin project of Hamilton Institute, Fraunhofer Fokus and TU Berlin, http://www.hamilton.ie/twinlin/
UC	Use case
UMTS	Universal Mobile Telecommunications System, 3rd generation mobile cellular system for networks based on the GSM standard, developed and maintained by the 3GPP
US DoT	Department of Defense of the United States of America

Abbreviation	Meaning
USB	Universal Serial Bus, data exchange standard for wired connections
V2I	Vehicle to Infrastructure
V2P	Vehicle to Pedestrian
V2V	Vehicle to Vehicle
V2X	Vehicle to Vehicle / Vehicle to Infrastructure
V2X-Vehicle-Network-Bridge	Enabler providing access to vehicle sensors and functions, see Part D, Section 1.3.1
VANET	Vehicular Ad Hoc Network
VDV 452	Verband deutscher Verkehrsunternehmen (association of German traffic companies) Schrift 452, document describing an interface for route network and schedule exchange for public transport
Vehicle-API	API to access sensors and functions of a vehicle
VII	Vehicle Infrastructure Integration, initiative fostering research and applications development for a series of technologies directly linking road vehicles to their physical surroundings in order to improve road safety
Voice over LTE	voice communication delivery over LTE networks
VSimRTI	V2X Simulation Runtime Infrastructure, comprehensive framework for the assessment of new solutions for Cooperative Intelligent Transportation Systems, http://www.dcaiti.tu-berlin.de/research/simulation/
WAVE	Wireless Access in Vehicular Environments, IEEE 1609 family of standards on top of IEEE 802.11p
Waze	Free social GPS application featuring turn-by-turn navigation, http://waze.com/
WCDMA	Wideband Code Division Multiple Access, UMTS air interface standard
WG HMI	TEAM working group for human machine interface
WHO	World Health Organization
Wi-Fi	Wireless LAN technology based on IEEE 802.11 standard
WiMAX2	IEEE 802.16m-2011, also known as Mobile WiMAX Release 2, standard for Wireless Metropolitan Area Networks
WP	TEAM work package
WPxy	TEAM work package x.y

Abbreviation	Meaning
xFCD	Extended Floating Car Data

References

[CM1] Connecting Cars: The Technology Roadmap – GSMA report available on: http://www.gsma.com/connectedliving/gsma-connecting-cars-the-technology-roadmap

[CM2] Rémi THOMAS, "LSTI - A Success Story about Boosting an Industry Eco-System in Telecommunications" available on: http://www.ngmn.org/events/ngmnevents/eventssingle1/article/huge-success-of-joint-gsma-ngmn-conference-stream-at-mobile-world-congress-2011-524.html?tx_ttnews%5BbackPid%5D=63&cHash=7874c2d3ea

[CM3] http://www.etsi.org/technologies-clusters/technologies/intelligent-transport

[CM4] http://en.wikipedia.org/wiki/IEEE_802.11p

[CM5] http://www.etsi.org/deliver/etsi_ts/102600_102699/1026360601/01.01.01_60/ts_1026360601v010101p.pdf

[CM6] http://www.etsi.org/WebSite/document/Technologies/16_Design_Principles_of_CALM.pdf

[CM7] http://its-standards.info/ITS_Venice_Session6_Fischer_v02.pdf

[CM8] http://www.ieee802.org/802_tutorials/06-November/IEEE%20802%20CALM%20Tutorial%20Part%202_v2.pdf

[CM9] http://vii.path.berkeley.edu/1609_wave/

[CM10] http://www.pre-drive-c2x.eu/

[CM11] http://www.safespot-eu.org/

[CM12] http://www.cvisproject.org/

[CM13] http://www.simtd.de

[CM14] http://www.teliasonera.com

[CM15] http://3gpplte-longtermevolution.blogspot.de/2010/06/3gpp-standardization-body.html

[CM16] http://www.itu.int/en/ITU-R/pages/default.aspx

[CM17] http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=4152738

[CM18] http://en.wikipedia.org/wiki/CALM_M5

[CM19] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51398

[CM20] http://en.wikipedia.org/wiki/IEEE_802.16

[CM21] http://www.comesafety.org/

[CM22] http://www.3gpp.org/

[CM23] http://ec.europa.eu/information_society/activities/esafety/ecall/index_en.htm

[CP1] R. H. Ordóñez-Hurtado, *Preliminary Overview of Cooperative Positioning Research for TEAM Project*, National University of Ireland Maynooth, Ireland, Technical Report, 36 p., March 2013.

[CP2] R. H. Ordóñez-Hurtado, *Overview of Cooperative Positioning in Vehicular Ad-hoc Networks for TEAM Project*, National University of Ireland Maynooth, Ireland, Technical Report, 11 p., March 2013.

[CS1] http://www.ocit.org/english.htm

[CS2] The protocol has been developed by the Transport Protocol Expert Group, http://www.tisa.org/technologies/tpeg/

[CS3] http://www.ndw.nu/pagina/en/16/about_ndw

[CS4] http://www.mdm-portal.de/

[CS5] J. Dean and S. Ghemawat, "MapReduce: Simplified Data Processing on Large clusters", in Proc. Sith Symposium on Operating System Design and Implementation, San Francisco, Ca, December, 2004.

[CS6] N. Smith, K. Wevers and S. Dreher, The Local Dynamic Map, a data-store for cooperative applications, Navigation News, Royal Institute of Navigation, March/April 2010

[CS7] http://www.safespot-eu.org

[CS8] http://www.cvisproject.org/

[PS1] 7th Framework programme, ICT for Cooperative Systems (2009): "PRE-DRIVE C2X - Security Architecture Deliverable D1.3," Final Deliverable, 2009-02-09.

[PS2] ETSI (2010): ETSI TR 102 893 V1.1.1 Intelligent Transport Systems (ITS); Security; Threat, Vulnerability and Risk Analysis (TVRA). Sophia Antipolis Cedex – France, March 2010

[PS3] Kurihara, T. M. (2006): IEEE 1609.2-2006 Trial Use Standard for Wireless Access in Vehicular Environments (WAVE) - Security Services for Applications and Management Messages, New York, USA

[PS4] ETSI (2010): ETSI TS 102 731 V1.1.1 Intelligent Transport Systems (ITS); Security; Security Services and Architecture. Sophia Antipolis Cedex – France, September 2010

[PS5] TS 33.401, 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution (SAE): Security architecture

[SG1] M. Prensky, "Digital game-based learning", ACM Computers in Entertainment, vol. 1, no. 1, 2003.

[SG2] M. Zyda. "From visual simulation to virtual reality to games". IEEE Computer, September 2005.

[SG3] F. Bellotti, R. Berta and A. De Gloria, "Designing Effective Serious Games: Opportunities and Challenges for Research", Special Issue: Creative Learning with Serious Games, Int.l Journal of Emerging Technologies in Learning (IJET), Special Issue: Creative Learning with Serious Games Vol. 5, 2010, pp. 22-35

[SG4] Gee, J.P. What video games have to teach us about learning and literacy. Palgrave MacMillan: New York. 2007

[SG5] Van Eck R., Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless, EDUCAUSE Review, vol. 41, no. 2, 2006

[SG6] Iacovides, I., Exploring the link between player involvement and learning within digital games. In Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology, Cambridge, UK, September , 2009

[SG7] www.games4change.org

[SG8] Swarz, J., Ousley, A., Magro, A., Rienzo, M., Burns, D., Lindsey, A.M., Wilburn, B., Bolcar, S., , "CancerSpace: A Simulation-Based Game for Improving Cancer-Screening Rates," Computer Graphics and Applications, IEEE , vol.30, no.1, pp.90-94, Jan.-Feb. 2010

[SG9] Alankus, G. M. May, A. Lazar, C. Kelleher. Towards Customizable Games for Stroke Rehabilitation. Proceedings of CHI 2010, Atlanta, GA, USA, 2010

[SG10] L. Gamberini, N. Corradi, L. Zamboni, M. Perotti, C. Cadenazzi, S. Mandressi, G. Jacucci, G. Tusa, A. Spagnolli, C. Björkskog, M. Salo, P. Aman, Saving is fun: designing a persuasive game for power conservation, Advances in Computer Entertainment Technology 2011: 16

[SG11] http://www.chromaroma.com/

[SG12] S. Deterding, M. Sicart, L. Nacke, K. O'Hara, and D. Dixon, "Gamification. using game-design elements in non-gaming contexts", in Proc. CHI Extended Abstracts, 2011

[SG13] G. Zichermann, C. Cunningham, "Gamification by Design: : Implementing Game Mechanics in Web and Mobile Apps", O'Reilly Media, 2011

[SG14] Y. Liu, T. Alexandrova, and T. Nakajima. 2011. Gamifying intelligent environments. In Proceedings of the 2011 international ACM workshop on Ubiquitous meta user interfaces (Ubi-MUI '11). ACM, New York, NY, USA

[SG15] http://www.fiat.com/ecodrive/

[SG16] http://media.ford.com/article_display.cfm?article_id=29300

[SG17] http://www.bmw.com/com/en/newvehicles/7series/sedan/2012/showroom/efficiency/eco-pro-mode.html

[SG18] http://automobiles.honda.com/insight-hybrid/fuel-efficiency.aspx

[SG19] http://arstechnica.com/gadgets/2011/11/is-the-chevy-volt-the-answer-to-urban-speeding/

[SG20] C. Shi, H. J. Lee, J. Kurczak, A. Lee, Routine Driving Infotainment App: Gamification and Performance Driving, 4th Int.l Conference on Automotive User Interfaces and Interactive Vehicular Applications (Automotive UI ,12), October 17-19, 1012 Portsmouth, NH, USA

[SG21] Nokia Maps APIs. http://api.maps.nokia.com/en/index.html

[SG22] Bose, R., Brakensiek, J., and Park, K.Y. Terminal Mode - Transforming Mobile Devices into Automotive Application Platforms. Proc. AutomotiveUI 2010, pp. 148-155.

[SG23] Meschtscherjakov, A., Wilfinger, D., Scherndl, T., and Tscheligi, M. Acceptance of Future Persuasive In-Car Interfaces Towards a More Economic Driving Behaviour. Proc. AutomotiveUI'09: 1st International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 2009. pp. 81–88,

[SG24] Inbar, O., Tractinsky, N. Driving the Scoreboard: Motivating Eco-Driving Through In-Car Gaming. Workshop on Gamification and HCI, as part of CHI2011.

[SG25] Koenig, V ; Boehm, F ; McCall, R Pervasive Gaming as a Potential Solution to Traffic Congestion: New Challenges Regarding Ethics, Privacy and Trust, UL-CONFERENCE-2012-436

[SG26] Nunes, A.A.; Galvao, T.; Falcao e Cunha, J.; Pitt, J.V.; , "Using Social Networks for Exchanging Valuable Real Time Public Transport Information among Travellers," Commerce and Enterprise Computing (CEC), 2011 IEEE 13th Conference on , vol., no., pp.365-370, 5-7 Sept. 2011

[SG27] http://sunset-project.eu

[SG28] http://www.mydrivesolutions.com/blog/driver-behaviour-profiling

[SG29] http://www.blackboxtelematics.co.uk/driverbehaviour.html

[SG30] http://m2m.telekomaustria.com/our-offer/solutions/eco-driving-solution/

[SG31] http://world.waze.com/

[SG32] S. Deterding, S. Bjoerk, D. Dixon, L. E. Nacke, "Designing Gamification: Creating Gameful and Playful Experiences", CHI 2013 Workshop http://gamification-research.org/chi2013/

[SG33] http://elgg.org/