Tomorrow's Elastic Adaptive Mobility

D1.0 TEAM users, stakeholders and use cases

Part D use cases and enablers for driver- and traveller-centric applications

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1.4	27.05.2013	Latest changes, more clarifiying
1.5	28.05.2013	Finalisation

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1 Applications and enablers for drivers and travellers

This Part D of Deliverable D1.0 outlines the work performed in another sub-project dedicated to applications for drivers and travellers. After a short introduction, a list of descriptions of applications and possible use cases for these applications follows. Another section lists the already identified enablers derived from these applications. For a detailed description of the concept of enablers please refer to Part A of Deliverable D1.0. This chapter closes with a section dedicated to Human Machine Interface design and guidelines for application development in TEAM.

1.1 Introduction

DIALOGUE intends to demonstrate how collaboration among drivers and travellers, through vehicular and cloud-based networking, can have major impact on future mobility towards a clean, efficient and safe driving and travelling. The collaborative approach of DIALOGUE differs from state-of-art Intelligent Transportation Systems (ref. DRIVE C2X, SAFESPOT), in that it does not limit to the awareness of neighbour vehicles, environment and driver information, but establishes contacts among road users and promotes an active cooperation, for mutual and collective benefit.

Based on technologies provided by EMPOWER, DIALOGUE focuses on smart applications on-board the vehicle, linking to FLEX for all the aspects requiring the infrastructure-based counterpart. DIALOGUE applications are meant to assist the driver/traveller and train him/her to be proactive in the road users community, by leveraging on three main concepts: (1) collaboration among all mobility stakeholders, especially drivers and travellers (2) coaching of drivers and travellers, and (3) team and community awareness. Collaborative strategies are being studied, whereby the human user and his/her acceptance, behaviour and actions are explicitly considered in the design of the system to make collaborative actions among users possible, resulting in increased individual and collective benefits. The driver coaching concept is aimed at supporting and motivating the user for a safe, eco-friendly and social behaviour, providing him/her the right information and recommendations, and – if necessary – providing incentives to act accordingly. Coaching is divided into five basic steps: meet the coach and get an idea of the vision, deduce and plan the actions, perform them, and acknowledge success. Team and community awareness is raised by novel concepts of serious gaming applied to mobility. Drivers are motivated to build communities by providing incentives ("virtual energy currency in the community") and a reputation mechanism. Social media, recognition of users' contribution to the collective (team) benefit, comparison among users, and learning from community driving and travelling experiences (best practices) will allow optimizing traffic efficiency and reducing the overall environmental footprint.

DIALOGUE is strongly based on EMPOWER, both in terms of components and enabling technologies, and has also several contact points with FLEX.

Concerning subsystems the DIALOGUE car is based on both the in-vehicle embedded system and/or the personal device. EMPOWER will address the vehicle ITS subsystem, including the interfaces with on-board sensors, while the personal ITS sub-system is tackled within DIALOGUE. The infrastructure and service centre subsystems, developed by EMPOWER and primarily used by FLEX, are planned to be used also by DIALOGUE but mainly to the extent of data exchange or call for specific functions (e.g. infrastructure-based traffic data).

In terms of EMPOWER technologies, collaborative systems pose strong requirements in terms of absolute and relative positioning of vehicles, whence the need of cooperative GPS. Collaboration is done via V2X communication, either with short range communication (802.11p/G5) or through mobile communication (3G/4G/LTE). Several data on user, vehicle and environment need to be aggregated, geo-referenced and stored on layered dynamic maps, the LDM++ locally and/or in the cloud. In addition, EMPOWER also provides DIALOGUE with the needed Security and privacy components, and data quality check component.

On its side, DIALOGUE directly addresses the so-called enablers, which are application-independent components. They serve applications with functionalities, which are implemented in a distributed way, such as algorithms for traffic monitoring and control, distributed HMI intelligence to enable collaboration, novel in-vehicle driver coaching strategies, specific cross-platform support infrastructure that enables easy development and deployment of applications to multiple mobile technological platforms, i.e. the in-vehicle ITS station and supported Smartphone platforms. Current activity of stakeholder identification and use case definition will allow for a better definition of the enablers as well as the applications. The final goal is to provide a set of highly effective applications, namely Collaborative Adaptive Cruise Control, Collaborative eco-friendly parking, Collaborative driving and merging, Green, safe and collaborative driving serious game and community building, Collaborative eco-friendly navigation.

Section 1.2 will focus on the aforementioned applications and outline the main use-cases, while Section 1.3 gives an initial list of already identified enablers for driver- and traveller-centric applications. Section 1.4 provides a description of the TEAM HMI approach and the TEAM HMI guidelines.

1.2 TEAM applications for drivers and travellers

In this section the collaborative and eco-friendly DIALOGUE applications are described. The applications in DIALOGUE focus on the collaboration between travellers and on the interaction between the driver and his vehicle.

For each application a short overview is provided first, and then the use cases are highlighted, showing the most relevant features of the application.

For the sake of completeness, the applications are described with rich functionalities. Not necessarily all such functionalities will be implemented within the time-frame of the project. However, we believe that it is important to state them here also to inform the design by giving a broad idea of the expected system.

1.2.1 Collaborative ACC

1.2.1.1 Application Overview

Application name	Collaborative adaptive cruise control
Application short name / Identifier	C-ACC
Application short description	The assumption is that vehicles shall communicate with other vehicles and infrastructure and share position and speed information. This information can be used to extend the foresight range of ACC Systems (Adaptive Cruise Control), allows appropriate reaction to adapt vehicle longitudinal speed and ultimately improve traffic flow. Addressing TEAM innovation points "Group-centric acceleration and deceleration", "Elimination of string instability"," Estimating traffic density in real-time based on in-vehicle estimation", "safe and green driving speeds", "Using map", "data Green MMI"
Platforms implementing the application	Smartphone/Vehicle-API, Fully vehicle-integrated, Backbone (traffic management centre)

Application objective	• increase the dynamics on the roads and lead to a more stable traffic flow with decreased accelerations and decelerations (improve highway platooning) • decrease traffic jams and adapt vehicles speed in order to, as fast as possible, get back to an uncongested situation; adapt vehicle speed to optimize emission traffic throughput adapt vehicle speed to current weather conditions promoting safety • act as a ACC safety margin assistant, which detects potentially dangerous traffic hindrance situations before their location is reached
Basic functioning	The main assumption that we make in this application is that a part of the road users are using a smartphone which is running the TEAM framework and through this their position, average speed per distance, average idle time per distance and optionally their direction (could be the next map point towards their destination) is communicated to the rest of TEAM users. In addition, traffic data information from the TEAM cloud server is available per road segment (e.g. avg. speed per road segment, queuing locations) and can be combined with information from other users in/heading to a specific area of interest (before a traffic jam) in order to better predict traffic density ahead and adjust ACC speed accordingly. Basically, each ACC strategy aims on calculating a certain velocity, the ego vehicle is supposed to drive in order to meet the use case relevant goals (see use cases below). This velocity, once calculated, can be used as input in three different ways to make the ego vehicle accelerate or decelerate respectively. 1. Speed advisory: the calculated velocity can be shown to the driver via in vehicle HMI or Smartphone, so the driver can accelerate or decelerate. 2. Road speed limit adaption: The speed limits of the road can be adapted, so the road users are forced not to exceed this limit. This approach assumes that drivers always drive as fast as possible.

	3. Cruise control: The ACC value of the vehicle is overridden and the vehicle adjusts the speed on its own.
Application's use cases	• Cooperative adaptive cruise control • Collaborative adaptive cruise control • Collaborative Road Budget Compliance • Green light optimizing cruise control • Slow driving with close distances in dense traffic • Road infrastructure awareness • Traffic data used to influence vehicle speed when Cruise Control is active. • Situational speed Basically, use cases 1 to 3 are cascading on each other. Use case 1 starts with limited V2V communication (speed/acceleration) and each vehicle solving string instabilities in a platoon independently. Use case 2 extends this setup by retrieving traffic density from V2V communication and so by calculating safe and distances and speed to optimize traffic throughput. Use case 3 additionally incorporates situation information of the derived from the infrastructure and so considers optimization of emissions. A "road budget" (for emission, throughput etc.) is calculated, which is being mapped on the road. This budget can be shared by road user in accordance to their relevant needs. • Use case 4 aims on controlling the traffic lights to create a traffic flow optimized on emissions and throughput. • Use case 5 addresses optimizing slow driving in dense traffic by reducing the inter vehicle gaps as much as possible. • Use case 6 incorporates road infrastructure information to optimize speed adaptation. • Use case 7 incorporates online traffic information to optimize

	speed adaptation. • Use case 8 incorporates a riders skills and abilities according to his/her user profile to optimize speed adaptation **A word on unequipped vehicles:** Unconnected vehicles which are running with an active basic ACC system will somehow become a part of the whole collaboration process, as they adapt their speed to the vehicle in front, as far as the vehicle in front is an equipped vehicle. Moreover, once we adapt the speed limit of a road, we implicitly influence even vehicles which are not having an ACC at all. For instance use case 4 (Green light optimized cruise control) takes unequipped vehicles into account. However, the detailed impact of unequipped vehicles is very complex and should be researched in simulations.
Required lower layer components	**"V2X-Vehicle-Network-Bridge"**: Required is a bridge between our collaborative infrastructure (that might be a certified/authorized/trusted application running in the OBU or an application running in the cloud) and the built-in ACC system of the car, where for instance, the collaborative application makes suggestions that the ACC system might take into account or not considering its own safety policy. So, a component in this case would be a "V2X-Vehicle-Network-Bridge" that allows interaction between our collaborative infrastructure and the car ACC system including the automatic emergency brake system. **HMI**: Graphic elements as those probably being considered in serious gaming applications, for instance the optimal speed indicator found in newer BMWs in eco-driving mode, could be an option, say, to keep the driver at a safe distance from the next driver. **Smartphone**: Addresses the same elements as described by "HMI", but displayed on a Smartphone instead. **Map Data**: from Smartphone or Backbone

1.2.1.2 Application use case 1: Cooperative adaptive cruise control

Overview

Use case name	Cooperative adaptive cruise control
Use case short name	COOP
Use case identifier	C-ACC_COOP
Use case short description	This use case is based on conventional ACC systems. Distance to the preceding vehicle in the lane measured by sensors is used to adapt the user's desired cruising speed. In addition, V2V communication is used prevent string instabilities. For this purpose, current speed and acceleration is exchanged between vehicles. Each vehicle processes the relevant data, according relevant algorithms, but no collaborative control is implemented here.
Precondition	ACC is active
Postcondition	ACC speed/acceleration is continuously being modified by the system
Normal flow	• Driver activates the ACC of the vehicle and defines the desired cruise control speed • Vehicle adapts its acceleration to meet the desired speed while not hitting another vehicle in front • Vehicle starts sending its speed and acceleration to the other vehicles around, also receives speed and acceleration of the other vehicles • Acceleration is adapted regarding the speed and acceleration of the vehicles in front, in order to avoid string instability
Deployment platforms (vehicle/smartphone/ backbone)	Fully vehicle-integrated On-board ACC unit responsible for use case 1

Expected frequency of use	high

External actors and components

Actors' short name	Short explanation
Driver	Defines the desired cruise control speed
Vehicle	Adapts vehicle acceleration to meet the desired speed while not hitting another vehicle in front Acceleration is adapted regarding the speed and acceleration of the vehicles in front, in order to avoid string instability
Other vehicles in front	Communicate speed and acceleration
Network providers	Mobile network

Definition of work

- Implement exchange of speed and acceleration values between vehicles
- Implement algorithm to create string stability
- Check technical solutions to set acceleration and speed to the vehicles ACC unit

Possible Challenges

Depending on the functionality of the ACC controller in the testing vehicles, we either implement our own ACC controller (e.g. targeting at an optimal ACC algorithm with guaranteed string stability) or we assume an interaction with ACC unit already installed in the vehicle.

Comments, additional features

None

1.2.1.3 Application use case 2: Collaborative adaptive cruise control

Overview

Use case name	Collaborative adaptive cruise control
Use case short name	COLLAB
Use case identifier	C-ACC_COLLAB
Use case short description	This use case extends the conventional ACC systems by trying to estimate traffic density online and thereby to calculate safe driving distances between the vehicles and safe driving speeds, which is then being communicated to all vehicles. For this purpose, V2V and V2I communication is used.
Precondition	V2V communication with other vehicles should be available Fixed and dynamic traffic management data should be available If ACC system pre-installed should allow modifications
Postcondition	ACC is active and continuously modifying the desired speed value for the ACC
Normal flow	1. Traffic data and V2V data are synchronized and checked for a region of interest (next node point on the map towards the driver's direction) 2. The application collaboratively computes a short/long-range traffic density estimation 3. The application calculates adaptive ACC speed and distance parameters.
Deployment platforms (vehicle/smartphone/back bone)	Fully vehicle-integrated, Smartphone
Expected frequency of use	Medium

External actors and components

Actors' short name	Short explanation
driver	Defines the desired cruise control speed
vehicle	Adapts the distance and speed to the vehicle in front according to what the calculated safe distance is
Other vehicles around	Communicate speed and acceleration
Data provider	Traffic management data (traffic density estimation, information on road events, queuing location)
Network providers	Mobile network

Input and Outputs

Input	• Speed and acceleration of the vehicles around • Estimated traffic density • Speed and acceleration of the vehicles in/heading to a specific point of interest (e.g. a traffic jam)
Output	• estimated traffic density (detection of the traffic situation based on local information) • adapted safe speed, adapted safe distance

Required functional components

Components short name	Short explanation
Vehicle data or phone data provider	Collaborative positioning and speed
LDM++ with cloud	Could contain information on fixed problematic locations (road construction) and dynamic information on traffic jams.
Communication components (LTE,	Communication of acceleration, speed, estimated traffic

802.11p)	density to other vehicles and receive it like wise
Other SP2 component	V2X-Vehicle-Network-Bridge to override acceleration and deceleration values of the ACC of the vehicle
Interaction between SP3 and SP4	Possible interaction with SP3 Collaborative pro-active urban/inter-urban monitoring?

Objectives

Adapt ACC speed and distance parameters based on local and non-local information in order to improve traffic flow in traffic congestion or traffic hindrance situations.

User benefits

Reduce overall delays and drivers' anxiety in traffic congestion or traffic hindrance situations.

Basic functioning

- traffic density estimation
- ACC adaptation

Definition of the work

1. Part I: An algorithm for the automatic real-time detection of the traffic situation based on local/non-local information. We may consider the detection of a finite set of several traffic situations as the following:
   - Moving in free traffic,
   - Approaching an upstream congestion front,
   - Moving in congested traffic,
   - Leaving the downstream congestion front and
   - Passing infrastructural bottleneck sections (such as work zones or intersections).

- These traffic situations have to be detected autonomously by each TEAM-ACC-equipped vehicle. A detection algorithm determines which of the five traffic situations mentioned above applies best to the actual traffic situation. Since autonomous detection alone is only possible with delays, we also consider supplementing the local information by means of roadside-to-car and inter-vehicle communication between suitably equipped vehicles.

2. Part II: A 'strategy matrix' that associates the autonomously detected traffic situation with speed and distance parameters of the ACC (safe speed, safe distance).

Possible challenges

- optimal ACC algorithm for eliminating string instabilities is not trivial task
- combining information from V2V and V2I nodes in a synchronized way is not trivial
- positioning of other vehicles delivered through V2V can be not accurate enough
- information on other vehicles direction in order to predict traffic situation ahead may not be available

Comments, additional features

None

1.2.1.4 Application use case 3: Collaborative road budget compliance

Overview

Use case name	Collaborative Road Budget Compliance
Use case short name	BUDGET
Use case identifier	C-ACC_BUDGET
Use case short description	This use case extends the "Collaborative adaptive cruise control" (as use case 2) by incorporating situation information derived from infrastructure in addition to the vehicle relevant information. By putting a feedback loop around the road, a certain budget derived from situation information (e.g. pollution,

	emission) is allocated to the road. A collaborative control adapts vehicle speed, distances etc. to the available road budget and so optimizes consumption and emissions. Special vehicles/activities on the road can be prioritized. An example for this approach is the TwinLin project (http://www.hamilton.ie/twinlin/).
Precondition	ACC is active
Postcondition	ACC is active and continuously modifying the desired speed value for the ACC
Normal flow	• Driver activates the ACC of the vehicle and defines the desired cruise control speed • Vehicle adapts its acceleration to meet the desired speed while not hitting another vehicle in front • Vehicle starts sending its speed and acceleration to the other vehicles around and the infrastructure as well, also receives speed and acceleration of the other vehicles • On a collaborative base, overall emissions and current pollution level etc. are calculated. These are continuously compared against a certain budget, which represents the maximum values of the named parameters for a certain road section. • According to particular characteristics of each vehicle and the needs of their driver, a certain speed value is calculated for each vehicle in the relevant road section (according to the road budget)
Deployment platforms (vehicle/smartphone/backbone)	Fully vehicle-integrated, Smartphone, Backbone (traffic management centre
Expected frequency of use	Medium

External actors and components

Actors' short name	Short explanation
Driver	Defines the desired cruise control speed
Vehicle	Adapts the its speed to what the backbone has calculated
Backbone	Calculates road budget from the traffic density and the emission of the vehicles and organizes collaborative control to adapt the speed of the vehicles

Input and Outputs

Input	vehicle emissions, driver's desired speed, traffic density (number of vehicles), road capacity
Output	Data certain speed for each vehicle

Required functional components

Components short name	Short explanation
LDM++ with cloud	Map data and road usage
Vehicle data or phone data provider	vehicle data, e.g. emission, current speed, desired speed, phone → map data
Communication components (LTE, 802.11p)	communication to backbone

Objectives

The objective is not to exceed a certain level of pollution in a certain area. This done by adapting the C-ACC speed of the vehicles.

User benefits

- Reduced emission and consumption

Basic functioning

- See the TwinLin Project, which had similar goals but assumed hybrid vehicles

Definition of work

- definition of road budgets for certain road sections according to the maximum pollution level (i.e. especially relevant for inner city low emission zones)
- Access online information of the current pollution level
- Implement exchange of relevant data
- Implement algorithm for calculation of speed values for the allocation of vehicles to the road budget
- Apply speed values

Possible Challenges

- how to get online pollution information

Comments, additional features

None

1.2.1.5 Application use case 4: Green light optimizing cruise control

Overview

Use case name	Green light optimizing cruise control
Use case short name	CLOCC
Use case identifier	C-ACC_CLOCC
Use case short description	This use case refers to automatically adjusting C-ACC speed to

	cross intersections and in general to green lights. When it's a convoy of vehicles that is approaching an intersection, they notify the intersection to get priority. The vehicles and the intersection negotiate traffic light time and phase so both can be optimized. Attributes of vehicles include emission, noise and eco information of single vehicles or averaged over convoys. User preferences refer among others to desired speed. Traffic lights are switching times are calculated according to these information.
Precondition	The vehicle receives signal phase and time of the traffic lights they are approaching and, if relevant, topology information from the intersection
Postcondition	Optimized driving though intersection. Group centric start stop.
Normal flow	• Vehicle(s) approaches an intersection • Vehicle(s) notify the intersection that it's approaching • A prioritization of vehicles, their approaching speed and the traffic light switching times are negotiated • Intersection prioritizes vehicle(s) • Vehicle(s) receives traffic light information and optimized speed • C-ACC optimizes speed • If the vehicle(s) needs to stop, the start-stop is optimized (for the group)
Deployment platforms (vehicle/smartphone/back bone)	Fully vehicle-integrated, Smartphone, Backbone (traffic management centre
Expected frequency of use	med

External actors and components

Actors' short name	Short explanation
User	The data provided in this use case is the route of the navigation system (destination) and the desired speed value of the acc.
Vehicle	The vehicle equipped with a TEAM ITS vehicle station
Intersection	The intersection with traffic lights equipped with a TEAM ITS roadside station

Input and Outputs

Input	• Signal time and phase from the traffic light • Position and distance to the traffic light • Vehicle speed • Number and type of vehicles approaching the traffic light
Output	• Optimized speed • Traffic light switching times

Required functional components

Components short name	Short explanation
User's profile	User preferences, among others the desired speed
LDM++ with cloud	Intersection topology Map with nearby vehicles, including convoy information
Vehicle data or phone data provider	Vehicle information, such as speed, acceleration, fuel consumption, emissions, braking capacity etc.
Communication components (LTE, 802.11p)	Communication between nearby vehicles and with the infrastructure

Other SP2 component	Lane level positioning
Interaction between SP3 and SP4	Related with SP3 Smart Intersections application Related with SP4 CDM application (use case Intersection Optimization)

Objectives

The system reduces Emissions and travelling times by adjusting traffic lights and ACC speed. This is done by regarding all relevant aspects, users' preferences and attributes of the vehicles and finding a way to meet all of them as best as possible.

Basic functioning

- C-ACC Module for speed computation
- Communication with Traffic Signal Infrastructure and other vehicles
- Components for encoding the message in standard formats
- Interface to the driver to communicate the speed/ acceleration and other information or V2X-Can bridge

Definition of work

- Implement V2X communication among the vehicles and the traffic light infrastructure
- Implement algorithms to calculate switching times for the traffic lights and the speed values of the vehicles
- apply switching times to traffic lights and the speed values to the vehicles
- implement group centric start/stop feature

Possible Challenges

- Get access to traffic lights

Comments, additional features

None

1.2.1.6 Application use case 5: Slow driving with close distances

Overview

Use case name	Slow driving with close distances
Use case short name	SDCD
Use case identifier	C-ACC_SDCD
Use case short description	This use case addresses driving with very close distances (less than a vehicle length) while slow driving in dense traffic. This should improve traffic throughput/road capacity and reduce emission especially in traffic jam situations. For this purpose, group-centric start/stop, acceleration/deceleration is implemented. Questions to be answered here: ● Compare spacing policies: dynamic gap with close distances vs. constant gap with very close distances (how close can we get) ● Which safety constraints and mechanisms for graceful degradation are implied by such closed gaps?
Precondition	ACC is active, traffic is dense and vehicles are driving "slowly"
Postcondition	Optimized driving in slow traffic
Normal flow	● Relevant data is shared among vehicles via V2X ● Optimized speed and acceleration / deceleration and inter vehicle gap is calculated ● Speed, acc. and dec. are applied to the vehicles
Deployment platforms	Fully vehicle-integrated

(vehicle/smartphone/back bone)	
Expected frequency of use	Medium

External actors and components

Actors' short name	Short explanation
driver	Defines the desired cruise control speed
vehicle	Adapts the distance and speed to the vehicle in front according to what the calculated safe distance is
Other vehicles around	Communicate speed and acceleration
Data provider	Traffic management data (traffic density estimation, information on road events, queuing location)
Network providers	Mobile network

Input and Outputs

Input	• Speed and acceleration of the vehicles from vehicles ahead in the same driving direction • Estimated short-range traffic density
Output	• adapted safe speed • adapted safe distance

Required functional components

Components short name	Short explanation
Vehicle data or phone data provider	Collaborative positioning and speed from vehicles ahead in the same driving direction

LDM++ with cloud	Could contain dynamic information on traffic jams as well as road data like slope.
Communication components (LTE, 802.11p)	Communication of acceleration, speed, estimated traffic density to other vehicles and receive it like wise
Other SP2 component	V2X-Vehicle-Network-Bridge to override acceleration and deceleration values of the ACC of the vehicle
Interaction between SP3 and SP4	Possible interaction with SP3: Collaborative pro-active urban/inter-urban monitoring

Objectives

Adapt ACC speed and distance parameters based on local information (vehicles ahead, road slope) in order to improve traffic flow in traffic congestion or traffic hindrance situations. Integrates start & stop functionality that can manages speed to a complete stop and resumes the set speed based on driver input such as touching the gas pedal or resume button.

User benefits

- Helps relieve driver fatigue induced by congested and stop-and-go traffic
- Improves Traffic throughput, reduces start/stop incidents

Basic functioning

- Short-range traffic density estimation (input from Use Case #2)
- Manages vehicle speed and headway gap using throttle control and limited braking (up to 0.3 g), including fully stopped conditions

Definition of the work

- Algorithm for optimal group centric ACC function maintaining small headway gaps and safe speed
- Algorithm for optimal group centric stop & go function

Possible challenges

This use case may imply the need for modifications of the vehicles ACC control unit in order to show its full potential

Comments

None

1.2.1.7 Application use case 6: Road infrastructure awareness

Overview

Use case name	Road infrastructure awareness
Use case short name	RIA
Use case identifier	C-ACC_RIA
Use case short description	Map data is incorporated in the ACC to be aware of approaching intersection, highway ramps, hilltops, sags, long curves, speed limit zones etc. When approaching, vehicles should avoid accelerating, can start to taxi early and can prepare shifting up and down early to keep the speed constant with low consumption/emission/traffic throughput. The collaboration is done independently so there is no need to for creating platoons since each unit operates independently. However vehicle speed desired by drivers can be slightly adapted by negotiating drivers' preferences and vehicle specific co2 emissions. So "platoon like" ad-hoc convoys can arise.
Precondition	ACC is active
Postcondition	ACC Speed value is modified in order to optimize consumption/emission/traffic throughput by taking road

	infrastructure into account
Normal flow	1. Ego vehicle is driving with desired ACC speed approaches a speed limit zone 2. Vehicle automatically begins to taxi early 3. Ego vehicle is driving slower than the desired ACC speed because it follows another car 4. The other car in front leaves the lane but the ego vehicle does not accelerate, as it approaches a road constriction
Deployment platforms (vehicle/smartphone/back bone)	Fully vehicle-integrated, Smartphone
Expected frequency of use	med

External actors and components

Actors' short name	Short explanation
driver	Defines the desired cruise control speed
vehicle	Adapts the distance and speed to the vehicle in front according to the desired cruise controls peed and considers map data

Input and Outputs

Input	Speed and acceleration of the vehicles in front, drivers desired speed, map data
Output	speed

Required functional components

Components short name	Short explanation

Vehicle data or phone data provider	Acceleration and speed, map data
Other SP2 component	V2X-Vehicle Network-Bridge to override acceleration and deceleration values of the ACC of the vehicle

Objectives

- Prevents useless acceleration
- Optimizes consumption/Emission

User benefits

- Prevents useless acceleration
- Optimizes consumption/Emission

Basic functioning

- Constantly checking if infrastructure ahead suggests to prevent acceleration or even start deceleration
- If so, apply to the current ACC speed value

Definition of work

- Identify relevant road infrastructure elements (i.e. speed limitation zones, gradient, highway ramps etc.)
- Check navigation route segment ahead for crossing relevant infrastructure elements
- Adapt ACC speed

Possible Challenges

None

Comments, additional features

Maybe mixed width UC 7 features

1.2.1.8 Application use case 7: Traffic data used to influence vehicle speed when Cruise Control is active.

Overview

Use case name	Traffic data used to influence vehicle speed when Cruise Control is active.
Use case short name	TVS
Use case identifier	C-ACC_TVS
Use case short description	We detect when a vehicle is approaching traffic ahead and automatically adjust its speed to compensate when cruise control is active. Take for example a multi-lane highway with a maximum speed of 120kph. In the event that the vehicle is traveling at the legally permitted speed, and the vehicle reaches a 1km distance (or even earlier e.g. 10km) from specified traffic, the vehicles speed is automatically reduced. We can adapt traffic speed to avoid highly congested roads. If we categorize the traffic to be severe (red), then we gradually reduce the speed of the vehicle to 60kph, alternatively, if the traffic is less severe (yellow), then we gradually reduce the speed to 80kph.
Precondition	ACC is active, online traffic information is available
Postcondition	ACC is active and continuously modifying the desired speed value for the ACC
Normal flow	1. Ego vehicle driving with desired ACC speed approaches a speed limit zone 2. Vehicle automatically begins to taxi early until speed of the

	traffic jam is reached
Deployment platforms (vehicle/smartphone/back bone)	Fully vehicle-integrated,
Expected frequency of use	Medium

External actors and components

Actors' short name	Short explanation
Vehicle	Adapts the distance and speed to the vehicle in front according to the available traffic data.

Input and Outputs

Input	Speed and acceleration of the vehicles in front, drivers desired speed, map, traffic and speed limit data.
Output	speed

Required functional components

Components short name	Short explanation
Vehicle data or phone data provider	Acceleration and speed, map data, traffic and speed limit data.
Other SP2 component	V2X-Vehicle Network-Bridge to override acceleration and deceleration values of the ACC of the vehicle

Objectives

Saves fuel and increases safety by starting to taxi early when approaching a traffic jam

User benefits

Through careful management of the vehicles speed through an understanding of the traffic on-route, we allow sufficient time for the traffic ahead to dissipate, thus greatly reducing the possibility that the user has to confront any level of traffic congestion, which is often such a frustrating experience.

Measurable benefits depend upon the vehicles that participate in such a system, including those drivers who comply. From an idealistic perspective, this could drastically reduce traffic levels.

Basic functioning

- Collect information on congested roads and traffic jam on the current route
- If vehicle is approaching a traffic jam, start decreasing ACC speed value

Definition of work

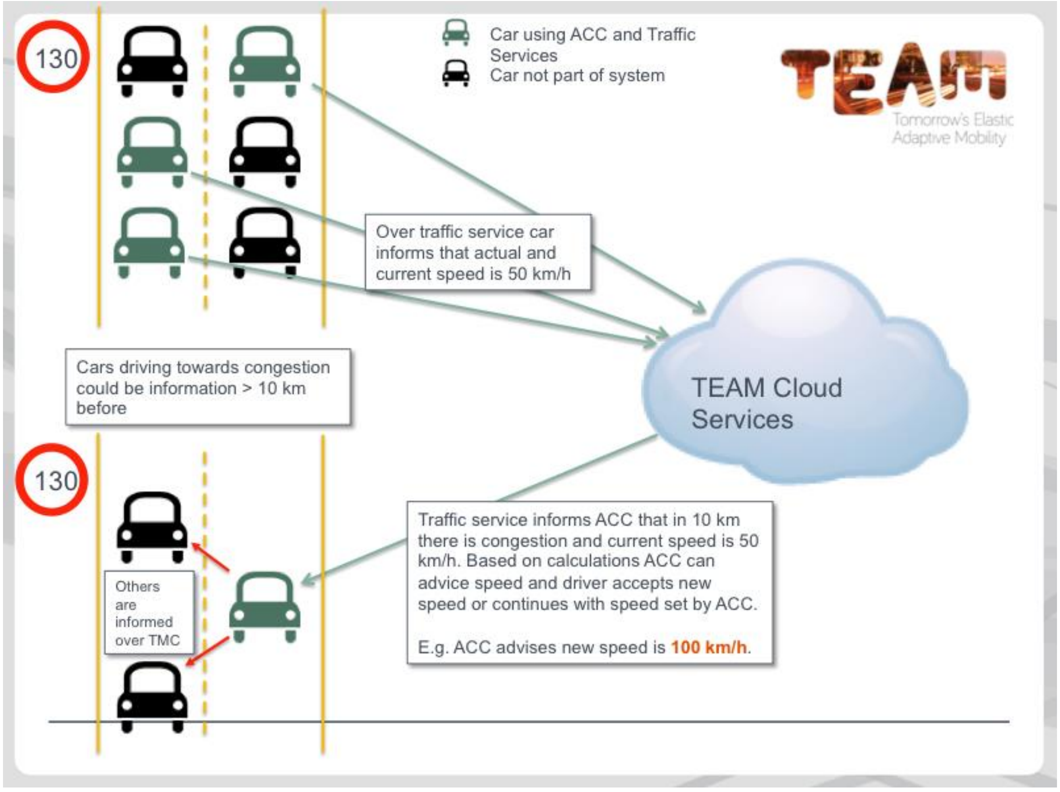

Figure 1.11: Definition of Work for C-ACC use case 7

Possible Challenges

Majority of vehicles on the road should participate on the system to make it work.

Comments, additional features

None

1.2.1.9 Application use case 8: Situational speed

Overview

Use case name	Situational speed

Use case short name	SSPEED
Use case identifier	SP4_SSPEED
Use case short description	Speed recommendation to rider according to location, traffic, speed limits and road conditions. Alert rider if needed. User profile is used determining recommendation.
Precondition	Road data available (map, speed limit data, road geometry) and user profile
Postcondition	The application updates user profile
Normal flow	First the rider chooses his/her profile, if he/she has not been the previous rider While riding the application warns rider for speeding and for too high situational speed. Application calculates the correct situational speed from the user profile. Application updates the user profile continuously
Deployment platforms (vehicle/smartphone/ backbone)	Fully vehicle-integrated, road database (map, speed limit, geometry)
Expected frequency of use	Daily, often

External actors and components

Actors' short name	Short explanation
n/a	

Input and Outputs

Input	Location, road data, user profile data.

Output	Speed recommendation within current speed limits, alert, user profile update.

Required functional components

Components short name	Short explanation
LDM++ with cloud	Static and dynamic road data and speed limit data
Vehicle data or phone data provider	Access to road data
Communication components (LTE, 802.11p)	LTE/3G: road data; 802.11p: road data, speed limit, traffic data
User profile	Individual speed recommendations
Other SP2 component	
Components from SP3 or SP4	

Objectives

Reduce accidents, especially curve accidents

User benefits

The rider is informed if he/she exceeds the rider-specific situational speed. The rider is given information regarding his/her surroundings, which might otherwise have gone unnoticed. This helps the rider to anticipate risks and drive more safely. Rider is informed when he/she exceeds the speed limit. The system determines the rider's abilities and skills, and adjusts the sensitivity of the warning triggers accordingly.

For example, the rider is given a warning about a tight curve ahead if the rider seems to not adjust his/her speed accordingly. Rider is identified by an RFID tag, NFC, or manual input

- User profile is stored in a cloud server, and is transportable between vehicles
- Infrastructure information is acquired from the LDM

- The information is then compared with the current speed
- Warning signal is triggered if limit values are exceeded

Possible Challenges

- Riding style recognition algorithm implementation might prove to be challenging

Comments, additional features

None

1.2.2 Collaborative eco-friendly parking

1.2.2.1 Application Overview

Application name	Collaborative eco-friendly parking
Application short name / Identifier	EFP
Application short description	Vehicles are connected to a cloud service that enables the distribution of information about available parking slots to individual TEAM users (vehicle drivers, but also any other user equipped with TEAM device/system). Through this cloud service TEAM users can thus receive, on demand, information about free parking places. The application includes the following features: **Detection of the parking searching context:** The application implements a method to infer if a TEAM user is currently searching for a slot. This way we may implement on-demand service provisioning: • Destination from navigation system

	• Favourites / POI / daily commuting • Turning around the block • Push the button **Open slot sensing:** There are multiple possibilities, we look at: hardware device to detect ignition starting or switching off, or smartphone to detect motion: • Push the button • Paying process • Engine switching on, start to move the vehicle, position (think also of park-of-my-house) • No-parking-slot-detection • Planned parking free slot / user indications (e.g. if a user knows he/she leaves a parking space at 3 pm) • Parking slot predictions based on statistics **Free parking markets:** Pricing: virtual coins (from gaming) could be used to get the indication of a parking slot which suits driver's preferences. The application will include a system which manages the knowledge about the free parking spaces and the allocation of parking spaces to look for users. Relevant statistics will also be possible, to guarantee an acceptable quality of service., e.g. filtering information about free slots (or in general individually preferred environments, such as safe routes where few accidents happen, non-complex crossings etc.). Special vehicles will also be considered (somehow as a kind of extension of the virtual coin approach).There may be some vehicles, which shall be prioritized in the parking slot allocation, e.g. electric vehicles for parking slots with a charging station, a doctor, handicapped drivers, people who are visiting a patient etc. This

	could be done with the support of virtual coins multipliers for all people with special needs. The application should be able differentiate between different kinds of parking slots. For instance, the parking slots specifically aimed at PTWs are unsuitable for other vehicles. The application should then be able to offer these parking slots only for PTWs. Constraints: vehicle relative positioning shall be considered to provide information only to the vehicle that is closer (and approaching from right direction) to the parking slot. The use of this application should not engage unsafe driving towards an open parking slot. This risk could be reduced e.g. through driving style monitoring and user rewarding. It will not be requested to operate in closed parked areas (like parking garages where positioning systems do not operate). In a first implementation a remote dynamic map (in the cloud) of free parking slots (addresses and number of free slots) can be queried on demand or offered around navigation destination. Interesting products in this domain are: • https://www.parkingpanda.com/ • https://www.parkatmyhouse.com/about/ (BMW is shareholder) • open slot by Google (was a product of Google labs in 2010, is offline today)
Platforms implementing the application	Smartphone and Vehicle-API Fully vehicle-integrated (including access to positioning system) Back-office (traffic management centre)
Application objective	To enable connected vehicles to access real time information about parking availability in the surrounding of the destination.
Basic functioning	Collaborative parking application offers real time information of

	location of free parking spaces either in the surrounding of the navigator destination or in the most probable destination (based on driving storyboard). Via manual trigger or autonomous parking/leaving detection the vehicle sends relevant data when entering /leaving a parking slot so that the cloud-based application can constantly monitor the availability of free parking slots. When asking for free parking, the driver of the car that will use the application may or may not enter destination information.If he/she enters route destination location, the system can have a precise reference of the destination (via local or cloud-based routing service). Otherwise the system will only estimate route final destination based on the driving storyboard of the specific vehicle (most frequent destinations). The latter functionality is especially suited for commuters which travel very frequently to the same destination and may want to be given automatically parking information.
Application's use cases	**Send and receive parking slot messages** send a message of – a car is leaving a parking slot at location x.y, receive aggregated messages of – at destination (or most probable destination) the number of free parking slot is n. and a map is shown on the navigator screen. **User community management** (where users are drivers looking for a partaking slot): • **User reputation management** to manage user credibility within the community, basing on the trustworthiness of the information provided and the driving style when using the application. Examples: • The user credibility is decreased if the user has provided false information (the coordinates are not corresponding to a parking slot) or he/she didn't respect the parking reservations eventually assigned him by the system.

	• The user credibility is decreased if the user driving style changes towards unsafe when user gets information about free parking slot. • **User rewarding management** to manage a rewarding scheme able to classify users in terms of their contribution to the community. The more the user contributes to the service more points he/she will get. In case of false information or unfair behaviours, the rewards points will be decreased. • **Data Validation** for the validations of users' received notifications. • **Connection to parking garages** (e.g. indicate that there is a garage with open slots nearby too)
Required lower layer components	LDM++ Vehicle data (e.g. GPS vehicle physical dimensions, ...) Internet connectivity Driving style monitoring (enabler)

1.2.2.2 Application use case 1: Send and receive parking slot messages

Overview

Use case name	Send and receive parking slot messages
Use case short name	EFP-UC1
Use case identifier	SP4-EFP-UC1
Use case short description	Available parking slot information is sent to the user, only if the user is searching for a place to park. This can be asked from the user or estimated based on vehicles driving style (a user confirmation can be requested). In the message there should be

	options to choose off-street parking place to minimize unnecessary driving in city centre for example.
	
	Visibility of on-street parking spaces shared.
	
	• Car informs of departed on-street parking place.
	• Filtering using vehicle characteristics and user profile (driving style and behaviour when using this application).
	• Location radius and driving route from A->B (open slot).
	• Traffic from A > B
	• User informs the system that it's heading to available space.
	    • Space is temporarily removed from system so that others in the system (drivers) do not have visibility.
	    • System tracks whether the car is heading to that space. If not, space is made visible to all in the system again.

Precondition	Parking service should be available from the cloud, and service should provide information about available on-street parking zones and off-street parking places. If needed user are guided to available parking area or garage.
Postcondition	User can select which parking option he/she likes, and application provides support/navigation to selected area.
Normal flow	1. User asks free parking places nearby vehicles location (on-street and off-street) 2. Parking service finds available option nearby the vehicle (e.g. 500m – 1000m radius) 3. User selects place what he/she likes (if possible pricing information is provided) 4. User is guided to parking area
Deployment platforms (vehicle/smartphone/	• Smartphone/Vehicle-API • Backbone (parking management centre)

backbone)	
Expected frequency of use	Every time when a user wants to park the car.

External actors and components

Actors' short name	Short explanation
Parking management centre	It shall be entitled to manage the availability of parking places in simulation mode: all tests will be conducted in controlled scenarios. Payment is not included.

Input and Outputs

Input	• Parking information (on-street parking zones, off-street parking garages) • User preferences (may be used to filter results)
Output	• service that helps the users to park their cars easier • New destination address/location to navigation system (to find free parking spot)

Required functional components

Components short name	Short explanation
LDM++ with cloud	Cloud server to collect and manage the parking slot availability (remote parking management server)
Vehicle data or phone data provider	Vehicle to send and receive parking slot and positioning messages (also based on engine on/off and vehicle manoeuvring)
Driving style monitoring	Evaluates driving style while using the application

(enabler)	
Communication components (LTE, 802.11p)	LTE
User profile	not needed
Other SP2 component	none
Interaction between SP3 and SP4	none

Objectives

Objective of this use case is to offer information of available parking spots nearby user current location or nearby final destination set by navigation. Parking service knows all available parking options, both on-street and off-street, and based on user preferences application is able to propose options to park the car. Challenge in on-street spots is that there is no guarantee that place is free as it cannot be reserved and thus available off-street options should be provided. Also user should be informed costs from that parking zone/garage. When user enters to parking zone and parks the car, he/she is able to start payment from his smartphone of embedded system.

User benefits

Decreasing the average time to search for a public parking place by 30%.

Basic functioning

Parking and payment service and information are provided by a cloud based service that will provide information of both on-street and off-street parking zones/garages. This information needs to be shown on top of the map so that user can see that visually.

Definition of work

- Cloud based service (e.g. REST API) to provide information of available on-street parking zones and off-street parking garages

- This information need to be shown on top of the map (longitude & latitude)

Possible Challenges

- Guarantee enough level of quality for on-street places. Significant statistical calculation and estimation can be done but it may be a challenge to guarantee free spot from on-street parking zone.
- To obtain parking zone information from all countries and cities required
- Dealing with the effect of delays.
- Estimation of arrival and departure processes
- Significant optimization problem (see work by Cassandras at Boston University)
- Unsafe driving behaviour:
  This application provides information of single on-street parking spot that is just come available to a driver who is looking for parking in busy city streets. If driver choose to take this opportunity, he/she might try to get there as soon as possible (as we cannot reserve the spot). If the spot is a few blocks or crossings away, it might lead to aggressive driving and unsafe actions to get there on time.
  To reduce this risk the application could provide information about free on-street slots to drivers when we know that there is a few free slots (not only one) and mainly to drivers with good or average driving style reputation.

Comments, additional features

None

1.2.2.3 Application use case 2: User community management

Overview

Use case name	User community management
Use case short name	EFP-UC2

Use case identifier	SP4-EFP-UC2
Use case short description	Algorithms that will be resident in the cloud service to: Manage the so-called "user reputation and rewarding" based on the trustworthiness of the information provided and the driving style when using the application by the user: virtual coins will be assigned to the users, the coins can then be spent either in this TEAM app or in other.
Precondition	A number of TEAM apps implement the "virtual coin" mechanism.
Postcondition	This use case changes the final number of "virtual coins" available to each user.
Normal flow	• The user community management algorithm calculate the rewarding mechanism (each time a user indicates that a parking is free) • The algorithms assigns (plus or minus) the virtual coin depending on the trustworthiness of the information • The algorithms assigns (plus or minus) the virtual coin depending on the driving style of the user when he/she uses the parking application • A user, requesting a parking slot, is given priority by the algorithms on the basis of user location and virtual coins
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/Vehicle-API
Expected frequency of use	each time a user is leaving and is looking for a parking slot

External actors and components

Actors' short name	Short explanation
Parking management	It shall be entitles to manage the availability of parking places in

centre	simulation mode: all tests will be conducted in controlled scenarios. Payment is not included.

Input and Outputs

Input	User previous reputation as EFP user/information source. Latest user actions related to EFP Driving style
Output	Updated reputation as EFP Possible additional rewards

Required functional components

Components short name	Short explanation
LDM++ with cloud	This algorithm shall operate on the cloud server.
Vehicle data or phone data provider	Vehicle leaving a parking slot, vehicle looking for a parking slot data shall be available.
Communication components (LTE, 802.11p)	LTE
Driving style monitoring (enabler)	Evaluates driving style while using the application
User profile	Each user shall be subscribed to the service and shall be identified at least with a pseudonym.
Other SP2 component	None
Interaction between SP3 and SP4	A number of TEAM apps shall implement the virtual coin mechanism.

Objectives

The objective is to create a mechanism that, in the spirit of the TEAM concept, is facilitates users' good behaviour and create win-win situations between the user and the community: the so called user reputation mechanism.

User benefits

Prioritisation of users' need for parking slots.

Basic functioning

Calculation of the virtual coin value (plus, minus) with specific algorithms resident in the cloud service.

Definition of work

- A user indicates that a parking is free
  - The information is correct, than the cloud server gives the user 1 virtual coin more
  - The information is incorrect, than the cloud server takes away 1 virtual coin more

- A user gets information about open (on-street) parking slot, accepts it and starts driving towards it. Driving style monitoring rates the driving behaviour
  - The driving style stays safe, the cloud server gives the user 1 virtual coin more
  - The driving style changes to unsafe, the cloud server takes away 1 virtual coin more
- A user, requesting a parking slot, needs priority and indicates its availability to spend a virtual coin to get priority.

Possible Challenges

- the rewarding mechanism is quite new, its usability shall be explored

Comments, additional features

Special attention should be paid to rewarding mechanisms, when dealing with both user-triggered information and autonomous parking/leaving detection by sensing systems.

1.2.3 Collaborative driving and merging

1.2.3.1 Application Overview

Application name	Collaborative driving and merging
Application short name / Identifier	SP4_CDM
Application short description	This application aims at controlling safety and improving energy efficiency. It refers to the case where two or more vehicles need to interact among themselves and/or with the road infrastructure for driving in specific situations. The application addresses the challenges in the collaboration among the vehicles. The most representative use case is lane change or lane merging; other relevant situations include roundabout driving, emergency braking or hazardous situation in front, intersection start and stop including vehicle-infrastructure collaboration, highway entrance or exit and speed limit adaptation. The application is implemented by the vehicle/driver and the TEAM backend.
Platforms implementing the application	• Vehicle+Driver • TEAM backend • Optionally a mobile device
Application objective	• Control and improve safety • Improve energy efficiency
Basic functioning	This application is mainly focus on coordinating the collaborative driving and merging of vehicles. This application provides a:

	1. Action for the driver or vehicle 2. Support to the driver/vehicle for decision making The Use Cases describe the various situations where the application is applied.
Application's use cases	1. Road restriction, reduction in number of lanes 2. Lane changing 3. Roundabout driving 4. Emergency braking 5. Emergency slowdown and stop 6. Intersection optimization 7. Speed limit adaptation 8. Highway entrance or exit 9. Custom clearance 10. Lane Advice 11. Overtaking The previous defined UCs that are described in the corresponding sections, have relationship among them. For example Road Restriction can be considered a special case of Lane changing and may be interact with the Emergency Braking UC as well.
Required lower layer components	• Communication Facilities • Incentive Facility • Map Facility • Crowd sourcing • Cloud aggregation service

1.2.3.2 Application use case 1: Road restriction (RR)

Overview

Use case name	Road Restriction
Use case short name	RR
Use case identifier	SP4_CDM_RR
Use case short description	• This use case deals with a situation where a road is partially blocked or theres exist a reduction in the number of lanes. The restriction in size of the carriageway or in the number of lanes could be temporary or extended for a long section of road. In this situation two or more vehicle need to merge from a section with a higher number of lanes to one with a reduced lane number. • Road restrictions are arising due to the following facts: • Traffic jam • Accidents • Weather condition • Road Constructions, other influences through any type constructions in that context • Urgencies • Prioritizations • Available number of lanes
Precondition	• The vehicles position • Speed • Direction vector • Preceding traffic situation • Weather Forecast

	• Deviations in place (alternate routing) • Road Restriction description: Cause and shape of the restriction • Withdrawn lanes on a road caused by the above incidents • Any additional information coming from other vehicle or infrastructure about the status of the road surface
Postcondition	• Reasonable amount of arising traffic is rerouted before approaching the road restricted area • Road restrictions are registered in central traffic informational systems for guidance and navigational purposes. • Influence of speed average guidance (collaborative) • Collaborative filtering of vehicles into the stream of traffic • The new throughput of the desired road segment is calculated and distributed to the collaborative vehicles (partners)
Normal flow	• Approaching of road restrictions will raise warning alerts of various levels of urgencies • Collaborative V2X communication computes the ideal approaching speed • C-ACC pre-setting accordingly • LDM++ and navigation set to bypass road restrictions whenever possible (e.g. by generating a lane change advice) • Performing collaborative filtering in of traffic, acceleration or retarding of approaching- and cruising- speed • Collaborative (geo-) broadcast for best practise to deal with the particular road restriction
Deployment platforms (vehicle/smartphone/ backbone)	• Fully vehicle-integrated • Smartphone • Backbone

Expected frequency of use	Steady awareness, depending on the road- and traffic-situation

External actors and components

Actors' short name	Short explanation
Driver	Interacts with the system
Vehicles	Communication among vehicles
Infrastructure (optional)	Communicate a road restriction

Input and Outputs

Input	• Map information on roads including their lanes, parking lanes, or parking spots in the direction of the vehicle shall be available. In addition distance to approaching roundabouts could be useful in order to avoid them if possible. • Vehicle lateral position in the road shall be available (distance from the side road end, distance from the right road edge). • Collaborative filter a vehicle into the stream of traffic, based on vehicle class, priority (emergency vehicle, police, fire brigades) or other external information • Side/Rear object tracking on the opposite side of the vehicle should be available in order to perform the lane exit manoeuvre to filter into the traffic flow • Steering and braking controls for assisted and automated vehicle driving/filtering in manoeuvres shall be permitted
Output	• V2X broadcasting about the current status, speed. Average speed of the involved collaborative vehicles • V2X current (collaborative) traffic density

	• V2X current weather at individual present vehicles position • V2X reporting of current obstruction of traffic

Required functional components

Components short name	Short explanation
LDM++ with cloud	To extract map information on lanes, parking lanes, auxiliary lanes in the direction of the vehicle shall be available. In addition estimates of when approaching the road restriction will be used to avoid for continues traffic flow.
Vehicle data or phone data	Vehicle data to recognise the upcoming road restriction
Provider Communication components (LTE, 802.11p)	For V2X vehicle generated notifications and messages from collaborative partners or backend systems. LTE, 802.11p, RSU
User profile	
Other SP2 component	Safe navigation rerouting and warning of the driver prior approaching the road restriction will be done in collaboration with infrastructure (backend systems) e.g. the guidance of a Road Control unit.
Interaction between SP3 and SP4	

Objectives

- Detect road restrictions prior approaching them
- Avoid dangerous vehicle stop situations
- Filter in the vehicles into the existing traffic flow safely
- Smoothing the overall traffic flow while approaching road restrictions

- Avoid traffic jams around road restrictions through rerouting

User benefits

- Lowering the risk of accidents
- Efficient and optimized path to destination
- Reduced physical fatigue
- Economical, collaborative traffic management

Basic functioning

This very complex UC requiring many vehicle control components and interactions with his collaborative environment:

- detection of road restrictions (visual, radar, laser scanning)
- slowing down, filtering the vehicle into the remaining free lanes
- C-ACC functionality to continue cruising after lane change
- Change back to normal cruise after passing road restriction
- Recalculate routing and Navigation (LDM++)

Definition of work

Design of architecture, protocols and other required techniques for vehicle merging in case of Road Restriction.

Possible Challenges

- Detection any kind of road restriction
- Automated, collaborative filtering into remaining lanes (into the traffic flow)
- Automated lane change is very challenging

Comments, additional features

As the automated filtering in of a vehicle into the existing traffic flow is a quite complex task it is recommended to split it into three parts:

- Filtering into existing traffic
- Alerting and notification prior approaching the road restriction
- Navigational recognition of collaborative notified road restrictions (within LDM++)

1.2.3.3 Application use case 2: Lane changing (LC)

Overview

Use case name	Lane changing
Use case short name	LC
Use case identifier	SP4_CDM_LC
Use case short description	In case the vehicle needs or want to pursuit a lane change, as for example when the vehicle need to turn right or left at the following intersection, the use case addresses all the actions that allow a smooth lane change allowing reduce energy consumption and allowing safety margin. Overtaking is a special case and is considered more detailed in another Use Case. Strong connection with other use cases in the same application (CDM) is present, as for example the road restriction SP4_CDM_RR user case.
Precondition	The vehicle shall be equipped with collaborative unit that records the vehicle trajectory and driver intention. The intention of the driver could be related to the other use cases.
Postcondition	The system has two major outcomes: • For the vehicle that is undertaking an lane change manoeuvre to inform and get clearance from nearby vehicles

	• For nearby vehicles to leave the way to the overtaking / lane changing vehicle • When multiple have to change lane in the same time the UC shall consider the interaction and produce the general solution • The back end system could also be informed of the manoeuvres so to consider for the overall traffic flow.
Normal flow	• A vehicle decides to change lane • The vehicle inform nearby vehicles • Nearby vehicle agree or disagree on vehicle movement • Vehicle movement take place
Deployment platforms (vehicle/smartphone/ backbone)	• In-vehicle platform • Optionally mobile device • Backend platform
Expected frequency of use	Medium/high

External actors and components

Actors' short name	Short explanation
Vehicle/Driver	There are two roles: • The lane-changing driver and • The leave-the-way driver Both need to interact and collaborate
Backbone Components	These component supports the vehicle manoeuvres with additional information;

Input and Outputs

Input	Data that is needed to implement the use case: • Vehicles' positions and trajectories • Driver driving intentions • Drivers' collaborative profiles that represents the collaboration history of the driver, from Collaborative backend • Output from other UCs, as S4_CDM_RR (road restriction) • Road topology and regulations • Possibly priority of some vehicles (emergency or police vehicles, public transport or truck) • Overall traffic state before and after the area of movement

Output	Data which is generated through the use case
	• Agreed manoeuvres
	  • Clearance
	  • Postponed
	• Detailed vehicle trajectory (optional)

Required functional components

Components short name	Short explanation
LDM++ with cloud	map data (e.g., green and safe curve, traffic light, lane positioning from the map side, positioning from the car side) Data Accessible as in a Cloud system.
Vehicle data or phone data provider	Yes, also user profiles
Communication components	Yes, short range communication

(LTE, 802.11p)	
User profile	yes
Other SP2 component	• Communication facility • Map data • Lane positioning
Interaction between SP3 and SP4	SP3: • possible traffic control state • Related with dynamic corridors SP3 app. SP4: • interaction with C-ACC. • Other use cases in the same application (CDM)

Objectives

- Allow lane changing with safety margin
- Allow energy consumption reduction of the single vehicle and of the overall traffic flow

User benefits

Improved energy consumption in lane changing manoeuvre and on general traffic flow

Basic functioning

The based either on driver or vehicle decision, the impact of the manoeuvre of the vehicle is compared with the traffic situation and nearby vehicles. The collaborative solution is defined with the nearby vehicles.

Definition of work

- Vehicle trajectory short range prediction for each involved vehicle in the scenario
- Implement longitudinal/lateral acceleration model for the overtaking vehicle and combine this with a vehicle following model (typical situations that usually occur in this chronological order are: (1) ego-vehicle is cruising unhindered in the original lane. (2) ego-vehicle decelerates when it approaches the preceding vehicle. (3) ego-vehicle intends a lane change and accelerates again. (4) ego-vehicle decelerates in the target lane when it approaches the preceding vehicle. (5) When there is a sufficient headway, ego-vehicle accelerates to its preferred speed.
- Safe and smooth Lane Changing Strategies (including braking during lane change) and computation of minimum safety spacing before beginning the overtaking manoeuvre under discrete different contextual conditions based on V2V information and optionally traffic flow information (avg. speed) and map data (speed limits, curve, slope) for the part of the road ahead.
- Based on these strategies provide the driver with the safety spacing and acceleration requirements to perform the overtaking manoeuvre once such an intention is detected, which may depend on the overall traffic flow status.

Possible Challenges

Unobserved external entities, as obstacles

Comments, additional features

None

1.2.3.4 Application use case 3: Roundabout driving (RD)

Overview

Use case name	Roundabout Driving
Use case short name	RD
Use case identifier	SP4_CDM_RD

Use case short description	This use case refers to the situation where two or more vehicles are engaging a roundabout and need to enter/leave the area. It demonstrates local coordination of a collaborative system of vehicles (possibly aided by infrastructure.

Precondition	The following information must be available
	• Lane-level vehicle position matched on lane-level map
	• Data related to manoeuvre
	• Data related to environment at the roundabout, as geometry and traffic rules
	• Low-latency wireless communication (LTE/ITS-G5)
	• Selective warning/indications, based on vehicles location, direction, intentions
	• Optionally:
	  • Intended vehicle direction after roundabout
	  • Weather conditions, as raining, snowing, ice presence

Postcondition	Vehicles engaging the roundabout act in a safer and more coordinated way, each driver being given specific indications/warning.
Normal flow	• A number of vehicles is engaging the roundabout and are identified by the collaborative system. • By the system, current situation is inferred, based on every vehicle entering inside or just exiting from the roundabout • Based on roundabout policy rules and driver's predicted trajectory, a priority is assigned to each vehicle either promoting entering in the roundabout or promoting staying in queue to promote safety. Optionally: Through predictive algorithms, the future "best situation" is evaluated • Indications are given to vehicles coming to/entering the

	roundabout, influencing their behaviour • Process is repeated until the event has ended
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/Vehicle-API / Backbone (system for monitoring the roundabout)
Expected frequency of use	From the single vehicle viewpoint, the frequency is roughly the number of encountered roundabouts under mid/high traffic conditions, and varies substantially between daytime and night-time conditions, secondary and primary roads, rural and urban areas, etc. Peak frequencies could be roughly1 event per 5-10 minutes. From the roundabout viewpoint, "event" starts when there are 2 vehicles or more, and ends where there are <2 vehicles in the interested area (entering, inside, just after). Again, the frequency of "event happening" at the specific roundabout strongly depends on time and area considered.

External actors and components

Actors' short name	Short explanation
Entering / Leaving - Vehicle / Driver	Driver and vehicle entering or leaving the roundabout
Vehicle / Driver	Driver and vehicle driving in the roundabout
Infrastructure	Local sensing system supports lane level detection, local communication supports networking, local Variable Message Sign (VMS) supports signalling to non-equipped vehicles. Optional integration with data from local infrastructure devices: communication, variable signs, sensing system

Input and Outputs

Input	Data that is needed to implement the use case are: Vehicle data including size, position, speed, yaw, brake, steering wheel angle, turning light, steering and moving capability and presence of trailer. Processed data like the vehicles' short future trajectory. Map data of roundabout, including speed limits, signage attributes, temporary attributes (e.g. roadworks)
Output	Data which is generated through the use case Warning/indications for vehicles engaging the roundabout.

Required functional components

LDM++ with cloud	LDM++ with cloud to map all static, temporary and dynamic attributes at the roundabout.
Vehicle data or phone data provider	Vehicle data provider, to infer vehicle manoeuvres or predict future trajectory of all vehicle actors.
Communication components (LTE, 802.11p)	To guarantee low latency interaction among vehicles. No need of large amount of data, but low latency
User profile	Not essential
Other SP2 component	Precise positioning technology.
Interaction between SP3 and SP4	Link to SP3 depends on the choice between (1) centralised or (2) distributed approach. (1) Centralised: SP3 cloud application uses cloud LDM, infers situation at roundabout and constantly issues indications that are valid e.g. for vehicles coming to a specific entrance of the roundabout; SP4 application of each vehicle approaching the area retrieves these indications and provides them to the driver; (2) Distributed: SP4 in vehicle application retrieves raw or pre-processed data from cloud LDM infers situation for that specific vehicle and issues indications to the driver.

Objectives

The use case should show that CDM maximises the overall traffic efficiency at the roundabout, whilst keeping each driver safe conditions.

User benefits

Main benefit is collision avoidance. Additional benefits are a reduced travel time and reduced stress at roundabout, since the driver is assisted by the system.

Basic functioning

Beacons from vehicles are constantly sent to the cloud, updating LDM++ with data over the baseline map. Application (centralised or distributed (retrieves data from the cloud and performs a situation assessment. Based on the "best" future state, it decides to influence behaviour of one or more vehicles approaching the roundabout.

Definition of work

Design architecture, protocol, data model and relevant technique for roundabout application implementation.

Possible Challenges

Lane level positioning is challenging, and impacts on deployment. If lane level positioning is not achieved (V2V may also be used to improve obtaining more accurate positioning), this use case is limited to small roundabouts.

Comments, additional features

A scalable application should be designed, working also based on few data from vehicles.

1.2.3.5 Application use case 4: Emergency braking (EB)

Overview

Use case name	Emergency braking
Use case short name	EB
Use case identifier	SP4_CDM_EB
Use case short description	This use case refers to the situation where one vehicle is following another vehicle and suddenly requires breaking, need to slow down or change lane. The situation also include when a vehicle need to break at the intersection; it demonstrates safety enhancement thanks to on-board warning.
Precondition	The following information must be available: ● Lane-level vehicle positions ● Data related to vehicle dynamics ● Low-latency wireless communication (LTE/ITS-G5) ● Weather conditions Optionally: ● Vehicle conditions
Postcondition	Vehicles following the braking vehicle can slow down smoothly or change lane in safety conditions.
Normal flow	● One vehicle is in front, a number of vehicles follow it ● Due to unexpected situation, first vehicle brakes ● Following vehicles receive warnings ● The vehicles following, either slow down or change lane if the adjacent lanes are empty ● Vehicles on parallel lanes receive also warnings, just to raise attention, or indications to slow down

	• other vehicles can be warned and action required when braking vehicle spins out of its lane and possibly affects the other lanes – huge hole on the road, spit oil, broken truck / lost load / animal obstacles several lanes, side wind, accident happened, etc.
Deployment platforms (vehicle/smartphone/ backbone)	Fully vehicle-integrated
Expected frequency of use	Seldom

External actors and components

Actors' short name	Short explanation
Active Vehicle / Driver	Vehicle that needs to slowdown/change lane
Cause Vehicle / Driver	Vehicle that is the cause of the slow down or change of lane
Other Vehicle / Driver	Other vehicles

Input and Outputs

Input	Data that is needed to implement the use case Data related to position and dynamics (speed, acceleration, brake pedal status) of all the vehicles
Output	Data which is generated through the use case Warnings to all following vehicles, and also to the parallel lanes.

Required functional components

Components short name	Short explanation
LDM++ with cloud	However, it should be evaluated whether this emergency situation can be treated through cloud computing and LTE,

	or directly through ITS-G5.
Vehicle data or phone data provider	Vehicle data provider, to provide the input data mentioned above.
Communication components (LTE, 802.11p)	Low latency communication.
User profile	Not essential
Other SP2 component	Precise positioning technology.
Interaction between SP3 and SP4	Overall this is mostly an SP4 Use Case. SP3 could enter in terms of traffic data provision on the interested road stretch.

Objectives

To inform and influence behaviour of all vehicles following the emergency braking vehicle, for a safe management of the associated collision risk.

User benefits

Drastic reduction of rear collision risk.As side effect, improvement of traffic efficiency.

Basic functioning

Basic mechanism is to infer emergency braking situation as well as surrounding situation, and provide warning/suggestions to incoming vehicles on the same lane and on adjacent lanes. Action following the Warning or suggestion may be automatically implemented in more advanced situations.

Communication technology is still to be evaluated, may be V2V through ITS-G5 due to low latency requirements.

Definition of work

- An HMI component to coach the driver
- A component to aggregate information about the situation and determine when it's an emergency
- Low latency communication component

Possible Challenges

Communication latency, Testing in real conditions.

Comments, additional features

Lane level position is good to have but not too critical here. A downscaled version of the use case could be demonstrated by providing the same kind of warning to vehicles on all lanes of the carriageway.

1.2.3.6 Application use case 5: Emergency slowdown and stop (ESS)

Overview

Use case name	Emergency slowdown and stop
Use case short name	ESS
Use case identifier	SP4_CDM_ESS
Use case short description	In case of reduced driver's vigilance the vehicle the vehicle should perform an automated safety procedure to commence an emergency hold/stop. This use case deals with the interaction among nearby vehicles in order to create a safety shield around the vehicle in problem.
Precondition	• Information on auxiliary lanes, parking lanes, or parking spots in the direction of the vehicle shall be available. • Vehicle lateral position in the road shall be available (distance

	from the right road end, distance from the right road edge). • The driver vigilance has to be continuously monitored.
Postcondition	Since this is emergency situation and the stop position held by the vehicle is considered temporary, some kind of emergency notification should be issued by the vehicle to: • other vehicles around • road authorities • the global traffic management system (for influencing active navigation)
Normal flow	• The vehicle senses reduced driver's vigilance during normal driving situation (as for example, unexpected release of the gas pedal; big slowing-down rate) • The vehicle activates the "alarm indicators" and sends an emergency notification to the vehicles around asking for emergency access to the lanes on its right. • The vehicle ADAS system influences power setting and guidance in order to guide the driver to a safe stop/hold position: this may include to maintain a safe position within the lane the vehicle was driving before the incident by slowing down and trying to head to the far right road lane or road edge in order to park. • Sensing the side rear region on his right and applying the right flash indicator, asks for permission to go right. If the field is clear, it proceeds by driving to next lane till it gets to the far right lane. Being stopped to the far right lane, examines the map data for auxiliary/parking lanes nearby and notifies the user. In the same time, warning lights and beacons are activated.
Deployment platforms (vehicle/smartphone/	Fully vehicle-integrated

backbone)	
Expected frequency of use	seldom (emergency situation)

External actors and components

Actors' short name	Short explanation
Active Vehicle / Driver	Vehicle that needs to slowdown/change lane
Cause Vehicle / Driver	Vehicle that is the cause of the slow down or change of lane
Other Vehicle / Driver	Other vehicles

Input and Outputs

Input	• Map information on auxiliary lanes, parking lanes, or parking spots in the direction of the vehicle shall be available. In addition distance to approaching roundabouts could be useful in order to avoid them if possible. • Vehicle lateral position in the road shall be available (distance from the right road end, distance from the right road edge). • Collaborative information on other vehicles position and dynamics in the vicinity of the ego-vehicle • Side/Rear object tracking on the right side of the vehicle should be available in order to perform the lane exit manoeuvre • Steering and braking controls for automatic driving shall be permitted.
Output	• V2X Notification: "vehicle emergency stop" + "Request for accessing the lanes on its right" • V2X Notification: "vehicle emergency parking at specific location" • Activation of the vehicle's warning beacons

	• Activation of the road infrastructure warning beacon in the vicinity of the emergency hold/stop.

Required functional components

Components short name	Short explanation
LDM++ with cloud	To extract map information on auxiliary lanes, parking lanes, or parking spots in the direction of the vehicle shall be available. In addition distance to approaching roundabouts could be useful in order to avoid them if possible.
Vehicle data or phone data provider	Vehicle data to detect the emergency situation (driver's lack of control)
Communication components (LTE, 802.11p)	For V2X vehicle generated notifications
User profile	-
Other SP2 component	Safe navigation to a temporary parking space could be done with collaboration with infrastructure e.g. the guidance of a Road Control unit. Traffic management system can issue a warning alert (or beacon if applicable) for the succeeding traffic.
Interaction between SP3 and SP4	-

Objectives

- Detect emergency lack of driving control situation
- Avoid dangerous vehicle stop situation when the driver has problems to control his vehicle by notifying nearby vehicles
- Drive/Navigate the vehicle to a safe stop position.

User benefits

Accidents' avoidance in roads when a driver is in a lack of driving control situation. Reduced traffic jams due to hindering vehicle.

Indirect benefits are: input for road restriction (UC1), speed adaption (UC7)

Basic functioning

This very complex UC requiring many vehicle control components:

1. detection of driver's lack of control situation
2. automatic lane keeping and slowing down
3. automatic changing to the next right lane
4. repeat of steps 2 + 3 till the far right lane of the road is reached by checking if the right side-rear area of the vehicle is free of moving vehicles.

Definition of work

Define architecture, protocols, data model and techniques necessary to develop the application.

Identify which methods are more suitable to detect emergency situations

Possible Challenges

- detection of emergency situation is not trivial if it is not signalled by the driver
- Automatic lane keeping is not trivial

Automatic lane change is challenging due to many external factors, as for example to the availability of stopping area or presence of obstacles

Comments, additional features

Addressing the assumption that the driver has no more control over the vehicle is quite hard to implement since it implies the need for automatic driving. It would be better if we assumed that the driver can still control the vehicle but needs some assistance. And even in this case I find this UC very complex for a TEAM application (do we handle emergency situations in TEAM SP4? handling active impact scenario).

We could alternatively offer the possibility of creating a safety shield around the vehicle in problem by only notifying the vehicles around and aim only to slow down and stop the vehicle (handling passive impact scenario).

1.2.3.7 Application use case 6: Intersection optimization (IO)

Overview

Use case name	Intersection optimization
Use case short name	IO
Use case identifier	SP4_CDM_IO
Use case short description	This use case refers to optimize the crossing of intersections with traffic lights by means of vehicle-infrastructure collaboration (SPaT provisioning, SPaT=Signal Phase and Timing). One approach is to coach the driver to follow an optimal speed to cross in green, when it's possible. When it's not possible to cross in green, the driver should be coached to brake in an eco-friendly way. Furthermore, when the vehicle stops at the red light, the start-stop function should receive information from the traffic lights to optimize the time. Additional information to the driver is the optimized lane selection to improve traffic flow. This use case also includes the case with intersections without traffic light, where the vehicles communicate with each other.
Precondition	The vehicle shall be equipped with collaborative unit that record the vehicle trajectory; vehicle shall communicate with nearby vehicles on the same lane; Precise positioning in the road;

Postcondition	Optimized driving though intersection.
Normal flow	• Vehicle approaches an intersection • Vehicle receives traffic light information(SPaT) from the roadside ITS station or from the other vehicles when the intersection has no traffic lights • Driver is coached to adapt speed (acceleration and deceleration) and/or give way • Driver is coached to select lane If the vehicle needs to stop, the start-stop is optimized
Deployment platforms (vehicle/smartphone/ backbone)	Fully vehicle-integrated, Backbone (traffic management centre) and road side infrastructure
Expected frequency of use	High

External actors and components

Actors' short name	Short explanation
Ego-Vehicle	The vehicle equipped with a TEAM ITS vehicle station
Intersection	The intersection with traffic lights equipped with a TEAM ITS roadside station
Driver of the ego-vehicle	Driver of the TEAM equipped driver
Other vehicles	Other vehicles approaching the intersection

Input and Outputs

Input	• Road characteristics, including special road marking – special lanes for busses and cycles, zebra, safety islands for pedestrians,

	parked vehicles • Signal time and phase from the traffic light • Position and distance to the intersection • Vehicle speed, acceleration/deceleration • Itinerary • Drivers' collaborative profiles
Output	Speed range and driver coaching which is generated through the use case

Required functional components

Components short name	Short explanation
LDM++ with cloud	Intersection topology Map with nearby vehicles
Vehicle data or phone data provider	Vehicle information, such as speed, acceleration, etc.
Communication components (LTE, 802.11p)	Communication between nearby vehicles and with the infrastructure
User profile	Driver profile
Other SP2 component	Map data Lane level positioning
Interaction between SP3 and SP4	Related with SP3 Smart Intersections application (SPaT provisioning) Related with SP4 C-ACC application (when automated driving through intersections)

Objectives

The objective of this use case is to improve the traffic flow through intersections by coaching the driver.

User benefits

The main benefits of this use case, together with the complete application are to improve traffic flow and reduce emissions.

Basic functioning

When the intersections are equipped with traffic lights, the vehicle receives information about signal phase and timing. The system calculates optimal speed for crossing in green. In case it is not possible, the system calculates optimal brake pattern. The driver is coached. If the vehicle needs to stop, the smart start-stop function should be synchronized with the traffic light.

When the intersections don't have traffic lights, the vehicle receives information from other approaching vehicles. In this case, the driver is informed if he/she has priority to cross first or to give way.

Definition of work

- A protocol to receive information from the traffic light
- A component to calculate the optimal speed range
- An HMI component to coach the driver
- A component to calculate the optimal braking pattern
- An interface with the start-stop function

Possible Challenges

- Possible extensions of protocols currently under standardization
- Interface with start-stop function
- Detection of necessary input data

- Braking coaching HMI

Driver behaviour, as with left turning, when the driver stop in the middle, to wait for the vehicle from the opposite direction to pass by; when driver stay on the stop-line even if the light is green with traffic head

Comments, additional features

None

1.2.3.8 Application use case 7: Speed limit adaption (SLA)

Overview

Use case name	Speed Limit Adaption
Use case short name	SLA
Use case identifier	SP4_CDM_SLA
Use case short description	Speed limits can have static or dynamic origin. They appear as fixed installed road signs or dynamically changeable displays showing the suitable limit. Locally, speed limits may not appear at all, e.g. on motorway 130 km/h in ordinary conditions and 110 km/h in rainy conditions is signalised only in few specific places. The use case also accounts also for the presence of variable speed limit and also for the influence of single vehicle speed adaptation on nearby vehicles. In case of constructions, hazards, or accidents speed limits can be introduced and removed dynamically on demand. A vehicle has at least to react on speed limits, in order to keep (or decelerate) below the limit. The speed limit adaption (SLA) does it automatically. Thus a collaborative and automated speed limit adaption has to influence

	the power setting of a vehicle that it moves within the desired limit. The collaborative aspect of the function consists in getting speed limits through the collaborative group of vehicles and transmitting notifications for other members of the collaboration network. Speed limit (range) can be visualized in the following ways: • Fixed installations (for years at the same limit at the same location) • Fixed installations (Dynamically changed limits at the same location through electronic displays) • Temporary limits (constructions, accident, …) • On board display Speed reduction rules due to bad weather or road conditions
Precondition	• The vehicles position • Current speed • Direction vector • Withdrawn lanes on a road caused by the incidents • Limit detection through position – map matching (LDM++) • Limit detection through optical scanning of the route • Limit detection derived from type of used road (highway, city road) • Recognition of country specific road type based speed limits (highway Germany = no limit, Austria = applied limit)
Postcondition	• Speed adapted to limit • Collaborative limit notification • Collaborative cursing speed adaption • Backend Systems for LDM++ and navigation will be notified

	about detected temporary speed limits
Normal flow	• Approaching of speed limits will raise collaborative alerts for succeeding traffic • Collaborative V2X communication computes the ideal approaching speed to limited area • Vehicles utilizing C-ACC are pre-setting accordingly • LDM++ and navigation is set to temporary speed limits
Deployment platforms (vehicle/smartphone/ backbone)	• Fully vehicle-integrated • Smartphone • Backbone
Expected frequency of use	• Continuously (depending on the road- and traffic-situation)

External actors and components

Actors' short name	Short explanation
Driver/Vehicle	The driver or vehicle that need to change speed
Infrastructure	This actor typically set the speed limit and traffic rules
Other vehicles	Other vehicles that follow or anticipate the current vehicle

Input and Outputs

Input	• Map information on roads including fixed speed limit road signs (navigational data, LDM++) • Vehicle position on the road, including lane-level position in two lane roads • Collaborative average speed in the vicinity of the vehicle • Collaborative speed limits (communication about speed limits

	ahead) • Optical captured road signs • Environmental conditions and other events affecting speed limit (weather, hazards)
Output	• V2X Reporting of new temporary speed limit road signs • V2X broadcasting about the current status and speed. Average speed of the involved collaborative vehicles • V2X current (collaborative) traffic density • V2X reporting of current obstruction of traffic

Required functional components

Components short name	Short explanation
LDM++ with cloud	• To extract map information about applicable speed restrictions (fixed road signs) • Recognition of dynamically reported speed limits. They will be used for navigational purposes and speed limit alerts during cruise • Collaborative exchange of recently detected speed limit within the vicinity of the vehicle
Vehicle data or phone data	Vehicle data to recognise the upcoming road restriction
Provider Communication components (LTE, 802.11p)	For V2X vehicle generated notifications and messages from collaborative partners or backend systems. LTE, 802.11p, RSU
User profile	
Other SP2 component	Safe navigation rerouting and warning of the driver prior approach of the speed restricted area. The restriction may be caused due an accident or construction, so it might be

	advised to accept a rerouting to destination.
Interaction between SP3 and SP4	

Objectives

- React on temporary speed restrictions prior approaching them
- Collaborative information flow within the influenced vehicles to get them informed about new speed limitations (value and affected road segment)
- Smoothing the individual cruise while approaching speed limit
- Smoothing the overall traffic flow while approaching speed limit
- Avoid speed limits through rerouting if the perception justifies it

User benefits

- Lowering the risk of accidents
- Efficient and optimized path to destination
- Reduced load on the driver (preserves physical forces)
- Economical, collaborative traffic management

Basic functioning

This complex UC requiring many vehicle control components and interactions with his collaborative environment:

- detection of temporary speed restrictions (visual, radar, laser scanning)
- matching the geo positions of fixed speed limitations with LDM++ data (if necessary updating them on the backend)
- slowing down the vehicle to the predicted approaching speed
- Influence C-ACC functionality to continue cruising after new speed limitation setting

- Change back to normal cruise after passing the speed restriction
- Recalculate routing and Navigation (LDM++)

Definition of work

Design the architecture, protocol, data model and special technique to deal with speed adaptation.

Possible Challenges

- Detection of any kind of speed restriction (through recognition of slowing down moving vehicle queues)
- Automated, collaborative adaption to the ideal bypassing speed
- Automated determination of best line cruising speed if different speed limits are applied to single lanes

Comments, additional features

As the automated acceleration (pos., neg.) of a vehicle is challenging task it is recommended to split it into parts:

- Advice for speed reduction to be performed by the driver
- Breaking down to the new restricted speed
- If equipped: C-ACC get new speed setting
- Navigational recognition of collaborative notified speed restrictions (within LDM++)

1.2.3.9 Application use case 8: Highway entrance or exit (HEE)

Overview

Use case name	Highway entrance and exit

Use case short name	HEE
Use case identifier	SP4_CDM_HEE
Use case short description	This use case refers to the case where one or more vehicles need to enter or exit an unattended (not controlled) ramp of a highway; the vehicle shall have space to exit or enter the highway ramp and shall collaborate with other vehicles in order for the action to be performed safely.
Precondition	The information on current and future trajectory of the vehicle and possible request of enter / exit of highway
Postcondition	The agreed lane changing manoeuvres
Normal flow	1. A vehicle communicate its intention to enter / exit an highway 2. The HEE application checks the occupancy in the exit lane ahead from other users and suggests the time to initiate the manoeuvre and the amount of deceleration/acceleration required. 3. The vehicle performed the agreed manoeuvre
Deployment platforms (vehicle/smartphone/ backbone)	In-vehicle platform Backend platform
Expected frequency of use	Medium

External actors and components

Actors' short name	Short explanation
Vehicle/Driver	There are two roles: 1. The entering/leaving driver and 2. The leave-the-way drivers In both roles, the actor needs to interact and collaborate with other

	users that are using/ going to use the exit/entrance lane.
Backbone Components	These components support the vehicle manoeuvres with additional information;

Input and Outputs

Input	• Vehicles' positions speed and trajectories in the exit/entrance lane and in the adjacent line • Driver driving intentions • Drivers' collaborative profiles • Map data • Vehicle characteristics, such as type, size, weight etc. • Vehicle dynamic characteristics (braking and acceleration capacity etc.) • Road topology with regulations Optionally • Weather situation, possibly side wind, bad visual conditions, slippery road, length of entrance lane

Output	• Agreed manoeuvres
	  • Clearance
	  • Postponed
	• Detailed vehicle trajectory (optional)
	• Impact on general traffic flow
	• Optimal speed for the users
	• Driver coaching information (recommended speed etc.)

Required functional components

Components short name	Short explanation
LDM++ with cloud	Data for distance of exit/entrance lane Road topology/geometry with regulations Map of surrounding vehicles
Vehicle data or phone data provider	Local data from other vehicles in the front and the rear heading to the same exit/entrance is needed to understand the situation Speed, position, weight, etc.
Communication components (LTE, 802.11p)	The component is used to communicate among vehicle and to the backbone centre.
User profile	The user profile that is used for the collaborative part.
Other SP2 component	Lane positioning

Interaction between SP3 and SP4	• SP4
	  • other UCs of the CDM application
	  • possibly C-ACC application, when signalled ramp metering
	• SP3
	  • interaction with the infrastructure

Objectives

- Reduce energy consumption
- Improve safety margin when entering/exiting in/from a highway
- Improve traffic flow

User benefits

Keeping safety margin, improve energy consumption and increased traffic flow

Basic functioning

This is a part of a lane change assistant application focusing only on entering an exit/entrance lane in a highway.

Definition of work

- Vehicle trajectory short range prediction for each involved vehicle in the scenario
- Detect possible threats from behind from vehicle already using the exit/entrance lane
- Implement longitudinal/lateral acceleration model for the exiting/entrancing vehicle and combine this with a vehicle following model if already a vehicle ahead using the exit/entrance lane
- Safe and smooth Lane Changing Strategies (including braking during lane change) and computation of minimum safety spacing before beginning the overtaking manoeuvre under discrete different contextual conditions based on V2V information and optionally traffic flow information (avg. speed) and map data (speed limits, curve, slope) for the part of the road after the exit/entrance (highway/rural) is finished.
- Based on these strategies provide the driver with the safety spacing and acceleration requirements to perform the exiting/entering manoeuvre once such an intention is detected or communicated.

Possible Challenges

- Model different vehicle dynamics based on vehicle type and load and recommend a manoeuvre that is feasible for all vehicles involved

Comments, additional features

None

1.2.3.10 Application use case 9: Custom clearance (CC)

Overview

Use case name	Custom clearance
Use case short name	CC
Use case identifier	SP_CDM_CC
Use case short description	Accommodating ambulances, fire trucks, and police cars so that vehicles in front can make room for their passing.
Precondition	Vehicles in range for accommodating emergency vehicle passing should be equipped with V2V communication
Postcondition	The authority can move traffic to get a free way during an emergency. Alternatively authority can communicate to a vehicle to stop (For instance the police pulls over a vehicle)
Normal flow	1. Authority wants to move traffic to get room 2. Authority vehicle sends out information to all vehicles in front of it. If a specific vehicle has to be addressed, this should also be possible for law enforcement situations. 3. Traffic receives information about wanted behaviour of the authorities (for instance lane changes to give room to authority or pull over to the police).
Deployment platforms (vehicle/smartphone/ backbone)	Fully vehicle-integrated Backbone Third party
Expected frequency of use	Frequent for ambulances and police. Not frequent for regular traffic.

External actors and components

Actors' short name	Short explanation
Emergency Vehicle	ambulances, fire trucks or police car that issues the V2V emergency passing request
Police car	A police car that issues a pull-over command to a vehicle in front.

Input and Outputs

Input	• Vehicle type • Truck, bus (long and short distance), tram, car, motorcycle, cyclist, ambulance, etc. • Position, speed and intended destination • Road topology • Map with surrounding vehicles and information
Output	Message to be sent to the surrounding vehicles

Required functional components

Components short name	Short explanation
LDM++ with cloud	Road topology Map with surrounding vehicles
Vehicle data or phone data provider	All relevant data about the vehicle
Communication components (LTE, 802.11p)	Communication with the vehicles nearby
User profile	
Other SP2 component	Lane positioning
Interaction between SP3 and	Other use cases of CDM

SP4	

Objectives

Collaboration in traffic to enable a safe passing of a vehicle issuing an emergency hurry-up situation

User benefits

Improving traffic situation when an authority or ambulance vehicle issuing an emergency hurry-up situation wants to pass.

Basic functioning

This use case could be triggered manually by the driver of the emergency vehicle or triggered automatically when the vehicle is in emergency mode (i.e. with emergency lights turned on). -

The UC is triggered by a human user (e.g. ambulance driver) thus no input data are required. Two main scenarios are possible for use case triggering:

1. Geo-broadcasting for emergency pass of an authority/ambulance vehicle
2. 1 to 1 communication for a pull-over command issuing.

Definition of work

- Component to communicate precise information to the surrounding vehicles
- HMI component to warn the drivers of the other vehicles and coach them with their expected manoeuvre.

Possible Challenges

How to handle congested traffic and intersections with long queues

Comments, additional features

None

1.2.3.11 Application use case 10: Lane advice (LA)

Overview

Use case name	Lane Advice
Use case short name	LA
Use case identifier	SP4_CDM_LA
Use case short description	Advice to the driver of a truck is given with regards to lane selection. This can be done for instance before a hill with multiple lanes.
Precondition	Road composed of Multiple lanes Map-data that contains the description of multiple lanes Map-data of upcoming geographical changes (hill, intersection, slope)
Post condition	The truck is positioned in the optimal lane depending on map data and respecting the traffic regulation. Other vehicles adjust position accordingly.
Normal flow	• The navigation system reads that there is an upcoming geographical change from the map data. • The driver is informed what lane to change to. If already in the optimal lane, no information is given to the driver since it would only cause unnecessary distraction. • When other collaborative vehicles are present in the target lane vehicle collaborate to lane position definition • The driver changes lane to the optimal lane.

Deployment platforms (vehicle/smartphone/ backbone)	Fully vehicle-integrated Central System for vehicle Coordination
Expected frequency of use	For long haul trucks, quite frequently.

External actors and components

Actors' short name	Short explanation
Truck Vehicle/Driver	The Truck Driver and vehicle need to interact to the system to agree on the lane change
Other Vehicles/Drivers	Other vehicle/drivers need to interact with the system to agree on lane change
Backbone TEAM platform	The backbone platform contains the user/vehicle profiles

Input and Outputs

Input	• Road topology, including traffic rules • Map with surrounding vehicles • Vehicle position, speed, weight, length and characteristics • Itinerary
Output	• Recommendation of lane. • Agreed lane position definition

Required functional components

Components short name	Short explanation
LDM++ with cloud	Road topology

	Map of surrounding vehicles
Vehicle data or phone data provider	Vehicle static and dynamic data
Communication components (LTE, 802.11p)	Short range communication among nearby vehicle Long range communication for user profile
User profile	Truck and normal vehicle user/vehicle profiles
Other SP2 component	Lane positioning
Interaction between SP3 and SP4	Other UCs in the CDM

Objectives

- Definition of the optimal lane for Truck based on Map data
- Exchange of information with other vehicles for coordination

User benefits

Smoother highway traffic flow

Basic functioning

The truck foresees the upcoming road layout change based on map data. It then determines the optimal lane to improve traffic flow and communicates that to the surrounding vehicles. The collaborating vehicles agree on the manoeuvre and positioning and perform the necessary lane changes.

Definition of work

- Interface with the Truck Driver to interact during lane definition and movement
- Interface with other vehicle drivers for lane change agreement

- Module for lane position computation
- Module for communication among actors

Possible Challenges

Integration of traffic rules with roadwork or other exceptional situation may represent a challenge

Comments, additional features

None

1.2.3.12 Application use case 11: Overtaking (OT)

Overview

Use case name	Overtaking
Use case short name	OT
Use case identifier	SP4_CDM_OT
Use case short description	In case the vehicle needs or want to overtake, this is a special case of lane changing, the use case addresses all the action that allow a smooth lane change during overtaking and smooth close of the manoeuver, while at the same time allowing reduce energy consumption and keeping safety margin.
Precondition	The vehicle shall be equipped with collaborative unit that records the vehicle trajectory and driver intention The vehicle is also equipped with sensor that support driver and the application to reconstruct current traffic situation, as for example optical based sensor.
Postcondition	The system has two major outcomes: 1. For the vehicle that is undertaking an overtaking manoeuvre to

	inform and get clearance from nearby vehicles 2. For nearby vehicle to leave the way to the overtaking vehicle
Normal flow	1. A vehicle decides to overtake, considering overall traffic situation 2. The vehicle inform nearby vehicles 3. Nearby vehicle agree or disagree on vehicle movement 4. Vehicle movement take place, possibly supported by optical or collaborative tools 5. The all manoeuvre is assisted and can be interrupted for safety reason
Deployment platforms (vehicle/smartphone/ backbone)	In-vehicle platform Backend platform
Expected frequency of use	medium/high

External actors and components

Actors' short name	Short explanation
Vehicle/Driver	There are two roles: 1. The overtaking driver and 2. The leave-the-way driver 3. Possibly reverse traffic is informed / influenced and interact in the manoeuvre definition and implementation Both need to interact and collaborate
Backbone Components	These component support the vehicle manoeuvres with additional information

Input and Outputs

Input	• Vehicles' positions and trajectories • Driver driving intentions • Drivers' collaborative profiles, which represents the user collaborative history. A user collaborative profile gives information on user history and collaborative intentions • Opposite direction vehicle's positions and intentions

Output	• Agreed manoeuvres
	  ◦ Clearance
	  ◦ Postponed
	• Detailed vehicle trajectory (optional)
	• Information messages to other road user (opposite direction vehicle, pedestrian, …)

Required functional components

Components short name	Short explanation
LDM++ with cloud	map data (e.g., green and safe curve, traffic light, lane positioning from the map side, positioning from the car side)
Vehicle data or phone data provider	Vehicle position and trajectories, user's profile.
Communication components (LTE, 802.11p)	Long and short range communication
User profile	The collaborative user profile
Other SP2 component	Communication facility

	Map data
Interaction between SP3 and SP4	• SP3: • possible traffic control state • Related with dynamic corridors SP3 app. • SP4: • Other UCs in CDM, as for example RR • Other application, C-ACC: for example by disabling the C-ACC function

Objectives

- Allow lane changing with safety margin
- Allow energy consumption reduction of the vehicle undertaking the manoeuvre or general traffic flow
- Alert opposite direction or surrounding vehicles in case of emergency situations

User benefits

- Improved energy consumption in lane changing manoeuvre
- Improve safety in normal and emergency situation

Basic functioning

Design of architecture, protocol, data model and special techniques for overtaking application.

Definition of work

- Vehicle trajectory short range prediction for each involved vehicle in the scenario

- Implement longitudinal/lateral acceleration model for the overtaking vehicle and combine this with a vehicle following model (typical situations that usually occur in this chronological order are: (1) ego-vehicle is cruising unhindered in the original lane. (2) ego-vehicle decelerates when it approaches the preceding vehicle. (3) ego-vehicle intends a lane change and accelerates again. (4) ego-vehicle decelerates in the target lane when it approaches the preceding vehicle. (5) When there is a sufficient headway, ego-vehicle accelerates to its preferred speed.
- Safe and smooth Lane Changing Strategies (including braking during lane change) and computation of minimum safety spacing before beginning the overtaking manoeuvre under discrete different contextual conditions based on V2V information and optionally traffic flow information (avg. speed) and map data (speed limits, curve, slope) for the part of the road ahead.
- Based on these strategies provide the driver with the safety spacing and acceleration requirements to perform the overtaking manoeuvre once such an intention is detected.

Possible Challenges

- Unobserved external entities, as obstacles
- Opposite traffic has to be carefully considered
- Use of optical sensor in the application and its integration

Comments, additional features

None

1.2.4 Green, safe and collaborative driving serious game and community building

This description involves two applications (namely the serious game and the community building application). Given the similar system architecture, we prefer having a single description, highlighting the common/similar requirements and use cases without duplications that would be annoying and introduce management overhead and possible technical inconsistencies in the documentation. However, in the following text we clearly distinguish between the two applications, when needed.

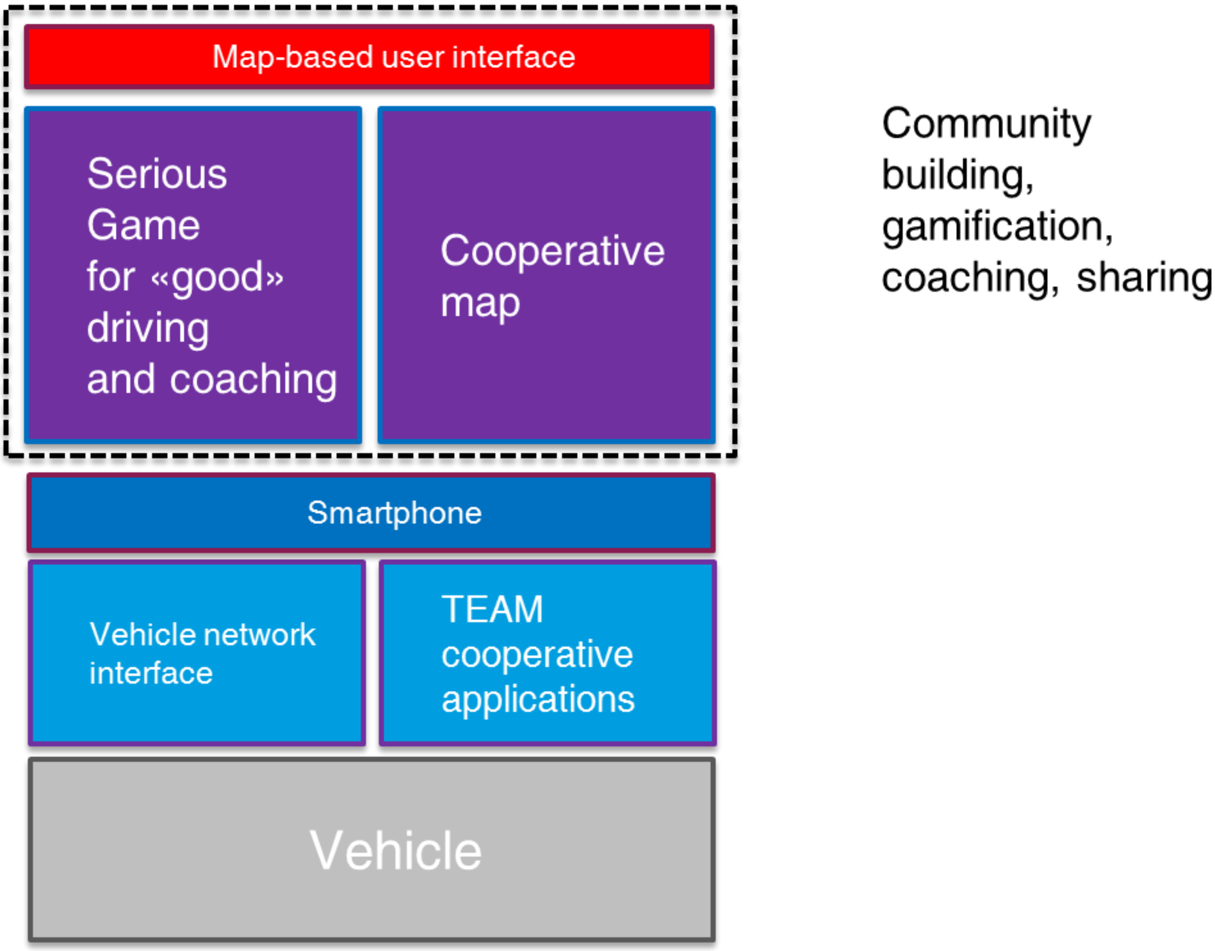

Figure 1.12: High-level sketch of the SG-CB applications architecture

1.2.4.1 Application Overview

Application name	Green, safe and collaborative driving serious game and community building
Application short name / Identifier	SG-CB
Application short	This application intends to promote and favour a proper driver behaviour, with a particular attention to collaborative applications

description	that are being developed in TEAM. The SG-CB application consists of a gamified social network environment where drivers and passengers can share their information and learn proper driving styles, in a pleasant and compelling way and featuring a map-based user interface. The application includes also a serious game (SG) that exploits car data in order to create a gentle/smart competition among drivers based on green and safe driving, with a pedagogical/coaching goal.
Platforms implementing the application	Smartphone (typically connected to the application server) /Vehicle-API Backbone (traffic management centre) Extensions can be considered, especially in a long-term perspective, using infrastructure in a cloud-computing based approach
Application objective	The general goal of the application is to promote and favour proper driver behaviour. This will be achieved in various ways. The gamified map-based social environment will allow people to share in real-time information about their driving situations, also exploiting information and data from the collaborative TEAM application. The SG will provide a contest environment where drivers can have challenges based on green and safe driving.
Basic functioning	The application will be available to the user through the Internet on Smartphone (also on PCs, where available). The application environment will strongly rely on local dynamic maps. While the user is driving, the application – connected to the vehicle's networks – processes data about the travel in real-time. This is important, since the driver will be playing (even if with a very limited impact on the cognitive workload) with the green/safe driving SG. The user interface will be very simple (and configurable by the user), limited to a very simple feedback about the current

	level of performance by the driver (e.g. a 3-colour traffic-light, or a performance meter/bar). While not driving, the user will be able to access a menu through which he can see several analytics about its performance. Also, he will be able to set challenges, on a particular path, with other people/friends. Each user will be able also to insert geo-referenced messages inside the social map environment, when the vehicle is not moving. Other messages could be automatically sent by the car (e.g., windscreen wipers, temperature, airbag, speed) also during the drive, if the user allowed it. This will allow creating and displaying on the map integrated information collected through the vehicles (this is an enhancement of the current Waze social driving application, which only relies on cell-phone data). Data could be used also by 3rd parties to build other related services. Area-wide instant weather information may be gathered and made available for weather prediction and weather alert. Selected (i.e. relevant to the driver) notifications will appear on the map during the drive. This application may be integrated inside a navigator (in particular the Nokia Feed and Road Book approaches). Beside the SG, gamification will involve a scoring system, with points gained from the quantity and quality of information provided to the system and from a proper use of the TEAM collaborative applications (specifications are to be negotiated soon with the various application leaders). Badges will be assigned to good performers, based on various criteria (e.g., time, space/area, friends, common interest, type of vehicle, etc.). Incentives are foreseen in terms of virtual gadgets/facilities and of real-world rewards, such as access to pool lanes, discounts for parking costs, free bus tickets, etc. The system will exploit a user model for driving and information

	and a user credibility management system. When not driving, the user will be able to access the information online through a website. From a technical point of view, the SG-CB is a TEAM meta-application, in the sense that it exploits data communicated by the other applications in order to support good user behaviour. The application involves significant privacy and security aspects.
Application's use cases	1. **Playing the green/safe driving serious game**: The driver drives on his way, with possibly no information at all from the SG. Different levels of feedback provision can be set. These may include: no feedback, a 3-color traffic light (or a similar performance-meter) showing how well the driver is behaving considering the target indicator(s), or the difference with respect to the competitor in a challenge (or average value of the other drivers). An integrated measure is displayed as well. Acceptance of proposed rerouting due to incidents such as weather, accidents, etc. may be rewarded as well. Driving suggestions ("coaching messages") are also active-able (e.g., "you drive with too many RPMs", "please stay more in the centre of your lane", "keep more distance from the car ahead", "you accelerate and brake too frequently"). 2. **Computation of the driver performance**: The car data are continuously processed to compute the target indicator(s) (e.g., fuel consumption, use of pedals, safety distance, distance from the centre of the lane, correct use of blinkers, a weighted sum of all). An incremental value (integrating all the values from the day, or the user's reset) is also computed. The data could be normalized with respect to the specific vehicle model, in order to allow an evaluation of the driver, keeping into account the strong differences among types of vehicles. In this case, not the absolute values would be considered, but each driver real-time distance from the ideal behaviour. We need that the car manufacturers support this preparation of a vehicle

	model for each vehicle. A set of rules is continuously processed in order to provide formative feedback to the user (with appropriate filters, in order not to have a cognitive overload). 3. **Create a challenge for the SG**: A person could go on a dedicate webpage of the application, select a friend with whom to make a challenge and define a route for the challenge. When the friend accepts, the system records the first performance of the two people in that road. The result of the comparison will be showed in a special section of the friends' page (see use case 5) 4. **Watching the performance – general**: Every user can access its own performance personal page of the application. The performance page shows, for each user, a number of analytics (e.g., fuel consumption, use of pedals, safety distance, distance from the centre of the lane, correct use of blinkers, break activity, accelerator activity, speed, a weighted sum of all as an aggregated performance indicator). Average values (on different, selectable, time periods and types of roads: urban, extra, motorway) are displayed. The user can select own routes and get his indicators only on these routes. The selected routes are recorded, so to facilitate the user interaction the next times. Some routes are selected automatically and performance results from several different users are shown there. For any data, it is possible to apply different filters: self, friends, type of car, interest, geographic area, time periods, etc. in order to reduce the number of displayed results. Different dimensions can be displayed: consumption. An aggregated value can be displayed as well. 5. **Watching the performance – diary view**: The user can watch his diary, where the journey he has made (the time for selecting the journey is provided by the user) is presented on a map,

	showing key actions performed and performance indicators (with comparison with the competitor, in case of a challenge). The route is segmented and filled with different colours according to the local value of a selected indicator (e.g., consumption, braking activity, speed, etc.). Driving suggestions are also displayed on the route. 6. **Thematic competitions**: Thematic competitions could also be set up periodically (in given time windows, in order to avoid inappropriate comparisons). For instance: who is the person who took more synchronized green traffic-lights? Who is the user who was able to keep a stable speed longer? Rewards are provided 7. **Provision of incentives**: Incentives are foreseen in terms of virtual gadgets/facilities and of real-world rewards, such as access to pool lanes, discounts for parking costs, free bus tickets, etc. 8. **Setting preferences**: The user sets preferences (e.g., what information can be sent automatically by the vehicle during the drive, type of feedback while driving, etc.) on his profile page. 9. **Automatic transmission of geo-referenced data**: According to the preferences set by the current user, the vehicle, through the smartphone, sends to the application server information such as: speed, position, windscreen wipers activity, suspensions activity, anti-fog lights, temperature, etc. This information is crucial to maintain dynamically updated collaborative map (use case 12). This information could be used by third parties as well for other services like weather forecast. 10. **Sending messages for the collaborative map**: The user (traveller) issues/writes (could be vocally, for the driver) messages that are geo-referenced. The messages can be free text or user customized instances from standard templates (based on a simple drive/transport ontology), in order to facilitate composition, comprehension and automatic

	processing. 11. **Rider assistance request**: Rider faces a problem, not an emergency, and needs to pull over. The rider can by simple means request road side assistance and the system sends assistance request signal to road users nearby. 12. **Proper collaborative behaviour, based on the other TEAM applications**: The SG-CB applications should promote a good use of all the TEAM collaborative applications. Every application should communicate about the behaviour of the driver, possibly in real time. Metrics for all the applications are kept, so that the driver can be rewarded or penalized. A virtual coin mechanics will be managed by the SG-CB application, so that "good" drivers will have more virtual coins that could be spent, in turn, to getter better quality of service in the TEAM applications themselves. 13. **Watching the collaborative map**: The user can watch the collaborative map, where different types of geo-coded data can be provided by several different users. These data are aggregated values from the automatic transmission of geo-referenced data (see use case 9). They could display average speed values, rain/fog levels, presence of an accident (airbag). Special vehicles (e.g., ambulances, garbage collection trucks) could show their presence in real time on the map. Notifications could appear (from friends or the system) that the user could open by clicking above (see use case 10). Integration with existing social networks (e.g. Facebook) will be possible. 14. **Community building gamification**: A scoring system will be set up, with points gained from the quantity and quality of information provided to the system and from a proper use of the TEAM collaborative applications (specifications are to be negotiated soon with the various application leaders – see use case 11). Badges will be assigned to good performers, based on various criteria (e.g., time, space/area, in a group, type of vehicle, etc.). The user will be notified about achievement of a badge. A

	general leader board will be maintained, with different segments (friends, type of vehicle, age, etc.). 15. **Log-in**: The user must log-in in car before initiating any activity with the SG-CB application. A user is identified by a person and a vehicle. Data in the SG-CB application are published (according to all the privacy settings) only for the users that do the log-in 16. **Friendliness**: The system manages friendliness, definition of interests and creation of groups. 17. **Friend suggestion**: Friends are suggested by the system also on the basis of trips and other user preferences **User registration and data management**: to add/modify/remove a user to the system and all the data related it 18. **Collaborative driving and serious game data validation**. Information, sent by a user to the TEAM collaborative SG-CB framework, is validated through the collection of confirmations by other community users 19. **User reputation management:** to manage user credibility within the community, basing on the trustworthiness of the information it provided Examples: the user credibility is decreased if the user has provided false information (the coordinates are not corresponding to a parking slot) or he didn't respect the parking reservations eventually assigned him by the system. 20. **User rewarding management**: to manage a rewarding scheme able to classify users in terms of their contribution to the community To manage a rewarding scheme able to classify users in terms of their contribution to the community. More the user contributes to the service more points he will get. In case of false information or unfair behaviours, the rewards points will be decreased

	Data ingestion: for the users' notifications, input to the ITS 2.0 system will be provided and managed as services functionalities to any SP4 application and will be analysed within the platform specification activities. Data Validation: for the validations of the users' notifications received
Required lower layer components	• Smartphone-vehicle network communication for receiving data about the vehicle • Telecom's ITS 2.0 for user management • User profiling module • Data from all the TEAM collaborative applications • Nokia's Feed and Road Book for the maps • Database of vehicles • Vehicle models in order to allow a proper evaluation of the drivers • Ontology for describing the driving context (operations, destinations, means of transport, etc.) • Application database • Accurate in lane positioning • Receiving data from infrastructure elements

1.2.4.2 Application use case 1: Playing the green/safe driving serious game

Overview

Use case name	Playing the green/safe driving serious game
Use case short name	Play_SG
Use case identifier	SP4_SG-CB_ Play_SG

Use case short description	The driver drives on his way, with possibly no information at all from the SG. Different levels of feedback provision can be set. These may include: no feedback, a 3-color traffic light (or a similar performance-meter) showing how well the driver is behaving considering the target indicator(s), or the difference with respect to the competitor in a challenge (or average value of the other drivers). An integrated measure is displayed as well. Acceptance of proposed rerouting due to incidents such as weather, accidents . etc. may be rewarded as well. Driving suggestions ("coaching messages") are also active-able (e.g., "you drive with too many RPMs", "please stay more in the centre of your lane", "keep more distance from the car ahead", "you accelerate and brake too frequently").
Precondition	The user is driving. The user has logged-in the system. A set of preferences has been set (also the default ones)
Post-condition	The driver is still driving, but he is informed (or even "coached") about his driving performance
Normal flow	• The driver is driving • On his navigation application (optional) his performance is displayed in real-time (e.g., through a bar or a 3-light traffic light metaphor) (optional). An integrated measure (in the day-route, or since the last re-set) is displayed as well (optional). • In the "challenge mode" (optional), the relative performance with respect to the selected competitor is shown in real-time through the traffic-light metaphor (optional) • When necessary, the driver receives coaching messages to improve his performance (according to the driver ability level and, anyway, optionally) • Optionally, the driver may define a journey (start and end), for facilitating display of information (see also use case 5) • The user may change the application settings directly while

	driving through a very simple user interface (the one described in use case 8 is more complete and complex)
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone (possibly connected to the application server) /Vehicle-API
Expected frequency of use	This is a normal condition while driving, which runs continuously. The map scene is updated continuously also the performance indicator is updated in real-time. The possible "coaching messages" are displayed when needed and with a proper frequency (e.g., no more than 2 every minute)

External actors and components

Actors' short name	Short explanation
Driver	The driver, who would like to improve his driving performance
Vehicle	The vehicle, which responds to the driver commands and sends sends its real-time data to a database accessed by the application
AppServer	The application server, that contains data from different users and sends data about a competitor (in the challenge mode)

Input and Outputs

Input	Vehicle real-time signals In the competitor mode, the server needs to send to the application the competitor's values, to be compared in real-time
Output	Display on the screen of the smartphone the real-time performance (also in comparison with a selected comparison, in case of the challenge mode) Performance data are also sent to the application server

Required functional components

Components short name	Short explanation
LDM++ with cloud	The application could be displayed on the LDM
Vehicle data or phone data provider	Vehicle data are needed to allow computing the driver performance (e.g., consumption, pedal activity, speed, position in the lane)
Communication components (LTE, 802.11p)	3G/4G needed to communicate with the application server.
User profile	Performance data can update the user profile on the application server. The player ability level must be continuously tracked, in order to provide to the driver info keeping into account his actual level
Other SP2 component	
Interaction between SP3 and SP4	

Objectives

Challenging and coaching the driver to have a good driving performance

User benefits

Driving performance improvement in terms of green/safe driving

Basic functioning

The car signals are processed in order to estimate in real-time the driver performance.

The aggregated performance indicator is updated.

In the challenge mode, comparison with the competitor is executed.

Possible suggestions for the driver are checked

If suited, all the above info is delivered to the user through the user interface and to the application server

Definition of work

See above

Possible Challenges

Real-time processing, availability of signals, availability of the connection for the comparison and for sending data to the application server. Very high usability, to avoid risks for the drive

Comments, additional features

None

1.2.4.3 Application use case 2: Computation of the driver performance

Overview

Use case name	Computation of the driver performance
Use case short name	CompDriPer_SG
Use case identifier	SP4_SG-CB_ CompDriPer_SG
Use case short description	The car data are continuously processed to compute the target indicator(s) (e.g., fuel consumption, use of pedals, safety distance, distance from the centre of the lane, correct use of blinkers, a weighted sum of all). An incremental value (integrating all the values from the day, or the user's reset) is also computed. The data could be normalized with respect to the specific vehicle model, in order to allow an evaluation of the driver, keeping into account the strong differences among types of vehicles. In this case, not the absolute values would be considered, but each driver

	real-time distance from the ideal behaviour. We need that the car manufacturers support this preparation of a vehicle model for each vehicle. A set of rules is continuously processed in order to provide formative feedback ("coaching messages") to the user.
Precondition	The user is driving. The user has logged-in the system.
Postcondition	The driver is still driving. Computation is completely transparent
Normal flow	• The driver is driving • The car data are continuously processed to compute the target indicator(s) (e.g., fuel consumption, use of pedals, safety distance, distance from the centre of the lane, correct use of blinkers, a weighted sum of all). An incremental value (integrating all the values from the day, or the user's reset) is also computed in real-time. • Comparison with the competitors' data are computed in the "challenge" mode • A set of rules is continuously processed in order to provide formative feedback to the user (with appropriate filters, in order not to have a cognitive overload).
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone (possibly connected to the application server) /Vehicle-API
Expected frequency of use	This is a normal condition while driving, which runs continuously. Performance data are regularly sent to the application server (e.g., 5 Hz)

External actors and components

Actors' short name	Short explanation
Driver	The driver, who would like to improve his driving performance

Vehicle	The vehicle, which responds to the driver commands and sends real-time signals to the database accessed by the application
AppServer	The application server, that contains data from different users and sends data about a competitor (in the challenge mode)

Input and Outputs

Input	Vehicle real-time signals In the competitor mode, the server needs to send to the application the competitor's values, to be compared in real-time
Output	Real-time performance (also in comparison with a selected comparison, in case of the challenge mode) to be displayed to the user Performance data are also sent to the application server

Required functional components

Components short name	Short explanation
LDM++ with cloud	The performance data need being geo-coded
Vehicle data or phone data provider	Vehicle data are needed to allow computing the driver performance (e.g., consumption, pedal activity, speed, position in the lane)
Communication components (LTE, 802.11p)	3G/4G needed to communicate with the application server. 802.11 could be useful for additional data (e.g., distances from the next car)
User profile	Performance data can update the user profile on the application server
Other SP2 component	
Interaction between SP3 and	

SP4	

Objectives

Challenging and coaching the driver to have a good driving performance

User benefits

Driving performance improvement in terms of green/safe driving

Basic functioning

The car signals are processed in order to estimate in real-time the driver performance.

The aggregated performance indicator is updated.

In the challenge mode, comparison with the competitor is executed.

Possible suggestions for the driver are checked

All these data are sent to the user interface and to the application server

Definition of work

See above

Possible Challenges

Real-time processing, availability of signals, availability of the connection for the comparison and for sending data to the application server

Comments, additional features

None

1.2.4.4 Application use case 3: Create a challenge for the SG

Overview

Use case name	Create a challenge for the SG
Use case short name	ChaCre_SG
Use case identifier	SP4_SG-CB_ ChaCre _SG
Use case short description	While using his smartphone or PC, a user could go on a dedicate webpage of the application, select a friend with whom to make a challenge and define a route for the challenge. When the friend accepts, the system records the first performance of the two people in that road. The result of the comparison will be shown in a special section of the friends' page
Precondition	The user accesses the application (on smartphone or PC). He is not driving
Postcondition	The challenge has been launched and the competing friend can accept the invitation. If the invitation is accepted, the challenge is set and the performance of the two friends, the next time they will make the selected route, will be compared.
Normal flow	The user is navigating the SG application website He enters his "Challenges" page He chooses a friend from the list. Optionally, he can also determine the friend's car to be employed He sets a route for the challenge by selecting the start and end point on a map. He could also define a time range (when?) for the challenge to be valid The friend is notified through a message on his personal page of the application If the friend accepts, the challenge is set (his friend is notified), the server records that a challenge will be played and next time he and

	his friend go through the selected route their performance are compared (see also use cases 1 and 5)
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Depends on the user preferences and attitudes. It could be once a day.

External actors and components

Actors' short name	Short explanation
User	The person who creates the challenge
Friend	The friend who is challenged

Input and Outputs

Input	The user choices (friend and path selected in the map)
Output	The friend is notified of the challenge (message in his home page). If he accepts, the friend is notified as well. If the challenge is accepted, the server is alerted, so that it can check when the two friends do that route (for the first time) and make the comparisons.

Required functional components

Components short name	Short explanation
LDM++ with cloud	The application will use the LDMs (or other maps, but they must be synchronized)
Vehicle data or phone data provider	-

Communication components (LTE, 802.11p)	Internet connection
User profile	For friend management
Other SP2 component	
Interaction between SP3 and SP4	Friend management is needed. An internal messaging system is needed.

Objectives

Challenging the driver through good improvement challenges

User benefits

Expected enjoyment and drive improvement

Basic functioning

While navigating the SG application website, a user enters his “Challenges” page

He chooses a friend from the friends’ list. Optionally, he can also select the friend’s car to be employed.

He sets a route for the challenge by selecting the start and end point on a map. He could also define a time range (when?) for the challenge to be valid.

The friend is notified through a message on his personal page of the application

If the friend accepts, the challenge is set (his friend is notified), the server records that a challenge will be played and next time he and his friend go through the selected route their performance are compared (see also use cases 1 and 5)

Definition of work

See above

Possible Challenges

Availability of the friend management module

Comments, additional features

-

1.2.4.5 Application use case 4: Watching the performance - general

Overview

Use case name	Watching the performance - general
Use case short name	GenPerfWatch_SG
Use case identifier	SP4_SG-CB_ GenPerfWatch _SG
Use case short description	Every user can access its own performance personal page of the application. The performance page shows, for each user, a number of analytics (e.g., fuel consumption, use of pedals, safety distance, distance from the centre of the lane, correct use of blinkers, break activity, accelerator activity, speed, a weighted sum of all as an aggregated performance indicator). Average values (on different, selectable time periods and types of roads: urban, extra, motorway) are displayed. The user can select own routes from the map and get his indicators only on these routes. The selected routes are recorded, so to facilitate the user interaction the next times. Some routes are selected automatically and performance results from several different users are shown there. For any data, it is possible to apply different filters: self, friends, type of car, interest, geographic area, time periods, etc. in order to reduce the number of displayed results.

Precondition	The user accesses the application (on smartphone or PC). He is not driving. He has already recorded some data through the application (by log-in in car)
Postcondition	The user has seen some interesting indicators about his (green/safe) driving performance.
Normal flow	• The user accesses its own performance personal page of the application. • The user can see several analytics/indicators about his average (safe/green) driving performance (e.g., fuel consumption, use of pedals, safety distance, distance from the centre of the lane, correct use of blinkers, speed). Indicators could be also aggregated (weighted sums of various parameters) • Through proper user interface controls, the user can choose to filter his average values by factors such as: time periods, types of roads (urban, extra, motorway) • The user can select own routes from the map (selecting the start and end point) and get his indicators shown only on these routes. • The selected routes are recorded, so to facilitate the user interaction the next times. • Some routes are selected automatically and performance results can be shown there. • For any of the above data, the user can see the standings/leader board. Beside the general leader board, he can apply several different filters: self, friends, type of car, interest, geographic area, time periods, etc. in order to reduce the number of displayed results. • The user can re-set the data collection
Deployment platforms (vehicle/smartphone/	Smartphone/PC (Internet connection needed)

backbone)	
Expected frequency of use	Depends on the user preferences and attitudes. It could be once a day.

External actors and components

Actors' short name	Short explanation
User	The user who wants to see his performance on the app website

Input and Outputs

Input	The user choices Data from the server about the user (and all the other users) performance
Output	Display on the webpage all the performance results

Required functional components

Components short name	Short explanation
LDM++ with cloud	The user may choose routes by defining the start and end point on the map
Vehicle data or phone data provider	Vehicle data are needed to allow computing the driver performance (e.g., consumption, pedal activity, speed, position in the lane) – this has been shown in the use case 2
Communication components (LTE, 802.11p)	Internet connection
User profile	Data storage for the user performance parameters is needed
Other SP2 component	

Interaction between SP3 and SP4	Friend management is needed

Objectives

Allowing the user to check his performance parameters and compare them with others

User benefits

Continuous improvement by checking performance results

Basic functioning

Every user's performance values (e.g., fuel consumption, use of pedals, safety distance, distance from the centre of the lane, correct use of blinkers, speed) are recorded in real-time and geo and time-tagged. This allows the system to show the average values, also in particular times of the day and in selected routes (these are computed dynamically, probably on the server, on user demand – a cache system can be foreseen) or types of roads (urban, extra, motorway).

Comparisons can be done, also with friends and according to parameters (e.g., vehicle types), through thematic leader boards.

Friend management is needed. A database of vehicles needs to be kept.

Definition of work

See above

Possible Challenges

Computation of all these figures, keeping account the position, the type of road and the time of the day. Huge amount of data needed. Availability of the friend management module.

Comments, additional features

-

1.2.4.6 Application use case 5: Watching the performance – diary view

Overview

Use case name	Watching the performance – diary view
Use case short name	DiaPerfWatch_SG
Use case identifier	SP5_SG-CB_ DiaPerfWatch _SG
Use case short description	The user can watch his diary, where the journey he has made (the time is provided by the user for selecting the journey) is presented on a map, showing key actions performed and performance indicators (with comparison with the competitor, in case of a challenge). The route is segmented and filled with different colours according to the local value of a selected indicator (e.g., instantaneous consumption, braking activity, speed, etc.). Possible driving suggestions are also displayed at the relevant points on the route.
Precondition	The user accesses the application (on smartphone or PC). He is not driving. He has already recorded some data through the application (by log-in in car)
Postcondition	The user has seen the diary of his (green/safe) driving performance.
Normal flow	• The user accesses his own diary page of the application • The user can select (through position and time) a journey • The journey is presented on a map, showing key actions performed and performance indicators (with comparison with the competitor, in case of a challenge). The route is segmented and filled with different colours (in the various segments) according to the local value of a selected green/safe drive indicator (e.g., instantaneous consumption, braking activity, speed, etc.). Possible driving suggestions are also displayed at

	the relevant points on the route. • The user can zoom and pan the map for properly following the journey
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Depends on the user preferences and attitudes. It could be once a day.

External actors and components

Actors' short name	Short explanation
User	The user who wants to see his performance on the app website

Input and Outputs

Input	The user choices Data from the server about the user (and all the other users) performance
Output	Display on the webpage the diary (from the safe/green drive viewpoint) of the user's trips

Required functional components

Components short name	Short explanation
LDM++ with cloud	The journey diary is shown on the map
Vehicle data or phone data provider	Vehicle data are needed to allow computing the driver performance (e.g., consumption, pedal activity, speed, position in the lane) – this has been shown in the use case 2

Communication components (LTE, 802.11p)	Internet connection
User profile	Data storage for the user performance parameters is needed
Other SP2 component	
Interaction between SP3 and SP4	-

Objectives

Allowing the user to check his performance parameters (and compare them with others) during a journey

User benefits

Continuous improvement by checking performance results

Basic functioning

See also use case 4 for the need for having the driver's performance data from his drive. The user should be able to choose a journey either by time/position or from a journey list.

The journey should be segmented in significant segments, for each one of which the system should be able to compute the average values of the performance indicators (e.g., instantaneous consumption, braking activity, speed, etc.), that should be displayed carefully. Since the space on the map (along the route) is limited, probably only the most significant value should be displayed for each segment (two or maximum three could be shown in parallel). The values should be anyway selectable for display.

Key actions performed (e.g. gear activity) should be published as well (as labels beside the trajectory).

Possible driving suggestions are also displayed at the relevant points on the route (these could be also somehow frequent, as there is not the risk to disturb the user).

The user can zoom and pan the map for properly following the journey

Definition of work

See above

Possible Challenges

Huge amount of data needed. Difficulty in identifying start and end of the journey (the user may be asked to explicitly define the start and end points).

Comments, additional features

-

1.2.4.7 Application use case 6: Thematic competitions

Overview

Use case name	Thematic competitions
Use case short name	ChaCre_SG
Use case identifier	SP4_SG-CB_ TheComp _SG
Use case short description	Thematic competitions could also be set up periodically (in given time windows, in order to avoid inappropriate comparisons). For instance: who is the person who took more synchronized green traffic lights ? Who is the user who was able to keep a stable speed longer? Rewards are provided The user is notified about these competitions, through a message in his messagebox. The criterion for sending the messages is geographic proximity (also based on historical data). The user can set preferences.

Precondition	The user accesses the application (on smartphone or PC).
Postcondition	The user is informed about the upcoming thematic challenges.
Normal flow	An application manager decides to launch a competition in an area (e.g., the city of Genoa). who is the person who took more synchronized green traffic lights ? Who is the user who was able to keep a stable speed longer? Who is the best driver in the city (urban driving)? He defines the time limits, etc. All the users that are frequent in Genoa (or that have set the preference to be notified about the Genoa activities) and that do want to be notified about thematic competitions receive the notification of the competition The system activates the pre-defined counters for the competition, if needed (e.g., the number of synchronized consecutive traffic-lights passed with green light) At the end of the competition the system need to compute the target values for all the notified users in the target period and area An award and (possibly) real-world is provided to the winners (see also use case 7), that are notified by the system A leader board is maintained, so to show the standings of the competition. The leader board can be filtered according to criteria such as: friends, type of vehicle The user is navigating the SG application website He checks the messages and is notified The user can visit the competition section and select a competition, for which he can see all the results (also filtered)
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)

Expected frequency of use	Depends on the app manager preferences. It could be once a day.

External actors and components

Actors' short name	Short explanation
User	The person who may be notified and may participate in the competitions

Input and Outputs

Input	The application manager needs a user interface (form) through which he can select a predefined list of possible competitions. The application manager's form need also to give possibility of specifying the place and time range for the competitions
Output	The system is activated, so that it can compute the scores and manage the leader boards.

Required functional components

Components short name	Short explanation
LDM++ with cloud	-
Vehicle data or phone data provider	Vehicle data are needed by the system to compute the performance values
Communication components (LTE, 802.11p)	Internet connection
User profile	For storing the result of the competitions
Other SP2 component	
Interaction between SP3 and	Friend management is needed

SP4	

Objectives

Challenging the driver through good improvement challenges

User benefits

Expected enjoyment and drive improvement

Basic functioning

A special page of the web application is available for managers to launch a competition in an area (e.g., the city of Genoa). The types of competitions are pre-defined. The manager selects a type and the time limits.

Relevant users are notified. Thus, the system will need to track who the relevant users are (preferences are also considered: people who do not want to be notified and people who want to be notified even if they are not frequently in the target area).

The system activates the pre-defined counters for the competition, if needed (e.g., the number of synchronized consecutive traffic-lights passed with green light)

At the end of the competition the system need to compute the target values for all the notified users in the target period and area. Then the leader boards are filled.

The leader boards sub-system should be able to filter its display results according to criteria such as: friends, type of vehicle

A notification system is needed.

An incentive system is needed (see also use case 7).

Definition of work

See above

Possible Challenges

Availability of the friend management module

Comments, additional features

-

1.2.4.8 Application use case 7: Provision of incentives

Overview

Use case name	Provision of incentives
Use case short name	InceProv_SG
Use case identifier	SP4_SG-CB_ InceProv_SG
Use case short description	Incentives are foreseen to winners and good performers in terms of virtual gadgets/facilities and of real-world rewards, such as access to pool lanes, discounts for parking costs, free bus tickets, etc. Virtual badges are provided to users, showing their status. Badges can come by winning thematic competitions and by overcoming certain thresholds to be defined (e.g., more than 10 times with a daily average fuel consumption level under a certain threshold)
Precondition	The user has accessed the application (on smartphone or PC) and some activity has been recorded.
Postcondition	The user is rewarded (virtual gadgets/badges and real-world).
Normal flow	The operation is activated when a user wins one of thematic competitions (see use case 6), typically for awarding badges The operation is activated in case the user overcomes certain thresholds (e.g., more than 10 times with a daily average fuel consumption level under a certain threshold), typically for status

	awards The user is notified about the win through a message In case of a virtual badge/gadget, the gadget is made available in the user's personal room
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Frequency of rewards depends on the user value. It could be once every month.

External actors and components

Actors' short name	Short explanation
User	The person who may be notified and may get the rewards (virtual and/or real world)

Input and Outputs

Input	The system must check (or be notified about) any thematic win or the overcoming of a threshold valuable for assigning a gadget or a badge
Output	The virtual gadgets are set in the winners' home pages.

Required functional components

Components short name	Short explanation
LDM++ with cloud	-
Vehicle data or phone data	-

provider	
Communication components (LTE, 802.11p)	Internet connection
User profile	For keeping into account the gained rewards
Other SP2 component	
Interaction between SP3 and SP4	-

Objectives

Incentivising the driver to good behaviours

User benefits

Expected enjoyment and drive improvement

Basic functioning

A number of awards and thresholds should be defined (e.g., more than 10 times with a daily average fuel consumption level under a certain threshold), beside the thematic competitions (see use case 6).

The user home page should be able to host badges and awards.

The user should have a displayable status, which is incremental

Definition of work

See above

Possible Challenges

Definition and checking of the competitions and of the thresholds

Comments, additional features

-

1.2.4.9 Application use case 8: Setting user preferences

Overview

Use case name	Setting Preferences
Use case short name	PreSet_SG
Use case identifier	SP4_SG-CB_ PreSet
Use case short description	The user sets preferences (e.g., what information can be sent automatically by the vehicle during the drive, type of feedback while driving, etc.) on his profile page.
Precondition	The user accesses the application (on smartphone or PC). He is not driving
Postcondition	The user preferences are updated in all the relevant applications
Normal flow	The user is navigating the SG application website He enters his "Settings" page The user can update his settings by using simple pre-defined menu items. Type of settings include: what information can be sent automatically by the vehicle during the drive, type of feedback while driving, etc. (depending on the actual details of the application)
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of	Depends on the user preferences and attitudes. It could be once a

use	month.

External actors and components

Actors' short name	Short explanation
User	The person who sets his preferences

Input and Outputs

Input	The user choices
Output	All the relevant application settings are updated.

Required functional components

Components short name	Short explanation
LDM++ with cloud	-
Vehicle data or phone data provider	-
Communication components (LTE, 802.11p)	Internet connection
User profile	The settings concern the editable part of the profile
Other SP2 component	
Interaction between SP3 and SP4	

Objectives

Allowing the user to set his preferences for the application

User benefits

More suited behaviour by the application

Basic functioning

While navigating the SG application website, a user enters his "Settings" page

The user can update his settings by using simple pre-defined menu items. Type of settings include: what information can be sent automatically by the vehicle during the drive, type of feedback while driving, etc. (depending on the actual details of the application)

More simple preferences settings are available also during the drive (but embedded in the application (e.g., SG) layout not through the settings page, as mentioned in use case 1).

Definition of work

See above

Possible Challenges

Usability must be high

Comments, additional features

-

1.2.4.10 Application use case 9: Automatic transmission of geo-referenced data

Overview

Use case name	Automatic transmission of geo-referenced data
Use case short name	AuTxData_CB

Use case identifier	SP3_SG-CB_ AuTxData _SG
Use case short description	According to the preferences set by the current user (see use case 8), the vehicle, through the smartphone, sends to the application server information such as: speed, position, windscreen wipers activity, suspensions activity, anti-fog lights, temperature, etc. This information is crucial to maintain dynamically updated collaborative map (use case 12). This information could be used by third parties for other services like weather forecast.
Precondition	The user is driving. The user has logged-in the system.
Postcondition	The driver is still driving. Transmission of data is completely transparent
Normal flow	• The driver is driving • The car data made available by the user through his settings (speed, position, windscreen wipers activity, suspensions activity, anti-fog lights, temperature, etc.) are continuously sent to the application server. Data could be exploited also by third parties for other services like weather forecast. • The server updates its maps accordingly, processing the inputs from the single vehicles and computing the averages values, that will be used to update the collaborative map • Information may be used, for instance, for weather prediction • Some data are pre-processed locally. For instance the suspension variation signal sends to the server only when a strong variation is detected (e.g., a hole in the road).
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone (connected to the application server) /Vehicle-API
Expected frequency of use	This is a normal condition while driving, which runs continuously. Data are regularly sent to the application server according to their nature

External actors and components

Actors' short name	Short explanation
Driver	The driver, who drives normally
Vehicle	The vehicle, which sends real-time signals to database, which in turn is accessed by the application on the smartphone
AppServer	The application server, that maintains the collaborative map

Input and Outputs

Input	Vehicle real-time signals
Output	The collaborative map is continuously updated in real-time based on the data from all the cars

Required functional components

Components short name	Short explanation
LDM++ with cloud	The performance data need being geo-coded. The collaborative map is actually an LDM
Vehicle data or phone data provider	Several vehicle data are needed to update the map
Communication components (LTE, 802.11p)	3G/4G needed to communicate with the application server.
User profile	Some vehicular data can update the user profile on the application server (see also use case 2)
Other SP2 component	
Interaction between SP3 and SP4	

Objectives

Keep continuously updated in real-time the collaborative map (use case 12)

User benefits

Availability of the map is very useful.

Incentives are provided to people who contribute more.

Basic functioning

The car data made available by the user through his settings (speed, position, windscreen wipers activity, suspensions activity, anti-fog lights, temperature, etc.) are continuously sent from the vehicle to a database which is accessed by the smartphone, which in turn sends data to the application server.

The server updates its maps accordingly, processing the inputs from the single vehicles and computing the averages values (in time and space), and shows the aggregated values in the collaborative map (use case 12).

Credibility of the user (as a sensor: its vehicle sensors, for instance, could be damaged) must be continuously verified and updated. The data contributions are weighted according to the credibility.

Some data are pre-processed locally. For instance the suspension variation signal sends to the server only when a strong variation is detected (e.g., meaning a hole in the road).

Definition of work

See above

Possible Challenges

- Availability of signals from the cars, availability of the connection for sending data to the application server
- On the server side: real-time processing of the signals from several different vehicles, ability to exploit good data and provide meaningful average values

Comments, additional features

-

1.2.4.11 Application use case 10: Writing messages for the collaborative map

Overview

Use case name	Sending messages for the collaborative map
Use case short name	SeMsgCollMap_CB
Use case identifier	SP3_SG-CB_ SeMsgCollMap _CB
Use case short description	The user issues/writes (could be vocally, for the driver) messages that are geo-referenced. The messages can be free text or user customized instances from standard templates (based on a simple drive/transport ontology), in order to facilitate composition, comprehension and automatic processing.
Precondition	The user (could be a driver or on his PC/smartphone) has logged-in the system.
Postcondition	The collaborative map is enriched with the received message
Normal flow	• The user vocally composes a message or (not being driving) writes a message (stating 1- its target localization: default GPS position, if available; 2- its relevance: for all, for friends, for categories, personal; 3- its time validity. Default values are provided). The user may specify a subject (immediately visible on the map) and a body (readable by a user after clicking on the

	message). • The credibility of the user is evaluated and considered • The system places the message on the collaborative map • The message will be readable (within a certain radius) to target people near there
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone (possibly connected to the application server) /Vehicle-API
Expected frequency of use	It depends on the user preferences and attitudes. Could be 1/5 times a day.

External actors and components

Actors' short name	Short explanation
Driver	The driver, who sends the messages
AppServer	The application server, that receives and processes messages from various users

Input and Outputs

Input	The driver by typing or through vocal interaction
Output	The messages are stored in the collaborative map, with the right receivers, time validity, space validity

Required functional components

Components short name	Short explanation
LDM++ with cloud	The application is based on the LDM (or another map format)

Vehicle data or phone data provider	-
Communication components (LTE, 802.11p)	3G/4G needed to communicate with the application server.
User profile	The user profile is updated based on the sent messages
Other SP2 component	
Interaction between SP3 and SP4	

Objectives

Allowing the traveller to communicate in the community

User benefits

The traveller can notify about road-works, accidents, multimodal transport opportunities, events, etc.

Basic functioning

The user communicates through a vocal interface or by typing. The user interface should support an easy setting of the message target position, time validity and target receivers. Default values can be provided. The user may specify a subject and a body.

The message is sent through the application to the server.

The server checks the credibility of the user. The profile of the user is updated. The system places the message on the collaborative map.

The message will be readable (within a certain radius) to target people near there

An ontology could support an easy and meaningful communication.

A rating system is necessary in order to support publication/survival of messages. Maybe certified organizations could be allowed to broadcast to (set messages for) all the users (some users may anyway disable this feature)

Definition of work

See above.

Possible Challenges

- It is difficult to determine the time validity of a message and its receivers. It would be nice that the system. Maybe a specific service could be set up, with certified info providers (e.g., the policy, municipality, transport operators)
- Some messages could concern a whole area (e.g., a city). So, special HCI solutions may be considered for this (e.g., a virtual area beside the map)

Comments, additional features

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1.2.4.12 Application use case 11: Rider assistance request

Overview

Use case name	Rider assistance request
Use case short name	RAR_CB
Use case identifier	SP3_SG-CB_ RAR _CB
Use case short description	Rider faces a problem, not an emergency, and needs to pull over. The rider can by simple means request road side assistance and the system sends assistance request signal to road users nearby.
Precondition	Rider runs into a problem, and is in need of assistance

Postcondition	Assistance if needed, right after problems have occurred
Normal flow	• Rider pulls over by the side of the road • Rider triggers the request • The applications send continuous assistance request signal • Road users nearby get the signal which includes the rider's location and need for help • Road user locates the rider and offers help • The rider can acknowledge the help on the interactive map thus increasing the helper's reputation in the Community Building system
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/Vehicle API
Expected frequency of use	Daily, but not by one user

External actors and components

Actors' short name	Short explanation
Motorcycle	The one who needs to be helped
Other vehicle	All the vehicles which receive the assistance request
Helping vehicle	The vehicle which answers the assistance request

Input and Outputs

Input	Location, map
Output	Assistance request signal, location (possibly as a message on the SG-CB interactive map). Possible increase in the helper reputation, if

	signalled by the motorcyclist.

Required functional components

Components short name	Short explanation
LDM++ with cloud	Map
Vehicle data or phone data provider	
Communication components (LTE, 802.11p)	802.11p to send continuous signal. LTE/3G Internet connectivity
User profile	Motorcyclist in non-life-threatening trouble
Other SP2 component	
Components from SP3 or SP4	

Objectives

Offers riders easy way to get help in minor problems.

User benefits

- Offers riders easy way to get help in minor problems without calling expensive professional assistance.

Basic functioning

- Rider pulls over by the side of the road
- Rider triggers the request
- The applications send continuous assistance request signal (possibly implemented as a message on the SG-CB interactive map)
- Road users nearby get the signal which includes the rider's location and need for help

- Road user locates the rider and offers help
- The rider can acknowledge the help on the interactive map thus increasing the helper's reputation in the Building system

Definition of work

- Part of ITS station application software.

Possible Challenges

This is a specific case of writing messages to the interactive map (see UC 10)

Comments, additional features

None

1.2.4.13 Application use case 12. Proper collaborative behaviour, based on the other TEAM applications

The SG-CB applications should promote a good use of all the TEAM collaborative applications. Every application should communicate about the behaviour of the driver, possibly in real time. Metrics for all the applications are kept, so that the driver can be rewarded or penalized. A virtual coin mechanics will be managed by the SG-CB application, so that "good" drivers will have more virtual coins that could be spent, in turn, to getter better quality of service in the TEAM applications themselves.

The idea is to set up a virtuous cycle, in order to promote an effective use of the TEAM applications.

1. Signaling good behavior

Each TEAM application define metrics that are used to quantify and signal good driver behaviors to the SG-CB application.

For instance, at the end of a navigation path, CONAV should report the "compliance" of the actual drive with respect to the suggested path. This should include 2 parameters: a "degree of adherence" (how well was the path followed) and a "degree of difficulty" (how "odd/difficult" was the path – i.e. "useful" for the community, requiring some sort of sacrifice on the driver's part)

As another example, the Parking application could reward drivers that declare at what time they will leave with their car from the parking slot and that meet this "promise".

2. Requesting "virtual coins"

The TEAM applications will provide different levels of services, that can be bought by the player by spending virtual coins through the SG-CB application.

For instance, a CONAV user requests SG-CB a certain amount of Virtual coins. This corresponds (in CONAV) to a certain quality of service (e.g., how many preferences can the driver insert, what priority he is assigned for path computation, etc.). SG-CB can respond ok or a lower amount of virtual coins, according to the actual availability.

As another example, the Parking application could provide earlier or more detailed info on free parking slots (and/or the expected leaving times of occupying cars) for people willing to spend virtual coins on this.

Summarizing, the virtual coins (shared among all the applications) are a quantitative means, shared among applications, to incentivize their good use (and community building).

Some relevant UCs are defined in other applications (e.g., CONAV).

1.2.4.14 Application use case 13: Watching the collaborative map

Overview

Use case name	Watching the collaborative map
Use case short name	ColMapWatch_CB
Use case identifier	SP3_SG-CB_ ColMapWatch _CB
Use case short description	The user (traveller) can watch the collaborative map, where different types of geo-coded data can be provided by several different users. These data are aggregated values from the automatic transmission of geo-referenced data (see use case 9). They could display average speed values, rain/fog levels, presence of an accident (airbag). Special vehicles (e.g., ambulances, garbage

	collection trucks) could show their presence in real time on the map. Notifications could appear (from friends or the system) that the user could open for more information by clicking above (see use case 10). Integration with existing social networks (e.g. Facebook) will be possible.
Precondition	The user (traveller) accesses the application (on smartphone or PC).
Postcondition	The user is informed about a status of the area.
Normal flow	• The user (traveller) accesses his collaborative map page of the application • The map shows various facts. For instance: average temperature in an area, intensity of rain, the average traffic speed, the fog level, the presence of road-works, the presence of special vehicles (e.g., buses). Different map layers could be selectable. Icons or continuous colour ranges could be used. • The user can select the geo-located messages. He can open them and delete them. • The user can rank (even simply: -1, 0, +1) the received messages (which is important for assessing their quality) • The user can zoom and pan the map for properly following the journey • Information about the user driving/collaborative profile may be automatically shared on Facebook (e.g. as icons in the user profile)
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Depends on the user preferences and attitudes. It could be several times a day.

External actors and components

Actors' short name	Short explanation
User	The user who wants to watch the map

Input and Outputs

Input	The user choices (e.g., layers) and hand gestures or clicks (e.g., to zoom/pan the map) to interact with the map
Output	The map is correctly shown as a consequence

Required functional components

Components short name	Short explanation
LDM++ with cloud	The application is based on the LDM (or another data format)
Vehicle data or phone data provider	Several vehicle data are needed to continuously update the map (use cases 9 and 10)
Communication components (LTE, 802.11p)	Internet connection
User profile	The user profile could record preferences about the user interaction with the map
Other SP2 component	
Interaction between SP3 and SP4	-

Objectives

Allowing the user to have a very detailed and updated panorama of an area, from the point of view of mobility

User benefits

Be continuously informed in a visually effective way

Basic functioning

The user (traveller) accesses through his PC/smartphone his collaborative map page of the application.

The map shows various facts. For instance: average temperature in an area, intensity of rain, the average traffic speed, the fog level, the presence of road-works, the presence of special vehicles (e.g., buses). Different map layers could be selectable. Icons could be displayed (and possibly confirmed/signalled/edited directly by users).

The user can select the geo-located messages. He can open and delete them.

The position of the map is centred on the user's current position. But he can zoom and pan the map for properly following or planning the journey, or just watching the situation of the area.

Definition of work

See above

Possible Challenges

- Very effective Human-Computer Interaction is needed in order to inform and not overwhelm the user, in particular concerning provision of messages. Icons could be used to show queues and accidents that must be detected (and possibly confirmed/signalled/edited directly by users).
- Need to aggregate (and reconciliation) various information sources
- Strong concerns of privacy and security
- Huge difficulty for the map to interpret the signal it receives. For instance, low speed could mean queue or accident (an icon could be displayed). Airbag activated from a car could mean accident, etc.

- 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 collaborative profile.

Comments, additional features

-

1.2.4.15 Application use case 14: Community building gamification

Overview

Use case name	Community building gamification
Use case short name	Gam_CB
Use case identifier	SP3_SG-CB_ Gam _CB
Use case short description	A scoring system will be set up, with points gained from the quantity and quality of information provided to the system (use cases 9 and 10) and from a proper use of the TEAM collaborative applications (specifications are to be negotiated soon with the various application leaders – see use case 11). Badges will be assigned to good performers, based on various criteria (e.g., time, space/area, in a group, type of vehicle, etc.), representing the user status. The user will be notified about achievement of a badge. A general leader board will be maintained, with different segments (friends, type of vehicle, age, etc.).
Precondition	The user has accessed the application (on smartphone or PC) and some activity has been recorded.
Postcondition	The user is rewarded (virtual gadgets/badges and real-world).
Normal flow	• The system continuously updates the user score, assessing his performance by evaluating his inputs (use cases 9, 10 and 12) • At every score update, the system checks whether the user

	overcomes certain thresholds (e.g., more than 10 times with a daily average fuel consumption level under a certain threshold), typically for status awards • The user is notified about the win through a message • In case of a virtual badge/gadget, the gadget is made available in the user's personal room
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Operation is activated whenever the user is given/subtracted some points. Rewards could be around every week.

External actors and components

Actors' short name	Short explanation
User	The person who may be notified and may get the rewards (virtual and/or real world)

Input and Outputs

Input	Changes in the players' score
Output	The virtual gadgets are set in the winners' home pages.

Required functional components

Components short name	Short explanation
LDM++ with cloud	-
Vehicle data or phone data provider	-

Communication components (LTE, 802.11p)	Internet connection
User profile	For keeping into account the gained rewards
Other SP2 component	
Interaction between SP3 and SP4	-

Objectives

Incentivising the traveller to good behaviours

User benefits

Expected enjoyment and travel performance improvement

Basic functioning

A number of awards and thresholds should be defined (e.g., more than 10 times a user provides a useful message or behaves well with any TEAM collaborative application), beside the thematic competitions (see use case 6).

The user home page should be able to host badges and awards

The user should have a displayable status, which is incremental

Definition of work

See above

Possible Challenges

- Definition and checking of the competitions and of the thresholds
- Metrics are to be identified for good user behaviours (see also use case 11)

Comments, additional features

-

1.2.4.16 Application use case 15: Log-in

Overview

Use case name	Log-in
Use case short name	LogIn_CB
Use case identifier	SP3_SG-CB_ LogIn _SGCB
Use case short description	The user must log-in in car before initiating any activity with the SG-CB application. A user is identified by a person and a vehicle. Data in the SG-CB application are published (according to all the privacy settings) only for the users that do the log-in
Precondition	The user intends to enter the system with its own log-in. The user has filled out a registration form
Postcondition	The user is logged-in the system, so he can share information, play the SG, watch personal messages and personalized map info layers
Normal flow	• The user makes the login from the application's home page (single-sign-on will also be possible in order not to annoy the user) • For the first access, the user has to fill a registration form
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Could be twice/four times a day.

External actors and components

Actors' short name	Short explanation
User	The person who makes the log-in

Input and Outputs

Input	The user key-strokes
Output	An error message if the log-in data are not correct

Required functional components

Components short name	Short explanation
LDM++ with cloud	-
Vehicle data or phone data provider	-
Communication components (LTE, 802.11p)	Internet connection
User profile	-
Other SP2 component	-
Interaction between SP3 and SP4	-

Objectives

Allowing access to personal data and to the actual SG-CB services

User benefits

Access to data and services

Basic functioning

The user must log-in in car before initiating any activity with the SG-CB application. A user is identified by a person and a vehicle. Data in the SG-CB application are published (according to all the privacy settings) only for the users that do the log-in

Definition of work

See above

Possible Challenges

- One single login could be considered from other social networks (single-sign-on), such as Facebook and Twitter

Comments, additional features

-

1.2.4.17 Application use case 16: friendliness

Overview

Use case name	Friendliness
Use case short name	Friend_SG-CB
Use case identifier	SP3_SG-CB_ Friend _SGCB
Use case short description	The system manages friendliness, definition of interests and creation of groups
Precondition	The user is logged-in the system

Postcondition	The user can have friends, belong to groups, state interests and share items with friends
Normal flow	• The user can search for and choose friends • The user can define interests (in particular with reference to map locations) • The user can create and join groups
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Could be even ten times a day.

External actors and components

Actors' short name	Short explanation
User	The person who is involved in the friendship

Input and Outputs

Input	The user choices and inputs (key-strokes) about friendship, user interest, etc.
Output	Information about friendship, definition of friends, access to groups, etc.

Required functional components

Components short name	Short explanation
LDM++ with cloud	-
Vehicle data or phone data	-

provider	
Communication components (LTE, 802.11p)	Internet connection
User profile	-
Other SP2 component	-
Interaction between SP3 and SP4	-

Objectives

Allowing people to become virtual friends, so to share information and make competitions

User benefits

Virtual friendship, sharing, possible competitions, messaging

Basic functioning

The system manages friendliness, definition of interests and creation of groups

Definition of work

State of the art open source tools, such as Elgg could be used as the basis for the development

Possible Challenges

- Availability of efficient tools atop of which to make the TEAM-specific development

Comments, additional features

-

1.2.4.18 Application use case 17: friend suggestion

Overview

Use case name	Friend suggestion
Use case short name	FriSugg_SGCB
Use case identifier	SP3_SG-CB_ FriSugg _SGCB
Use case short description	Friends are suggested by the system also on the basis of his trips and other preferences
Precondition	The user is logged-in the system. He has set some preferences, he has some friends and participates in some groups, etc.
Postcondition	The user is suggested proper friends by the system
Normal flow	• The user gets friend suggestions in a list • He can select and become friend of some of them
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/PC (Internet connection needed)
Expected frequency of use	Could be even ten times a day.

External actors and components

Actors' short name	Short explanation
User	The person who receives the friendship suggestions

Input and Outputs

Input	The user preferences and other personal data (e.g. friends)

Output	A list of suggested friends

Required functional components

Components short name	Short explanation
LDM++ with cloud	-
Vehicle data or phone data provider	-
Communication components (LTE, 802.11p)	Internet connection
User profile	-
Other SP2 component	-
Interaction between SP3 and SP4	-

Objectives

Allowing people to become virtual friends, so to share information and make competitions

User benefits

Virtual friendship, sharing, possible competitions, messaging

Basic functioning

Friends are suggested by the system also on the basis of his trips and other preferences. The user is logged-in the system. He has set some preferences, he has some friends and participates in some groups, etc. This is the basis for the friend suggestion algorithm

Definition of work

State of the art open source tools, such as Elgg could be used as the basis for the development

Possible Challenges

- Availability of efficient tools atop of which to make the TEAM-specific development

Comments, additional features

-

1.2.4.19 User community management

User Community management is a set of functions that can be represented through different use cases.

A first set of use cases: (User Registration, User Authentication, User Data Management and Event/data reporting) have been described in the CSE document[14] since they are part of the "Community services enablers (CSE)": a set of functions allowing to receive, validate and publish a series of contents, generated by a community of users, about mobility issues/conditions.

This document, on the other hand, will be focused use cases: User Reputation management, User rewarding management and Data Validation that are more linked to the specific application by which they are used.

1.2.4.20 Application use case 1: Collaborative driving and serious game data validation[15]

Overview

Use case name	Collaborative driving and serious game data validation

[14] CSE use cases description, available on: https://www.cooperative-team.eu/redmine/dmsf/files/677/download

[15] IMPORTANT disclaimer: the term "validation" considered within this use case MUST be interpreted as "information confirmed by the user community". No liaison with "official" data validation, operation that can be carried out only by Public Authorities or Police enforcement forces.

Use case short name	DataV
Use case identifier	SP4_ SG-CB_DataV
Use case short description	A info, sent by a user to the TEAM collaborative SG-CB framework, is validated through the collection of confirmations by other community users
Precondition	Users already registered on TEAM framework A user sent an information on TEAM collaborative SG-CB framework (see Event/data reporting use case on "CSE use cases description" document)
Postcondition	The credibility information sent to the application has been confirmed by a number of users calculated on the base of the reputation of the user source of the info
Normal flow	*From Event/data reporting use case*: CSE Data ingestion records the event/data received and starts a lifetime related to the kind of event/information received **Mobile side** ● Through a proper HMI a user sends a confirmation/ denial about the considered info **Server side** ● For every info received DataValidation component get the user reputation and computes the number of confirmations needed to validate the info ● For every confirmation/denial a validation counter is updated up to the validation process result (within a defined timeout) ● The validation status of the information is updated on the event/data DB
Deployment platforms (vehicle/smartphone/	Smartphone Backbone

backbone)	
Expected frequency of use	Very high; every time a user has sent information on the TEAM SG-CB collaborative framework

External actors and components

Actors' short name	Short explanation
User	The user, who would like to confirm/deny an info collected through TEAM SG-CB collaborative framework
MobileApp	The client application allowing the user to confirm/deny such an info
Data Validation component	The server component able to manage validation about info collected by the users

Input and Outputs

Input	Users confirmation/denial SG-CB information source user reputation
Output	Validation status of the evaluated info

Required functional components

Components short name	Short explanation
LDM++ with cloud	NA
Vehicle data or phone data provider	NA
Communication components (LTE, 802.11p)	Internet connection
User profile	Provides a history of validations to decrease number of required confirmations from other users

Other SP2 component	NA
Interaction between SP3 and SP4	NA

Objectives

Confirming the credibility of the information collected by TEAM collaborative SG-CB framework

User benefits

Ability to exploit the collaborative paradigm of the TEAM SG-CB framework identifying only reliable information

Basic functioning

- A mobile app allows the user to select amongst the various info available, the one he wants confirm/deny
- An acknowledgement is sent by the server side in order to notice the user if its confirmation has been collected or not
- Data Validation server component for every info received is able to calculate the number of confirmation/denial necessary to validate this information. The algorithm considers the reputation of the users as a basis for this calculation. Higher user' reputation results in less confirmations necessary to validate the info. The process has to be carried out within a defined timeout
- Data Validation updates event/data DB

Definition of work

See avove

Possible Challenges

The effectiveness of this use case is based on a clear and un-ambiguous identification of the information that need validation

Comments, additional features

-

1.2.4.21 Application use case 2: User reputation management

Overview

Use case name	User reputation management
Use case short name	URep
Use case identifier	SP4_ SG-CB_URep
Use case short description	The credibility of a TEAM user is increased/decreased on the base of the validation received by the info he sent to the TEAM collaborative SG-CB framework
Precondition	Users already registered on TEAM framework A user sent an information on TEAM collaborative SG-CB framework The info has been confirmed or not by other TEAM users
Postcondition	The reputation of the user which sent the info is updated on the base of the validation status

Normal flow	• User reputation component receives as input:
	  • notification about the final validation status on a parking info sent to collaborative parking app
	  • username of the user sent the information
	• User reputation component applies the user reputation algorithm in order to update the user reputation

	• User reputation component updates the reputation of the user
Deployment platforms (vehicle/smartphone/ backbone)	Backbone
Expected frequency of use	Very high; every time a user has sent information about parking on the TEAM collaborative framework

External actors and components

Actors' short name	Short explanation
User Reputation Component	The server component able to manage user reputation

Input and Outputs

Input	• notification about the final validation status on a parking info sent to collaborative SG-CB framework • username of the user sent the information
Output	User Reputation

Required functional components

Components short name	Short explanation
LDM++ with cloud	
Vehicle data or phone data provider	
Communication components (LTE, 802.11p)	Internet connection
User profile	User reputation algorithm is necessary in order to be able to update the user reputation on the base of the credibility

	of the information received
Other SP2 component	
Interaction between SP3 and SP4	User management component is necessary in order to recognize the user.(CSE SP4_Enab_ UAuth)

Objectives

Making able TEAM collaborative SG-CB framework to identify the most reliable TEAM users

User benefits

Ability to identify the best information sources

Basic functioning

User Reputation Component receives notification in input

The data are used in order to run a "User Reputation Algorithm" able to calculate reputation increase/decrease on the base of the number of the validated info he provided

User Reputation Component updates Users/Reputation DB

Definition of work

See above

Possible Challenges

Privacy issues

Comments, additional features

-

1.2.4.22 Application use case 3: User rewarding management

Overview

Use case name	User rewarding management
Use case short name	URew
Use case identifier	SP4_ SG-CB_URew
Use case short description	Each TEAM collaborative SG-CB user is associated to a credits account that can be increased every time he provides a confirmed information. The credits can be used/spent for any kind of initiative considered within TEAM collaborative framework
Precondition	Users already registered on TEAM framework A user sent an information on TEAM collaborative SG-CB framework The info has been confirmed or not by other TEAM users
Postcondition	The credits account of the TEAM user which sent the info is updated if the info has been confirmed by the community
Normal flow	• User rewarding component receives as input: • username of the user sent the information confirmed by the community • User rewarding component increases User Credits Account
Deployment platforms (vehicle/smartphone/ backbone)	Backbone
Expected frequency of use	Very high; every time a user has sent information about parking on the TEAM collaborative framework

External actors and components

Actors' short name	Short explanation
User Rewarding Component	The server component able to manage user credits account

Input and Outputs

Input	Username of the user sent the information confirmed by the community
Output	User credits account

Required functional components

Components short name	Short explanation
LDM++ with cloud	
Vehicle data or phone data provider	
Communication components (LTE, 802.11p)	Internet connection
User profile	User rewarding component is necessary in order to manage/update the user credits accounts
Other SP2 component	
Interaction between SP3 and SP4	User management component is necessary in order to recognize the user.(CSE SP4_Enab_ UAuth)

Objectives

- Rewarding TEAM users on the base of their contributions to TEAM collaborative SG-CB framework

User benefits

- Earning credits that can be spent in order to access to value added services/initiatives

Basic functioning

- User Rewarding Component receives notification in input
- The data are used in order to calculate increases in user's credits account
- User Rewarding Component updates user's credits account on Users/Reputation DB

Definition of work

See above

Possible Challenges

Privacy issues

Comments, additional features

-

1.2.5 Collaborative eco-friendly navigation

1.2.5.1 Application Overview

Application name	Collaborative eco-friendly navigation

Application short name / Identifier	CONAV
Application short description	The application is a turn-by-turn navigation application running on Smartphones and on a vehicle-integrated platform. It does routing and navigation for vehicles considering individual user's needs and community (system-centric) needs. This application provides the interface to the user while he is driving and makes turn-by-turn instructions. It monitors the user behaviour especially looking at his and triggers new route calculations (both in case he/she behaves different to the instructions or if traffic conditions have changed). Different to today's navigation systems, it provides route recommendations, which are optimized based on multifold needs (environment, traffic load balancing, robustness, queuing at gas stations, balanced pollution levels, safety). The application will consider real-time traffic information provided by the infrastructure. We explicitly consider the reaction of non-planned events. We distinguish two stages of expansion. The first stage includes the applications features below. The character of stage one is that it works with static (traffic) data. **1. Route calculation incorporating vehicle-specific constraints** The calculation would be basically the same as today. We will make use of vehicle info (accessed through vehicle data provider or e.g. OBD2) to find routes such as routes along gas stations (in case fuel level is low) or low energy routes. We may also circumnavigate dirty vehicles from environmental hotspots, while we let clean vehicles pass. **2. Routes to balance traffic load on road network** Stochastic routing to avoid local congestion at hotspots, queuing at gas stations etc. Vehicle-specific information is incorporated.

3. **Personalized routing**

   We assume that drivers who are not familiar with the environment make navigation mistakes at complex crossings. We find routes, where this considered in a way, where such mistakes are not bad and where such crossings are avoided. We call such routes robust. We may also find known routes - these are routes which pass known environments (or in general individually preferred environments, such as safe routes where few accidents happen, non-complex crossings etc.).

The second stage of expansion incorporates V2X (and/or communicating smartphone app). Moreover, we assume that real-time environment data could be processed, such that non-expected events could be sensed and considered in route planning. Demonstrating the application with stage two features is more complex than in stage one. The following features are added to the ones above:

4. **Adaptive stochastic routing and balancing to handle real-time events**

   Assume a not-foreseen event occurs. Stochastic routing is adapted accordingly to adapt routes. We could react now to events. Varying penetration rate has a big impact on the employed models and algorithms.

5. **Adaptive routing based to handle real-time events/conditions with help of price information**

   Assume a not-foreseen event occurs. We'll implement routing with feedback control with help of edge pricing to protect important routes. As before varying penetration rate has a big impact on the employed models and algorithms (open/closed loop, feedback control, ...).

In the final step, the application will implement a global optimization method:

	6. Globally optimized navigation Here we assume that drivers share their desired destinations, relevant preferences and constraints. This information is collected in a central or infrastructural server, which calculates routes for every TEAM user optimizing the overall benefit. Necxt to user data, environmental data such as weather conditions, constructiuon works, systems needs etc. are considered. In all stages, we will realize sequential routing, which implements short-term decision making within the TEAM-specific time window. Approaches are highly variable to control various (and also multidimensional) variables, e.g. pollution, congestion, etc.
Platforms implementing the application	• Smartphone with access to Vehicle-API (assume cloud integration for step two and three) • Fully vehicle-integrated platform (assume cloud integration for step two and three)
Application objective	Different to today's navigation and routing applications, we develop an application which respects individual preferences (not only desired destination) and constraints but also needs from other users, or the traffic system in general (e.g. balancing of traffic on the road network).
Basic functioning	Similar to today's navigation system, the user defines the destination he/or she wants to go. The user defines the route calculation method (another possibility is to calculate all in parallel and let the user choose afterwards). The selected method is applied and the route is calculated and presented including some meta-information, e.g. calculated length, time, CO-emission, network-balancing-index etc.
Application's use cases	1. Enter route start location and time 2. Enter route destination location and time

	3. Enter vehicle characteristics 4. Enter personal preferences, e.g. fear from complex crossings, etc. (may include predefined profiles and weights) 5. Initiate route calculation incorporating vehicle constraints and characteristics 6. Initiate route calculation incorporating driver constraints and characteristics 7. Initiate route calculation to balance traffic load 8. Initiate route calculation according to user preferences 9. Initiate route calculation incorporating real-time traffic information 10. Initiate route calculation with open loop control and feedback control 11. Initiate route calculation with global optimization 12. Access driver compliance information, performance for gaming application
Required lower layer components	LDM++, Positioning, User profile

1.2.5.2 Application use case 1: Enter route start location and time

Overview

Use case name	Enter route start location and time
Use case short name	EST
Use case identifier	SP4_CONAV_EST
Use case short description	The user enters the route start and time either manually (e.g. typing in address, POI, …) or (preferably) it is deduced automatically. The

	input could be done orally; it could be typed in or inferred from the user's calendar. There are multiple ways to define the start location, e.g. ([nation, city, street, number], [nation, postal code], [POI from list], [person from an available address book]. etc. The user could use the smartphone or the vehicle-integrated system. The system checks if the location is valid – that means, that it could be used for the route calculation in the end. In parallel the user could enter the start location time by pressing one button or telling the system orally (from here, now).
Pre-condition	The system is prepared to listen to the user's input for route information.
Post-condition	The system has all data regarding the route's start time and start location to start the route calculation.
Normal flow	• User tells system from here and now • Get ego-location from GPS or LDM • Get time from GPS or other component
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone, which has vehicle-API access Fully vehicle-integrated
Expected frequency of use	Minimum once per trip and every time, the route needs to be recalculated

External actors and components

Actors' short name	Short explanation
Vehicle driver	The vehicle driver enters the desired start location and time.
Other application	The vehicle driver is the main and default actor. It may be the case, that another application may initiate the route calculation and may

	enter start location and start time.

Input and Outputs

Input	No data, except the start point data (location and time) provided by the driver
Output	The start location and time is now available for the route calculation

Required functional components

Components short name	Short explanation
LDM++ with cloud	The use case includes a validation of the entered start location and time. We require map data and POI lists… for that. Thus LDM++ is used. Moreover we assume that the start location and time is set automatically. We assume that we could access vehicle data provider / phone data provider and have the GPS location mapped to an address.
Vehicle data or phone data provider	Normally, we wish to have the start location and time set automatically (from now, from here). We would need access to position (and deduced address by map matching) and time (maybe through LDM++, it depends on the architecture in in the end).
Communication components (LTE, 802.11p)	This is only needed, if the validation of the entered start location and time is remote. I am currently assuming that we don't need communication components to implement the use case.
User profile	One of the POIs might be "home", or "work" or any other personal favourites. I assume that this list might be included in the user profile.
Other SP2 component	No more components needed to implement the use case.

Interaction between SP3 and SP4	None.

Objectives

The objective is that the system has a defined start time and location, which could be used for route calculation.

User benefits

The user benefit is mainly defined through the HMI. Entering the location and time should be very intuitive and not time consuming. The system checks whether the entered location and time is valid.

Basic functioning

The scope of the use case is that the system has all information regarding the route's starting point (location and time).

Entering the location and time could be done in various ways:

- The user enters location and time through HMI (touch screen, keyboard, voice)
- The location could be taken from an address book of the user or list of POIs etc.
- The time (and location) could be taken from a calendar entry of the user

The entered location and time is checked if it makes sense and if it could be used for route calculation:

- The location must be included in the underlying map (LDM++)
- The given time should be in present or near future

Definition of work

- Define interface to the HMI: enter data, feedback if entered data is not valid

- Define interface to user profiles: getHome, getPOIs, etc.
- Define interface to LDM++
- Implement check, if entered location and time could be used for route calculation

Possible Challenges

The underlying map should be defined early on.

Comments, additional features

Unclear how LDM++ and GPS interworks. Who would answer the location question? As this result must be map matched to make routing feasible.

1.2.5.3 Application use case 2: Enter route destination location and time

Overview

Use case name	Enter route destination location and time
Use case short name	EDT
Use case identifier	SP4_CONAV_EDT
Use case short description	The user enters the route destination either manually (e.g. typing in address, pointing via touch screen, selecting POI, …) and a time. The input could be done orally; it could be typed in or inferred from the user's calendar. There are multiple ways to define the destination location, e.g. ([nation, city, street, number], [nation, postal code], [POI from list], [person from an available address book]. etc. The user could use the smartphone or the vehicle-integrated system. The system checks if the location is valid – that means, that it could

	be used for the route calculation. In parallel the user could enter the start location time by pressing one button or telling the system orally (from here, now).
Precondition	The system is prepared to listen to the user's input for route information.
Postcondition	The system has all data regarding the route's arrival time and destination location to start the route calculation.
Normal flow	User tells system address to navigate to from now on (without selecting desired arrival time) Get ego-location from GPS or LDM Get time from GPS or other component
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone, which has vehicle-API access Fully vehicle-integrated
Expected frequency of use	Minimum once per trip and every time, the route needs to be recalculated

External actors and components

Actors' short name	Short explanation
Vehicle driver	The vehicle driver enters the desired destination
Other application	The vehicle driver is the main and default actor. It may be the case, that another application may initiate the route calculation and may enter start location and start time.

Input and Outputs

Input	No data, except the destination data provided by the driver
Output	The desired destination is now available for the route calculation

Required functional components

Components short name	Short explanation
LDM++ with cloud	The use case includes a validation of the entered destination. We require map data and POI lists... for that. Thus LDM++ is used.
Vehicle data or phone data provider	In case we wish to calculate the time required to get a desired location, we might require vehicle characteristics (e.g. top speed, fuel or battery level)
Communication components (LTE, 802.11p)	This is only needed, if the validation of the start location is remote. I am currently assuming that we don't need communication components to implement the use case.
User profile	One of the POIs might be "home", or "work" or any other personal favourites. I assume that this list might be included in the user profile.
Other SP2 component	No more components needed to implement the use case.
Interaction between SP3 and SP4	None.

Objectives

The objective is that the system has a defined desired destination (time and) location, which could be used for route calculation.

User benefits

The user benefit is mainly defined through the HMI. Entering the location and time should be very intuitive and not time consuming.

Basic functioning

The scope of the use case is that the system has all information regarding the route's destination point (location and time).

Entering the location and time could be done in various ways:

- The user enters location and time through HMI (touch screen, keyboard, voice)
- The location could be taken from an address book of the user or list of POIs etc.
- The time (and location) could be taken from a calendar entry of the user

The entered location and time is checked if it makes sense and if it could be used for route calculation:

- The location must be included in the underlying map (LDM++)
- The given time should be in present or near future

Definition of work

- Define interface to the HMI: enter data, feedback if entered data is not valid
- Define interface to user profiles: getHome, getPOIs, etc.
- Define interface to LDM++
- Implement check, if entered location and time could be used for route calculation

Possible Challenges

The underlying map should be defined early on.

Comments, additional features

Unclear how LDM++ and GPS interworks. Who would answer where I am (mapmatched)?

1.2.5.4 Application use case 3: Enter vehicle characteristics

Overview

Use case name	Enter vehicle characteristics
Use case short name	EVC
Use case identifier	SP4_CONAV_EVC
Use case short description	The user enters characteristics of his vehicle. This is implemented in an easy-to-use way (e.g. the user just selects the model from a type database). The information may also come from the vehicle itself, e.g. via OBD2, or Vehicle ITS Station. In case the application cannot access all required information automatically, the user can enter navigation-relevant vehicle characteristics (e.g. fuel level, engine type (ev. electric, hybrid, ICE), emission factors, max speed, cabriolet, etc.). Moreover, the HMI displays the information to the user, which could be accessed from the vehicle interface. The system may check if the entered information is plausible.
Precondition	Not all navigation-relevant information about the vehicle characteristics is available.
Post-condition	All navigation-relevant information which could be provided is provided.
Normal flow	• The user may navigate (in the HMI) to a properties field, where he is able to review given vehicle characteristics and to provide additional one. When the navigation app is started and vehicle-specific routing is chosen, the system checks if all relevant information about the vehicle is available • The use case requests the vehicle interface (if available) for the information • The information available is displayed to the user

	• The user is asked to provide missing info. • The user enters and confirms this info.
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone without vehicle-access Smartphone, which has vehicle-API access Fully vehicle-integrated
Expected frequency of use	At least once, or every time the navigation is launched and the vehicle-specific info is still missing

External actors and components

Actors' short name	Short explanation
Vehicle driver	The driver enters the vehicle characteristics
Vehicle API / Enabling component	Even though the vehicle API is passive: It may provide the use case with information about the vehicle, e.g. mean fuel consumption, emission class etc.

Input and Outputs

Input	(Static) data about the vehicle
Output	Information about vehicles that allow vehicle-specific routing is available and processed.

Required functional components

Components short name	Short explanation
LDM++ with cloud	No.
Vehicle data or phone data provider	In case we wish to access information directly/automatically from the vehicle, we should have access.

Communication components (LTE, 802.11p)	No.
User profile	No.
Other SP2 component	We may want to store the information about the vehicle in one component. Unclear whether this is a SP2 component or a SP4 enabler.
Interaction between SP3 and SP4	No.

Objectives

We wish to implement routing considering vehicle characteristics (e.g. circumnavigate dirty vehicles from environmental hotspots). This use cases objective is to make the according vehicle characteristics available to the routing application. If possible we want to avoid that wrong characteristics are provided, such that drivers trick to application.

User benefits

We wish to avoid asking the user multiple times. In case the vehicle data could be accessed through an enabler to the Vehicle API, we will do that. We will save the information provided by the user such that he does not need to provide it every time again.

Basic functioning

The user starts the application and chooses a routing method that requires information about vehicle-characteristics. In case information is available (stored as the user entered it earlier or everything is available via Vehicle API), the information is accessed and processed without having the user in the loop. If the information is not available, the user is asked to provide it.

The user may choose from option menus or free text fields to define the vehicle characteristics. It is checked that the data makes sense.

Definition of work

- Define where vehicle data is stored.
- Provide access to the information about vehicle characteristics in case it is available on the data
- Define which data is required for vehicle specific routing
- Look up if any other applications require (static) information about the vehicle
- Provide HMI to enter data (could be within the vehicle but maybe also via web)
- Provide method to check if entered data makes sense

Possible Challenges

None

Comments, additional features

None

1.2.5.5 Application use case 4: Enter personal preferences

Overview

Use case name	Enter personal preferences
Use case short name	EPP
Use case identifier	SP4_CONAV_EPP
Use case short description	The application collaborative eco-friendly navigation considers personal preferences (and constraints) for routing and navigation. Preferably, these are given from a profile, which could be accessed. One example is, that we might want to circumnavigate users from complex crossings (e.g.in case the user is not familiar with the environment).

Pre-condition	Personal preferences, which should be considered in the CONAV application are not (already fully) available or need to be updated. Therefore, we ask the user (or the user wished to update) to update.
Post-condition	The user got the chance to edit and add personal preferences, which could be used for the CONAV app. All information the user wants or is able to share with the system is now included and (as far as possible) validated.
Normal flow	The user may review and edit the information he provided (or which were deduced from the system somehow) by navigating to the relevant field in the HMI. Each time (or on a regular basis) the CONAV application is opened and the personalized (which includes here the globally optimized) navigation is requested, the user is asked to provide the information. The user reviews the given info, has the possibility to edit it, add extra data and confirms.
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone only Smartphone with access to Vehicle-API Fully vehicle-integrated
Expected frequency of use	At least once – in case not all data is available the use case is called on a regular basis when the personalized navigation is requested.

External actors and components

Actors' short name	Short explanation
Vehicle driver	The vehicle driver is the one, who normally interacts with the system to define his/her (routing-specific) preferences and constraints.
Other application or component	A driver profile component has been discussed. It may be possible, that another application or component interacts with this application

	to sharpen the given information (e.g. when another application has learned the driving style automatically, it may push this information to the routing application here.).

Input and Outputs

Input	The external component or actor (commonly the vehicle driver) provides relevant information, which could include the following: • Location of personalized POIs (e.g. home, work, friends, family, restaurants, etc.). This information may serve as shortcuts for destinations etc. • Route preferences: Preference to consider highways, risky roads, complex crossings etc. on the route or whether the driver would like to circumnavigate such routes. • Routing algorithm preferences: The user may define (in detail) his preferences regarding the weighting of route algorithms. For instance, he may define how much time he would accept in order to have a route which is globally better than the individually shortest. • Individual characteristics: We may want to circumnavigate risky drivers from particular routes (e.g. where a lot of crosswalks are). This information might be valuable. Other examples are slowly driving people (it makes no sense to give them routes where the maximum allowed speed is much higher than the speed they would go anyway). Etc.
Output	The given information is stored in a safe way. The system acknowledges that the given input is valid and could be used for routing.

Required functional components

Components short name	Short explanation

LDM++ with cloud	No.
Vehicle data or phone data provider	No.
Communication components (LTE, 802.11p)	No.
User profile	Yes – extensively. The input could be stored in the user profile or the input may come from the user profile.
Other SP2 component	The user profile information should be stored securely.
Interaction between SP3 and SP4	No.

Objectives

We wish to avoid asking the user multiple times. In case the vehicle data could be accessed through an enabler (a personalization component or a use profile), we will do that. We will save the information provided by the user such that he does not need to provide it every time again.

User benefits

The use benefit is not directly associated to the use case – it is more the application in general. Nevertheless, the use interface should be designed in an intuitive way and the information provided should be plausibility-checked. The need for user interaction should be minimized. At the same time, the user preferences should be safe from attacks.

Basic functioning

The user starts the application and chooses a routing method that requires information about user-characteristics. In case information is available (stored as the user entered it earlier and now available through the user profile), the information is accessed and processed without having the user in the loop. If the information is not available, the user is asked to provide it.

The user may choose from option menus or free text fields to define his characteristics. It is checked that the data makes sense.

Definition of work

- Define where user data is stored (user profile component)
- Provide access to the information about driver characteristics in case it is available on the data
- Define which data is required for driver specific routing
- Provide HMI to enter data (could be within the vehicle but maybe also via web)
- Provide method to check if entered data makes sense

Possible Challenges

Privacy issues

Comments, additional features

None

1.2.5.6 Application use case 5: Initiate route calculation incorporating vehicle constraints and characteristics

Overview

Use case name	Initiate route calculation incorporating vehicle constraints and characteristics
Use case short name	RCCC
Use case identifier	SP4_CONAV_RCCC
Use case short description	Depending on actual vehicle characteristics we are able to propose optimal route for given vehicle.

Precondition	Vehicle need to provide characteristics from CAN bus (or other facility component, Vehicle API, or similar, as defined in previous use cases) and ADAS data and map data to inform road characteristics. The origin and destination is known, also the time.
Postcondition	Navigation system provides an optimal route based on one's vehicle (and of course traffic and infrastructure sustainability).
Normal flow	• Each vehicle provides alternative road options (that means two different vehicles may receive different route recommendations for the same origin-destination pair) • Environmental data (such as weather information) could be considered. For example fro the use case, that a certain route may be very unatrractive for bicycle riders, when the go through rainy regions. • We promote the one that best fits to vehicle characteristics • User selects route that he/she likes • System provides navigation guidance to final destination
Deployment platforms (vehicle/smartphone/ backbone)	• Smartphone only, • Smartphone/Vehicle-API, • Fully vehicle-integrated, • Backbone (traffic management centre),
Expected frequency of use	• Each time you are intended to navigate your final destination. • High frequency

External actors and components

Actors' short name	Short explanation
Driver	The vehicle driver tells the system that he wishes to have vehicle-

	specific route recommendation. This information (that he wishes such an algorithm to calculate the route recommendation) might be stored somewhere, such this option does not need to be chosen every time.

Input and Outputs

Input	• Vehicle network data • Traffic data • ADAS • Map data
Output	• Generated route based on vehicle characteristics. • Traffic management • Infrastructure management

Required functional components

Components short name	Short explanation
LDM++ with cloud	Yes, it will be needed to access map data, latest traffic conditions, etc.
Vehicle data or phone data provider	Vehicle data needed to get characteristics of vehicle
Communication components (LTE, 802.11p)	Connection to cloud services.
User profile	The information that a user wishes to have route recommendations incorporating vehicle characteristics could be stored here.
Other SP2 component	No.
Interaction between SP3 and	No specific (the information given from the infrastructure

SP4	which effects routing must be made available through the LDM++)

Objectives

Objective of this use case is to combine driver profile (application use case 6) and vehicle characteristics and use that for route guidance. Based on these information driver can be routed based on his preferences or driving style. Vehicles that are dangerous or causing congestion, e.g. big cars are narrow roads, can be routed differently and thus balancing infrastructure.

User benefits

Better routes for the end user. The information could be used for implementing also system-optimal routing (e.g. balancing dirty vehicles, circumnavigate dirty vehicles from environmental hotspots. Thus, the use benefit might be broad – not only to the driver. Moreover there might be some cases where there are access restrictions to particular vehicles (e.g. in some areas, only electric vehicles or clean vehicles – e.g. Umweltzone Berlin). This could be easily incorporated in this use case. It would result in much better routes.

Basic functioning

The use case does normal routing but respects vehicle characteristics. The use case starts with an initiation to calculate such a route (origin, destination and timing information is available). Then the routing algorithm is started which incorporates vehicle characteristics.

Definition of work

- Define the vehicle characteristics which may be relevant
- Define the metrics to represent these characteristics
- Develop routing algorithms, which incorporate vehicle features.
- Develop interface to vehicle data store

Possible Challenges

None

Comments, additional features

None

1.2.5.7 Application use case 6: Initiate route calculation incorporating driver constraints and characteristics

Overview

Use case name	Initiate route calculation incorporating driver constraints and characteristics
Use case short name	RCDC
Use case identifier	SP4_CONAV_RCD
Use case short description	Based on driver profile and performance vehicle and driver can be guided avoiding certain areas e.g. routes with cross-walks for pedestrians, environmental hotspots etc.
Precondition	• Driver performance reporting implemented and we have driver profile in place • Origin, destination and timing information available • Vehicle network data • Traffic data • ADAS data • Map data
Postcondition	• Routing • Traffic management

Normal flow	Depending on driving characteristics we are able to route driver to the road that best fits to driver's driving behaviour
Deployment platforms (vehicle/smartphone/ backbone)	• Smartphone only, • Smartphone/Vehicle-API, • Fully vehicle-integrated, • Backbone (traffic management centre)
Expected frequency of use	As part of default routing parameters, expected to use every time.

External actors and components

Actors' short name	Short explanation
Driver	The driver will commonly the one who initiates the route calculation..
Other component	Next to the driver, it might make sense to integrate the use case with other applications.

Input and Outputs

Input	Vehicle network data Driver profile / report Traffic data ADAS Map data
Output	Generated route based on vehicle & driver characteristics. Traffic management Infrastructure management

Required functional components

Components short name	Short explanation
LDM++ with cloud	For the normal routing requirements (to have a map, link weights, etc.)
Vehicle data or phone data provider	Vehicle data needed to get characteristics of vehicle
Communication components (LTE, 802.11p)	Connection to cloud services.
User profile	Yes, essentially for this use case as the information will be provided form the user profile.
Other SP2 component	No.
Interaction between SP3 and SP4	Just for the basic data requirements for routing – not because of the specifics regarding the use profile information incorporation.

Objectives

Objective of this use case is to use driver profile and use that to calculate route based on driver performance. E.g. dangerous drivers or driver, who as speeding are routed differently avoiding e.g. routes with many crosswalks etc. Driver reports could be shared with companies to get discounts in insurances for example.

User benefits

The information could be used for implementing also system-optimal routing (e.g. balancing risky vehicles, circumnavigate risky drivers from safety hotspots. Thus, the use case's benefit might be broad – not only to the driver. Moreover there might be some cases where there are access restrictions to particular vehicles (toll roads). This could be easily incorporated in this use case. We may implement routes, which consider that some drivers prefer to pass specific locations (e.g. complex crossing) and others don't.

Basic functioning

The use case does normal routing but respects driver characteristics and preferences. The use case starts with an initiation to calculate such a route (origin, destination and timing information is available). Then the routing algorithm is started which incorporates driver characteristics. It results in route visualization and a turn-by-turn-navigation.

Definition of work

- Define the driver characteristics (preferences, constraints, characteristics) which may be relevant
- Define the metrics to represent these characteristics
- Develop routing algorithms, which incorporate these features.
- Develop interface to user profile

Possible Challenges

Privacy

Comments, additional features

None

1.2.5.8 Application use case 7: Initiate route calculation to balance traffic load

Overview

Use case name	Balance Traffic Load with Constraints
Use case short name	BTL
Use case identifier	SP4_CONAV_BTL
Use case short description	We will use coordinated routing strategies to balance load on infrastructure. A further embodiment will balance traffic mix across

	geographic area. The goal is to avoid congestion/pollution hotspots developing in an urban setting. Here the term “congestion” is generic and can mean demand on infrastructure (charging spots, schools, bridges, parking places).
Precondition	• Information about actual traffic and network state. • Arrival processes and likely delays. • Network connection (not necessarily C2X). • Desired destination and route.
Post-condition	Route recommendation is available.
Normal flow	1. User enters destination. 2. Route is calculated. A number of similar routes are calculated based on user acceptances. Single route is selected stochastically using RED-like algorithm with the objective of balancing traffic or demand across all routes. Kelly-like and consensus ideas may be included here. 3. Route is presented to user. 4. Route is continually updated based on context information and traffic state, and comparison of actual performance versus measured performance.
Deployment platforms (vehicle/smartphone/ backbone)	• Smartphone/vehicle API • Vehicle integrated platform • Backbone
Expected frequency of use	Often

External actors and components

Actors' short name	Short explanation

Driver	Driver starts application.
Other component	By default it is the driver. It must be analysed if there should be an interface that could be used by another component or application.

Input and Outputs

Input	• Origin Destination pair • Context information • Vehicle constraints • Costs given by municipality visa LDM++
Output	Route

Required functional components

Components short name	Short explanation
LDM++ with cloud	Yes. Access state information and municipal constraints.
Vehicle data or phone data provider	GPS information. Vehicle characteristics.
Communication components (LTE, 802.11p)	Yes, as we need to exchange information about traffic states, environmental pollution etc. with the traffic management centres.
User profile	Driver behaviour patterns.
Other SP2 component	No.
Interaction between SP3 and SP4	Yes. Information required from municipalities.

Objectives

We will use coordinated routing strategies to balance load on infrastructure. A further embodiment will balance traffic mix across geographic area. The goal is to avoid congestion/pollution hotspots developing in an urban setting taking into account temporal characteristics of cities (schools closing, rush hours etc.). Here the term "congestion" is generic and can mean demand on infrastructure (charging spots, bridges, parking places).

User benefits

Balanced demand on infrastructure. Lower queuing times, reduced demand on critical infrastructure, and better quality of city experience for citizen. For example, lower pollution levels, improved safety, etc. Overall reduced travel times.

Basic functioning

We calculate different routes with a normal routing algorithm. We now rank these routes according to a balancing metric. We suggest the best ranked.

Definition of work

1. Take a normal routing algorithm.
2. Generate a number of alternatives.
3. Rank order alternatives.
4. Select route based on stochastic optimization, taking into account need to balance traffic load/mix and uncertainty.
5. Suggest route to driver.
6. Update suggestion based on feedback from environment.

Possible Challenges

Flapping, stability issues, complexity of optimization, non-participating vehicles, possibility of attacks from misbehaving users. Motivation of users.

Comments, additional features

None

1.2.5.9 Application use case 8: Initiate route calculation according to user preferences

Overview

Use case name	Objective here is to take into account user preferences in a balanced manner.
Use case short name	UP
Use case identifier	SP4_CONAV_UP
Use case short description	Different users have different concerns when driving. Some like to stay to main well lit roads, while others prefer shortest time/minimal fuel consumption, or where the cost of making a mistake is minimized (one way streets).
Precondition	1. Information about actual traffic and network state. 2. Information from driver concerning preferences. 3. Arrival processes and likely delays. 4. Network connection (not necessarily C2X). 5. Desired destination and route.
Post-condition	Route recommendation is available.
Normal flow	1. User enters destination. 2. Route is calculated based in infrastructure and driver information. A number of similar routes are calculated based on user acceptances. Single route is selected stochastically using RED-like algorithm with the objective of balancing traffic or

	demand across all routes. Kelly-like and consensus ideas may be included here. 3. Route is presented to user. 4. Route is continually updated based on context information and traffic state, and comparison of actual performance versus measured performance.
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/vehicle API Vehicle integrated platform Backbone
Expected frequency of use	Very often

External actors and components

Actors' short name	Short explanation
Driver	Driver starts application.

Input and Outputs

Input	Origin Destination pair Driver preferences are uploaded and updated based on context. Context information Vehicle constraints Costs given by municipality
Output	Route

Required functional components

Components short name	Short explanation
LDM++ with cloud	Yes. Access state information and municipal constraints.
Vehicle data or phone data provider	GPS information. Vehicle engine characteristics.
Communication components (LTE, 802.11p)	LTE.
User profile	Driver behaviour patterns.
Other SP2 component	
Interaction between SP3 and SP4	Yes. Information required from municipalities.

Objectives

We will use coordinated routing strategies to balance load on infrastructure. Driver preferences will be incorporated as well as uncertainty. A further secondary enhancement will balance traffic mix across geographic area. The goal is to avoid congestion/pollution hotspots developing in an urban setting taking into account temporal characteristics of cities (schools closing, rush hours etc.) while respecting driver constraints and preferences. Here the term "congestion" is generic and can mean demand on infrastructure (charging spots, bridges, parking places).

User benefits

Better experience delivered to driver. Balanced demand on infrastructure. Lower queuing times, reduced demand on critical infrastructure, and better quality of city experience for citizen. For example, lower pollution levels, improved safety. Etc.

Basic functioning

1. Upload driver preferences.
2. Upload cost from municipality.

3. Incorporate uncertainty.
4. Take a normal routing algorithm.
5. Generate a number of robust alternatives.
6. Rank order alternatives according to user preferences.
7. Select route based on stochastic optimization, taking into account need to balance traffic load/mix and uncertainty.
8. Suggest route to driver.
9. Update suggestion based on feedback from environment.

Definition of work

- Review potential algorithmic approaches and choose these, do some simulation
- Define requirements regarding data needs and communication needs
- Collect data
- Provide interface to gaming application

Possible Challenges

Privacy; Complexity of optimization. Motivation of users to choose non-optimal routes.

Comments, additional features

None

1.2.5.10 Application use case 9: Initiate route calculation incorporating real-time traffic information

Overview

Use case name	Objective here is to take into account user preferences in a balanced manner making strong use of real-time information.
Use case short name	RTR
Use case identifier	SP4_CONAV_RTR
Use case short description	Objective is to implement routing strategies based on real-time information (traffic throughput, emission, pollution) in a manner that avoids flapping and localized congestion. Flapping is the phenomenon whereby congestion hotspots flap or move in response to traffic patterns and must be highlighted here. The use case is on extension of the ones described before in a way that we incorporate real-time information into use cases described before (might be beneficial to turn off real-time access if network is connection is not wanted, like in foreign countries). This use case could be implemented in combination with the algorithmic approaches in the other use cases of CONAV. We wish to highlight here that real-time data brings extra complexity and possibilities to the application. Besides such real-time information like traffic flow information, pollution information etc., we will also look at real-time information without direct relation to the vehicles (such that no flapping problems may occur). Such information might be weather information.
Precondition	Access to real-time traffic information (also other information, such as pollution information, weather information, etc.).
Post-condition	The user is not aware of or the system has no access to real-time data from the infrastructure.
Normal flow	• User enters destination. • The user defines the routing algorithm and chooses the option that real time traffic information will be incorporated. • Route is calculated based in infrastructure and driver

	information with help of the selected algorithm (see use cases 5, 6, 7, 8, 10, 11). • Calculated route(s) is/are presented to user. • Route is continually updated based on context information and traffic state, and comparison of actual performance versus measured performance.
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/vehicle API Vehicle integrated platform Backbone
Expected frequency of use	Very often

External actors and components

Actors' short name	Short explanation
Driver	Driver starts application.

Input and Outputs

Input	• Origin Destination pair • Driver preferences are uploaded and updated based on context. • Context information • Vehicle constraints • Costs given by municipality • Real-time information about selected features (e.g. traffic flow information per link, noise levels, environmental hotspots, etc.)
Output	Route

Required functional components

Components short name	Short explanation
LDM++ with cloud	Yes. Access state information and municipal constraints.
Vehicle data or phone data provider	GPS information. Vehicle engine characteristics.
Communication components (LTE, 802.11p)	LTE
User profile	(Driver behaviour patterns.)
Other SP2 component	No
Interaction between SP3 and SP4	Yes. Information required from municipalities (such as desired pollution levels, and costs per link to control road traffic)

Objectives

In extension to the objectives outlined in the other use cases of CONAV, we underline here the benefit the incorporation of real time data may affect.

User benefits

Avoidance of congestion and pollution peaks, reduce overall fuel consumption, better driver experience, less frustration, faster routes, etc.

Basic functioning

This use case is an extension to the algorithmic route calculation use cases described for this application CONAV. It includes next to the algorithmic requirements from the other use cases requirements for real time data. Thus it is essential here, that real-time data could be accessed when the route calculation is triggered.

Definition of work

- Review potential algorithmic approaches and choose these, do some simulation
- Define requirements regarding data needs and communication needs
- Collect data
- Provide interface to gaming application

Possible Challenges

Characterization and adequate handling (mathematical) of delays.

Comments, additional features

None

1.2.5.11 Application use case 10: Initiate route calculation with feedback control

Overview

Use case name	Objective here is to adapt in real-time routing strategies based on a feedback signal from the infrastructure with the objective of closed loop regulation.
Use case short name	CLL
Use case identifier	SP4_CONAV_CLL
Use case short description	Objective here is the implement routing strategies with the objective of closed loop regulation based on feedback signal from the infrastructure. All previous use cases can be casting in this framework.
Precondition	Access to feedback signal
Post-condition	Vehicles react to feedback signal in a coordinated manner with

	other vehicles.
Normal flow	Based on measurements, or based on information communicated from vehicles, infrastructure generates an error signal. This signal is communicated to the vehicle fleet via broadcast. Fleet modifies routing strategies in a coordinated manner to regulate error to zero. Stochastic and deterministic strategies are possible.
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone/vehicle API Vehicle integrated platform Backbone
Expected frequency of use	Very often

External actors and components

Actors' short name	Short explanation
Driver	Driver starts application.

Input and Outputs

Input	• Origin and destination pair • Timing information • User constraints and preferences • Real time data to be used in the route calculation (e.g. traffic flow, environmental pollution, etc.)
Output	Route with route information

Required functional components

Components short name	Short explanation
LDM++ with cloud	Yes. Access state information and municipal constraints.
Vehicle data or phone data provider	GPS information Vehicle engine characteristics
Communication components (LTE, 802.11p)	LTE
User profile	(Driver behaviour patterns.)
Other SP2 component	No
Interaction between SP3 and SP4	Yes. Information required from municipalities.

Objectives

There are different routing strategies as outlined in the previous (and the following) use case. In this use case a closed loop in implemented. That means that the effect of actions is monitored. The next action will take this information into account.

User benefits

City can respond to different requirements: Congestion and travel times, pollution, noise, etc.

Basic functioning

The use is as described in other use cases with the additional step of adjusting the routing strategies based on a feedback signal.

Definition of work

This use case focuses on the implementation of the feedback signal only. So, it is important here to include real-time data that is suited to monitor the effect of actions. We will implement a control loop here.

Possible Challenges

Technical and scientifically very challenging combining both routing and feedback control of large scale systems in one element. In addition, characterization and adequate handling (mathematical) of delays and other instability mechanisms needs to be resolved.

Comments, additional features

None

1.2.5.12 Application use case 11: Initiate route calculation with global optimization

Overview

Use case name	Initiate route calculation with global optimization
Use case short name	CGO
Use case identifier	SP4_CONAV_CGO
Use case short description	After the user's start locations and times, route destinations, vehicle characteristics and personal preferences are gathered, a global route optimization is run. The goal is to calculate a route for each user such that the performance of the overall system (e.g. total emissions, total travel time, or total fuel consumption) is optimized.
Precondition	The system is informed about the user's start locations and times, route destinations, vehicle characteristics and personal preferences. Map and traffic data are available.

Post-condition	The system knows a route for each used such that a certain global objective (e.g. total emissions, total travel time, total fuel consumption) is optimized.
Normal flow	New user enters the system Global optimization is run Every user is informed about route updates
Deployment platforms (vehicle/smartphone/ backbone)	Smartphone, which has vehicle-API access Fully vehicle-integrated
Expected frequency of use	Minimum every time a new user enters the system. Potentially every fixed time interval to react on changes in traffic conditions.

External actors and components

Actors' short name	Short explanation
Vehicle driver	After a new user entered the system, the global optimization is run.

Input and Outputs

Input	Start location, start time, destination, vehicle characteristics, personal preference for each user of the system.
Output	One route for each user such that a certain global objective (e.g. total emissions, total travel time, total fuel consumption) is optimized.

Required functional components

Components short name	Short explanation

LDM++ with cloud	The global optimization will most probably take place remote (thus not on the vehicle system). Thus, LDM++ would not be needed. We may implement some distributed approaches, where the LDM++ would be needed.
Vehicle data or phone data provider	Yes – at least to get location information.
Communication components (LTE, 802.11p)	Communication is needed to exchange data. The route destinations, start times, vehicle characteristics, and personal preferences have to be communicated to the server. Moreover, the routes calculated at the server need to be received via communication components.
User profile	Not needed.
Other SP2 component	No.
Interaction between SP3 and SP4	Yes, as main calculation of optimal routes will most probably be central.

Objectives

The objective is to use the data of all user in order to calculate routes for each user that are globally optimal (e.g. as they minimize the total emissions, total fuel consumptions or total travel time)

User benefits

All users of the system benefit from using this system as the overall performance of the system is increased. However, special attention must be given to the fact that the global optimization may assign routes to some users that are not favourable to them. In that case some external rewards may be necessary. However, it can be expected that on average each user will benefit from using the system.

Basic functioning

First, the server gathers all available data. Then, a mathematical model based on selfish network flows is built from the data. Then, the model is solved with sufficient accuracy and the resulting individual routes are communicated to the users.

Definition of work

- Clarify the mathematical model and the tools to solve them.
- Define interfaces for the exchange of data
- Discuss how to cope with the fact that temporarily some users might not benefit from using the system as they are assigned routes that are longer than those that they would normally choose.

Possible Challenges

- Computation is time-critical, as (in principle) a re-computation is triggered every time a new user enters the system.
- Some users might not want to use the system as it assigns routes to them that are longer than the routes they would normally choose.

Comments, additional features

- It is unclear which events trigger a re-computation of the routes. A new computation should be run at least every time a new user enters the system. However, this could also be relaxed if computations are too time consuming.

1.2.5.13 Application use case 12: Signalling good behaviour

Overview

Use case name	Signalling good behaviour
Use case short name	SIGNAL

Use case identifier	SP4_CONAV_SIGNAL
Use case short description	The CONAV application will interface serious game/community building (SG-CB) application. This use case describes one part of it. The gaming application will interface CONAV and will be able to receive information about the quality of the behaviour of the driver using CONAV. This means that CONAV has a metrics that provides information about the driver's compliance to suggested routes, indicating in particular whether the driver did accept navigation instruction or not. The metric will be two-dimensional: • First, a metric that provides information about the difference between recommended navigation instructions and the actually executed navigation behaviour (e.g. a normalized ratio of number of accepted navigation instructions and number of provided navigation instructions or, better, the difference in social cost/benefit among the suggested/not suggested and the actually made routes. This assessment would need to be done within the CONAV application logic). We call this metric: compliance metric. • Second, a metric that provides information about the quality of compliance. That might be explained with an example: Assume that there is an origin destination pair, say O and D. There are multiple routes available from O to D. One (A) requires 10 min, a second one (B) 20min and a third one (C) 30 min. An ego-centric navigation application will recommend the shortest route. But in some cases, CONAV will recommend the route that lasts 20 min or even the route that takes half an hour, e.g. in case these optimize the overall benefit of the community. So, assume route C is the one that is optimizing the global benefit and is thus the one recommended by CONAV. Assume route B is the second best, route A the third best option when looking at the community benefit (i.e. the CONAV viewpoint and suggestion).

	Now, let's assume that the user chooses to take route B. The metric here will assess this behaviour with a feedback, let's say 10 points. In case the user would have chosen route C, the user would have received 20 points, while A 0 points. The amount of points shall be defined by the CONAV application, translating in a quantitative way the "social" advantage of using one route instead of a more "ego-centric" one. Thus, this metric is a quality of the route metric. We call this metric: merit metric. Proper normalizations may be needed for both the metrics.
Precondition	At the end of the navigation route, CONAV supplies the SG-CB application with information about the driver performance (compliance and merit metrics).
Postcondition	The SG-CB application received required information about the driver performance (compliance and merit metrics). This information will be translated into proper rewards by the SG-CB.
Normal flow	The SG-CB application interfaces the CONAV application in order to support a better driver behaviour. The CONAV application provides information about driver performance at the end of the routes and SG-CB reacts accordingly.
Deployment platforms (vehicle/smartphone/ backbone)	• Smartphone only • Smartphone/Vehicle-API • Fully vehicle-integrated • Backbone
Expected frequency of use	If this functionality is activated, it will be triggered at the end of each suggested route, when some "socially preferable" alternative routes are available.

External actors and components

Actors' short name	Short explanation

SG-CB application	It is the external gaming/community building application, which interacts via a specified interface.

Input and Outputs

Input	This UC requires two inputs (provided at the end of a navigation route): • The compliance metric • The merit metric
Output	Call to the SG-CB application providing the possibly normalized values of the compliance and merit metrics.

Required functional components

Components short name	Short explanation
LDM++ with cloud	No.
Vehicle data or phone data provider	No.
Communication components (LTE, 802.11p)	No.
User profile	Maybe. The use case may enrich the compliance information with more static information about the user (e.g. the quality metric may be influenced if it is know that the driver is not familiar with the environment and thus may not comply to navigation instructions by accident).
Other SP2 component	No.
Interaction between SP3 and SP4	No.

Objectives

The SG-CB application interfaces CONAV through this use case (and the following one). It will receive information about the driver compliance to socially relevant suggestions. The information will be provided at the end of the trip.

User benefits

The user benefits implicitly as he or she can gain points by following the "socially relevant" CONAV suggestions. This also means that the community may benefit from it.

Basic functioning

The use case will compare the route recommendations with the actual navigation decisions from the driver and will calculate a metric.

The compliance metric might be implemented by considering, e.g., navigation decisions taken by driver in compliancy with the given instructions / given instructions, or, better, the difference in social cost/benefit among the suggested/not suggested and actually made routes. The merit metric may rank different route choices from a community point of view. Both the computations take into account the social cost, which can be actually very complex.

Definition of work

In the first place it is necessary to specify the gaming application and deduce the relevant requirements to the CONAV application.

Possible Challenges

Computation of the metrics, also considering a possible normalization.

Comments, additional features

The use case may be related to the interfaces of the driver profile in SP2.

1.2.5.14 Application use case 13: Requesting virtual coins

Overview

Use case name	Requesting virtual coins
Use case short name	COINS
Use case identifier	SP4_CONAV_COINS
Use case short description	The CONAV application will interface gaming/community building (SG-CB) application, from where the user has virtual coins. In the CONAV context, he may spend some amount of this budget (virtual coins) to get some better levels of service. Examples of levels of service could be: quality of the navigation graphics, quality of the navigator voice, availability of detailed and frequently updated real-time traffic information.
Precondition	The player requests a certain level of service (see above) in the CONAV application. The player has a profile in the SG-CB application.
Postcondition	The CONAV enables the requested level of service provided that the SG-CB can accommodate the requested amount of virtual coins.
Normal flow	The CONAV application is started by the user. The user has entered origin and destination pair as well as timing information. The user requires a certain level of service. CONAV computes the cost of the user requests and sends the virtual coin request to the SG-CB application. SG-CB replies ok or not, depending on the actual virtual coins available to the current user. The driver's budget is reduced accordingly, in the SG-CB application.
Deployment platforms (vehicle/smartphone/	• Smartphone only

backbone)	• Smartphone/Vehicle-API • Fully vehicle-integrated • Backbone
Expected frequency of use	Depends on frequency of use of the CONAV and SG-CB applications. The use case is called each time CONAV is started, provided that the user subscribed the SG-CB application.

External actors and components

Actors' short name	Short explanation
Vehicle driver	The user has confirmed that he or she joins the gaming application. He interacts with CONAV, where features of the gaming application are integrated.
SG-CB application	The application providing the virtual coins

Input and Outputs

Input	Origin and destination pair. Route timing information. Map data (possibly including real-time information) including information which makes it possible to calculate system-optimizing routes. The level of service requested by the driver.
Output	Route (and relevant navigation interaction features) according to the amount of spent coins and new available budget of virtual coins (managed by the SG-CB application).

Required functional components

Components short name	Short explanation
LDM++ with cloud	Yes (only as route calculation is included – not directly for ht use case).

Vehicle data or phone data provider	No.
Communication components (LTE, 802.11p)	No.
User profile	Maybe – we require budget information, which might be coming from the user profile or the gaming application.
Other SP2 component	No.
Interaction between SP3 and SP4	No.

Objectives

The use case incentives the driver to collect virtual coins across various TEAM collaborative applications, so that he can have better levels of services in any of them (e.g., CONAV, in this case).

User benefits

By allowing better CONAV services through availability of virtual coins, we intend to serve the society in general and (not only) the individual driver.

Basic functioning

The CONAV application is started by the user. The user has entered origin and destination pair as well as timing information. The user requires a certain level of service. CONAV computes the cost of the user requests and sends the virtual coin request to the SG-CB application. SG-CB replies ok or not, depending on the actual virtual coins available to the current user. The driver's budget is reduced accordingly, in the SG-CB application.

Definition of work

Define ways to assess level of services (e.g., route options) and translate them to coins. Interface with the gaming application.

Possible Challenges

Identification and assessment of levels of services.

Comments, additional features

No.

1.3 DIALOGUE enablers

The applications that are planned to be designed and developed in the DIALOGUE TEAM sub-project 4 are collaborative applications that imply the use of a minimum set of enablers (HW and SW) and of HMI solutions (HW and SW).

The enablers have been collected (although not exhaustively) with the same methodology in SP3 and in SP4 by the same partner (INTEL) and they are basically derived from the detailed description of each application and related use cases: per each application the team of partners working on it has already identified a set of indispensable enablers.

1.3.1 Enablers' character

Enablers are used to designate three groups of entities: 1) data or aggregated data, 2) algorithms used by the applications and 3) tools.

1. **Enablers related to data or aggregated data** support application development. Such kind of data is e.g. the status of the traffic light, dynamic and static parking information, public transport time tables, routes and fares, fuel consumption information, real time traffic situation, road side aggregated data about the road status, FCD and XFCD from the field (incl. sensor data), traffic LOS and events, control strategy rules, indication of components operation (i.e. active, inactive components, reliability values) and so on.
2. **Enablers related to algorithms** are for instance:
   - algorithms/metrics to evaluate different behavioural options from a system-centric perspective

- logic/algorithms for mobility behaviour orchestration
- conflict resolution algorithms
- co-modal routing algorithms (in cooperation with DIALOGUE)
- social network monitoring
- optimal control of users' incentives
- driver, stakeholder and context modelling for cooperative driving
- macro-level game theory-derived dynamic routing strategies providing incentives to drivers that contribute to the common benefit
- micro-level game theory-derived collaboration strategies for vehicle/infrastructure traffic control strategy providing incentives that redefine win-win situations for both parties,
- highway traffic control strategies based on cloud computing, cloud-based data analysis of driver/traveller movements
- trip cost comparison mechanisms

Strategies for adaptive traffic management and control to achieve the optimization of the network operation at both network level and local level (e.g. intersection level for start and stop application) belong to this group. Some examples are: intersection rules that manage cooperative signalling, interaction manager which gives appropriate instructions to approaching vehicles based on their current position and the duration of traffic light phases (e.g. turn on/off engine), algorithms for calculating traffic light phase parameters (duration of traffic light phases in real time, vehicle position in a queue etc.).

3. **Enablers related to tools** include:

- a tool to evaluate different behavioural options from a system-centric perspective
- a gateway for integrating data/information from different relevant infrastructural data providers (i.e. a data adaptor which processes data from data providers and formats it in a way, that it could be handled by TEAM)
- a tool to handle all stakeholder needs such that they can be further processed
- the simulation as a tool for applications (not for evaluation purposes but to serve applications directly)

- a social driving platform, with sub-modules such as geo-tagging, geo-messaging, car-transport semantics, support for proximity, community building and analysis and ad-hoc gaming support.

1.3.2 Enablers list from SP4 applications

The following table describes a preliminary list of enablers covering SP4 applications. An extensive list of enablers will be provided in an upcoming document.

Data Enablers	**Surrounding vehicles**: A component that aggregates position and relevant information about the nearby vehicles (relative to a traffic infrastructure or another vehicle)
	Vehicle characteristics: A component that aggregates all relevant static and dynamic vehicle characteristics (type, current speed, size, weight, load, passengers, etc.)
	e-Horizon: A component providing information about the road ahead (exits, intersections, speed limits, hills)
	Traffic flow: A component that aggregates information about the traffic conditions in a certain region (i.e. congestions)
	Vehicle data or phone data provider: Vehicle to send and receive parking slot and positioning messages (also based on engine on/off and vehicle manoeuvring)
Algorithm Enablers	**Organizer**: A component prioritizing the different recommendations and speed limits from different parts and systems (traffic planning, traffic light RSU, speed limits from Navi)
	Vehicle dynamics model: A component to model the vehicle stability and behaviours in critical situations. (emergency braking and harsh steering)
	Control algorithms: A component to handle the controls strategies for the different states. (queue scenarios, high speed scenarios, etc.)
	Driving style monitoring: Evaluates driving style while using the application
Tools Enablers	**Vehicle controlling**: A component that can control several aspects of the vehicle (i.e. start-stop, electricity/diesel, maximum revolutions, maximum speed, etc.)
	Access control: A component to verify and grant or deny access to a certain transport

	infrastructure. In this context a lane or an especially regulated area, but it could be extended to bridges, tunnels etc.
	Driver HMI: An HMI component to inform and interact with the driver.
	Communication: A component that provides short range and long range communication abilities. (V2X, 3G, 4G)
	On-board sensors: Perceptions components to collect information about the surrounding environment. (radar, lidar and camera)
	Mode selection unit: A component handling the different states of the application. (Close distance control, low speed, high speed)
	LDM++ with cloud: Cloud server to collect and manage the parking slot availability (remote parking management server)

1.4 Human machine interface

1.4.1 TEAM HMI approach

The applications of SP4 are conceived to effectively support the driver to adopt a safe and eco driving style in the long terms and to facilitate also the adoption of co-modality options in specific areas (like city centres). This chapter is therefore giving the first indications on how the TEAM's HMI working group (under construction) may proceed in creating an effective "DIALOGUE" between the vehicle, the driver, the community of people on the move.

The basic principle that gave the origin of this project acronym is that cooperation in a win-win schema rather than competition is to be applied in the mobility community: the mobility arena is shared by several actors and means, capacity of the mobility transport is flexible only up to certain extent, therefore a pure competitive approach (when driving for example) cannot be an affordable approach anymore.

TEAM shall create the ground for this collaborative approach, and to do so the big challenge is not only to design the so-called "collaborative" applications or functions, but also to create a dialogue with the driver that will make the driver feel to be in the community of people on the move and be part of it: a community where (as driver) I have all advantages in driving safe and eco (in principle) but I also have community-given advantages (the virtual coins approach) when driving / behaving in a way that is of benefit for the community of drivers.

Another novel concept that the TEAM HMI working group has the opportunity to introduce is the concept of identification of the driver with the community of drivers and with the community of cars. This is not a new concept, as it is well experienced in social networks, but it's new in respect to the context, and it's considered as worth to be investigated.

The TEAM WG HMI has the opportunity to start from the basic rules to create a dialogue: for an effective dialogue between two parties the most important rules are, at least, the agreement on:

- the creation, selection or adaptation of a common language:
  - the (public) outcomes of the ecoHMI working group, that operated in 2012 among the eCoMove integrated project activities will be taken into account
  - every language is composed of a SW (or algorithmic) and of a HW (or mean to communicate) part
    - the most recent HMI technological solutions adopted by OEMs and (for example) presented at the 83rd International Motor Show, in March 2013 in Geneva, will be revised and matched with a thorough analysis of the most promising advanced HMI solutions available in the consumer market (e.g. trackpad, padfone, …)
    - the guidelines to design an integrated and adaptive HMI (Human Machine Interface) and intelligent management of the information (developed by the AIDE European project) will be a starting point to develop the TEAM HMI strategies
- the creation, selection or adaptation of a minimum set of guidelines and rules to achieve dialogue's effectiveness:
  - a first version of a document on "TEAM HMI Guidelines to Minimize Driver Distraction" is already available (ref. author Mark Foligno, NOKIA connected car)
  - the European Statement of Principle on HMI (ESoP) document content will be taken into account
- the (figurative) identification of the two parties involved in a common dialogue:
  - the identification of a driver in an avatar is a concept (again derived from social media network) that will be explored

This list is not conceived to be exhaustive, it's now the task of the TEAM working group on HMI to develop the concept and explore its potential in all its parts. As a starting point of the activity the next paragraph reports the first release of the TEAM guidelines to minimize driver distraction.

1.4.2 TEAM HMI guidelines to minimize driver distraction

This paragraph is created to support the design and development of visual and auditory interfaces for use while driving. The following principles represent core guidelines any application should follow.

These guidelines draw upon recent research findings on driver distraction as well as existing recommendations issued by

- Alliance of Automobile Manufactures
- Commission of the European Communities
- Japan Automobile Manufactures Association
- National Highway Traffic Safety Association
- International Organization of Standardization,

However, these guidelines are not comprehensive. In particular, there isn't yet sufficient research data concerning novel in-car interaction methods, such as gesture based touch screen interactions. Thus, they will be constantly updated, as there will be new interaction solutions available and more up-to-date research findings.

Furthermore, "the guidelines must not replace or prevent evaluation phase. Even the most careful design will require testing with actual users in order to confirm the value of good features and discover what bad features may have been overlooked." (HARDIE Guidelines, 1996)

The core guidelines are grouped as follows:

- Display Design
- Interaction with Displays and Controls
- System Behaviour
- Verification
- Definitions

A first detailed version of the guidelines is available and will represent a solid ground to base the user centred design of an attentive and effective TEAM HMI.

1.5 Summary

DIALOGUE intends to prove a set of vehicle centric applications based on collaborative mobility. The latter extends co-operative mobility by adding major concepts of driver- and traveller-in-the-loop, of road usage negotiation and social networking, for a safe, sustainable and efficient mobility.

This is reflected by the set of applications addressed, which are mostly targeted at preventive safety and efficient driving. The vehicle focus is evident in that the applications primarily address the user behaviour in the different tasks and scenarios connected to his/her private mobility - with respect for instance to FLEX applications, focussed on infrastructure management and co-modality.

The continuity with intelligent transportation roadmap is also clear, indeed almost all applications are strongly related to existing in vehicle systems and infrastructure, such as collaborative ACC, eco-friendly parking, driving and merging applications, and eco-friendly navigation. Overall, these applications are an enhancement of ITS state-of-art with the collaborative nature of TEAM. As such they are strongly relying on real-time feedbacks among all entities, posing several requirements on technologies such as LTE and G5, enriched LDM, HMI, as well as on the integration of these technologies into the vehicle systems. A major aspect emerging from this analysis is the need of accurate data from the environment, as well as the challenge of managing and retrieving these data, either locally (e.g. low latency V2V applications, ego-vehicle sensors, etc.) or in the cloud (download of data thanks to broadband connectivity) or both. Especially for cloud-based functions, a combination with FLEX functionalities has to be evaluated.

The application green, safe and collaborative driving serious game and community building deserves a separate mention, being one of the main novelties as well as one of the core features of DIALOGUE, addressing both coaching, and team and community awareness. This explains the need to define a large set of use cases for its definition, and additional functions of User community management. Beyond the application itself, an important aspect to be carefully investigated is the integration of this application with the other ones, considering the right trade-off between driving freedom and constraints in combined scenarios, e.g. where a game competition is on-going and a an application like C-ACC or CDM advises the multitude of vehicles to keep a certain behaviour. The solution has to be found on the one hand within the gaming application by defining proper rules for team collaboration, on the other hand within DIALOGUE by fostering from the beginning a joint design, with integration and orchestration of the applications.

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 Part B, 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 Part B, 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

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