Tomorrow's Elastic Adaptive Mobility

D3.3.1

FLEX requirements and initial specifications

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1.2	26.07.2013	Final version
1.3	09.05.2014	Update after 1st Annual Technical Review comments.
1.4	14.09.2014	Update after 2nd Year Interim Review comments.

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Summary

FLEX sub-project aims at flexible energy efficient and eco-friendly mobility from the infrastructure's side based on interactions between all relevant users (i.e. travellers, vehicles, infrastructures). The key concept in FLEX is "elastic" transport infrastructures, which implies that infrastructures, such as parking places, road lanes and public transport, will start to be flexible and change based on citizens' or cities' demand.

At the beginning of this document the methodology for the collection of the applications requirements and the work related to the identification of elastic infrastructure enablers and their mapping to the applications requirements are highlighted. In general, the work is divided into two main categories, namely applications and enablers, as dictated by the TEAM workflow. The work in WP3.2 reported in this deliverable is based on the analysis made on the outcome of WP3.1, FLEX application and enablers use cases (reference to chapter 4 of D1.0). In WP3.1 the elastic infrastructure related stakeholders, the applications layout and specific use cases have been defined. In WP3.3 the general requirements to achieve these use cases are presented. For each application and enabler dedicated working group based on partner expertise and involvement were established. Each group made a thorough investigation on relevant use cases' feasibility, needs and condition to be realised and the outcome of this work became FLEX application and enablers requirements. The requirements cover a wide range of functional and non-functional ones, including architectural, equipment, communication, security, technological and other requirements. Then in close cooperation with the other two technical SP's (EMPOWER and DIALOGUE) this list was enriched and refined to conclude to the final list of FLEX applications and enablers requirements presented in D3.3.1.

In the following chapter the requirements of FLEX applications to the elastic transport infrastructure are highlighted based on a common template defined by TEAM within WP43 (in DIALOGUE). The same approach is followed in the next chapter where the requirements from DIALOGUE applications to the elastic transport infrastructure are now presented.

Finally, the performed work concludes with the identification of the elastic transport infrastructure enablers. These are deriving both from FLEX internal needs and from DIALOGUE applications needs. Their objective is to serve the needs of all TEAM applications from the infrastructure's point of view. This is also highlighted through the mapping of FLEX enablers to the applications requirements in the relevant tables available in that chapter.

Technical details on the realization of these requirements are out of scope of this report and are the objective of the coming WP's were these requirements' examination will generate the actual

FLEX system technical specifications. During the development and evaluation phase the final system will evaluated against the initial requirements and use cases.

1 Introduction

This chapter provides a short introduction of the document and the related work performed so far in WP33 *Requirements and specification*. It is divided into three different subchapters, namely the motivation and objectives, the methodology followed and the structure of the remaining document.

1.1 Motivation and objectives

Today's mobility systems are based on infrastructures which are in general static and just inform road users about the weather or incidents without any interaction or collaboration with them. In TEAM and especially in the FLEX sub-project the scope is to make infrastructures really *flexible* and adaptable to the needs of the cities and the citizens based on interactions between all the related actors. Through this *elasticity* at the infrastructure side the orchestrated use of different modes of transport (multi-modal mobility) will be promoted with the primary aim to increase traffic efficiency and minimize pollution which is one of the main problems in modern cities.

This deliverable describes the work performed so far in WP33. According to DoW this work package will highlight the requirements and specifications of FLEX enablers and applications based on the input from the use cases provided by the previous WP. The term "enablers" is used for data, tools and algorithms to be used by the relevant applications. These enablers will be used not only by FLEX applications but also by DIALOGUE ones. Therefore this work package is working with requirements and specifications divided into two main categories, namely enablers and applications. The scope of this work package targets mainly two points: (1) requirements and (2) specifications of elastic infrastructure applications and enablers. This report is focused on the requirements while the full set of specifications together with the architecture will be available in D2.0 "TEAM system specification and architecture" due month 14 (end of December 2013).

The main objective is to highlight the work performed with the requirements in the elastic transport infrastructure (FLEX) and the interactions and close cooperation both with the enabling technologies (in EMPOWER) and with the vehicle/traveller side (DIALOGUE).

Another central objective of this document is the identification of FLEX enablers based both on FLEX internal needs and their mapping to the application requirements as well as the enablers serving the needs of DIALOGUE applications through the respective requirements received be SP4.

Last but not least the work described in this document is based on the work performed in the previous WP, namely WP32 *Users, stakeholders, and use cases*, and mainly the work related to the

use cases (available in D1.0). This also shows a good process of the work towards the next phases of the project.

1.2 Methodology

The methodology followed in this document is based on the general TEAM workflow, which is depicted in Figure 1.1. As a result the work in FLEX (as well as in DIALOGUE) is divided into two main categories: applications and enablers.

For the applications, working groups for collecting the requirements have been established. The work was heavily based on the use cases that were available per application in D1.0. So each established working group had to identify the relevant requirements and fill in the relevant template (see Table 1.1).

For the enablers the basis was the initial list of enablers per application, which was identified in D1.0, and was refined afterwards by each application's working group. Also the work performed for the identification of application functionalities (task 3.2.3) was used as input, since the aggregated functionalities will be realised by specific enablers performing the relevant functionality. Moreover, the needs of DIALOGUE from the infrastructure side have to be addressed from relevant enablers in FLEX so the requirements from DIALOGUE were also considered.

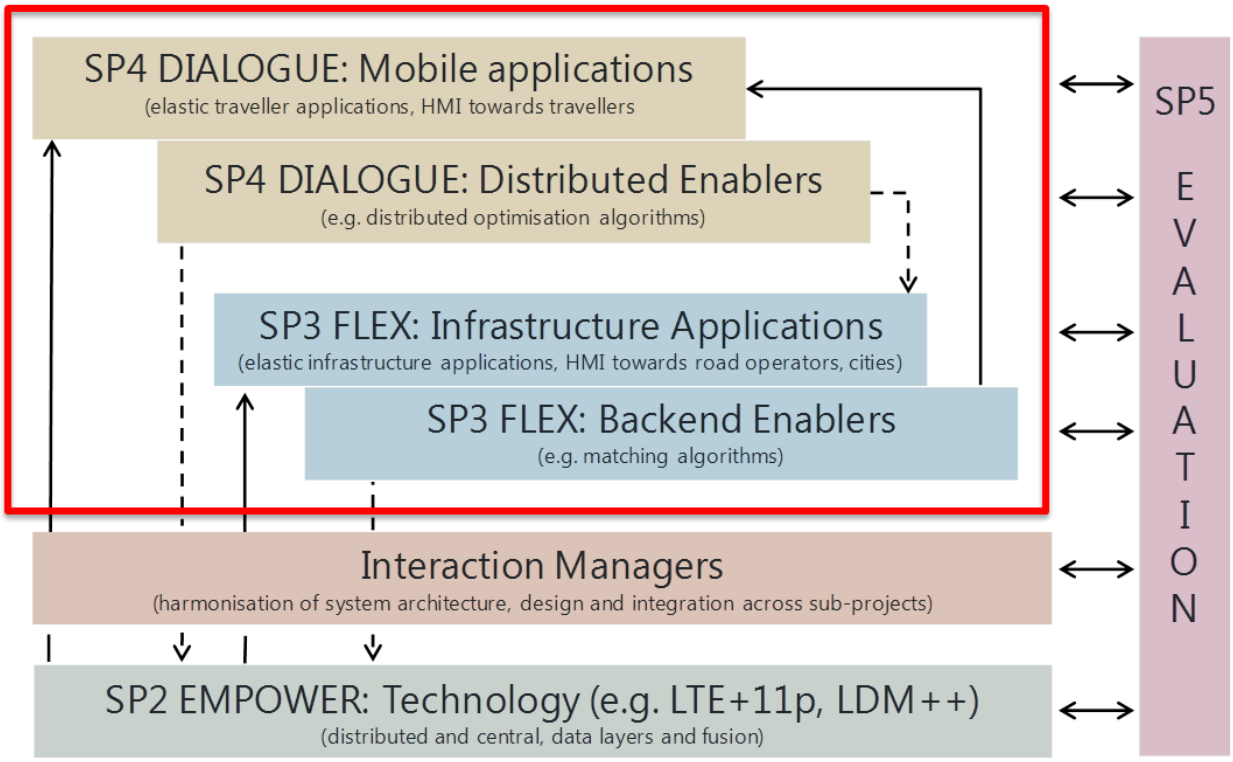


Figure 1.1: TEAM workflow

In general the methodology included the collection of application requirements, the identification of the enablers (serving both FLEX and DIALOGUE applications) and the mapping of the application requirements to the enablers.

Input documents

The documents that were used as input to the work here are the following:

- D1.0 TEAM users, stakeholders and use cases [1]
- IR4.3.1 DIALOGUE requirements to EMPOWER and to FLEX [3]
- IR4.3.2 Common format and defined processes for requirements engineering [4]

Template

For the requirements collection the following template (in a table format) was proposed in the internal document [4] and is used in the rest of the document.

Table 1.1: Requirements tabular template

Requirement ID	SPx_REQ_y_vZ.z (x is the SP name, y is the serial number of the requirement, and Z.z is the version number)
Name of requirement	A title assigned by the author
Created by	Person/Partner that created the requirement
Assigned partner	Partners to which the requirement has been assigned
Source (TEAM application or enabler)	From which application/enabler the requirement has been created
Requirement category	Functional or non-functional - General architectural and equipment requirements - Connectivity and communication requirements - Application requirements - Security requirements - User acceptance - Technological and development requirements
Goal	Short description for why this requirement is specified
Definition	Self-explanatory
Critical level (priority)	Define the importance of the requirement
Validation Method (tests, indicators, performance bounds)	e.g. function availability
Acceptance criteria	The acceptance criteria identified at this stage are from the users'/stakeholders' perspective; what will make them to say that the related use case will be accepted. Can be either functional (what the module/application/systems should provide) or non-functional (properties of a module/application/systems), and their role is to

	complement a high-level system requirement in a way that will promote user acceptance.
Relationship with other requirements	Self-explanatory Same level relationship or hierarchical relationship
Potential conflicts	Conflicts with other requirements
Risk analysis	Identify the risks if this requirement is not met. Also identify the risks for meeting this requirement.
Status	New: The requirement has been named. It does not necessarily have all fields filled in. Especially the target release does not need to be set for new requirements. Working: The work has started to meet the requirement. All fields have to be filled in. Further requirements may be yielded during the course of work for the requirement. Closed. The work has been finished to meet the requirement. The requirement is regarded as being met by the development. Rejected. The requirement is rejected for some reason. Most of the time, the reason is that a requirement actually is a duplicate to some other requirement.
Other	Anything that could not fit in the above fields is mentioned here.

Requirements collection for FLEX has been proven a difficult task as it serves a wide range of applications with demanding use cases. Every application use case was taken into consideration and analysed with multiple requirements to be extracted. These in some cases were conflicting. but these conflicts have been eliminated and requirements have been merged, where applicable. The outcome of this procedure is what the reader cab find in this deliverable. Evaluation of feasibility of initial requirements will take place throughout the project, including the architectural, design and implementation phases when a more solid system view will be defined.

1.3 Structure of the document

The document is structured as follows. In chapter 2 an overview of both FLEX and DIALOGUE applications is provided. In chapter 3 the requirements of FLEX applications to the elastic transport infrastructure are highlighted, whereas in chapter 4 the requirements from the DIALOGUE applications to the elastic infrastructure side are described. The work related to FLEX enablers and their mapping to both FLEX and DIALOGUE applications requirements is depicted in chapter 5. Finally, conclusions are drawn in chapter 6.

At this point it should be mentioned that the requirements of the applications which are focusing on the vehicle and the traveller side are covered in D4.3.1 *Requirements of DIALOGUE components, enablers and applications* [2] which follows the same structure.

2 Applications overview

An overview of TEAM applications (both FLEX and DIALOGUE) will be provided in this section. For a more detailed description on the applications and their relevant use cases the interested reader will be prompted to take a look at the D1.0 "TEAM users, stakeholders and uses cases" [1].

2.1 FLEX applications

Through a specific methodology followed in the first months of the project we have identified six FLEX applications that are of interest for the project stakeholders such as infrastructure suppliers, traffic managements centres, road operators, public transport operators etc. For more information on the methodology followed for the selection of the applications as well as on the project stakeholders and their preferences and constraints one can refer to [1].

FLEX related applications are given below and are briefly highlighted in the following sections:

1. Collaborative pro-active urban/inter-urban monitoring and ad-hoc control (CMC)
2. Collaborative co-modal route planning (COPLAN)
3. Co-modal coaching with support from virtual/avatar users (CCA)
4. Collaborative smart intersection for intelligent priorities (CSI)
5. Collaborative public transport optimization (CPTO)
6. Dynamic collaborative corridors (DC)

2.1.1 Collaborative pro-active urban/inter-urban monitoring and ad-hoc control

TEAM equipped vehicles & travellers (through their smartphones) monitor urban roads and recognize incidents or special events and provide real-time information to the TMC which validates the reliability of this information and optimizes the traffic efficiency. Data from existing legacy monitoring systems is also considered. A short overview table of this application is given below.

Table 2.1: CMC application overview

Application name	Collaborative pro-active urban/inter-urban monitoring and ad-hoc control
Application short name / Identifier	CMC
Application short	TEAM equipped vehicles monitor urban roads and recognize

description	incidents or special events (road closures, work zones, public large-scale events, ...) while driving, provide real-time information to the TMC which validates the reliability of this information and optimizes the traffic efficiency. Such innovative paradigm is based both on the information that comes from the vehicle side as a monitoring sensor and proactive traffic management centre through a V2I communication and information from other data sources (e.g. crowd sourcing, mobile devices tracking, ...) and existing legacy monitoring system.
Platforms implementing the application	• Smartphone/Vehicle-API • Backbone (traffic management centre) • Third party (data providers, public authorities) (to be further investigated in next project phases and/or next applications specification iterations)
Application objective	This application will become a B2B base for the TEAM categorized application. Since the info will be gathered from different corners thanks to the cars used as sensors and also from existing monitoring systems, this application will provide an helicopter view information and control at a wide area network level, that supports other TEAM application to take advantages to the dynamic nature of the information to be used in a real time to coordinate collaborative traffic control in order to reduce congestion, fuel consumption and consequently emissions level.
Basic functioning	Data coming from xFCD enabled collaborative vehicles and mobile devices are collected and mashed up. Traditional road sensors data are included in this fused data set. Then, algorithms for reliable network status forecast are applied. Specific related control policies are actuated, evaluating the impact of these by implementing a double feedback loop approach.
Application's use cases	• Collaborative data collection

	• Data set completion • Network observation • Definition of multi-layered policies • Application of collaborative pro-active control • B2B info publication
Required lower layer components	• LDM++ • Communication components • Vehicle data provider • Collaborative vehicles xFCD interface adapter • Traffic status estimation and forecast module • Actuation components (to be defined in the next steps of the project) • Web services for B2B information publication

2.1.2 Collaborative co-modal route planning

COPLAN will provide collaborative co-modal route planning by fusing and aggregating heterogeneous data from multiple end-user and infrastructure applications such as pollution sensor data and traffic density as well as information from third parties relevant to real-time road incidents. Other sources from which information can be collected are e.g. Public Safety Answering Points (PSAP), municipality services, road operators and historical traffic related data gathered from TEAM users. A short overview table of this application is given below.

Table 2.2: COPLAN application overview

Application name	Collaborative co-modal route planning
Application short name / Identifier	COPLAN
Application short	The TEAM multi-modal planner, in addition to providing

description	multimodal information, has an omni-comprehensive system view integrated into global network optimization (coming from the "Collaborative pro-active urban/inter-urban monitoring and ad-hoc control" application) and user-centric route planning methods and is able to connect to advanced services like the "Co-modal coaching with support from virtual/avatar users". This application has a high environmental impact, thanks to the inclusion of the more eco-efficient modes (increase in the usage of public transportation), and routes, and through more optimized usage of the whole transportation system.
Platforms implementing the application	Smartphone/Vehicle-API Backbone (traffic management centre)
Application objectives	COPLAN will provide • Collaborative multi-modal route planning as a service for deployed collaborative applications by fusing and aggregating information coming from multiple FLEX and DIALOGUE applications. These include heterogeneous data from e.g. the Collaborative pro-active urban/inter-urban Monitoring and Ad-Hoc Control application such as environmental sensor and traffic-related data, or even information from 3rd parties relevant to real time or/and to predicted/forecasted/planned road incidents, etc. as well as serious gaming aspects from applications such as "co-modal coaching"; The stakeholders/sources from which information can be collected can be: 1. Public Safety Answering Points (PSAP), police or fire brigade: providing information about an emergency incident that took place on the road, or at a specific location, 2. Municipality services, road operators etc.: e.g. providing information regarding planned civil works that will be

performed on a part of the road at specific dates, thus rendering specific roads or lanes inaccessible.

3. Historical traffic related data (e.g. any kind of info gathered from TEAM users).

Based on this information, the application will provide end-users with alternative routes and transportation modes based on user-centric info (e.g. origin and destination, Departure time, User preferences (travel time, cost, environmental criteria, number of changes, transportation type, etc.))

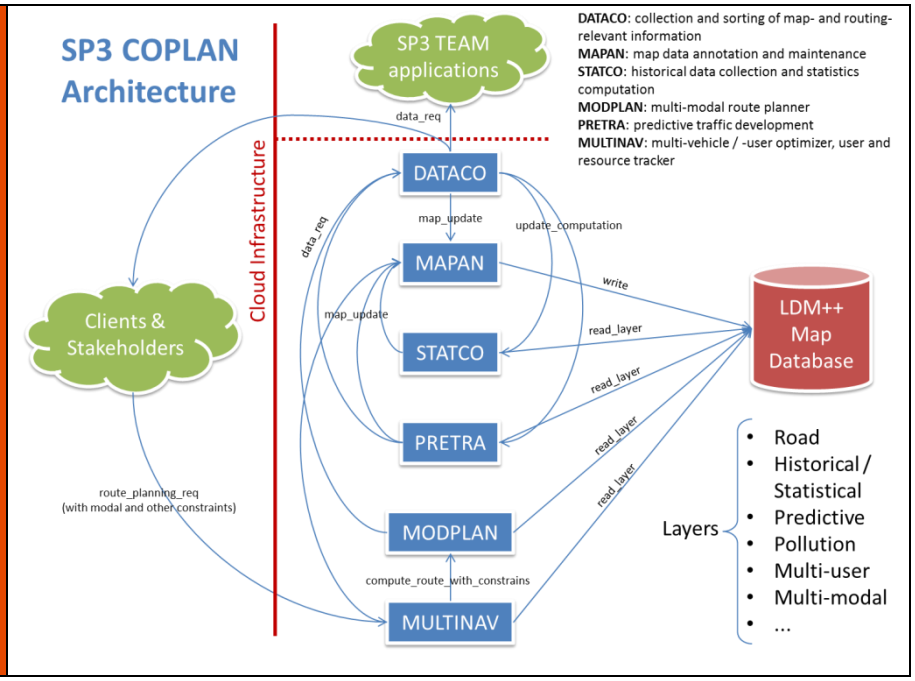
- Statistical information for specific geo-locations upon request, for instance by generating dynamic statistics (e.g. moving average) of a given road intersection or location, or even along a computed route. Statistical information can be derived from processing historical traffic related data, gathered from TEAM users or other stakeholders/sources as described above. In this way, in-vehicle routing algorithms can decide to avoid specific locations (i.e. dangerous crossings, problematic traffic areas, etc.)

- Real-time evaluation and computation of predictive traffic development based on information regarding real-time events as well as on information provided by TEAM users regarding their preferences and decisions (origin, destination, travel time, selected co-modal route); COPLAN uses this predictive information on computed routes to determine whether the current route should be considered or alternatives must be computed. The basic assumption is that the vehicle needs time to arrive up to the event, which is changing over time and therefore alters the time-of-arrival continuously.
In this context, depending on the interest expressed (e.g. based on origin-destination) and taking into account any kind of available info (3rd parties, historical data), the TEAM system may come up with an additional, more appealing, co-modal route, e.g. a new bus line from A->B, and communicate it to the

	interested TEAM stakeholders/users. • Evaluation of location-specific multi-vehicle routing data to provide feedback information for truly collaborative navigation, i.e. global optimization of a fleet of vehicles collaborating to compute individual routes in a coordinated way, for instance providing additional routing constraints • Optionally, in case a TEAM user selects its own car option and requests a parking space at destination, the system should investigate the possibility to offer a parking upon arrival so as to reduce the travel time, cost, traffic at destination area and environmental impact and the passengers' stress level
Basic functioning	COPLAN receives requests either to evaluate or compute multi-modal routes. It combines information coming from a number of sources, including other FLEX and DIALOGUE applications, in order to provide accurate predictions regarding time-of-arrival and other predictive information and makes suggestions for specific co-modal routes based on specific optimisation criteria. COPLAN complies with metrics-annotated requests of the sort being proposed by SP4 Collaborative Application Framework, so that the application can prioritize requests according to currently available information / resources and can generate adequate constraints for the optimization engine.
Application's use cases [+ DRAFT DESCRIPTIONS]	1. Heterogeneous data and service requests collection, aggregation and compilation 2. COPLAN issues requests to different TEAM services and applications to collect diverse data on traffic state for all supported routing modes available in the region. COPLAN uses a layered processing scheme to aggregate data at different granularity levels, i.e. assessing traffic state at different geographic scales. After analysing and bringing heterogeneous data to a common format, COPLAN employs a scoring system for particular locations, paths and regions, according to the supported routing modes. This scheme enables a simpler multi-

	modal route optimization in a later stage. Annotations are dynamic and contribute to the creation of statistical data (see UC 4) 3. Map data annotation 4. COPLAN annotates maps (e.g. using concepts introduced in LDM++) to enable faster multi-modal route optimization. Map data annotation should be a centralized operation, in order to avoid map inconsistencies. This use-case also involves the actual management of the multiple layers being kept in the LDM++ database. 5. Multi-modal route planning 6. A user request (e.g. complying with SP4 Collaborative Application Framework message protocol) triggers the calculation of a route. The message contains information related to user preferences such as the optimisation criteria e.g. travel time, cost, environmental criteria, number of changes, desired traffic modes (perhaps even with a given priority), etc. COPLAN considers requests made by other traffic actors to optimize traffic even further. 7. Statistical / historical geo-location specific data collection 8. COPLAN collects data in an event- or time-triggered fashion building e.g. a running average of significant traffic data. This information is delivered to other TEAM applications or used to compute routes considering the history of particular locations, roads or regions. Thus, COPLAN will avoid or inform the user of particularly dangerous or problematic locations, roads and areas. The computation of co-modal routes should include links / elements from serious gaming applications. 9. Real-time evaluation and computation of predictive traffic development 10. COPLAN can recognize dynamic events from the periodically collected data / historical data (this functionality can also be part

	of other applications or be in itself an application). Dynamic events may have a geometrical form (point, line, area) and a dynamic evolution (change over time, stored as snapshots at specific time intervals). Such events can be bottlenecks, slow moving traffic, etc. This information can be used to compute predictive behaviour to be involved in the route computation (i.e. the multi-objective, multi-variable optimization algorithm). 11. Multi-vehicle routing data evaluation, computation and large-scale coordination for collaborative navigation 12. COPLAN considers multiple routing requests and previous calculated routes (e.g. based on user preferences and selected tentative travel plans that have been sent to the application) to deliver new routes. Thus avoiding sending too much traffic over the same routes. This UC introduces additional constrains in the optimization algorithm.
Required lower layer components	COPLAN is made up of the following modules (we take each use case specified above as a module performing an specific function): • DATACO: collection of map- and routing-relevant information • MAPAN: map data annotation and maintenance • STATCO: historical data collection and statistics computation • MODPLAN: multi-modal route planner • PRETRA: predictive traffic development analyzer • MULTINAV: multi-vehicle / -user optimizer, user and resource tracker The following diagram establishes relations among the different modules:



2.1.3 Co-modal coaching with support from virtual/avatar users

A co-modal application with post trip cost/benefit analysis functionalities, made through a comparison of the behaviours of the real user and the "virtual" avatar user. It is not based on vague pre-trip forecasts but reliable and exact post-trip information about realized trip alternatives a user would have had for the same origin-destination pair including monitoring and displaying their true costs, travel times and CO_2 emissions. A short overview table of this application is given below.

Table 2.3: CCA application overview

Application name	Co-modal coaching with support from virtual/avatar users
Application short name / Identifier	CCA
Application short description	This is a co-modal app with post trip cost/benefit analysis functionalities, made through a comparison of the behaviours of the real user and the "virtual" avatar user. The proposed idea does not aim on vague pre-trip forecasts but reliable and exact post-trip information about realized trip alternatives a user would have had for the same origin-destination pair including monitoring and

	displaying their true costs, travel times and CO_2 emissions based on real-time knowledge about occurred traffic jams or delays in public transport, private transport etc.
Platforms implementing the application	Smartphone/Vehicle-API Backbone (traffic management centre)
Application objective	The idea in here is to understand the users' mobility patterns and provide co-modal real-time route recommendations, that integrate environmental footprint costs on post planned journey, offering travellers the opportunity to choose the most environmental friendly alternative of mode for their journey by making.
Basic functioning	A comparison will be made through real time monitoring the individual route of a user and the encountered trip alternatives of an avatar travelling by optimal transport modes from the same origin to the same destination at mostly the same time. Such cost-benefit analysis can create good understanding on a user in taking decisions about a real mobility options on his next trips. The integration of this app with collaborative and social aspects of TEAM will further increase its end-user impact.
Application's use cases	O/D recognition User/Avatar preferences setting Avatar trip simulation On-trip Avatar coaching Post-trip Avatar coaching
Required lower layer components	Components related to application "Collaborative pro-active monitoring and ad-hoc control" to get all the traffic information needed to perform the coaching function Vehicle HMI (for in-vehicle coaching) – this components belongs to DIALOGUE enablers Smartphone HMI (for public transport on-trip and post-trip

	travellers coaching)

2.1.4 Collaborative smart intersection for intelligent priorities

An integrated application for intersections. Priority techniques can optimize public transport. Also priorities are set based on the vehicle type and on other factors. This application also includes communication and synchronization of multiple traffic lights in a region to optimize traffic flow (green wave). Additionally, the application includes start and stop functionality based on information that comes from smart and pro-active RSUs. A short overview table of this application is given below.

Table 2.4: CSI application overview

Application name	Collaborative smart intersections for intelligent priority
Application short name / Identifier	Smart Intersections / CSI
Application short description	This is an integrated application for intersections. One of the main objectives is to optimize public transport, giving priority to buses. Priority techniques can generate improvements in service regularity, which usually means alignment with nominal time-tables and headways. A regular service guarantees a good level of transport capacity (expressed in terms of "passengers per hour"): the major goal of transport management. Moreover it makes service planning easier, reduces the time lost by passengers at bus or tram stops, increases user satisfaction and reduces driver stress. The priorities can also be considered based on the vehicle type (e.g. truck, bus, tram, car, motorcycle, pedestrians, cyclists etc.) and on other factors (truck with dangerous goods, ambulance, disabled person wanting to cross the street, etc.). This application also includes communication and synchronization of multiple traffic lights in a region to optimize traffic flow. The vehicles will send their intended destination to the current intersection and that one will communicate with the next ones to

	help regulate the traffic flow, based on the number of vehicles that will follow in each direction. The vehicles will receive a speed recommendation in order to get to the next traffic light in green. Additionally, the application includes start and stop functionality based on information that comes from smart and pro-active RSUs (i.e. how long do they have to turn off the engine, when to turn on the engine, duration of the red light phase, when the lights will be green, position in a queue etc.)
Platforms implementing the application	Smartphone/Vehicle-API, Fully vehicle-integrated, Backbone (traffic management centre), Road side
Application objective	The goal of this application is to have fully collaborative intersections that can dynamically optimize the traffic flow by giving priorities to certain vehicles, but at the same time taking into account the current traffic conditions.
Basic functioning	The intersections broadcast time and phase information for all traffic lights. The vehicles send relevant information about themselves to the intersection. The intersection then can prioritize and change time and phase for different traffic lights accordingly and then communicate the new information to the vehicles. The in-vehicle HMI coaches the driver to cross the intersection in green or to brake eco-friendly with smart start-stop.
Application's use cases	Intersection broadcast information Vehicle sends information Intersection adapts to priority and flow

	Green Light Optimal Speed Advisor Smart start-stop and braking recommendation
Required lower layer components	LDM++ Communication components Prioritization algorithms Vehicle data provider GLOSA component In-vehicle HMI

2.1.5 Collaborative public transport optimization

A public transport operator taking into account the origin and destination information from the travellers together with information about the current traffic situation or even information regarding aspects such as the number of passengers that will take the bus at every stop or the estimated time that a bus will spend in a stop, dynamically adapts the timetables and the routes in order to achieve a specific goal. A short overview table of this application is given below.

Table 2.5: CPTO application overview

Application name	Collaborative public transport optimization
Application short name / Identifier	CPTO
Application short description	This application is closely related to the concept of "elastic transport infrastructures" which intend to serve the needs of modern cities. A public transport operator taking into account the origin and destination information from the travellers together with information about the current traffic situation or even information regarding aspects such as the number of passengers that will take the bus at every stop or the estimated time that a bus will spend in a stop, dynamically adapts the timetables and the routes in order

	to achieve a specific goal. For example, the optimization of the overall network efficiency which in turn will lead to CO_2 emissions reduction.
Platforms implementing the application	• Third party (e.g. public transport operator) • Smartphone/Vehicle
Application objective	The goal of this application is to highlight the flexibility of the transport infrastructure serving dynamically the demand of the cities and the citizens (adapted to their needs). This application will focus mainly on buses but can be extended to other means of transport such as trams, trains, metros taking into account the specific constraints of these transport means. Actually the main restriction in the latter case is that these means have fixed infrastructure (i.e. rails) but the timetables and the stops could be adapted dynamically based on the demand. It would be desirable TEAM to be capable of proposing changes to the schedules (even routes) of the public transportation means (buses, etc.) in order to flexibly serve the demand (based on historical data, user information, etc.), although it should be considered that the reliability of such suggestions implies wide adoption of the TEAM apps.
Basic functioning	The main assumption that made in this application is that the majority of the users/travellers are using a smartphone which is running the TEAM framework with CPTO application installed. They are using it to communicate their position (start point) and their intended destination (end point) to this framework and possibly "declare" the selected bus line(s) and the departure time. This way they will provide the TEAM system with valuable information towards both the short and the long term bus scheduling optimization. In cases of relative low penetration rate of CPTO mobile application between travellers then the use cases that change fundamentally public transport operation will not be implemented in full extend. This will be limited so as to not frustrate unregistered public transport users. Alternatively in such

cases the transmission of information on changes to every traveller, with public open access interfaces in bus stops or on the web, will be investigated.

Taking into account this information together with information about the traffic (current situation on the road) or even information regarding aspects such as the number of passengers that will take the bus at every stop or the estimated time that a bus will spend in a stop, the public transport operator dynamically adapts the timetables and the routes in order to achieve a specific goal. In our case an example of such goal could be the optimization of the overall network efficiency which in turn will lead to CO2 emissions reduction. Another example could be to avoid sending out buses travelling around without actual demand at a certain point in time minimizing the cost for the operator (as well as the environmental impact), or to make speed recommendations to further increase the efficiency of the network. Of course cancellation of bus schedule is a rare case that could be implemented in low demand and line with limited connections.

This is an interactive application and the dynamic rescheduling can be done within an interactive window of at least 5 sec to 5 min based on real time traffic data, available historical/statistical data and the dynamic requests of the travellers (current demand). Of course the interactive time window may be greater and varies depending on the incident and the actual infrastructure restrictions (e.g. speed of vehicles/buses, time to withdraw a train from a lane etc.).

Real time information from the public transport operator (or the bus itself) will be also communicated to the travellers to keep them informed about the current location of the bus of interest, the time they have to wait at the stop for the bus, their current position when they are on the move, info on the forthcoming stations, the estimated time to their destination, considerable delays on the route of interest, suggestions on alternative routes, etc.

In future it might be possible also to adapt the route in order to

	dynamically create new stations/stops when there is a high demand.
Application's use cases	1. Accident or traffic based route adaptation 2. Event-based route adaptation 3. Adding and/or skipping bus stops 4. Headway adaptation 5. Input data from the traveller 6. En-route information to the traveller 7. Pre-trip information to the traveller
Required lower layer components	• LDM++ with cloud • Vehicle data or phone data provider • Communication components (LTE, 802.11p) • HMI components for bus drivers and travellers

2.1.6 Dynamic collaborative corridors

Establish corridors for heavy vehicles, being trucks or buses, in a dynamic way. Certain lanes could be reserved for certain vehicles during a certain period. The collaborative aspect of this application is the possibility of dynamically start or finish a dedicated lane depending on the traffic conditions and priorities. Additionally, drivers could be motivated by serious games to improve their behaviour and increasing their priority in accessing those lanes. A short overview table of this application is given below.

Table 2.6: DC application overview

Application name	Collaborative Dynamic Corridors
Application short name / Identifier	Dynamic Corridors / DC
Application short description	This is an application of the concept of transport corridors with an ITS perspective.

	The application could be understood as a set of digital services the infrastructure provider (or someone contracted by the provider) offers to users of the road infrastructure. It will be the digital infrastructure of the smart highway. Some of these services might be free i.e. they are paid through the tax bill, others might be premium services paid by road users on demand. The main objective is to establish corridors for heavy vehicles, being trucks or buses, in a dynamic way. Certain lanes could be reserved for certain vehicles during a certain period. For example, a bus lane could be assigned in the city centre only for buses during the period of peak in traffic, in order to prioritize public transportation schedule. Another example is to have lanes dedicated to distribution vehicles during the early morning to deliver goods in an efficient way. As a last example, inter-urban roads could have dynamic dedicated lanes only for heavy trucks. The collaborative aspect of this application is the possibility of dynamically start or finish a dedicated lane depending on the traffic conditions and priorities. Additionally, drivers could be motivated by serious games to improve their behaviour and increasing their priority in accessing those lanes. Another way to create a more dynamic traffic environment is to have dynamic vehicles that can adapt to local regulations. An example could be low noise zones where vehicles can choose different strategies to fulfil the regulation that allow them to enter the area; a hybrid vehicle can turn into full electric mode while a diesel truck can prevent heavy accelerations or high number of revolutions. Access control is an important feature and should be monitored in real-time. The vehicles could have lane position to determine if they are using the lanes inappropriately and also could require access remotely and be granted via in-vehicle HMI. For this application, there is the possibility of connecting with the SP4 “Cooperative Driving” application with the merging feature,

	which can help the drivers of heavy vehicles to access the corridor lanes. The assistance should be given both to the heavy vehicle driver and to the nearby car drivers in order to merge in an eco-friendly and safe way.
Platforms implementing the application	Smartphone/Vehicle-API, Fully vehicle-integrated, Backbone (traffic management centre), Third party (e.g. public transport operator)
Application objective	The goal of this application is to have fully collaborative dynamic transport corridors focused on heavy vehicles to optimize the utilization of lanes, assist the drivers to access and leave those lanes and enable monitoring and control of usage.
Basic functioning	The central system has a map of dedicated lanes currently available and areas with special local regulations. The vehicles approaching the lanes or areas receive a notification of availability and acceptance criteria. The vehicle requests permission to enter and receives a response. If access is granted, the merge assistance coaches the driver to join the lane. Data is logged for compliance analysis and planning.
Application's use cases	1. Dynamic Dedicated Lanes for Corridors 2. Dynamic Vehicle Adaption to Local Regulations 3. Serious games for eco driving 4. Intelligent Access Control 5. Lane merge assistance 6. Data logging
Required lower layer components	• LDM++ • Communication components

	• Lane level positioning • Prioritization algorithms • Vehicle data provider • Vehicle controlling and adaptation component • Data logging • Serious gaming component • Merge assistant • In-vehicle HMI

2.2 DIALOGUE applications

Following the same methodology, as for FLEX applications, also in DIALOGUE, we have identified five applications that are of interest for the project stakeholders. These are given below and are briefly highlighted in the following sections:

1. Collaborative ACC (C-ACC)
2. Collaborative eco-friendly parking (EFP)
3. Collaborative driving and merging (CDM)
4. Collaborative eco-friendly navigation (CONAV)
5. Green, safe and collaborative serious game and community building (SG-CM)

More details on the DIALOGUE applications and their requirements the interested reader can refer to D4.3.1 "Requirements of DIALOGUE components, enablers and applications" [2].

2.2.1 Collaborative ACC

The assumption is that vehicles and smartphones shall communicate with each other and with the infrastructure. In addition, traffic data information from the cloud server is available per road segment and can be combined with information from other users in a specific area of interest. This information can be used to extend the foresight range of ACC (Adaptive Cruise Control) systems in order to predict the traffic density ahead and adjust ACC speed accordingly, ultimately improving traffic flow. A short overview table of this application is given below.

Table 2.7: C-ACC 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	1. Cooperative adaptive cruise control 2. Collaborative adaptive cruise control 3. Collaborative Road Budget Compliance 4. Green light optimizing cruise control 5. Slow driving with close distances in dense traffic 6. Road infrastructure awareness 7. Traffic data used to influence vehicle speed when Cruise Control is active. 8. Situational speed
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

2.2.2 Collaborative eco-friendly parking

This application's objective will enable connected vehicles to access real time information about parking availabilities along their destination. The vehicles are connected to a cloud service that informs individual road users (vehicle drivers and other device equipped read users) with data about available parking spots. A short overview table of this application is given below.

Table 2.8: EFP 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 - Open slot sensing - Free parking markets
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). Through dedicated on-board algorithms, based on vehicle CAN data, positioning data, navigation-related data and profile (e.g. frequent destinations) the system autonomously detects the driver's intentions (parking, leaving, looking for parking) and correlates them with any additional manual input by the driver. Based on the estimated level of confidence, the system may further ask for driver confirmation after detection. In this way, the cloud-based application can constantly monitor the availability of free parking slots on the one hand, and update the terminals of TEAM users with parking information of interest on the other hand. The user can of course make a manual request for parking availability. In this case , the driver 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	1. Send and receive parking slot messages. 2. User community management 3. User reputation management 4. User rewarding management 5. Data Validation 6. Connection to parking garages
Required lower layer components	LDM++ Vehicle data (e.g. GPS vehicle physical dimensions, ...) Internet connectivity Driving style monitoring (enabler)

2.2.3 Collaborative driving and merging

The application addresses the challenges in the collaboration among the vehicles to increase safety and improve energy efficiency. It refers to situations where two or more vehicles need to interact among themselves and/or with the road infrastructure to solve specific driving situations. 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. A short overview table of this application is given below.

Table 2.9: CDM application overview

Application name	Collaborative driving and merging
Application short name / Identifier	CDM
Application short	This application aims at controlling safety and improving energy

description	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
Required lower layer components	• Communication Facilities • Incentive Facility • Map Facility • Crowd sourcing • Cloud aggregation service

2.2.4 Collaborative eco-friendly navigation

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. It implements features like route calculation incorporating vehicle-specific constraints, routes to balance traffic load on road network, personalized routing, adaptive stochastic routing and balancing to handle real-time events, globally optimized navigation. A short overview table of this application is given below.

Table 2.10: CONAV 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 and/or if traffic conditions have changed). Different to today's navigation systems, it provides route recommendations, which are optimized based on multi-fold 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. The application includes the following features below: - Route calculation incorporating vehicle-specific constraints - Routes to balance traffic load on road network - Personalized routing - Adaptive stochastic routing and balancing to handle real-time events - Adaptive routing based to handle real-time events/conditions with help of price information - Globally optimized navigation
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

2.2.5 Green, safe and collaborative serious game and community building

The goal of this application is to promote proper driver behaviour and local community administrations by providing a contest environment where users can have challenges based on their green and safe driving ability. Exploiting information and data from the other collaborative TEAM applications, the serious game and community building application consists of a gamified map-based social environment where drivers and passengers can share their information and learn proper mobility styles in a pleasant and compelling way. The application will be available to the user through the internet on smartphones (also on PCs, where available). A short overview table of this application is given below.

Table 2.11: SG-CB application overview

Application name	Green, safe and collaborative driving serious game and community building
Application short name / Identifier	SG-CB
Application short description	This application intends to promote and favour proper driver behaviour, with a particular attention to collaborative applications 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.). Generally speaking, incentives are possible 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.). Of course, physical rewards depend on local agreements and, for the specific TEAM framework, may be considered in the context of the SP5 EcoChallenge. 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 2. Computation of the driver performance 3. Create a challenge for the SG

	4. Watching the performance – general 5. Watching the performance – diary view 6. Thematic competitions 7. Provision of incentives 8. Setting preferences 9. Automatic transmission of geo-referenced data 10. Sending messages for the collaborative map 11. Rider assistance request 12. Proper collaborative behaviour, based on the other TEAM applications 13. Watching the collaborative map 14. Community building gamification 15. Log-in 16. Friendliness 17. Friend suggestion 18. Collaborative driving and serious game data validation 19. User reputation management 20. User rewarding management
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

3 Requirements to elastic infrastructure from FLEX applications

In this chapter the requirements per FLEX application are highlighted. These requirements are towards the elastic transport infrastructure and are gathered and presented briefly here, whereas analytical requirements' tables, based on the template outlined in section 1.2, are provided in Annex 1.

3.1 Collaborative pro-active urban/inter-urban monitoring and ad-hoc control

A quick overview of the CMC relevant requirements is given below, while in Figure 3.1 the grouping and the relationship among these requirements are illustrated. The detailed requirements' tables are included in Annex 1 - A) for readability purposes.

Functional requirements

SP3_REQ_Int_CMC_1_v1.0: CMC shall be able to collect collaborative information from equipped vehicles. Equipped Vehicles can provide real time data about traffic status/condition; these vehicles are able to collect at least their position, speed and direction plus a time stamp and send these info (raw data) to a fleet control centre.

CMC shall be able to act as a fleet control centre directly managing raw data and/or shall be able to get aggregated data from other fleet control centres.

SP3_REQ_Int_CMC_2_v1.0: CMC shall match collaborative vehicle info to the reference map. Data coming from street need to be referenced on a known network in order to be used by CMC functions. Row data needs to be map matched and then joined with already aggregated data. The definition and availability of a reference network is crucial and mandatory.

SP3_REQ_Int_CMC_3_v1.0: CMC shall be able to collect collaborative information from TEAM travellers. TEAM traveller via some device shall be able to provide information on him/her self relevant for the application. Information including location, but also connection with social network systems.

SP3_REQ_Int_CMC_4_v1.0: CMC shall be able to collect and integrate data coming from external and legacy systems. This implies the definition of a group of supported external / legacy systems and knowledge of the corresponding interfaces. Interfacing external data providers will require the implementation of bridges between services (i.e. TEAM <–> non-TEAM services) in order to translate to a common format that CMC and other TEAM applications can understand. CMC shall also support TEAM messaging system and thus correct translation / fulfilment of message metrics have to be implemented in the service bridges.

SP3_REQ_Int_CMC_5_v1.0: CMC shall run data fusion techniques. This technique need to include all the data that comes from the different source and provide an integrated and consistent view of the traffic state

SP3_REQ_Int_CMC_6_v1.0: CMC shall support PT optimisation functionalities. That is, it shall be possible to influence traffic in a way that priorities public transport. By improving public transport, more travellers will be able and willing to use public transport, which will in turn lead to less traffic and congestion and an overall improvement of traffic flows.

SP3_REQ_Int_CMC_7_v1.0: CMC shall be able to forecast traffic flows. The TEAM TMC shall be able to forecast relevant traffic flow parameters such as:

- Travel time
- Vehicle flows
- Length of the queue

In the short (e.g. by time series extrapolation and filtering) and in the long time (e.g. by dynamic traffic assignment), starting from collaborative information coming from TEAM vehicles and travellers and, if useful, from data gathered from integrated sub-systems (e.g. existing legacy traffic monitoring systems).

SP3_REQ_Int_CMC_8_v1.0: CMC shall optimise traffic control taking into account traditional and innovative parameters. The CMC application will be able to optimize collaborative traffic control both on the TMC side, by running pro-active traffic light control algorithms, and on the vehicle side, by enabling DIALOGUE V2I applications for intersection (e.g. collaborative GLOSA – SPaT provisioning) and lane (e.g. dynamic speed limit) assistance.

Pro-active traffic control will be able to optimise strategy in real-time during the execution of the cycle by modifying timing and phases. Pro-active traffic control shall be able to optimize traffic lights operation by taking into account traffic parameters forecasts and policies coming from the local authorities, considering as part of optimization function parameters such as:

- Traditional parameters:
  - Queues
  - Number of stops
  - Travel time
  - PT priority
- Innovative parameters:
  - Energy consumption
  - Pollutants emissions

- Vehicles duty cycle

SP3_REQ_Int_CMC_9_v1.0:
The CMC application has to support and take into account a number of multi – layered traffic control policies that are defined by the TMC. By doing so the CMC application will utilize commands given by the policies (both at tactical and strategic level) benefiting from the resulting optimization of the performance of the transportation network.

- Strategic level refers to the management of the estimated operations of the Origin/Destination matrix and of traffic volumes assignment on the road system, according to the current and forecasted traffic conditions; these estimations are based on a larger calculation time interval.
- Tactical level refers to the management of operations related to the on-line estimation on the status of the monitored network. Data validation and data fusion are implemented in this level, which provides also historical data (profiles) and elaborates predictions.

The outcomes of these two levels are a number of multi-layered (strategic and tactical) policies that are applied to collaborative traffic control systems.

SP3_REQ_Int_CMC_10_v1.0: CMC application will be able to publish processed traffic information and /or events in order to be used by B2C applications through standardized interfaces such as DATEX. Further clarification is required in whether this requirement is considered as a tool for the CMC application functionality or whether it is simply a side requirement.

Non-functional requirements

SP3_REQ_Int_CMC_11_v1.0: Degraded mode shall be available in case of poor reliability of information. CMC will issue messages with the collected information containing a quality metric for the reliability of the provided information, e.g. QM_reliability = {good, poor, unknown}.

CMC will evaluate the information source in different ways:

- by requesting validity / reliability certificates (e.g. is the provided information certified to be true to a given degree?)
- by testing for data consistency over periodic requests, e.g. CMC will have to evaluate whether the source has noise, changes with given trend, or its data is random and thus unreliable

CMC will check the communication link by issuing test messages over the service bridge. If the link is unstable CMC will look for alternative information sources providing similar information.

After evaluation of the information, CMC will determine what information to deliver. If the data is very noisy but still has a certain degree of reliability, it will issue a message to the requesting application having the requested information. It will provide appropriate quality metrics labelling the information: QM_reliability = {good, poor, unknown}, QM_std_deviation = {figure} (if applicable), etc.

If the link is not reliable, CMC might decide to reduce the refresh rate of the information (by periodic information requests) and inform the requesting service with appropriate quality metric (e.g. QM_period = {figure}, QM_degraded_mode = {on,off}) or a specific message (e.g. CMC_UNRELIABLE_DATA, etc.)

Degraded mode will be available also as a reaction to security issues, such as a cyber-physical attacks. In this case, CMC subsystems in charge of the actuation part (e.g. traffic light, VMS, information gateways, …) will operate in a safe mode as soon as they will identify any kind of anomaly in the commends received from the CMC core. A detailed analysis of these methods is out of the scope of TEAM, but it is still interesting to underline that in most cases (e.g. for traffic lights local controllers) such features are already implemented in state-of-the-art devices in a safe way,, such that operational logics cannot be modified by an external actor using a remote connection.

SP3_REQ_Int_CMC_12_v1.0: CMC shall interface with other TEAM applications. The CMC Application will give B2B information services to other vertical TEAM applications. If the CMC application outcomes (mainly TMC-related information) will be available for other vertical TEAM applications, all of them will be enabled and/or their functionalities will be improved – therefore with significant benefits from the overall users' experience in TEAM

SP3_REQ_Int_CMC_13_v1.0: The TMC database defined in CMC application shall interface with LDM++. Reliable data exchange with LDM++ enables different vertical TEAM applications to cooperate properly without counteracting each other, hence improving the performance of all.

SP3_REQ_Int_CMC_14_v1.0: MAP protocol. The MAP message set will be specified with all relevant information based on the SAE J2735 data elements under development with ISO

SP3_REQ_Int_CMC_15_v1.0: SPaT protocol. The SPaT message set will be specified with all relevant information based on the SAE J2735 data elements under development with ISO

SP3_REQ_Int_CMC_16_v1.0: CAM protocol. The optional data element for prioritisation request in the CAM message shall be available and filled with data.

SP3_REQ_Int_CMC_17_v1.0: CMC shall support SIRI, TPEG and DATEX2 standards. The standardized protocols SIRI for public transport, TPEG for traveller and vehicles info and DATEX2 for B2B communication units will be integrated within the TEAM-requirements and eventually they will be used and implemented or extended in the sense of the standards.

A graphical overview of the requirements and their grouping is highlighted in the following figure.

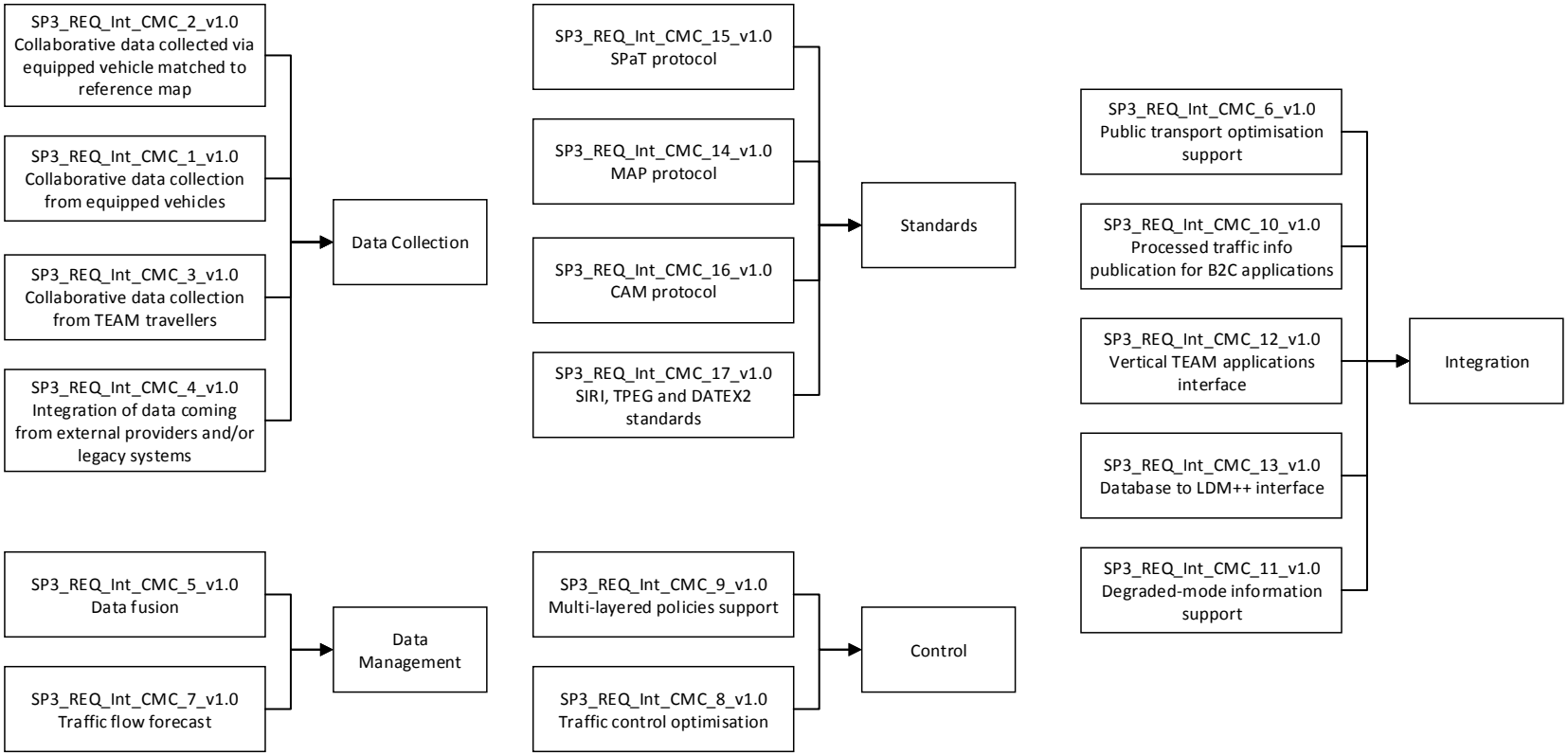


Figure 3.1: CMC requirements overview

3.2 Collaborative co-modal route planning

A quick overview of the COPLAN relevant requirements is given below, while in Figure 3.2 the grouping and the relationship among these requirements are illustrated. The detailed requirements' tables are included in Annex 1 - B) for readability purposes.

I/O Requirements

SP3_REQ_Int_COPLAN_1_v1.0: The COPLAN end-user application part shall be able to accept the necessary input regarding the user preferences (origin, destination, time of travel, preferences regarding the number of modes' change, transportation type etc.), and shall be able to propagate it to the rest of the COPLAN functions so that it can be further processed.

SP3_REQ_Int_COPLAN_2_v1.0: The COPLAN end-user application part shall be able to present the COPLAN results to the user in a readable, user friendly format.

SP3_REQ_Int_COPLAN_3_v1.0: The COPLAN application server shall have application layer connectivity interfaces with specific external servers/applications (i.e. through CMC application) in order to exchange information with 3rd parties such as:

a. The road operators: providing information about the traffic conditions in specific road segments (either directly from their application servers or through an interconnection with the CMC application)

b. Public Safety Answering Points (PSAP), police or fire brigade: providing information about an emergency incident that took place on the road, or at a specific location,

c. Municipality services, road operators etc.: e.g. providing information regarding planned civil works that will be performed on a part of the road at specific dates, thus rendering specific roads or lanes inaccessible.

d. Historical traffic related information data bases (e.g. any kind of info gathered from TEAM users).

e. Public transport operators: providing time based data related to the public transport vehicle fleet such as timetables, routes, current location of means, availability, load (linked to the data modules of CPTO application).

f. Parking owners/infrastructures: providing data regarding parking space availability at certain locations (link to SP4's EFP application).

Data Related Requirements

SP3_REQ_Int_COPLAN_4_v1.0: The 3rd parties (road operators, PSAPs, Municipality services, public transport operators, parking owners etc.) should provide real-time access to the needed data to the CPTO application (as well as the whole TEAM Framework, including SP4 CONAV).

SP3_REQ_Int_COPLAN_5_v1.0: The format of the data provided by the 3rd parties shall be in a readable format by other TEAM applications.

SP3_REQ_Int_COPLAN_6_v1.0: The COPLAN application server shall be able to store (historical) user information related to user transport preferences regarding e.g. usual origin, destination, time of travel, preferences regarding the number of mode's changes, transportation type etc.

SP3_REQ_Int_COPLAN_7_v1.0: (Historical) information regarding e.g. traffic load and conditions etc. per road segment and for specific timeframes, usual public transport availability/time schedules, parking availability etc. shall be stored (either by COPLAN or by other linked applications).

Data Processing related Requirements

SP3_REQ_Int_COPLAN_8_v1.0: COPLAN shall be able to assess the real time roads' status regarding their availability, traffic load etc.

SP3_REQ_Int_COPLAN_9_v1.0: COPLAN shall be able to assess the real-time availability and conditions of a number of various transportation modes for various routes/route segments.

SP3_REQ_Int_COPLAN_10_v1.0: Historical data related to traffic load of various transport modes as well as to traffic conditions for a number of road segments and for specific timeframes shall be processed so that short/long term predictions regarding characteristics such as efficiency, availability, evolution of various transport modes for various road segment/route can be made.

SP3_REQ_Int_COPLAN_11_v1.0: COPLAN shall be able to process historical data related to the actual demand for various transport modes per road segment and for specific timeframes and predict future demand for each transport mode, per road segment and for specific timeframes.

SP3_REQ_Int_COPLAN_12_v1.0: COPLAN shall be able to identify the impact of using each transportation mode for various routes/route segments to the total user travel time, to the total number of transportation mode changes of the user, the environmental impact etc.

Taking into account the travellers' transport preferences, the traffic/transport related information provided by the 3rd parties, and the prediction processes results

SP3_REQ_Int_COPLAN_13_v1.0: COPLAN shall be able to calculate alternative multi-modal routing solutions for a user wishing to travel from a certain origin to a certain destination depending on various optimisation criteria such as: travel time, modes' changes, environmental impact etc.

SP3_REQ_Int_COPLAN_14_v1.0: COPLAN shall be able to evaluate real-time information, and accordingly, provide changes to the initial recommendations to the users.

SP3_REQ_Int_COPLAN_15_v1.0: COPLAN shall be able to perform multi-vehicle routing for global optimisation of a fleet collaborating to compute individual routes in a coordinated way – link to SP4's CONAV.

Application Layer Data Exchange Requirements

SP3_REQ_Int_COPLAN_16_v1.0: The user part of the COPLAN application shall be linked and connected to the COPLAN application server, and data between these two parts shall be always synchronised/continuously updated (application layer connection).

SP3_REQ_Int_COPLAN_17_v1.0: The 3rd parties' information related to e.g. the transport means' time schedules/availability, traffic conditions, road segments' availability, parking vacancies etc. sent to the COPLAN application server shall be continuously updated so that information between the two entities (3rd parties and COPLAN application) is always synchronised (application layer connection).

A graphical overview of the requirements and their grouping is highlighted in the following figure.

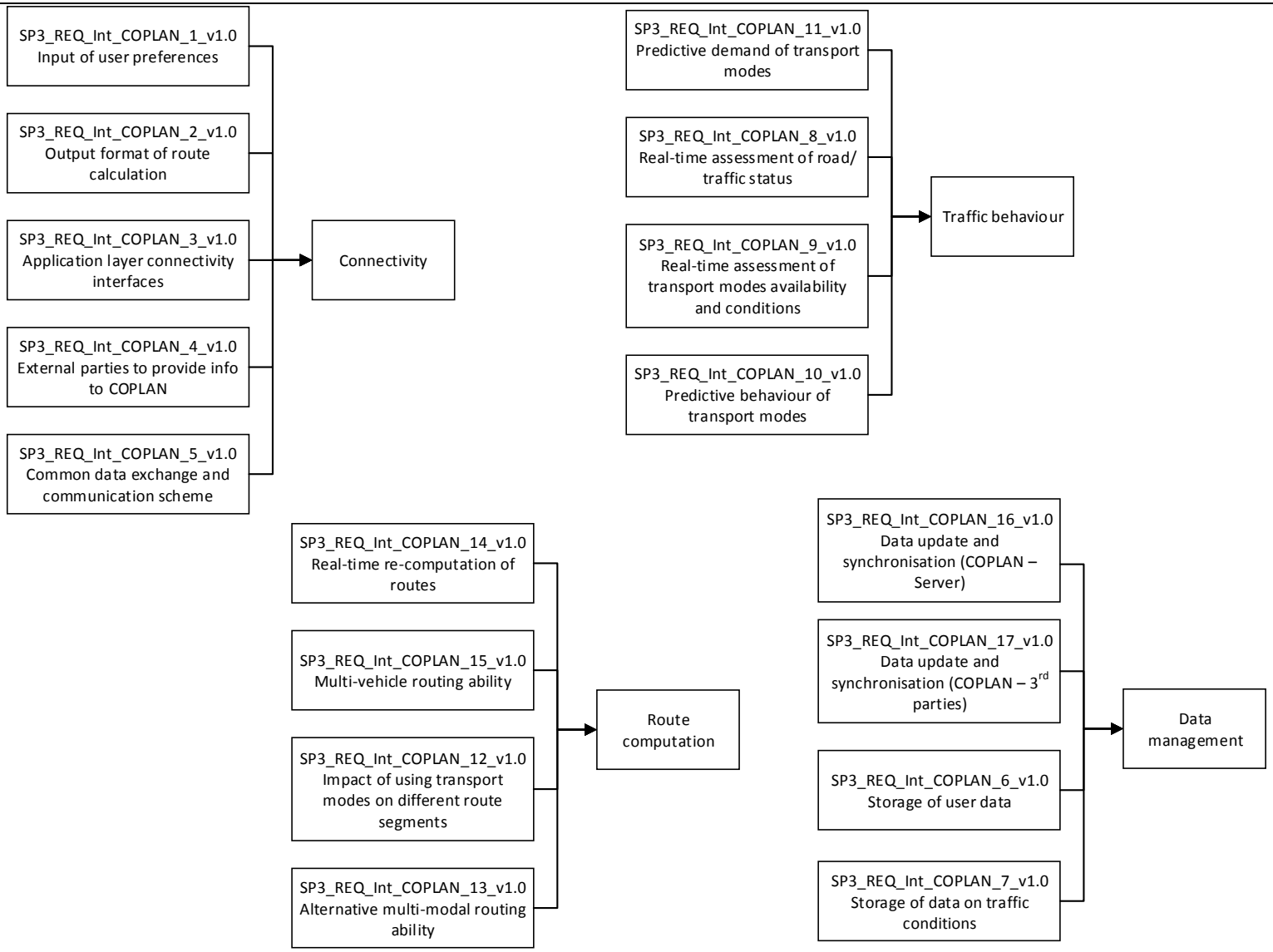


Figure 3.2: COPLAN requirements overview

3.3 Co-modal coaching with support from virtual/avatar users

A quick overview of the CCA relevant requirements is given below, while in Figure 3.3 the grouping and the relationship among these requirements are illustrated. The detailed requirements' tables are included in Annex 1 - C) for readability purposes.

Functional requirements

SP3_REQ_Int_CCA_1_v1.0: CCA shall learn and identify most probable O/D locations. This requirements is divided into the following specific sub-topics:

- **SP3_REQ_Int_CCA_1.1_v1.0:** CCA shall provide information of the most probably activities of the user given the time of day and the possibly the present activity state of the user
- **SP3_REQ_Int_CCA_1.2_v1.0** CCA shall connect to one or more social network media accounts of the user to extend the information on activity
- **SP3_REQ_Int_CCA_1.3_v1.0:** CCA could provide location, time, duration and type of activity associated with each activity
- **SP3_REQ_Int_CCA_1.4_v1.0:** CCA shall connect to the positioning system to collect the position and time of the user movement
- **SP3_REQ_Int_CCA_1.5_v1.0:** CCA could allow the user to update social network media based on its current location and activity
- **SP3_REQ_Int_CCA_1.6_v1.0:** CCA shall provide a way to the user to input the current activity
- **SP3_REQ_Int_CCA_1.7_v1.0:** CCA could estimate the destination and the activity type of the user even for time periods at which historical data are not provided

SP3_REQ_Int_CCA_2_v1.0: CCA shall consider user preferences for optimisation. Closely related to the CONAV application, the CCA shall consider user preferences. In CCA, it means that the application looks for alternative routes (that were not taken) but would suit to the user preferences. One example may help: Assume a user does not like complex crossing and has defined that those should be avoided. In consequence, the CCA application will consider those (better) alternatives in a special way, which includes such crossings.

SP3_REQ_Int_CCA_3_v1.0: CCA shall coach the traveller during his co-modal trip. The CCA shall provide a seemingly constant feedback on the choices of the traveller in the co-modal environment. To this is end CCA communicates the performance of the travellers' trip compared to the CCA suggestion and optimal solutions for other calibrations of the objective function.

SP3_REQ_Int_CCA_4_v1.0: CCA shall calculate the simulated optimal trip. The CCA application shall be able to use optimal trip as a benchmark item for coaching the travellers and for giving estimations about potential savings. Optimal trip shall be computed according to:

- Availability of different co-modal transport solutions
- Preferences defined by the user
- Real-time traffic information coming from the CMC application

SP3_REQ_Int_CCA_5_v1.0: CCA shall assess the impact (e.g. for what concerns fuel consumption, pollutants emissions, time spent, cost, …) of the traveller trip considering his modal choice and related impacts, according to environmental and time/economy parameters to be further defined.

SP3_REQ_Int_CCA_6_v1.0: CCA shall update its simulations at a specified rate (e.g. every 5 minutes). This will enable CCA to provide an estimate of the journey duration, cost, and CO_2 emission for all possible alternative routes on a regular basis

SP3_REQ_Int_CCA_7_v1.0: CCA shall coach the traveller at specific waypoints. At specific way points that connect reasonable subpaths the traveller might reconsider again using or deviating from CCA suggestions. The requirement is to support this decision.

SP3_REQ_Int_CCA_8_v1.0: CCA shall coach the traveller at the end of the trip. TEAM should provide at the end of the trip a recommendation to the user on the route to follow in the next trip

SP3_REQ_Int_CCA_9_v1.0: CCA shall be able to give stats about the last period of usage providing to the user the statistics on the duration, cost, and CO_2 emission of the recent journeys

Non-functional requirements

SP3_REQ_Int_CCA_10_v1.0: CCA shall link with CMC to get real-time traffic info. CCA application shall be able to use elaborated information coming from the CMC application about current and forecasted traffic conditions as a basis for travellers' coaching

SP3_REQ_Int_CCA_11_v1.0: CCA shall link with CONAV, in order to integrate CCA and CONAV applications in the in-vehicle phase. In case public transport should play a role, COPLAN needs to be integrated as well. It is expected that then, CONAV is considered by connecting to COPLAN (as we assume, that COPLAN integrates CONAV for the vehicle routing part).

SP3_REQ_Int_CCA_12_v1.0: CCA parameters shall be based on time and economy figures. The impact assessment of traveller and Avatar trip shall be based on a number of defined parameters belonging to three different categories:

- Environmental:
    - Pollutants emissions
    - Impact on traffic (contribution in creating congestion of the single trip)
- Time:
    - Total travel time
    - Travel time share on preferred mean of transport
    - Delay (actual travel time / free flow travel time)
- Economy:
    - Fuel consumption
    - Highways tolls
    - LTZ access fees

SP3_REQ_Int_CCA_13_v1.0: Co-modal coaching shall be supported (CPTO app integration). The information from the CPTO can be used in the CCA

SP3_REQ_Int_CCA_14_v1.0: CCA shall use the TPEG protocol for information exchange. TPEG is a well-established technology to exchange traffic information. The TPEG standard shall be considered, when low bandwidth requirements are there and when exchanged information relate to standard traffic events information, for which TPEG codes are defined.

A graphical overview of the requirements and their grouping is highlighted in the following figure.

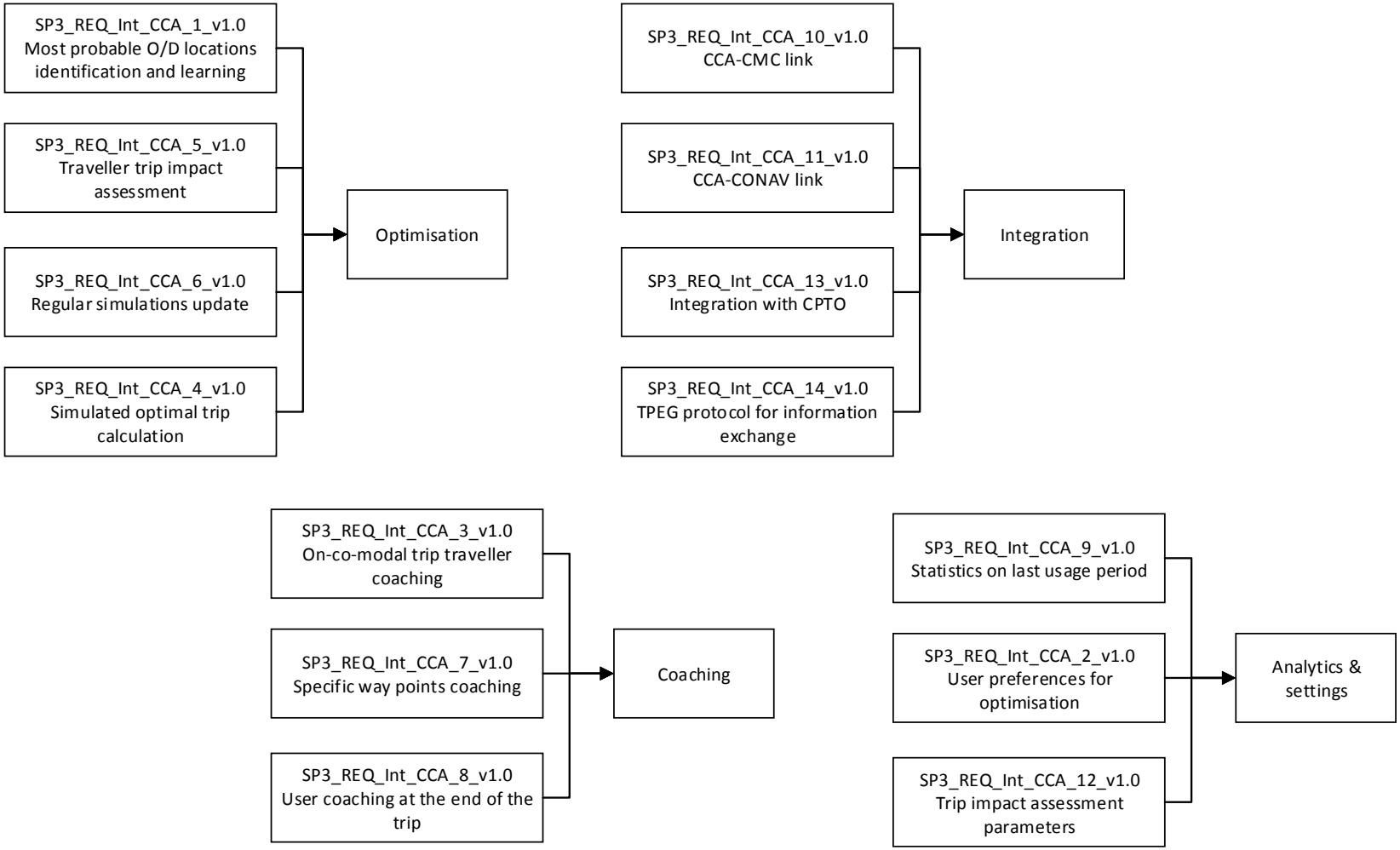


Figure 3.3: CCA requirements overview

3.4 Collaborative smart intersection for intelligent priorities

A quick overview of the CSI relevant requirements is given below, while in Figure 3.4 the grouping and the relationship among these requirements are illustrated. The detailed requirements' tables are included in Annex 1 - D) for readability purposes.

SP3_REQ_Int_CSI_01_v1.0: Historical data is accessible for planning time and phase for the traffic lights. Logged data is recorded from the intersections for a time long enough to calculate reliable prediction values.

SP3_REQ_Int_CSI_02_v1.0: Traffic controller knows the topology of the intersection and is able to provide it. Data content for the MAP message must be measured and provided on the road side unit.

SP3_REQ_Int_CSI_03_v1.0: Protocol for sending topology information continuously as broadcast. The MAP message set will be specified with all relevant information based on the SAE J2735 data elements under development with ISO.

SP3_REQ_Int_CSI_04_v1.0: Protocol for sending signal phase and time continuously as broadcast. The SPaT message set will be specified with all relevant information based on the SAE J2735 data elements under development with ISO.

SP3_REQ_Int_CSI_05_v1.0: Module for prioritisation is able to prove the permission level for prioritisation. The authentication system provides a service that enables the access to the authentication data the vehicle has sent. Either the permitted vehicles like bus or emergency vehicle carries an allowed level in their identification or the prioritisation module knows the level of each authentication ID.

SP3_REQ_Int_CSI_06_v1.0: Hosting of Smart Intersection application. Smart Intersection application needs to run locally at the traffic light intersection and requires adequate hardware to respect planned performances. The controller unit has to be able to manage connection with external devices (sensors and transmission module).

SP3_REQ_Int_CSI_07_v1.0: External event detectors – traffic, pedestrian etc. The Smart intersection application needs to acquire information (traffic flow, queue, pedestrian request etc.) from the environment around the traffic light. This requirement should be accomplished preferably by receiving the data from existing systems.

SP3_REQ_Int_CSI_08_v1.0: Time and confidence of signal phases are available for the upcoming changes of traffic signals. Based on historical data and the actual events a prediction is calculated

for the next two phase changes of each traffic light group. Content of data to predict is under standardization at CEN/ISO and specified in the SPaT message.

SP3_REQ_Int_CSI_09_v1.0: The traffic authority is able to fine tune the prioritization based on different parameters, such as congestion, public transport, emergency vehicles etc. A tool for reconfiguration is necessary; this tool should work local at the controller and remote from a central side. The tool for configuration needs a database for the archiving of the local configurations.

SP3_REQ_Int_CSI_10_v1.0: The intersection must be able to receive and process information received from the vehicles, such as vehicle type, load, weight, number of passengers, schedule, position, CACC platoon information etc. Out of the parameter set for priority the prioritisation actions are calculated. The results are provided to the traffic application. The status of prioritisation is distributed to the vehicles via SPaT optional fields.

SP3_REQ_Int_CSI_11_v1.0: The intersection must be able to broadcast the updated signal phase and time. Dependent on the requests the prediction out of historical data needs to be extended by reactions to requests.

SP3_REQ_Int_CSI_12_v1.0: Intersection is able to control the traffic lights phase and time. The traffic application needs to have different strategies for different levels of adaptation requests. It must be extended by access to the prioritisation levels out of the prioritisation management.

SP3_REQ_Int_CSI_13_v1.0: To provide the applications with information about transport tasks, such as planned itinerary and schedule. An API is available where the application can request information such as schedule for distribution trucks and public transport (stops, time behind or ahead, etc.).

SP3_REQ_Int_CSI_14_v1.0: Traffic controller can plan a green wave across multiple intersections and send the recommended speed to the vehicles. For at least some hours of the day the traffic controllers will run in a time coordinated mode which is planed providing a green wave. The green wave speed and the direction may differ over the time of day. If there are adaptations from the controller to prioritisation request destroying the green wave, this information shall not be sent for this time.

A graphical overview of the requirements and their grouping is highlighted in the following figure.

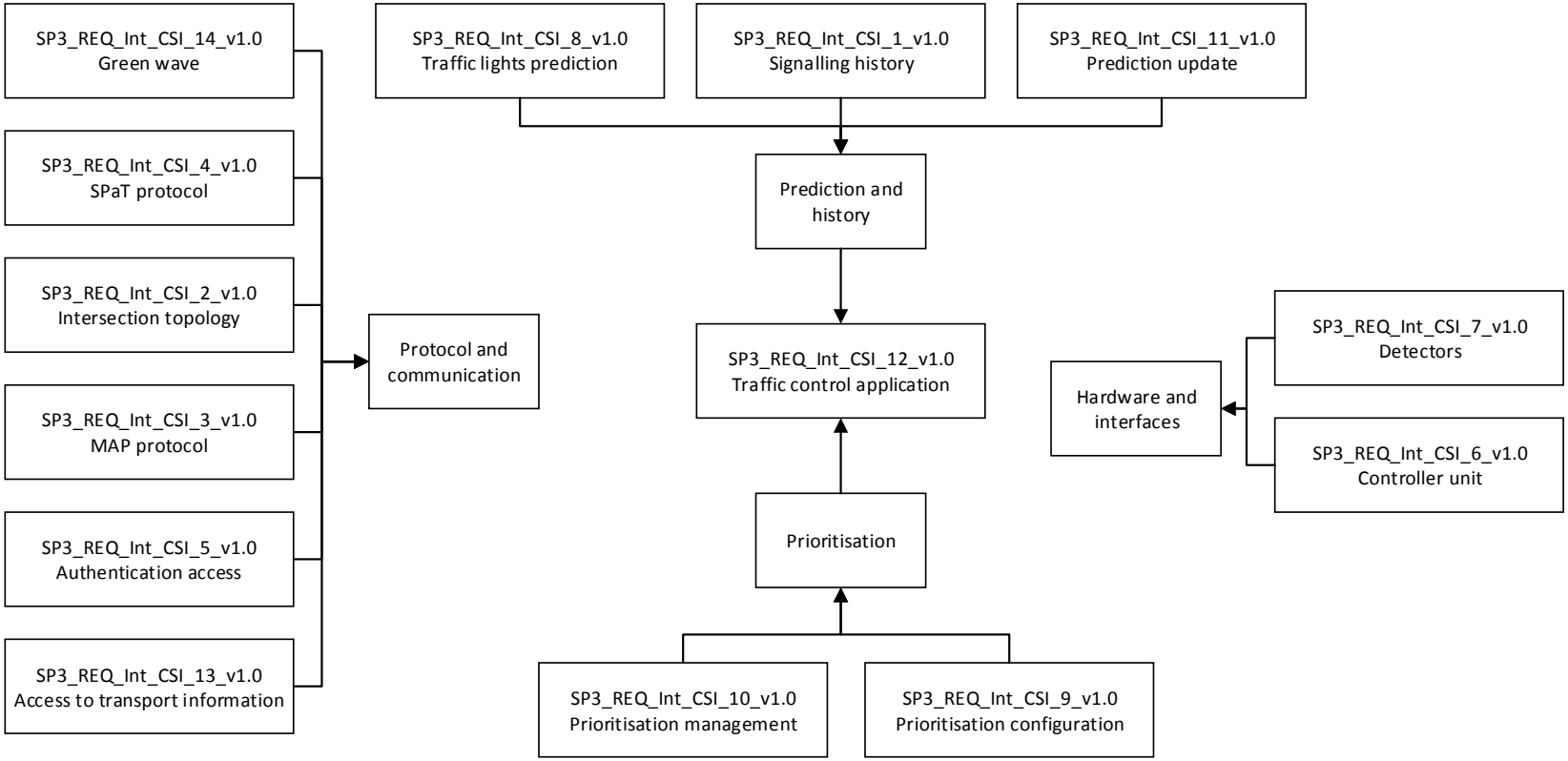


Figure 3.4: CSI requirements overview

3.5 Collaborative public transport optimization

A quick overview of the CPTO relevant requirements is given below, while in Figure 3.5 and Figure 3.6 the grouping and the relationship among these requirements are illustrated. The detailed requirements' tables are included in Annex 1 - E) for readability purposes.

I/O Requirements

SP3_REQ_Int_CPTO_1_v1.0: The CPTO end-user application part shall be able to accept the necessary input regarding the user preferences (origin, destination, time of travel, preferences regarding the means of transport etc.), and shall be able to propagate it to the rest of the CPTO functions so that it can be further processed.

SP3_REQ_Int_CPTO_2_v1.0: The CPTO end-user application part shall be able to present the CPTO results to the user in a readable, user friendly format.

SP3_REQ_Int_CPTO_3_v1.0: The CPTO application server shall have application layer connectivity interfaces with specific external servers/applications in order to exchange information with:

a. The public transport operator's infrastructure (e.g. application server)
b. The road operators' infrastructure (either directly from their application servers or through an interconnection with the CMC application).

Data Provisioning Related Requirements

SP3_REQ_Int_CPTO_4_v1.0: The public transport operator should provide real-time access to the needed data to the CPTO application (as well as the whole TEAM Framework) such as:

a. Current location of each public transport unit (bus, train),
b. Availability,
c. Load,
d. Bus sizes,
e. Fixed/Mutable Timetable schedules of transport means (bus, train),
f. Mixed/mutual routes of transport means (bus, train),
g. Event organisation (e.g. conference, football game etc.) and relevant requirements (e.g. opening/closing hours, amount of people expected, available bus fleet etc.).

SP3_REQ_Int_CPTO_5_v1.0: The format of the data provided by the public transport operator shall be in a readable format by the CPTO application.

SP3_REQ_Int_CPTO_6_v1.0: Information regarding the road conditions (traffic data, accidents etc.) and availability shall be provided in a readable format to the CPTO application (either directly by their road operators' application servers or through an interconnection with the CMC application).

SP3_REQ_Int_CPTO_7_v1.0: The CPTO application server shall be able to store user information related to user transport preferences - demand for public transport means (origin, destination, time of travel, preferences regarding the means of transport etc.). Also historic user data will be stored.

SP3_REQ_Int_CPTO_8_v1.0: Information regarding the traffic load and conditions etc. per road segment and for specific timeframes shall be stored (either by CPTO or by another linked application). Also historic traffic information will be stored.

Data Processing related Requirements

SP3_REQ_Int_CPTO_9_v1.0: The CPTO shall be able to assess the roads' status regarding their availability, traffic load etc.

SP3_REQ_Int_CPTO_10_v1.0: The CPTO shall be able to identify the bus routes that are affected by "difficult" conditions experienced in specific road segments.

SP3_REQ_Int_CPTO_11_v1.0: The CPTO should be able to calculate dynamically an alternative route in case of unavailability of specific road segment (e.g. in case an accident happens, civil works take place etc.).

SP3_REQ_Int_CPTO_12_v1.0: The CPTO should take into account the transport preferences (origin, destination, time of travel, preferences regarding the means of transport etc.) from the travellers and dynamically make recommendations to the public transport operator in order to:

a. add and/or skip stops
b. add and/or skip complete scheduled itineraries.

SP3_REQ_Int_CPTO_13_v1.0: It shall be possible for the public transport operator to support this dynamic adaptation of the schedule/routes etc., to update the relevant information of the public transport means, and propagate this information to the CPTO application.

SP3_REQ_Int_CPTO_14_v1.0: The CPTO application shall provide speed recommendations to the bus driver to further increase the efficiency of the network.

SP3_REQ_Int_CPTO_15_v1.0: The CPTO application shall be able to make recommendations regarding the speeds and time slots that the bus drivers have to leave the bus stops.

SP3_REQ_Int_CPTO_16_v1.0: The CPTO application shall be able to calculate the best alternative routes and frequencies for buses to head to or out of an organised event after a relevant request from the Public transport operator.

SP3_REQ_Int_CPTO_17_v1.0: The CPTO application shall be able to monitor the headway between two or more consecutive buses and in case these buses are getting too close together or too far apart to dynamically adapt their headway taking into account the current traffic situation and other information (e.g. the passenger load, the travellers' demand). Then the application notifies the bus drivers to adapt their distance by choosing speed or waiting times etc.

SP3_REQ_Int_CPTO_18_v1.0: The CPTO application shall be able to associate a traveller with a specific bus. This way the information that will be pushed to the traveller will be relevant not only to his/her position but also to the current bus route and schedule.

SP3_REQ_Int_CPTO_19_v1.0: The CPTO application shall be able to process historical data related to demand for public transport means etc. per road segment and for specific timeframes and predict future demand per road segment and for specific timeframes.

SP3_REQ_Int_CPTO_20_v1.0: Historical data related to traffic load shall be processed so that possible short/long term changes in stops and/or complete scheduled itineraries can be predicted.

SP3_REQ_Int_CPTO_21_v1.0: The CPTO application (as the majority of TEAM applications) should provide real-time information to the traveller such as the following:

a. the current location of the bus of interest,
b. the time they have to wait at the stop for the bus,
c. info on the forthcoming stations,
d. the estimated time to their destination,
e. considerable delays on the route of interest,
f. suggestions on alternative routes

Application Layer Data Exchange Requirements

SP3_REQ_Int_CPTO_22_v1.0: The user part of the CPTO application shall be linked and connected to the CPTO application server, and data between these two parts shall be always synchronised/continuously updated (application layer connection).

SP3_REQ_Int_CPTO_23_v1.0: The public transport operator information e.g. related to the transport means' time schedules/availability etc. sent to the CPTO application server shall be continuously updated so that information between the two entities (public transport operator servers and CPTO application) is always synchronised (application layer connection).

SP3_REQ_Int_CPTO_24_v1.0: The road operators' information e.g. related to the road segment availability and traffic load information/data sent to the CPTO application server shall be continuously updated so that information between the two entities (road operators servers and CPTO application) is always synchronised (application layer connection).

A graphical overview of the requirements and their grouping is highlighted in the following figures.

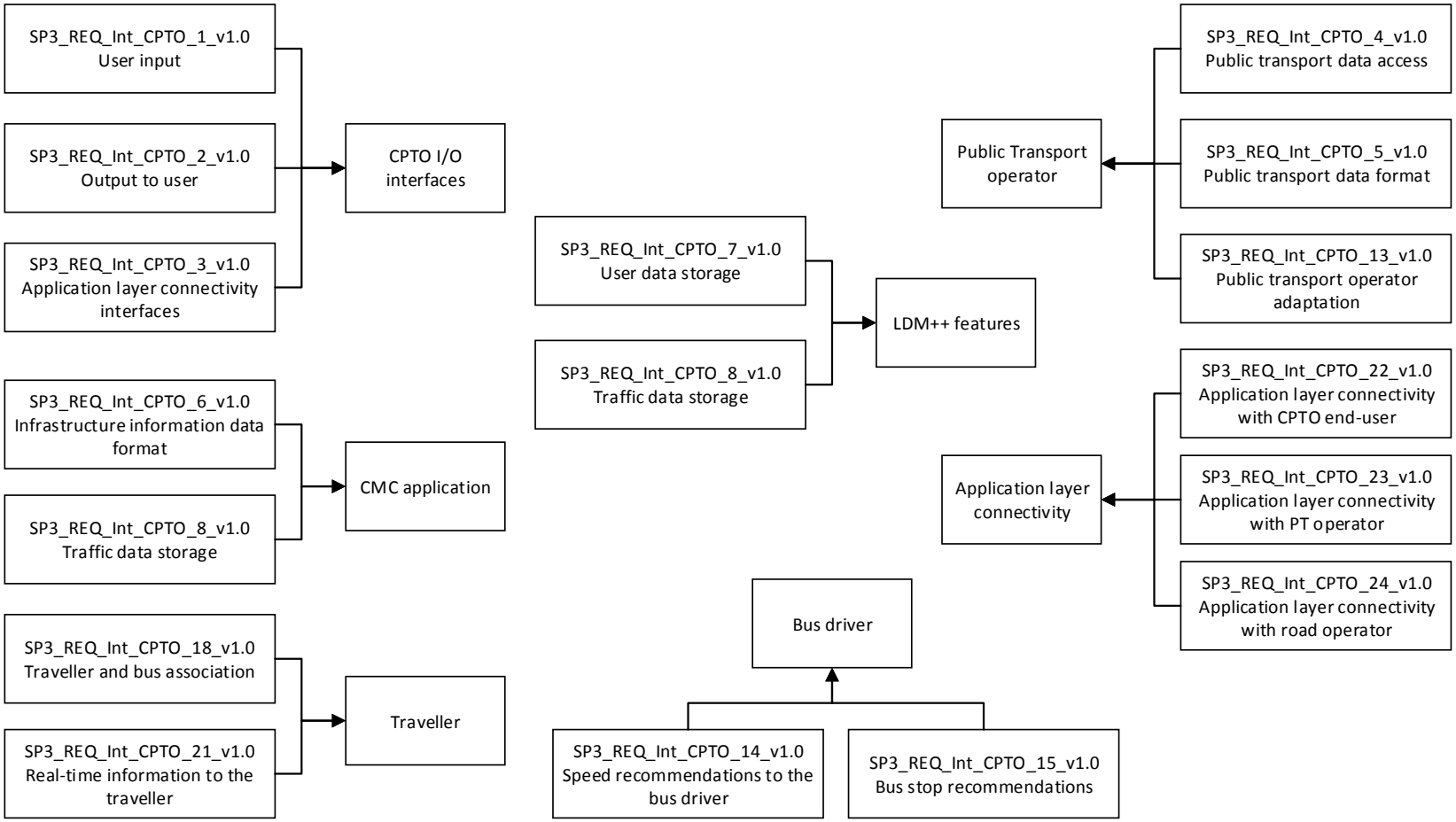


Figure 3.5: CPTO requirements overview - Part A

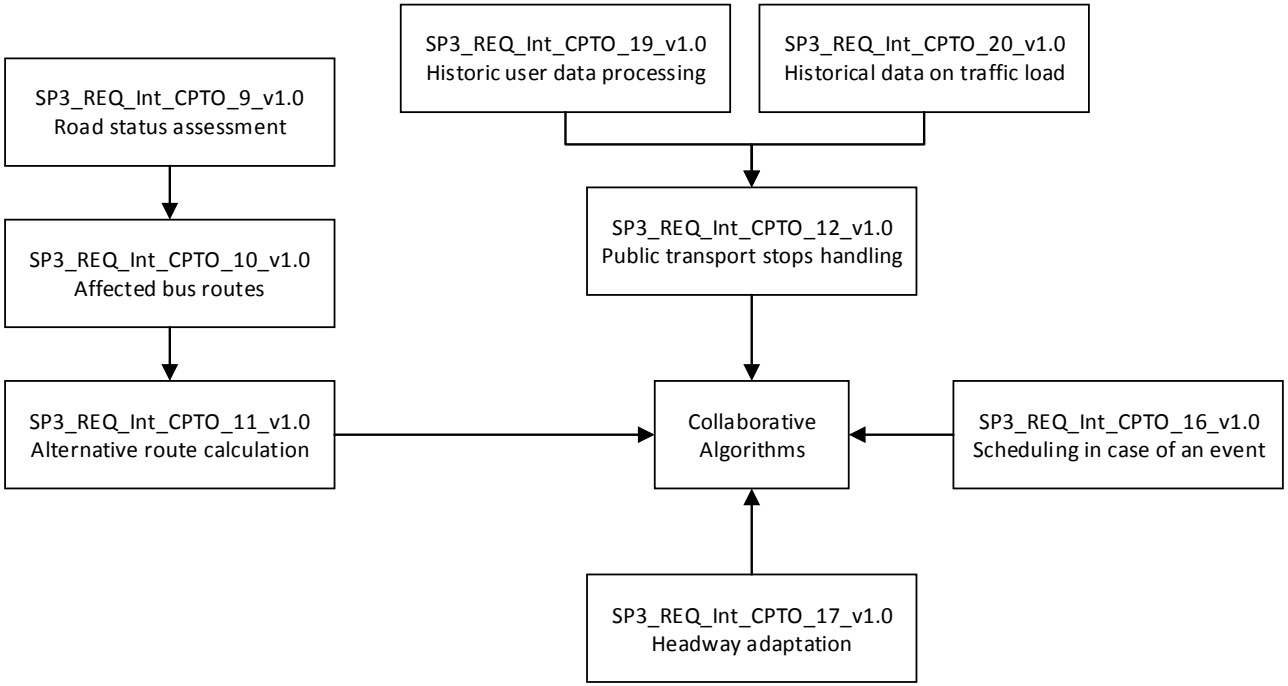


Figure 3.6: CPTO requirements overview - Part B

3.6 Dynamic collaborative corridors

A quick overview of the DC relevant requirements is given below, while in Figure 3.7 the grouping and the relationship among these requirements are illustrated. The detailed requirements' tables are included in Annex 1 - F) for readability purposes.

SP3_REQ_Int_DC_01_v1.0: The driver shall receive a warning when the vehicle is about to enter a lane that is dedicated to another traffic or vehicle type. The driver shall receive the warning in advance, so it's possible to change lane in a safe way. The ideal position (or time) for when this information shall be presented is to be decided. It could depend on the speed, the traffic situation etc., and is something that has to be evaluated during the project. The driver shall receive a new warning if the vehicle is entering the dedicated lane. This warning shall probably be of a higher priority (like go from yellow to red).

SP3_REQ_Int_DC_02_v1.0: The system shall inform the driver when there is a suitable alternative dedicated lane available. This information shall not be presented before the dedicated lane is available, in contrast to the warning of driving into a dedicated lane where the vehicle is not allowed being. If the driver does not change to the dedicated lane, reminders shall be given.

SP3_REQ_Int_DC_03_v1.0: The system shall know about all the dedicated lanes, and their regulations and restrictions, to be able to give the driver information, advices, and warnings regarding the use of dedicated lanes.

SP3_REQ_Int_DC_04_v1.0: The vehicle shall know about the current regulations in the area where it operates so that it can automatically adapt to these.

SP3_REQ_Int_DC_05_v1.0: Every TEAM application should compute some user performance evaluation metrics that can be fed to the SG/CB application so that it can incentive proper usage of the application. The SG/CB application shall convert the user feedback coming from the SP3 (and 4) applications into virtual coins that, in turn, could be spent on acquiring higher quality of services in the SP3 (and 4) applications, thus building a virtuous cycle. In the DC application case, good metrics (to be computed in real time during a DC drive) could involve:

- Keeping right speed
- Keeping right distance
- Keeping low fuel consumption
- Respect the dynamic local regulations

Actually, a penalty function should be defined, penalizing drivers whose behaviour deviates from the optimal behaviour. Parameters, such as weather, and road conditions will also be considered. Moreover, the actual use of the dynamic lanes, when available, will be considered as a merit parameter. Normalization will also be necessary to keep into account the fact that a driver could drive through the corridor more or less frequently and could drive through different corridors. Also, different vehicle models should be considered. Since different vehicles have inherently different behaviours (e.g., fuel consumption levels and other dynamic features) and the driver performance should be evaluated in a vehicle-independent way, it is important to decouple the driver assessment from the actual raw data (e.g., plain consumption).

SP3_REQ_Int_DC_06_v1.0: The application should be able to provide different levels of services (e.g., in terms of contents, look & feel, quality of information, etc.) so that the user can spend virtual coins on it. For the DC application, we can foresee that virtual coins could be spent to enter the (reserved) dynamic corridors, or could benefit from the assistance services for lane merging. Different quality/levels of feedback to a driven in a dynamic corridor may be provided based on the virtual coins spent by the driver. Moreover, information about available dynamic corridor in an area could be provided earlier to people having more coins.

SP3_REQ_Int_DC_07_v1.0: The system shall have knowledge of vehicle, goods and type of operation to be able to perform access control.

SP3_REQ_Int_DC_08_v1.0: The traffic operator shall be able to dedicate a lane to a certain traffic or vehicle type. This should either be made momentarily, or scheduled so that for example a lane is dedicated to bus traffic every working-day between 7 to 9 am and 4 to 6 pm.

SP3_REQ_Int_DC_09_v1.0: It shall be possible for a traffic manager to define areas to which regulations can be applied. An area is either defined as a geographic area (rectangle, circle etc.) or as a road segments.

SP3_REQ_Int_DC_10_v1.0: Specific road and traffic regulations should be enforced in certain defined geographic areas. The following regulations shall be possible to apply to an area:

- Max noise (expressed as a number of abstract levels e.g. high, medium, low, or as measurable values [db]
- Max emission (expressed as a number of abstract levels or a measurable value, e.g. CO2/km)
- Max speed [km/h]
- Safety level

SP3_REQ_Int_DC_11_v1.0: The system shall be able to inform the traffic manager about the effect of regulations. It shall be possible to understand what kind of vehicles can and cannot adapt to the given regulations. It shall also be able to estimate the expected impact of certain regulations, e.g. on emissions, noise, traffic flow etc.

SP3_REQ_Int_DC_12_v1.0: The TEAM infrastructure will be able to deliver the following information to the SP3_DC application:

- Information on current traffic state at different spatial scales
- Information on current traffic state at different temporal scales (but considering the time horizon of the DC application –seconds / minutes-)
- The spatial / temporal information is adapted and filtered to the requirements of the current vehicle according to the desired routing / driving requirements. That is, only information is delivered that directly affects the vehicle using the DC application and / or is related to the currently selected route
- Low-granularity information (i.e. seconds or meters) is locally gained (i.e. in the vehicle) by evaluating data coming from other vehicles and the lowest-level infrastructure.

SP3_REQ_Int_DC_13_v1.0: To have information on future traffic state that directly affects the DC application.

- The TEAM infrastructure will deliver information on traffic state to the vehicles using the DC application
- The delivered information is filtered and adapted to the needs of the current vehicle being routed / whose route is known
- The vehicle running the DC application will make a request for predictive traffic information according to a best-guess / intended route.

SP3_REQ_Int_DC_14_v1.0: The system shall be able to "understand" how dedicated lanes affects the traffic situation, so that it could decide when they shall be used and not.

- The DC application will issue event- or time-triggered requests demanding lane organization information
- The TEAM infrastructure will issue lane organization information in a unified format (similar to that of traffic rules information) that the DC application will be able to understand
- The DC application will be able to make sense of lane organization information by feeding it to a local / in-vehicle "Traffic Management Unit".

SP3_REQ_Int_DC_15_v1.0: The traffic manager shall be able to define areas where access control is required. An area is either defined as a geographic area (rectangle, circle etc.) or as one or more road segments.

- The DC application will send periodic requests to the local Traffic Management Centre to check for validity / permission of the DC application in the requested area
- Whenever a new lane change is detected or predicted, a request for authorization for the DC application will be issued
- If authorization from the TMC is granted the DC application will be active for the requested area
- Areas might involve geometric shapes (square, circle, etc)
- Roads and road segments should be also individually addressable.

SP3_REQ_Int_DC_16_v1.0: It shall be possible to set criteria for when a vehicle is permitted to enter an area or not. Criteria (examples):

- Vehicle (weight and dimensions, engine type, emission or noise level etc.)
- Load (dangerous goods could for example be not allowed)
- Type of operation (commercial transport, public transportation etc.)
- Certifications
- Membership in organizations.

SP3_REQ_Int_DC_17_v1.0: The system shall be able to understand when, and when not, the total traffic situation would benefit from having lanes dedicated to certain traffic or vehicle types. Lanes will automatically be dedicated according to this understanding.

SP3_REQ_Int_DC_18_v1.0: The system shall be able to know when a vehicle is about to enter an area with access control, as well as the vehicles that are already inside the area The main objective is to monitor and control occupancy and priorities.

SP3_REQ_Int_DC_19_v1.0: The infrastructure should be able to gather information about participants. The vehicles shall be able to identify themselves and give information about the type (truck, bus, car, taxi, etc), the goods, passengers, type of operation etc.

SP3_REQ_Int_DC_20_v1.0: The system shall be able to evaluate if the vehicle is allowed to enter the area. When a vehicle approaches a controlled area the system should be able to evaluate if the vehicle is allowed to enter and communicate the access granted/denied in good time.

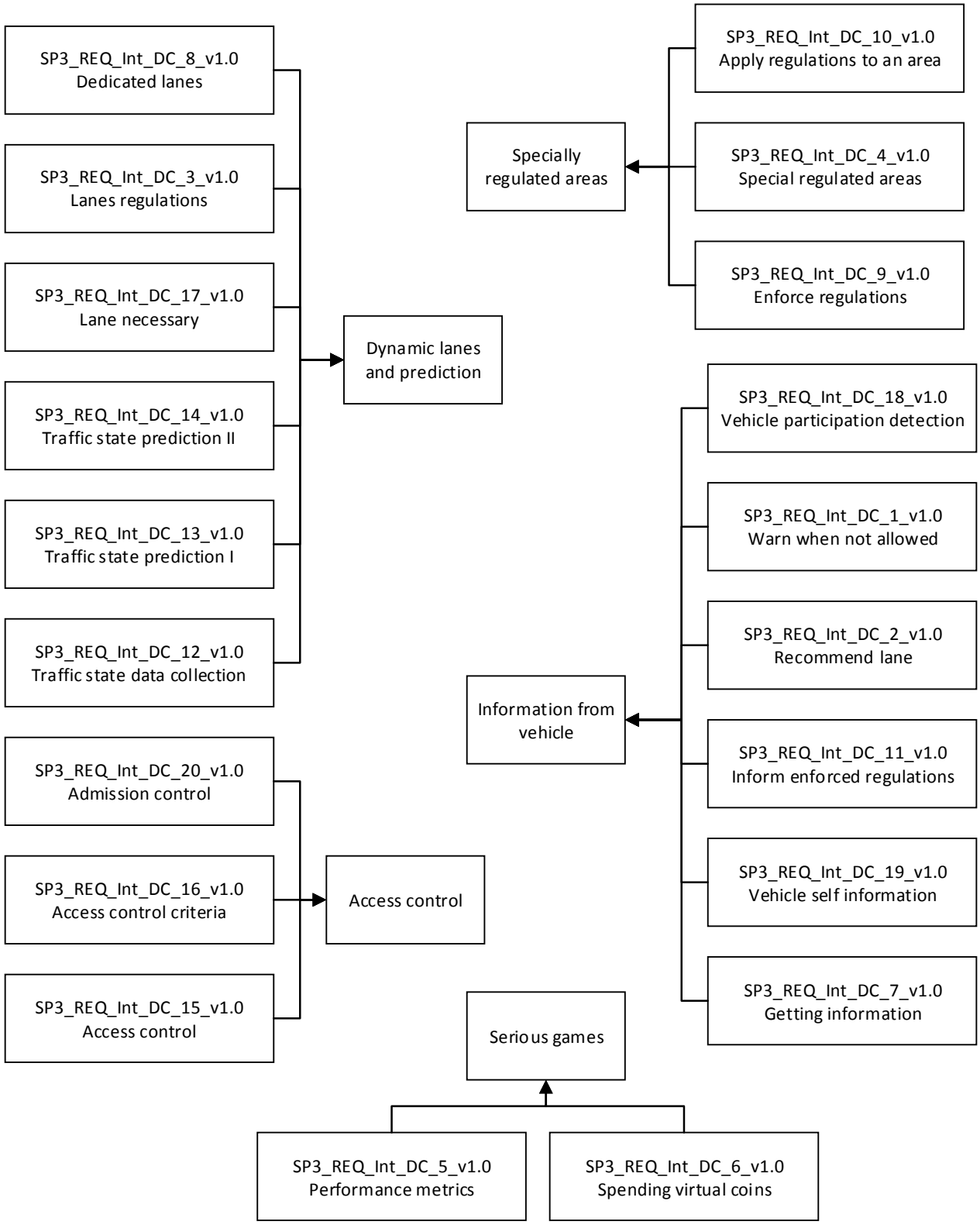


Figure 3.7: DC requirements overview

4 Requirements to elastic infrastructure from DIALOGUE applications

In this section the requirements from the DIALOGUE applications to the infrastructure side are highlighted. These requirements were received from DIALOGUE as an internal report and were discussed and refined together with FLEX & DIALOGUE partners before inserted into this document. In the following, these requirements will be mapped to infrastructure enablers needed by the DIALOGUE applications to operate as planned. These enablers are highlighted in the next chapter.

4.1 Collaborative ACC

Requirement ID:	SP4_REQ_CACC_TRAFFIC-SITUATION_v0.1
Name of requirement:	Traffic situation information retrieval
Created by	DCAITI - kay.massow@fokus.fraunhofer.de
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Adaptive Cruise Control (CACC)
Requirement category	Technological and development requirements
Goal	The goal is to store and provide information about current number of vehicles driving through a road segment, their speed and emission rate. The emission characteristics and the current speed will be provided by the vehicle itself.
Definition:	Using this information, a certain emission budget for each vehicle can be calculated and allocated to the vehicles.
Critical level (priority)	High
Validation Method (tests, indicators, performance	All the mentioned data should be available to the CACC application

bounds)	
Acceptance criteria	Availability of the above mentioned data
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Availability of the mentioned data is necessary for a proper functioning of the application. Traffic situation information provision will be a fundamental TEAM design aspect. If this requirement fails, the use case "Collaborative Road Budget Allocation" of the CACC application cannot get operational.
Status	New
Other	The idea is to reduce the emissions in environmental zones. For this purpose, we calculate the maximum emission level, which should be not exceeded by all the vehicles in that zone, and so a certain emission budget for each vehicle. What we need is to know all the vehicles in the zone and their particular emission characteristics. These characteristics and also it current speed will be provided by the vehicle itself, we would like SP3 to store this information and make it available to our calculation algorithms, which will be either located on the vehicles or on a central server. To be more detailed, we need to know the current speed, current emission level, current route, and certain emission characteristics of each vehicle. We can provide this information if SP3 doesn't have relevant access, but we need a local storage which can be accessed by the vehicles.

Requirement ID:	SP4_REQ_CACC_TRAFFIC-LIGHTS_v0.1

Name of requirement:	Traffic lights interaction
Created by	DCAITI - kay.massow@fokus.fraunhofer.de
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Adaptive Cruise Control (CACC)
Requirement category	Technological and development requirements
Goal	The goal is to enable communication (application layer) with traffic light and grant access to their switching times.
Definition:	Traffic lights switching times are supposed to be synchronized with the ACC speed of the vehicles and vice versa. For this purpose, the traffic light need to provide their current status, current switching times and a proper way for TEAM equipped vehicles to request changes to the traffic light switching times.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	The mentioned data/interface should be available to the CACC application.
Acceptance criteria	Availability of the above mentioned data/interface
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Availability of the mentioned data/interface is necessary for a proper functioning of the application. Traffic lights interaction will be included in TEAM design. If this Requirement fails, the "Green light optimizing cruise control" use case of the CACC cannot get operational.
Status	New

Other	No

Requirement ID:	SP4_REQ_CACC_ROADSPEED_v0.1
Name of requirement:	Setup Speed for Road Segments
Created by	DCAITI - kay.massow@fokus.fraunhofer.de
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Adaptive Cruise Control (CACC)
Requirement category	Technological and development requirements
Goal	The goal is enable the adaption of current maximum speed of certain road segments.
Definition:	In order to adapt the ACC speed of the vehicles, adaption of the maximum speed limit of certain road segments is required (e.g. via switchable speed limitation signs).
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	The mentioned interface to the road infrastructure should be available to the CACC application.
Acceptance criteria	Availability of the above mentioned interface
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Availability of the mentioned interface is necessary for a proper functioning of the application. However, the risk of not achieving licence to adapt maximum speed exists and depends on local authorities. TEAM will investigate the option to use this characteristic in a limited - controlled area. If this Requirement fails, the second

	stage of the CACC application realization as described under the term "Road speed limit adaption", cannot get operational.
Status	New
Other	No

Requirement ID:	SP4_REQ_CACC_TRAFFIC-INFO_v0.1
Name of requirement:	Traffic information
Created by	DCAITI - kay.massow@fokus.fraunhofer.de
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Adaptive Cruise Control (CACC)
Requirement category	Technological and development requirements
Goal	The goal is provide current traffic information, especially about congested road (traffic jam). Also information about the length of a traffic jam and the estimated duration of passing it is desirable.
Definition:	Vehicles shall be enabled to slow down, when approach relevant locations.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	The traffic information should be available to the CACC application.
Acceptance criteria	Availability of the above mentioned information
Relationship with other requirements	N/A

Potential conflicts	None
Risk analysis	Availability of the mentioned information is necessary for a proper functioning of the application. Traffic information provision is a key element of TEAM architecture and the risk of missing such a component is low. If this requirement fails, the use case "Traffic data used to influence vehicle speed when Cruise Control is active" od the CACC cannot get operational.
Status	New
Other	No

4.2 Collaborative eco-friendly parking

Requirement ID:	SP4_REQ_EFP_PARKIND_v0.1
Name of requirement:	Parking indication
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To receive indications about the parking location
Definition:	The system shall provide parking location indication suitable to the specific use case E.g. -specific spot -area of interest
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Field Tests or simulated tests of SP3 system giving parking indication, for different cases of parking area (square areas, avenues, etc.). Measurement of effectiveness, i.e. was the parking space found/could it be found based on indications, and efficiency, i.e. how long it took with respect to absence of any indication.
Acceptance criteria	Useful parking indications
Relationship with other requirements	Depends on SP4_REQ_EFP_CURRPARKAVAILINF_v0.1, SP4_REQ_EFP_FUTPARKAVINF_v0.1

Potential conflicts	Care should be paid to scalability: what paring indication is given for simultaneous requests by several users.
Risk analysis	Risk of useless or misleading indications. Risk of non-scalable application. TEAM will ensure the correctness of indication to eliminate the risks. Early tests in Turin are planned for November 2014, in order to ensure that meaningful indications are given.
Status	New
Other	As for vehicle case, parking indication in EFP can be effective even with low accuracy position (e.g. within 100-200m) but can improve performance when availing of more accurate data.

Requirement ID:	SP4_REQ_EFP_PARKTYPE_v0.1
Name of requirement:	Parking type indication
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To receive indications about the parking type
Definition:	The system shall provide parking type indication Examples of parking type data are roadside row/square area, open/closed, guarded/unguarded, public/private, special parking (e.g. for mobility impaired), parking owner.
Critical level (priority)	High

Validation Method (tests, indicators, performance bounds)	Agreement by partners during design phase.
Acceptance criteria	Useful parking indications
Relationship with other requirements	Depends on SP4_REQ_EFP_PARKIND_v0.1
Potential conflicts	None
Risk analysis	Risk of misleading indications or unsuitable parking spaces for the user. TEAM will take measures to avoid the risks of false information. Considering the integration and/or simulation of existing parking services will limit this risk. This process of linking to existing services has already been undertaken and will be strengthened.
Status	New
Other	This requirement is on the data to be provided from off-board to the vehicle (SP3 to SP4) not on the data to be displayed by SP4 driver assistant.

Requirement ID:	SP4_REQ_EFP_PARKREQ_v0.1
Name of requirement:	Parking indication requests
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To ensure initial communication between on board and off board system (SP3) in order to receive parking

	indications
Definition:	The EFP service shall receive parking requests from the users
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests of data exchange between off-board EFP service (SP3) and onboard systems (SP4).
Acceptance criteria	System works as designed.
Relationship with other requirements	"Father" requirement
Potential conflicts	None
Risk analysis	Sound agreement SP3-SP4 on EFP implementation: low risk, but high impact, of wrong communication between SP4 application and SP3 enablers (thus, no parking service supplied). This is being taken into account through a cross-SP working group: the EFP development working group is composed by the partners providing the on board application and also by those providing the off-board enablers.
Status	New
Other	No

Requirement ID:	SP4_REQ_EFP_PARKINDREQTYPE_v0.1
Name of requirement:	Parking indication request: needed data type
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or	Collaborative Parking (EFP)

enabler)	
Requirement category	Technological and development requirements
Goal	To enable EFP indication in different ways, depending on the availability and type of navigation system in the vehicle, the infrastructure should provide the relevant information in different ways e.g. simple coordinates, a list of waypoints etc. This should be discussed in detail in the specifications and design phase. A link also with the SP4-CONAV application is foreseen.
Definition:	Vehicle system and off board system shall agree
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests.
Acceptance criteria	User of a vehicle without on board navigation can receive parking information
Relationship with other requirements	Depends on SP4_REQ_EFP_PARKREQ_v0.1
Potential conflicts	None
Risk analysis	Sound agreement SP3-SP4 on EFP implementation: low risk, but high impact, of having an application that relies only on navigation systems, or an application that is completely detached from navigation application. This is being taken into account: both standalone EFP operation, also EFP-CONAV integration are being tackled.
Status	New
Other	No

Requirement ID:	SP4_REQ_ EFP_BOOKREQUEST_v0.1
Name of requirement:	Parking booking request
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To have possibility of booking a parking slot
Definition:	The off board system shall receive parking booking requests
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Agreements in design phase. Functional tests.
Acceptance criteria	System works as designed.
Relationship with other requirements	"Father requirement"
Potential conflicts	None
Risk analysis	The risk is medium. Without booking requests possibility, the application works only in local and short time conditions, but nevertheless such an application would be useful in several cases.
Status	New
Other	None

Requirement ID:	SP4_REQ_ EFP_BOOKREQUESTCONF_v0.1

Name of requirement:	Parking booking request prioritization
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	Based on the evaluation of booking confidence performed by DIALOGUE FLEX has to prioritize/handle the different parking booking requests. Evaluation of booking confidence is done by DIALOGUE , also thanks to SP4 enabler "Credibility management system". Factors increasing or decreasing the confidence are: user spontaneous request, system inference of parking intentions (with/without user confirmation), booking cancellation history, etc.
Definition:	Parking booking requests shall include confidence level in order to be prioritized.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Agreements in design phase. Functional tests.
Acceptance criteria	At least 3 levels of confidence are handled: high, medium, low.
Relationship with other requirements	Depends on SP4_REQ_ EFP_BOOKREQUEST_v0.1
Potential conflicts	None
Risk analysis	The risk analysis is the same as for booking request.
Status	New

Other	None

Requirement ID:	SP4_REQ_EFP_CURRPARKAVAILINF_v0.1
Name of requirement:	Current parking availability inference
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To obtain information on the availability of parking slots in an area E.g. To be able to know, with in an area, the sub-area having the highest probability of finding parking places.
Definition:	For a defined area, the number of parking spaces shall be inferred by off board system fusing all the available data. Example of data are: Collaborative parking state notification by user, Cooperative parking notification by vehicle/infrastructure; Reservation data; Legacy system data (e.g. parking sensors, parking counters).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Testing availability of parking data output with different input data sources, and in different use cases of vehicles entering/exiting parking spaces.
Acceptance criteria	Parking information available
Relationship with other requirements	Related and dependent on *Localization data update*, but not overlapped. *Current parking availability* relates to aggregation of information to provide parking indication,

	not just on location information.
Potential conflicts	"Father requirement"
Risk analysis	Might be difficult to aggregate TEAM parking input data with other data from legacy systems. Risk is medium, but it is being mitigated by the link to existing services which is already being tackled.
Status	New
Other	No

Requirement ID:	SP4_REQ_ EFP_ PARKBOOKDATAMNG_5
Name of requirement:	Parking booking data management
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP2/LDM++ group
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To manage and provide information on the availability of parking slots by users for the future, based on booking requests, in a flexible way
Definition:	For a defined area, a parking booking list shall be constantly updated based on available data. Example of data are: Booking requests, Current Parking Availability, Parking Availability Forecast.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests with different use cases, especially addressing overlapping booking requests and unplanned events.

Acceptance criteria	System is responsive with respect to changes of plans.
Relationship with other requirements	SP4_REQ_ EFP_BOOKREQUEST_v0.1, SP4_REQ_ EFP_BOOKREQUESTCONF_v0.1
Potential conflicts	None
Risk analysis	Risk: low confidence bookings might lead to an unmanageable situation and thus prevent future parking availability inference. The overall impact is on the on the long-term prediction capability of the parking application. The solution is to foster as much as possible a coherent behaviour by the users' through social gaming incentives but also by design (see "other").
Status	New
Other	The internal requirement will be stated, that the system shall ask for driver confirmation.

Requirement ID:	SP4_REQ_EFP_FUTPARKAVAILINF_v0.1
Name of requirement:	Future parking availability inference
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	SP4: To obtain information on the availability of parking slots in an area, for the future. SP3: to aggregate information for a reliable parking availability evaluation.
Definition:	For a defined area, the number of parking spaces shall be

	inferred by off board system based on available data. Example of data are: Collaborative parking state notification by user, Cooperative parking notification by vehicle/infrastructure; Booking data; Legacy system data (e.g. parking sensors, parking counters).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Testing availability of parking data output with different input data sources, and in different use cases of vehicles entering/exiting parking spaces.
Acceptance criteria	Parking information available
Relationship with other requirements	*Future parking availability* relates to aggregation of information to provide parking indication for the future
Potential conflicts	Depends on P4_REQ_EFP_PARKBOOKDATAMNG_v0.1, SP4_REQ_EFP_CURRPARKAVAILINF_v0.1,
Risk analysis	Might be difficult to demonstrate. The solution could be to use a simulator.
Status	New
Other	No

Requirement ID:	SP4_REQ_EFP_LOCACCURACY_v0.1
Name of requirement:	Parking location accuracy
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)

Requirement category	Technological and development requirements
Goal	To enable parking indications with different level of accuracy
Definition:	The accuracy of the geo-referenced parking indication shall be provided along with parking location data.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests on developed system to check the compliancy with design.
Acceptance criteria	Localization data are always accompanied by the indication of accuracy
Relationship with other requirements	Depends on SP4_REQ_EFP_VEHPOSAV_v0.1, SP4_REQ_EFP_PARKIND_v0.1
Potential conflicts	None
Risk analysis	Incomplete localization information. TEAM collaborative positioning will asist in eliminating this risk.
Status	New
Other	None

Requirement ID:	SP4_REQ_EFP_COLLABPARK_v0.1
Name of requirement:	Collaborative parking state notification by user
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP2/LDM++ group and SP3
Source (TEAM application or	Collaborative Parking (EFP)

enabler)	
Requirement category	Technological and development requirements
Goal	To know and inform that a vehicle is parking/leaving at given moment in a given area, from the reception of an user notification.
Definition:	A vehicle arriving at an area and requiring parking space should receive information about vehicles leaving/entering parking space in useful time and accuracy, to help with park place finding. Data: Parking/Leaving state indicating that a vehicle is entering or exiting a parking area; localization with sufficient accuracy (see area requirements); user notification indicator ("collaborative" mark); confidence level (depending on user profile).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests in different area, accuracy and latency measurements, degraded performance measurements (e.g. urban canyon)
Acceptance criteria	Collaborative indication can be used by EFP as parking indication for 95% of the assessed cases.
Relationship with other requirements	Depends on SP4_REQ_EFP_VEHPOSAV_v0.1, SP4_REQ_EFP_ VEHPOSUPDATE_v0.1 SP4_REQ_EFP_LOCMEANS_v0.1. SP4_REQ_EFP_LOCACCURACY_v0.1 Same mechanism as "Cooperative parking state notification by vehicle" but with user-input, and thus more rewarded in terms of virtual coins.
Potential conflicts	Conflicts among different indications should be managed by SP3 in Current Parking Availability inference.

Risk analysis	Custom layers are needed for a proper functioning of the application. This is a design characteristic, therefore relevant risk is low.
Status	New
Other	No

Requirement ID:	SP4_REQ_EFP_COOPPARK_v0.1
Name of requirement:	Cooperative parking state notification by vehicle/infrastructure
Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP2/LDM++ group and SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To know and inform that a vehicle is parking/leaving at a given moment in a given area, from the data of vehicle and/or roadside unit.
Definition:	A vehicle arriving at an area and requiring parking space should receive information about vehicles leaving/entering parking space in useful time and accuracy, to help with parking. Data: Parking/Leaving state indicating that a vehicle is entering or exiting a parking area; localization with sufficient accuracy (see area requirements); indication of autonomous parking state detection ("cooperative" mark); confidence level (depending on detection system reliability)
Critical level (priority)	High

Validation Method (tests, indicators, performance bounds)	True/False positive/negative tests in different area, accuracy and latency measurements, degraded performance measurements (urban canyon), reliability measurements to tune the confidence levels
Acceptance criteria	Cooperative indication can be used by EFP as parking indication for 80% of the assessed cases.
Relationship with other requirements	Depends on SP4_REQ_EFP_VEHPOSAV_v0.1, SP4_REQ_EFP_ VEHPOSUPDATE_v0.1 SP4_REQ_EFP_LOCMEANS_v0.1. SP4_REQ_EFP_LOCACCURACY_v0.1
Potential conflicts	Potential conflicts among multiple parking state notifications, if not properly prioritized (e.g. a vehicle detected by system and giving its own parking state and a collaborative notification by user).
Risk analysis	Custom layers are needed for a proper functioning of the application. Possible difficulties in stating that the vehicle has parked. . This risk is being taken into account in the early implementation of the application. Fall back solution is to rely on driver's notification.
Status	New
Other	Same mechanism as "Collaborative parking state notification by vehicle" but with autonomous inference by TEAM SP3 system (no user), and thus less/not rewarded in terms of virtual coins: maybe reward in case of detection by the vehicle, no reward in case of detection by infrastructure.

Requirement ID:	SP4_REQ_EFP_VEHUSERDATA_v0.1
Name of requirement:	Infrastructure data

Created by	CRF - filippo.visintainer@crf.it
Assigned partner	SP2 and SP3
Source (TEAM application or enabler)	Collaborative Parking (EFP)
Requirement category	Technological and development requirements
Goal	To provide EFP with useful data to optimize and tailor service provision
Definition:	Infrastructure data relevant for EFP shall be provided at every operational phase needed by the user and the vehicle (request, parking state indication, etc.). Data shall be carefully defined between SP3 and SP4 and may include e.g. vehicle type, size, user serious gaming ID, parking preferences, willingness to pay for parking, mobility impairment.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Validation in design phase
Acceptance criteria	Minimum set to be agreed in specification phase
Relationship with other requirements	Depends on SP4_REQ_EFP_PARKREQ_v0.1, SP4_REQ_ EFP_BOOKREQUEST_v0.1
Potential conflicts	Privacy
Risk analysis	The risk is low as infrastructure data provision is a a fundamental TEAM characteristic.
Status	New
Other	Data definition depends on inference mechanisms

4.3 Collaborative driving and merging

Requirement ID:	SP4_CDM_R_00001
Name of requirement:	Road Restriction Information is available
Target for TEAM application or enabler	SP4_CDM
Requirement category	Application requirements
Goal	Road Restriction along the path of the vehicle shall be made available in order for the CDM application to be able to support the driver and the other vehicles to manoeuver.
Definition:	A Restriction of the Road due to any cause: road work, accident, presence of obstacle or any other. The information shall be communicated to the vehicle or the CDM application along withs its location, validity and the area affected by the restriction and the effect in term of traffic and possibly any associated speed change.
Created by	F.Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	SP3
Critical level (priority)	Medium
Related use cases	SP4_CDM_RR use case
Related user scenarios	N/A
Input or event	The Road Restriction Event (external) Position of the vehicles
Behavior	The system shall be able to collect and send the Road Restriction information to each vehicle, possibly based on its current position
Output	The RR information that is sent to the interested vehicles.
Data model	The information shall be updated whenever a Road Restriction event changes;

	RR is composed by location, start date, end date, type of restriction, which lanes are blocked
Validation criteria (tests, indicators, performance bounds)	Presence of service; format specified; communication to vehicle available.
Acceptance criteria	Generated or real traffic restriction is communicated to the interested vehicles
Relevant test application	CDM
Relationship with other requirements	N/A
Potential conflicts	The information shall be integrated with information describing the traffic state of the area.
Risk analysis	The RR-UC cannot be implemented, because it is based on the knowledge of any restriction along the path of the vehicle. It should however be noted that there are other data sources for the CDM lane- and speed advice, which means that these functionalities can be validated even if no information about road restriction is available.
Status	New
Other	None

Requirement ID:	SP4_CDM_R_00012
Name of requirement:	Weather info
Target for TEAM application or enabler	SP4_CDM
Requirement category	Application requirements
Goal	Current and forecasted weather condition at the vehicles position and planned itinerary
Definition:	The vehicle should receive weather information for its current position and for the planned itinerary. This should include also road surface information (slippery, ice, etc.)

Created by	F.Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	SP3
Critical level (priority)	Low
Related use cases	all CDM
Related user scenarios	N/A
Input or event	Vehicle position Weather status update
Behavior	The weather information is sent to the interested vehicles; vehicle can register to receive the information or send a request.
Output	Weather information
Data model	Vehicle position Weather status description
Validation criteria (tests, indicators, performance bounds)	Data correctly received; Refresh rate able to follow significant weather changes
Acceptance criteria	Data correctly received; weather information relevant for the area.
Relevant test application	CDM
Relationship with other requirements	Related to SP4_CDM_R_00028 (the road surface status), together with other external/internal information describes the safety driving conditions
Potential conflicts	None
Risk analysis	Relevant information to maintain safety margin for all usecases of the application. The core functionality of the CDM application can still be verified without knowledge about weather information.
Status	New
Other	None

Requirement ID:	SP4_CDM_R_00020

Name of requirement:	Get static and dynamic traffic rules
Target for TEAM application or enabler	SP4_CDM
Requirement category	Application requirements
Goal	Provide the current (static or dynamic) traffic rule: • speed limit, • turning rules/allowed manoeuvres • lane restriction/closure • presence of stop lines • presence of giveway/precendence of manoeuvres This information is used for example to determine the movement between lanes. The rules should include dynamic information such as rules due to roadwork or other restrictions.
Definition:	see goal
Created by	F.Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	SP3
Critical level (priority)	High
Related use cases	all CDM, starting from Lane Change
Related user scenarios	N/A
Input or event	Current position (if necessary) Area of interest Type of rules (static/dynamic)
Behavior	Based on the area of interest, the traffic rules are sent to the vehicle
Output	The traffic rules
Data model	N/A
Validation criteria (tests, indicators, performance bounds)	Reliability of information and completion of the content
Acceptance criteria	Reliability of information and completion of the content

Relevant test application	CDM
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Not having the traffic rules, may result in proposing manoeuvres that are either dangerous or that result in a negative effect.
Status	New
Other	None

Requirement ID:	SP4_CDM_R_00021
Name of requirement:	Get traffic information
Target for TEAM application or enabler	SP4_CDM
Requirement category	Application requirements
Goal	Provide traffic information and events: • road restriction, • accident, • incident, • traffic density and congestions, • general traffic related information
Definition:	Any abnormal traffic condition affecting the vehicle's route or current area, shall be communicated to the vehicle. That includes presence of obstacles, accident, incident, change in the traffic condition but also overall traffic conditions such as density and congestions.
Created by	F.Alesiani, R.Basso - Francesco.Alesiani@neclab.eu
Assigned partner	SP3
Critical level (priority)	High
Related use cases	all CDM

Related user scenarios	N/A
Input or event	Current position/area of interest
Behavior	Based on the target area the traffic information and events are sent to the vehicle by request.
Output	Traffic information and events
Data model	Area of interest Traffic information Events
Validation criteria (tests, indicators, performance bounds)	Content and reliability of information
Acceptance criteria	Content and reliability of information
Relevant test application	CDM
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Not having traffic information and events may reduce the efficiency of the implementation of the applications. Core functionalities of the CDM application, such as lane change advice and speed advice can however still be validated.
Status	New
Other	None

Requirement ID:	SP4_CDM_R_00029
Name of requirement:	Traffic lights information
Target for TEAM application or enabler	SP4_CDM
Requirement category	Application requirements

Goal	Provide traffic lights information, such as real time phase and timing, intersection layout etc.
Definition:	This information can potentially be covered by SPaT and TOPO/MAP messages already existing or with custom extensions.
Created by	F.Alesiani, R.Basso - Francesco.Alesiani@neclab.eu
Assigned partner	SP3
Critical level (priority)	High
Related use cases	Intersection Optimization
Related user scenarios	N/A
Input or event	On regular basis
Behavior	N/A
Output	The state of the traffic lights and the topology of the area is transmitted to vehicles
Data model	Area of the intersection Traffic signal state description
Validation criteria (tests, indicators, performance bounds)	Message content and format correctly generated and received.
Acceptance criteria	The necessary information is available
Relevant test application	CDM
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	High risk for implementing the IO use case. A green light optimized speed advisory, which depends on information about traffic light signal phases, is part of the speed advice functionality of CDM.
Status	New
Other	None

4.4 Collaborative eco-friendly navigation

Requirement ID:	SP4_REQ_CONAV_SP3_01
Name of requirement:	Edit network information centrally
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	Group or partner from SP3
Source (TEAM application or enabler)	CONAV
Requirement category	Functional
Goal	The city shall have the possibility to influence routing from vehicles as an instrument to control traffic or pollution etc. They should be able to edit the following information. Since routing algorithms are commonly based on graph theory algorithms, we require information updates linked to edges. • Pollution information: traffic managers (or other relevant users) shall be able to update pollution information (like air quality per edge). The information should a multidimensional, e.g. to consider different aspects of pollution (noise, carbon monoxide, NOx, etc.) • Traffic flow information: information representing current traffic flow info. • Speed limits: Traffic managers should be able to edit speed limits, which will also influence routing choices. • Access information: in some cases, we wish that (some) vehicles are banned from certain areas. This should be made adaptively, e.g. to ban slow

	vehicles from highways, dirty vehicles from inner cities, trucks from small streets etc. • Forecasted information: Traffic managers should have the possibility to edit forecasted information on traffic flow and pollution levels per edge.
Definition:	Stakeholders, which are allowed to edit the network information (there shall be different rights for authorities, who may edit information which leads to more or less direct influences on traffic, but also third parties, which may update the information they gave earlier like time schedules from public transport) should be able to do that with help of a unified interface (API and software). The edited information (see above) may have metadata to describe it (e.g. reliability information, time to live information etc.).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Test if information has been edited and propagated in time and in a reliable way.
Acceptance criteria	Relevant users (traffic managers) accept the interface. Edited information is propagated correctly. Edited information is propagated in time.
Relationship with other requirements	The interface given to users (like the traffic management centers) may be the same as in SP4_REQ_CONAV_SP3_02.
Potential conflicts	None seen.
Risk analysis	Stakeholders may update information with conflicting information, which may lead to inconsistent, redundant, conflicting and wrong information. Rights to edit the information are sensible. Only validated

	users should be able to do that. It must be granted, that only one editor at a time is editing the information.
Status	New
Other	None

Requirement ID:	SP4_REQ_CONAV_SP3_02
Name of requirement:	Traffic managers should be able to communicate various control information
Created by	CONAV Group - florian.haeusler@fokus.fraunhofer.de
Assigned partner	Group or partner from SP3
Source (TEAM application or enabler)	CONAV
Requirement category	Functional
Goal	For some control approach, we wish to share information about desired control values (e.g. desired traffic flow per edge). It is not a status info, it is a desired value.
Definition:	Stakeholders, which are allowed to edit the network control info (there shall be different rights for authorities, who may edit information which leads to more or less direct influences on traffic, but also third parties, which may update the information they gave earlier like time schedules from public transport) should be able to do that with help of a unified interface (API and software). The edited information (see above) may have metadata to describe it (e.g. reliability information, time to live information etc.).
Critical level (priority)	High
Validation Method (tests,	Test if information has been edited and propagated in

indicators, performance bounds)	time and in a reliable way.
Acceptance criteria	Relevant users (traffic managers) accept the interface. Edited information is propagated correctly. Edited information is propagated in time.
Relationship with other requirements	The interface given to users (like the traffic management centers) may be the same as in SP4_REQ_CONAV_SP3_01.
Potential conflicts	None seen.
Risk analysis	Stakeholders may update information with conflicting information. People who do not have the rights to edit control information shouldn't have the possibility to do so as these information and controls could lead to a traffic chaos. Rights to edit the information are sensible. Only validated users should be able to edit information.
Status	New
Other	None

Requirement ID:	SP4_REQ_CONAV_SP3_03
Name of requirement:	Network info updates should (also) be pushed to users if the info is important
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	Group or partner from SP3
Source (TEAM application or enabler)	CONAV
Requirement category	Functional
Goal	There might be very important information, which are relevant in routing. For instance there is a disaster on the

	route, the central instance shall have the possibility to push the information to drivers and travellers independently from what has been defined by the user. The traffic manager shall define this feature of the information.
Definition:	See Goal.
Critical level (priority)	Medium.
Validation Method (tests, indicators, performance bounds)	Functional test.
Acceptance criteria	User acceptance (mainly HMI) from traffic manager (or relevant user). Functional test (info shall arrive in real-time) at users.
Relationship with other requirements	Connect to SP4_REQ_CONAV_SP3_01 and SP4_REQ_CONAV_SP3_02 -, the difference is, that we may want to flag the info described in the other requirements.
Potential conflicts	None.
Risk analysis	The risk is low as possible absence of such information will not affect application proper operation. Moreover, it is an assumption (and thus considered in the system or application design), that applications do not need to have a constant communication link to a central infrastructure (e.g. in tunnels). That means that it must be taken into account, that the applications consider that.
Status	New.
Other	None.

Requirement ID:	SP4_REQ_CONAV_SP3_04

Name of requirement:	Right management for editing routing-relevant information
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	Group or partner from SP3
Source (TEAM application or enabler)	CONAV
Requirement category	Functional
Goal	Only selected users shall have the right to edit routing-relevant information.
Definition:	There shall one instance, which defines the rights from other relevant users to edit information centrally which leads to adapted routing of individual vehicles.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional test
Acceptance criteria	Functional test successful
Relationship with other requirements	Relates to the requirements where relevant info (forecasts, control info) is edited: SP4_REQ_CONAV_SP3_01, SP4_REQ_CONAV_SP3_02, SP4_REQ_CONAV_SP3_03
Potential conflicts	None.
Risk analysis	The risk of improper access to data. Basically, these are the same risks as in SP4_REQ_CONAV_SP3_01. TEAM user rights mechanism will ensure that this risk will be minimised.
Status	New.
Other	None.

4.5 Green, safe and collaborative serious game and community building

Requirement ID:	SP4_REQ_SGCB_PMET_v0.1
Name of requirement:	Computation of performance metrics
Created by	UniGe - franz@elios.unige.it
Assigned partner	SP3 Applications
Source (TEAM application or enabler)	Serious Game and Community Building (SG_CB)
Requirement category	Serious gaming and community building
Goal	To ensure that all the SP3 applications interact with the SG
Definition:	Every SP3 application should define its user performance evaluation metrics, so that, during the drive, positive feedback can be given to the SG/Community Building application so that it can incentivize proper usage of each SP3 application. The SG/CB application shall convert the user feedback coming from the SP3 (and 4) applications into virtual coins that, in turn, could be spent on acquiring higher quality of services in the SP3 (and 4) applications, thus building a virtuous cycle.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Verify the quality/relevance of the real-time user performance assessment implemented by each SP3 application
Acceptance criteria	Good user performance evaluation
Relationship with other requirements	SP4_REQ_SGCB_SPCO_v0.1

Potential conflicts	None
Risk analysis	Lack of link to the SG/Community Building application would deprive the driver of a compelling way of continuously verifying and improving his performance in using an SP3 application. Links will be included to applications HMI design to minimise this risk.
Status	New
Other	No

Requirement ID:	SP4_REQ_SGCB_SPCO_v0.1
Name of requirement:	Spending virtual coins on application quality levels
Created by	UniGe - franz@elios.unige.it
Assigned partner	SP3 Applications
Source (TEAM application or enabler)	Serious Game and Community Building (SG_CB)
Requirement category	Serious gaming and community building
Goal	To ensure that all the SP3 applications interact with the SG
Definition:	Every SP3 application should be able to provide different levels of services (e.g., in terms of contents, look & feel, quality and timeliness of information, etc.) so that the user can spend virtual coins to access better levels of service
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Verify the quality/relevance of the differentiation among the various access levels within an application

Acceptance criteria	Good access level offer by each application
Relationship with other requirements	SP4_REQ_SGCB_PMET
Potential conflicts	None
Risk analysis	Lack of link to the SG/Community Building application would deprive the driver of a compelling way of continuously verifying and improving his performance in using an SP3 application. Links will be included to applications HMI design to minimise this risk.
Status	New
Other	No

Requirement ID:	SP4_REQ_SGCB_CuTrSt
Name of requirement:	Get the current traffic state
Created by	SP4_SGCB - franz@elios.unige.it
Assigned partner	SP3
Source (TEAM application or enabler)	SGCB
Requirement category	Traffic information
Goal	Provide the taffic state in specific area of the network
Definition:	The system should provide periodic (every 5 minutes) updates about the traffic state in all the roads
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional and user acceptance tests

Acceptance criteria	User acceptance of the provided information and usability of the interface
Relationship with other requirements	SP4_CDM_R_00013 SP4_CDM_R_00011 SP4_REQ_SGCB_AccInf SP4_REQ_SGCB_RoRes SP4_REQ_SGCB_TrafJamInf
Potential conflicts	None
Risk analysis	Traffic information is necessary for the collaborative map. Traffic information provision is a basic TEAM design concept and the risk of not having such information will be low.
Status	New
Other	No

Requirement ID:	SP4_REQ_SGCB_TrafJamInf
Name of requirement:	Availability of realtime information about traffic jams
Created by	SP4_SGCB - franz@elios.unige.it
Assigned partner	SP3
Source (TEAM application or enabler)	SGCB
Requirement category	Traffic information
Goal	Provide immediate and update information about traffic jams in the road network
Definition:	The system should provide immediate notification and periodic (every 5 minutes) updates about traffic jams in all the roads
Critical level (priority)	High
Validation Method (tests,	Functional and user acceptance tests

indicators, performance bounds)	
Acceptance criteria	User acceptance of the provided information and usability of the interface
Relationship with other requirements	SP4_CDM_R_00013 SP4_CDM_R_00011 SP4_REQ_SGCB_CuTrSt SP4_REQ_SGCB_RoRes SP4_REQ_SGCB_AccInf
Potential conflicts	None
Risk analysis	Absence of traffic jam information would decrease the content value of the map, especially with respect to the customers' expectation. However, for the sake of the application, it could be at least partially replaced with traffic information.
Status	New
Other	No

Requirement ID:	SP4_REQ_SGCB_AccInf
Name of requirement:	Availability of realtime information about accidents
Created by	SP4_SGCB - franz@elios.unige.it
Assigned partner	SP3
Source (TEAM application or enabler)	SGCB
Requirement category	Traffic information
Goal	Provide immediate and update information about accidents in the road network
Definition:	The system should provide immediate notification and periodic (every 5 minutes) updates about accidents in all

	the roads
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional and user acceptance tests
Acceptance criteria	User acceptance of the provided information and usability of the interface
Relationship with other requirements	SP4_CDM_R_00013 SP4_CDM_R_00011 SP4_REQ_SGCB_CuTrSt SP4_REQ_SGCB_RoRes
Potential conflicts	None
Risk analysis	Absence of accident information would decrease the content value of the map, especially with respect to the customers' expectation. It could be partially replaced with traffic information.
Status	New
Other	No

Requirement ID:	SP4_REQ_SGCB_RoRes
Name of requirement:	Availability of realtime information about road restrictions
Created by	SP4_SGCB - franz@elios.unige.it
Assigned partner	SP3
Source (TEAM application or enabler)	SGCB
Requirement category	Traffic information
Goal	Provide immediate and update information about restrictions in the road network

Definition:	The system should provide immediate notification and periodic (every 5 minutes) updates about restrictions in all the roads
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional and user acceptance tests
Acceptance criteria	User acceptance of the provided information and usability of the interface
Relationship with other requirements	SP4_CDM_R_00013 SP4_CDM_R_00011 SP4_REQ_SGCB_CuTrSt
Potential conflicts	None
Risk analysis	Absence of road restriction information would decrease the content value of the map, especially with respect to the customers' expectation. It could be partially replaced with traffic information.
Status	New
Other	No

Requirement ID:	SP4_REQ_SGCB_MapDataAggreg
Name of requirement:	Data aggregation on a collaborative map
Created by	SP4_SGCB - franz@elios.unige.it
Assigned partner	SP3
Source (TEAM application or enabler)	SGCB
Requirement category	Miscellaneous: Traffic information and user data
Goal	Support aggregation of hetereogeneous data inside a

	collaborative map
Definition:	A mapping system able to aggregate and manage (and matching) highly dynamic information layers in the cloud (also including geo-tagging and geo-messaging by drivers and passengers)
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional and user acceptance tests
Acceptance criteria	User acceptance of the provided information and usability of the interface
Relationship with other requirements	SP4_REQ_SGCB_CuTrSt SP4_REQ_SGCB_RoRes SP4_REQ_SGCB_AccInf SP4_REQ_SGCB_TrafJamInf
Potential conflicts	None
Risk analysis	The main risks concern usability (presentation of the aggregated values) and meaningfulness of aggregation themselves, especially in areas/periods with low vehicle density. Attention should be paid to early lab tests for identifying the best solutions, thus reducing risks of a negative impact on the users.
Status	New
Other	No

5 FLEX enablers

The word "enabler" is used for data or aggregated data, tools and algorithms to be used by the applications. These enablers will be used not only in FLEX applications but also in DIALOGUE ones.

The *first group* of enablers consists of **data or aggregated data** that will support application development. The *second group* of enablers comprises **algorithms** which serve the applications. The *third and last group* of enablers include the **tools** that will be developed in this sub-project.

As already stated in the introduction of this document in D1.0 a first draft list of enablers relevant to different FLEX applications were already identified. This list was refined based on the work performed by each application working group and on the outcome of the application functionalities task. Also the requirements to the elastic infrastructure received from DIALOGUE completed the list of FLEX enablers which are described in this chapter.

Based on the application requirements that were highlighted in the two previous chapters we initially specify the enablers in the following. The work is divided into two sub-chapters, the first related with FLEX applications needs while the latter related with DIALOGUE applications needs.

5.1 FLEX internal

In the following the internal FLEX enablers are presented per category. The relevant applications as well as the associated applications requirements are also highlighted.

5.1.1 Data enablers

Enabler	Associated Requirements	Relevant applications
LDM++ tables/features: Integrate the LDM++ database with tables/features for supporting FLEX needs and applications (e.g. for supporting collaborative traffic monitoring and control functionalities). Note: The tables/features needed by FLEX side will be addressed during the specifications phase to the EMPOWER LDM++ group. The ideal solution would be to receive the LDM++ tailored to FLEX needs directly from EMPOWER and not develop a new enabler in FLEX.	SP3_REQ_Int_CMC_13_v1.0 SP3_REQ_Int_COPLAN_6_v1.0 SP3_REQ_Int_COPLAN_7_v1.0 SP3_REQ_Int_CPTO_7_v1.0 SP3_REQ_Int_CPTO_8_v1.0	CMC COPLAN CPTO
Public transport (PT) information: • Public transport timetables and routes • Data on the public transport vehicle fleet (location, availability, load)	SP3_REQ_Int_CMC_4_v1.0 SP3_REQ_Int_COPLAN_4_v1.0 SP3_REQ_Int_CPTO_4_v1.0 SP3_REQ_Int_CPTO_5_v1.0	CMC COPLAN CPTO
Traveller information: A module retrieving user centric information regarding starting position (start point) and intended destination (end point) along with their departure time, time constraints and user preferences (also avatar related) e.g. optimization criteria such as time to reach their destination, environmental impact, number of modes' changes, transportation type etc. Note: This has to be addressed and discussed with DIALOGUE since this SP is working with the traveller side.	SP3_REQ_Int_CMC_3_v1.0 SP3_REQ_Int_COPLAN_1_v1.0 SP3_REQ_Int_CCA_1.3_v1.0 SP3_REQ_Int_CCA_1.6_v1.0 SP3_REQ_Int_CPTO_1_v1.0	CMC COPLAN CCA CPTO
Vehicle information: A module receiving information about the status	SP3_REQ_Int_CMC_1_v1.0	CMC

of the vehicle itself and environmental conditions (based on the xFCD paradigm). This component aggregates all relevant static and dynamic vehicle characteristics (type, current speed, size, weight, load, passengers, etc). This component also supplies information about the vehicle itinerary and schedule (bus stops or deliveries). <u>Note:</u> This has to be addressed and discussed with DIALOGUE since this SP is working with the vehicle side and with EMPOWER that is also working on the vehicle signals part.	SP3_REQ_Int_CCA_1.3_v1.0 SP3_REQ_Int_CCA_1.6_v1.0	CCA
Transport infrastructure data: Raw data (coming from legacy road sensors and specific systems) and processed information about the current and forecasted status of the network (e.g. accidents, expected congestion, etc.), traffic control parameters (e.g. SPaT) and demand driving multi-layered policies.	SP3_REQ_Int_CMC_4_v1.0	CMC
User profiles: A module which includes the user profiles including also their preferences. To be defined together with other TEAM applications and especially with Serious gaming and Community building application.	SP3_REQ_Int_COPLAN_1_v1.0 SP3_REQ_Int_CCA_1.1_v1.0 SP3_REQ_Int_CCA_2_v1.0 SP3_REQ_Int_CPTO_1_v1.0	COPLAN CCA CPTO
Data on traveller demand and time constraints: A module aggregating all the relevant information from the travellers into a time based data base, that is a module collecting all users' starting position (start point) and intended destination (end point) along with their departure time (and possibly their expected time to reach their destination), and their tentative preferences regarding the means of transport they will take and the route they will follow.	SP3_REQ_Int_COPLAN_6_v1.0 SP3_REQ_Int_CPTO_7_v1.0	COPLAN CPTO
Real-time traffic data (incl. accidents): This module retrieves traffic	SP3_REQ_Int_CMC_10_v1.0	CMC

information (such as low/high congested routes/road segments) and possible temporary, current or short/long term unavailability status information for specific road segments (e.g. in case of an accident, flood, civil works etc.). This enabler is linked to the "Collaborative pro-active urban/inter-urban monitoring and ad-hoc control" application and/or 3rd parties.	SP3_REQ_Int_CPTO_6_v1.0 SP3_REQ_Int_DC_12_v1.0	CPTO DC
Real-time or planned traffic data from 3rd parties such as: • Public Safety Answering Points (PSAP), police or fire brigade: providing information about an emergency incident that took place on the road, or at a specific location, • Municipality services, road operators etc.: e.g. providing information regarding planned civil works that will be performed on a part of the road at specific dates, thus rendering specific roads or lanes inaccessible. • Historical traffic related data (e.g. any kind of info gathered from TEAM users). <u>Note:</u> In the specifications and design phase it will be checked which 3rd party information will be actually supported in TEAM	SP3_REQ_Int_CMC_4_v1.0 SP3_REQ_Int_COPLAN_3_v1.0 SP3_REQ_Int_COPLAN_4_v1.0 SP3_REQ_Int_COPLAN_6_v1.0 SP3_REQ_Int_DC_12_v1.0	CMC COPLAN DC
User Activity (O/D) Identification: This function support CCA application by providing the typical and next predicted activity of the user which includes: • Location of the next activity • Possibly the Transport mode selection for the undertaken trip • Duration of the activity • Type of activity	SP3_REQ_Int_CCA_1.1_v1.0 SP3_REQ_Int_CCA_1.6_v1.0 SP3_REQ_Int_CCA_1.7_v1.0	CCA

• Recurrence status of the activity Requirements of the functions are: • Connection to user social network media, in particular Twitter • Recording of information from the user, particularly his/her location and time • Current and past performed trips (origin , destination, time, duration and transport means)		
Intersection information: A component that contains information about coming phase and time for main traffic lights in an intersection	SP3_REQ_Int_CSI_1_v1.0 SP3_REQ_Int_CSI_2_v1.0	CSI
Local regulations: A component that have a set of special regulations for selected areas (noise, emission, speed, safety)	SP3_REQ_Int_DC_3_v0.1 SP3_REQ_Int_DC_4_v0.1	DC

5.1.2 Algorithm enablers

Enabler	Associated Requirements	Relevant applications
Collaborative data aggregation/validation/fusion: This module fuses information from different sources e.g. collaborative vehicle data with infrastructure data and validates the received information from the infrastructure side	SP3_REQ_Int_CMC_5_v1.0	CMC
Traffic forecast: This module provides a traffic forecast based on the needs of all TEAM applications	SP3_REQ_Int_CMC_7_v1.0 SP3_REQ_Int_DC_13_v1.0	CMC DC
Multi-layered policies agent: This algorithm is in charge to consider all the available information and the constraints given by the operator to	SP3_REQ_Int_CMC_9_v1.0	CMC

create ad-hoc multi-layered traffic control policies and generate events to be used as an input from vertical applications such as COPLAN and CCA (e.g. expected congestion, re-routing, etc.)		
Traffic control optimization: This algorithm extends multi-layered policies agent and aims at the definition of the local optimal control to be applied e.g. at the intersection level and/or at road section level, taking into account all the needs of vertical applications (e.g. Smart Intersection-PT priority, Green Corridors, etc.) including DIALOGUE applications and use cases (e.g. collaborative start & stop). Pro-active optimisation carried out by this enabler is based on parameters such as queuing vehicles, average delay, fuel consumption, pollutants emissions and includes collaborative functionalities to be developed in cooperation with DIALOGUE.	SP3_REQ_Int_CMC_6_v1.0 SP3_REQ_Int_CMC_8_v1.0 SP3_REQ_Int_CSI_12_v0.1 SP3_REQ_Int_DC_8_v1.0 SP3_REQ_Int_DC_9_v1.0 SP3_REQ_Int_DC_14_v1.0 SP3_REQ_Int_DC_15_v1.0 SP3_REQ_Int_DC_17_v1.0 SP3_REQ_Int_DC_20_v1.0	CMC CSI DC
Ideal path algorithm: Co-modal algorithm for the dynamic identification of the ideal co-modal trip to be followed (differently from the consolidated approach in transportation engineering, not necessarily the shortest one in terms of distance/time). To be interfaced/integrated with the "Trip Simulator" tool	SP3_REQ_Int_CCA_3_v1.0	CCA
Impact assessment algorithm: This algorithm aims at the estimation of the impact of the real co-modal trip carried out by the traveller in terms of travel time, costs, fuel consumption, pollutants emissions, etc. Potential integration with ideal path algorithm for what concerns the Avatar trip (to be further studied in the next phases)	SP3_REQ_Int_COPLAN_12_v1.0 SP3_REQ_Int_CCA_5_v1.0 SP3_REQ_Int_CCA_12_v1.0	COPLAN CCA
Routing algorithm providing alternative routes and transportation modes based on COPLAN data modules, and based on various optimization criteria such as: time to reach their destination,	SP3_REQ_Int_COPLAN_2_v1.0 SP3_REQ_Int_COPLAN_9_v1.0 SP3_REQ_Int_COPLAN_10_v1.0	COPLAN

environmental impact, number of modes' changes, transportation type etc.	SP3_REQ_Int_COPLAN_12_v1.0 SP3_REQ_Int_COPLAN_14_v1.0	
Algorithm processing historical traffic related data for the generation of dynamic statistics (e.g. moving average) of a given road intersection or location, or even along a computed route.	SP3_REQ_Int_COPLAN_10_v1.0 SP3_REQ_Int_CPTO_20_v1.0	COPLAN CPTO
Prediction algorithm for traveller demand: This algorithm calculates the demand per time frame, per transport means (e.g. bus, train, taxi), per route segment etc. in terms of number of passengers.	SP3_REQ_Int_COPLAN_11_v1.0 SP3_REQ_Int_CPTO_19_v1.0	COPLAN CPTO
Algorithm performing real-time evaluation and computation of predictive traffic development based on information regarding real-time events as well as on information input from the prediction algorithm for traveller demand; based on the fact that the vehicle needs time to arrive up to the event, which is changing over time and therefore alters the time-of-arrival continuously.	SP3_REQ_Int_COPLAN_10_v1.0	COPLAN
Algorithm performing multi-vehicle routing for global optimization of a fleet of vehicles collaborating to compute individual routes in a coordinated way - link to SP4's CONAV.	SP3_REQ_Int_COPLAN_12_v1.0 SP3_REQ_Int_COPLAN_14_v1.0 SP3_REQ_Int_COPLAN_15_v1.0	COPLAN
Road status assessment module: For assessing the current situation on the road and identifying blocked routes and involved buses. This module will use as input the real-time traffic data and public transport data and will provide a list of blocked routes and involved buses.	SP3_REQ_Int_CMC_6_v1.0 SP3_REQ_Int_COPLAN_8_v1.0 SP3_REQ_Int_CPTO_9_v1.0 SP3_REQ_Int_CPTO_10_v1.0	CMC COPLAN CPTO
Time related Origin-Destination matrix module: A module to dynamically estimating the Origin-Destination matrix of users for a certain time window.	SP3_REQ_Int_COPLAN_11_v1.0 SP3_REQ_Int_CPTO_19_v1.0 SP3_REQ_Int_CPTO_20_v1.0	COPLAN CPTO
Event scheduling module: The public transport operator should be somehow aware of an event and the relevant requirements in order to	SP3_REQ_Int_CPTO_16_v1.0	CPTO

serve the attendees (opening, closing hours, amount of people expected etc.) and calculate the best alternative routes and frequencies for buses to head to or out of the event.		
Alternative routes calculator module: Based on the output of the "Road status assessment" module and the current routes of the involved buses this module proposes alternative routes.	SP3_REQ_Int_CPTO_11_v1.0	CPTO
Bus stops handler module: A module for dynamically calculating (adding and/or skipping) bus stops based on the real-time travellers' demand. This module should quickly aggregate the input data from the travellers and optimize the list of bus stops and inform accordingly bus drivers and travellers should be implemented. <u>Note:</u> The issue of people not using the TEAM services should be further investigated and it should be checked if this enabler will be implemented in FLEX (to be decided in the design phase)	SP3_REQ_Int_CPTO_12_v1.0 SP3_REQ_Int_CPTO_15_v1.0	CPTO
Headway calculation and adaptation module: A module that monitors the headway between buses as well as the demand and the current traffic situation and dynamically adapts the headway.	SP3_REQ_Int_CPTO_15_v1.0 SP3_REQ_Int_CPTO_17_v1.0	CPTO
Bus drivers coaching module: A module for calculating and recommending speeds and time slots that the bus drivers have to leave the bus stops (also disseminate the relevant information to the travellers).	SP3_REQ_Int_CPTO_14_v1.0 SP3_REQ_Int_CPTO_15_v1.0	CPTO
Traveller and bus association module: A module that detects whether a traveller is currently on a particular bus. This module enables us to give travel recommendations not only based on GPS location, but also on the current bus route and schedule.	SP3_REQ_Int_CPTO_18_v1.0	CPTO

Prediction algorithm for future (short/long term) changes in bus schedules/routes etc.: This algorithm processes historical information regarding the traffic conditions for specific timeframes and road segments and calculates/predicts future (short/long term) changes in bus schedules/routes etc.	SP3_REQ_Int_CMC_6_v1.0 SP3_REQ_Int_CPTO_19_v1.0	CMC CPTO
Individual traveller journey planner: A module which based on the updated schedules, the traveller O/D and current position provides in real-time information to the traveller such as: ● the current location of the bus of interest, ● the time they have to wait at the stop for the bus, ● info on the forthcoming stations, ● the estimated time to their destination, ● considerable delays on the route of interest, ● suggestions on alternative routes <u>Note:</u> The target in this application (as in all TEAM applications) is the optimization of the overall network's efficiency, so this module provides the abovementioned information to the traveller based on this assumption.	SP3_REQ_Int_COPLAN_2_v1.0 SP3_REQ_Int_CPTO_2_v1.0 SP3_REQ_Int_CPTO_21_v1.0	COPLAN CPTO
Prioritization algorithms: Algorithms that can analyze priority of vehicles according to a set of criteria (can be used for dedicated lanes, regulated areas and also intersections)	SP3_REQ_Int_CSI_8_v1.0 SP3_REQ_Int_CSI_9_v1.0 SP3_REQ_Int_CSI_10_v1.0 SP3_REQ_Int_CSI_11_v1.0 SP3_REQ_Int_CSI_14_v1.0	CSI

5.1.3 Tool enablers

Enabler	Associated Requirements	Relevant applications
Gateways (a tool that aggregates heterogeneous data from various input sources, e.g. 3rd parties and other applications, and processes them to a common data format) for integrating data enablers provided in section 4.1.1 into a format usable by all FLEX applications. An example is the gateway which integrates info from different public transport operators that is needed from most FLEX applications.	SP3_REQ_Int_CMC_4_v1.0 SP3_REQ_Int_COPLAN_5_v1.0 SP3_REQ_Int_CPTO_5_v1.0	CMC COPLAN CPTO
Collaborative map matching: A module that map match the data of interest. A common standard protocol should be implemented (e.g. starting from the S.I.M.O.N.E. protocol) so that all applications/input/output information is consistent and uses the same reference system.	SP3_REQ_Int_CMC_2_v1.0	CMC
A module that serves the information/data exchange between the end-user and the central application platform; that is an application layer communication module that uses the underlying communication interface/module of the end-device. An example could be a module that serves the information/data exchange between the traveller and bus driver devices and the central application platform.	SP3_REQ_Int_COPLAN_5_v1.0 SP3_REQ_Int_COPLAN_16_v1.0 SP3_REQ_Int_COPLAN_17_v1.0 SP3_REQ_Int_CPTO_3_v1.0 SP3_REQ_Int_CPTO_22_v1.0 SP3_REQ_Int_CPTO_23_v1.0 SP3_REQ_Int_CPTO_24_v1.0	COPLAN CPTO
B2B information service: To be used to deliver traffic info to internal and external actors (mainly vertical FLEX and DIALOGUE applications).	SP3_REQ_Int_CMC_10_v1.0 SP3_REQ_Int_CMC_12_v1.0	CMC
Traveller trip monitor: A module that monitors the trip of the traveller	SP3_REQ_Int_CCA_3_v1.0	CCA

in order to support his coaching either in real-time or during the post trip analysis	SP3_REQ_Int_CCA_7_v1.0 SP3_REQ_Int_CCA_8_v1.0 SP3_REQ_Int_CCA_9_v1.0	
Avatar trip simulator to run the ideal path algorithm and then generate the ideal trip followed by the Avatar. The concept is rather different than tradition micro-simulators used for Decision Support and evaluations, therefore a specific study is needed.	SP3_REQ_Int_CCA_4_v1.0 SP3_REQ_Int_CCA_6_v1.0 SP3_REQ_Int_CCA_8_v1.0 SP3_REQ_Int_CCA_9_v1.0	CCA
Social driving app interface: A component that can grade drivers based on their behaviour	SP3_REQ_Int_CCA_1.2_v1.0 SP3_REQ_Int_CCA_1.5_v1.0 SP3_REQ_Int_DC_5_v1.0 SP3_REQ_Int_DC_6_v1.0	CCA DC
Simulator: Simulators such as VSimRTI will be examined for testing. Also traffic simulators such as TSS Aimsun and CUBE Dynasim will be investigated for testing and benchmarking	N/A	All FLEX applications

5.2 DIALOGUE related

In the following the FLEX enablers deriving from DIALOGUE applications needs are presented per category. The relevant applications as well as the associated applications requirements are also highlighted.

5.2.1 Data enablers

Enabler	Associated Requirements	Relevant applications
A **traffic light interaction module** which provides the current status of the traffic light, the current switching times and a	SP4_REQ_CACC_TRAFFIC-LIGHTS_v0.1 SP4_CDM_R_00029	C-ACC CDM

proper way for TEAM equipped vehicles to request changes to the traffic light switching times. Also the same or an additional module should handle the traffic light requests by the vehicles and provide relevant information to them.		
Parking requests and indications module: A module that can receive parking requests from the Collaborative parking application and responds with proper parking indications including the needed information e.g. available parking spot location(s), type of available parking, accuracy in the location of the parking spot etc.	SP4_REQ_EFP_PARKIND_v0.1 SP4_REQ_EFP_PARKTYPE_v0.1 SP4_REQ_EFP_PARKINDREQTYPE_v0.1 SP4_REQ_EFP_LOCACCURACY_v0.1 SP4_REQ_EFP_VEHUSERDATA_v0.1	EFP
Road restriction information module: Provides information with respect to road restrictions along the vehicle path. Example of road restrictions are road works, accidents, presence of an obstacle or any other. The location, validity and the area affected by the restriction should be communicated to the drivers	SP4_CDM_R_00001 SP4_REQ_SGCB_RoRes SP4_REQ_SGCB_AccInf	CDM SG-CB
Weather information provider module: Provides current and forecasted weather condition at the vehicles position. This module also provides information on the status of the road surface e.g. presence of ice, slippery road etc. <u>Note:</u> About the latter we have to check if this info will be available in TEAM	SP4_CDM_R_00012	CDM
Static and dynamic traffic rules module: Provides the current (static or dynamic) traffic rule e.g. speed limit, turning	SP4_CDM_R_00020	CDM

rules/allowed manoeuvres, lane restriction/closure, presence of stop lines, presence of giveway/precedence among manoeuvres etc.		
Traffic information module: Transmits any abnormal traffic condition affecting the vehicle's route or area of movement. This includes presense of obstacles, accident, incident, change in the traffic condition etc. It also provides the traffic status in a specific area of the network.	SP4_CDM_R_00021 SP4_REQ_SGCB_CuTrSt	CDM SG-CB
Traffic control module: Traffic managers should be able to communicate various control information Note: Probably this functionality will be covered by the output of the CMC application and no additional enabler will be needed but it is listed here for completeness	SP4_REQ_CONAV_SP3_02	CONAV
Map data aggregation module: A mapping system able to aggregate and manage highly dynamic information layers in the cloud (also including geo-tagging and geo-messaging by drivers and passengers)	SP4_REQ_SGCB_MapDataAggreg	SG-CB

5.2.2 Algorithm enablers

Enabler	Associated Requirements	Relevant applications
A module that **adapts the current maximum speed** of certain road segments dynamically Note: Probably this functionality will be covered by the output of the CMC application and no additional enabler will be needed but it is listed here for completeness	SP4_REQ_CACC_ROADSPEED_v0.1	C-ACC
A module for **calculating traffic jams** and their characteristics e.g. length, estimated duration of the traffic jam etc. Note: Probably this functionality will be covered by the output of the CMC application and no additional enabler will be needed but it is listed here for completeness	SP4_REQ_CACC_TRAFFIC-INFO_v0.1 SP4_REQ_SGCB_TrafJamInf	C-ACC SG-CB
Parking booking module: This module should handle parking booking requests and prioritize them according to the confidence information provided by DIALOGUE. Also this module should handle future booking requests.	SP4_REQ_ EFP_BOOKREQUEST_v0.1 SP4_REQ_ EFP_BOOKREQUESTCONF_v0.1 SP4_REQ_ EFP_ PARKBOOKDATAMNG_5	EFP
Parking availability inference module: This module calculates the availability of parking slots in an area or sub-area. This concerns both current and future estimations of availability of parking places. Note: This is highly depended on the legacy parking systems	SP4_REQ_EFP_CURRPARKAVAILINF_v0.1 SP4_REQ_EFP_FUTPARKAVAILINF_v0.1	EFP

and on the available equipment at the relevant test sites and will be analysed further in the specification and design phase.		
A module for assessing and transmitting important information to the users: Network info updates should (also) be pushed to users in case the information is considered important (we have to define a set of information which are considered as relevant to be transmitted)	SP4_REQ_CONAV_SP3_03	CONAV

5.2.3 Tool enablers

Enabler	Associated Requirements	Relevant applications
A **module for gathering and storing TEAM equipped vehicles information** such as their current speed and position and their emission characteristics in order for the Collaborative ACC to have access to that info and perform the relevant algorithms (e.g. calculate a certain emission budget for each vehicle).	SP4_REQ_CACC_TRAFFIC-SITUATION_v0.1	C-ACC
Collaborative parking state notification handler module: This module handles the notifications issued by the user or the vehicle leaving a parking spot and informs other interested vehicles in the area.	SP4_REQ_EFP_COLLABPARK_v0.1 SP4_REQ_EFP_COOPPARK_v0.1	EFP
A module which continuously updates the information	SP4_REQ_CONAV_SP3_01	CONAV

linked to the road network edges. This include pollution information, traffic flow information, speed limits, access information, forecasted information. Stakeholders, which are allowed to edit the network information should be able to do that with help of a unified interface (API and software) Note: Probably this functionality will be covered by the output of the CMC application and no additional enabler will be needed but it is listed here for completeness		
Management of write access of the users to the central infrastructure. This is an important aspect of TEAM that might be considered in SP2 or SP3 generally speaking (this might be overlapping with the first enabler of CONAV above)	SP4_REQ_CONAV_SP3_04	CONAV

6 Conclusion

This document summarizes the results of the work performed within WP33 *Requirements and specification* at the moment of writing of this deliverable. This deliverable fulfils the DoW task that is to highlight the requirements and specifications of FLEX enablers and applications based on the input from the use cases provided by the previous WP. This task includes the FLEX applications requirements to the elastic transport infrastructure, the requirements of DIALOGUE applications to the infrastructure side as well as the identification of the needed FLEX enablers to support all TEAM applications and their mapping to the relevant application requirements.

The main objective of this document is to emphasize the work performed with the requirements in the elastic transport infrastructure side (in FLEX) as well as the corresponding interactions and close cooperation needed both with the enabling technologies (in EMPOWER) and with the vehicle/traveller side (in DIALOGUE).

One of the main challenges of the work done is the identification of elastic infrastructure enablers based both on FLEX internal needs and their mapping to the application requirements as well as the enablers serving the needs of DIALOGUE applications through the respective requirements received be SP4.

The work performed within chapter 5 of this document, which is related to the enablers and their mapping to the applications requirements, is considered as the first step towards final specification and the definition of the elastic transport infrastructure's architecture.

The next step will be to refine and finalise this work and map the enablers to specific applications. Then based on a tabular template which is commonly discussed and defined among the different sub-projects the relevant specifications, such as related HW, interfaces etc., will be provided and they will be also associated with the existing requirements in this document. In addition to the tabular template, behavioural UML diagrams will be created to better specify and model the behaviour of FLEX applications and enablers.

The work on final specifications and on the architecture will run in parallel and the outcome will be included inside D2.0 *TEAM system specification and architecture* (available end of December 2013).

Concluding this document the reader should take into account the fact that a lot of work items run in parallel in the different sub-projects. Therefore, it must be stated, that the descriptions are not yet perfectly aligned, especially with the work performed in the other SPs, however this issue will be tackled in the next steps of the project, when specifications and architecture will be completed.

List of abbreviations and acronyms

Abbreviation	Meaning
ACC	Adaptive Cruise Control
API	Application Programming Interface
B2B	Business to business
B2C	Business to customer
C-ACC	Collaborative ACC
CAM	Cooperative Awareness Message
CCA	Co-modal coaching with support from virtual/avatar users
CDM	Collaborative driving and merging
CMC	Collaborative pro-active urban/inter-urban monitoring and ad-hoc control
CONAV	Collaborative eco-friendly navigation
COPLAN	Collaborative co-modal route planning
CPTO	Collaborative Public Transport Optimization
CSI	Collaborative smart intersection for intelligent priorities
DATEX 2 / DATEX II	DATEX II TS 16157 1-3, Standard for communicating and exchanging traffic information, http://www.datex2.eu/
DC	Dynamic collaborative corridors
EFP	Collaborative eco-friendly parking
ETSI	European Telecommunications Standards Institute
FCD	Floating car data; data and information collected by probe vehicles, typically speed and position
GLOSA	Green Light Optimal Speed Advisor
GNSS	Global navigation satellite system
GPS	Global Positioning System, a GNSS developed by US Department of Defence
HMI	Human machine interface
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
LDM	Local dynamic map
LDM++	TEAM concept based on the LDM
LTE	Long-term evolution, marketed as 4G LTE. Standard for wireless communication of high-speed data for mobile phones and data terminals.
MAP	Map Data (protocol for sending topology information continuously as broadcast)
PSAP	Public Safety Answering Points

Abbreviation	Meaning
PC	Personal Computer
PT	Public Transport
RSU	Road Side Unit
SG-CB	Green, safe and collaborative serious game and community building
SIRI	Service Interface for Real Time Information, model for real time public transport data exchange, http://www.kizoom.com/standards/siri/
SP	Sub-project
SPaT	Signal phases and timing of traffic lights
TMC	Traffic Management Centre
TPEG	Transport Protocol Experts Group
UC	Use case
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to Vehicle / Vehicle to Infrastructure
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/
WP	Work package
xFCD	Extended Floating Car Data

References

[1] TEAM FP7 integrated project , D1.0 "TEAM users, stakeholders and uses cases"

[2] TEAM FP7 integrated project, D4.3.1 "Requirements of DIALOGUE components, enablers and applications"

[3] TEAM FP7 integrated project, IR4.3.1 "DIALOGUE requirements to EMPOWER and to FLEX"

[4] TEAM FP7 integrated project, IR4.3.2 "Common format and defined processes for requirements engineering"

[5] Tomorrow's Elastic Adaptive Mobility (TEAM), FP7 integrated project, Nov. 2012 - Oct. 2016, website: https://www.collaborative-team.eu/.

Annex 1 Requirements tables for FLEX applications

A) Collaborative pro-active urban/inter-urban monitoring and ad-hoc control

The CMC requirements briefly highlighted in section 3.1 will be provided in more detail in the following by filling in the tabular template presented in Table 1-1.

Requirement ID	SP3_REQ_Int_CMC_1_v1.0
Name of requirement	Collaborative data collection from equipped vehicles
Created by	M. Cocozza (5T) - massimo.cocozza@5t.torino.it
Assigned partner	CMC development group
Source (TEAM application or enabler)	CMC application
Requirement category	Functional: - Application requirements
Goal	CMC shall be able to collect information (mainly Floating Car Data) from equipped vehicles and from fleets control centres.
Definition	Equipped Vehicles can provide real time data about traffic status/condition; these vehicles are able to collect at least their position, speed and direction plus a time stamp and send these info (raw data) to a fleet control centre. CMC shall be able to act as a fleet control centre directly managing raw data and/or shall be able to get aggregated data from other fleet control centres.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Data availability (Row data and aggregate data) matching time and geographical constraints. Tests of availability and accuracy of collected data by means of on-site

	surveys.
Acceptance criteria	Raw data and aggregated data have to be provided within 5 to 10 minutes (to be evaluated in the next phases of the project, probably a time window of 5 minutes will be the most appropriate solution) if they have to be used for real time traffic monitoring. Aggregate data need to be provided together with their accuracy (how many samples have been aggregated or statistical standard deviation)
Relationship with other requirements	Parent of: - SP3_REQ_Int_CMC_2_v1.0: CMC shall match collaborative vehicle info to the reference map Same level of: - SP3_REQ_Int_CMC_3_v1.0: CMC shall be able to collect collaborative information from TEAM travellers
Potential conflicts	Not foreseen at this stage
Risk analysis	If the Req. is not implemented, then the application will not provide expected results in terms of collaborative data collection. In this case, the utilisation of simulation tools may help.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_2_v1.0
Name of requirement	Collaborative data collected via equipped vehicle matched to reference map
Created by	M. Cocozza (5T) - massimo.cocozza@5t.torino.it

Assigned partner	CMC development group
Source (TEAM application or enabler)	CMC application
Requirement category	Functional: - Application requirements
Goal	CMC shall be able to map match row data and aggregate all data available against a reference map and network.
Definition	Data coming from street need to be referenced on a known network in order to be used by CMC functions. Row data needs to be map matched and then joined with already aggregated data. The definition and availability of a reference network is crucial and mandatory.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Data availability on reference network. Statistics related to the availability of collaborative vehicle data in the TEAM TMC Database.
Acceptance criteria	Data availability on reference network respecting time constraint.
Relationship with other requirements	Child of: - SP3_REQ_Int_CMC_1_v1.0: Collaborative data collection from equipped vehicles
Potential conflicts	Not foreseen at this stage
Risk analysis	If the Req. is not implemented, then the application will not provide expected results in terms of efficiency in using the available collaborative data. Specific solution can be put in practice (e.g. by referring to object IDs, stored in the LDM++ database, in order to reduce map

	matching workload).
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_3_v1.0
Name of requirement	Collaborative data collection from TEAM travellers
Created by	F. Alesiani (NEC) - Francesco.Alesiani@neclab.eu
Assigned partner	CMC development group
Source (TEAM application or enabler)	CMC application
Requirement category	Functional: - Application requirements
Goal	CMC shall be able to collect collaborative information from TEAM travellers
Definition	CMC shall be able to collect collaborative information from TEAM travellers. TEAM traveller via some device shall be able to provide information on him/her self relevant for the application. Information including location, but also connection with social network systems.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Depending on the application configuration, this can include: • Check the single user has any device to input data • There is some device that automatically send data to TEAM application • There is a connection to a system where the user can

	input his/her data
Acceptance criteria	The possibility to input data into the application is essential; the minimum acceptance level is related to the impact of the application by using this information to provide benefits to the traveller.
Relationship with other requirements	Same level of: - SP3_REQ_Int_CMC_1_v1.0: Collaborative data collection from equipped vehicles - SP3_REQ_Int_CMC_4_v1.0: Integration of data coming from external providers/legacy systems
Potential conflicts	Not foreseen at this stage
Risk analysis	If the Req. is not implemented, then the application will not provide expected results for what concerns the integration of mobile devices data to collaborative vehicles data. In this case, the utilisation of simulation tools may help. However, the likelihood of this risk is lower, considering the higher amount of available nomadic devices.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_4_v1.0
Name of requirement	Integration of data coming from external providers/legacy systems
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	SP2 / SP3 CMC development group
Source (TEAM application or enabler)	CMC application

Requirement category	Functional: - Application requirements
Goal	CMC shall be able to integrate data coming from external providers/legacy systems
Definition	• CMC shall be able to collect and integrate data coming from external and legacy systems. • This implies the definition of a group of supported external / legacy systems and knowledge of the corresponding interfaces. • Interfacing external data providers will require the implementation of bridges between services (i.e. TEAM <–> non-TEAM services) in order to translate to a common format that CMC and other TEAM applications can understand. • CMC shall also support TEAM's messaging system and thus correct translation / fulfilment of message metrics have to be implemented in the service bridges.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	• Test to show two-way communication between CMC and external/legacy systems, i.e. bridge performance and capabilities. • Validation and ranking of trusted data sources shall be made by data fusion techniques (see SP3_REQ_Int_CMC_5_v1.0) • Test to demonstrate fulfilment of quality metrics for TEAM's messaging system
Acceptance criteria	CMC can extract and eventually request information from the external / legacy systems with no detriment on system performance.

Relationship with other requirements	Parent of: - SP3_REQ_Int_CMC_5_v1.0: Data fusion
Potential conflicts	Not foreseen at this stage
Risk analysis	Since there are a large number of information sources that are not directly related to TEAM, this Req. is fundamental to achieve the goals of the project. Integration will be finalised at SP5 level.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_5_v1.0
Name of requirement	Data fusion
Created by	CMC working groups - marco.bottero@swarco.com
Assigned partner	Swarco Mizar
Source (TEAM application or enabler)	CMC
Requirement category	Functional - Application requirements
Goal	CMC shall run data fusion techniques
Definition	CMC shall run data fusion techniques. This technique need to include all the data that comes from the different source and provide an integrated and consistent view of the traffic state
Critical level (priority)	High
Validation Method (tests, indicators, performance	Check the output information with respect to real condition and verify the accuracy is sufficient for the

bounds)	application to provide expected results.
Acceptance criteria	The result of the requirement shall be available through some interface. The acceptance criteria are that: • The data is generated timely (e.g. within 5 minutes) with respect to the input information. Time constraints will be defined in later stages of the project • The output accuracy is sufficient for the application
Relationship with other requirements	Child of: - SP3_REQ_Int_CMC_1_v1.0: Collaborative data collection from equipped vehicles - SP3_REQ_Int_CMC_3_v1.0: Collaborative data collection from TEAM travellers - SP3_REQ_Int_CMC_4_v1.0: Integration of data coming from external providers/legacy systems
Potential conflicts	Not foreseen at this stage
Risk analysis	If the requirement is not met, then the accuracy of the application may be threatened. Experienced partners within the consortium are committed with this req.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_6_v1.0
Name of requirement	Public Transport Optimisation Support
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	CMC and CPTO developers

Source (TEAM application or enabler)	CMC
Requirement category	Functional - Application requirements
Goal	CMC shall support PT optimisation functionalities
Definition	CMC shall support public transport optimization functionalities. That is, it shall be possible to influence traffic in a way that prioritises public transport.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Simulations and possibly real life tests can be used to validate this requirement.
Acceptance criteria	By improving public transport, more travellers will be able and willing to use public transport, which will in turn lead to less traffic and congestion and an overall improvement of traffic flows.
Relationship with other requirements	None
Potential conflicts	Not foreseen at this stage
Risk analysis	If the requirement is not met, public transport may be more susceptible to delays and timetable disturbances However, failure to meet this requirement will not harm the smooth operation of both CPTO and CMC.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_7_v1.0

Name of requirement	Traffic flow forecast
Created by	Swarco Mizar - marco.bottero@swarco.com
Assigned partner	CMC developers
Source (TEAM application or enabler)	CMC
Requirement category	Functional: - Application requirements
Goal	This requirement is aimed at defining the capability of the CMC application to calculate a reliable forecast of traffic flow parameters evolution
Definition	The TEAM TMC shall be able to forecast relevant traffic flow parameters such as: - Travel time - Vehicle flows - Length of the queue In the short (e.g. by time series extrapolation and filtering) and in the long time (e.g. by dynamic traffic assignment), starting from collaborative information coming from TEAM vehicles and travellers and, if useful, from data gathered from integrated sub-systems (e.g. existing legacy traffic monitoring systems).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Evaluation of the accuracy of traffic flow forecasts, to be measured in pilots in different traffic conditions and different demand patterns
Acceptance criteria	If the CMC application will carry out accurate traffic flows estimations, all the other FLEX and DIALOGUE applications will benefit of this reliable knowledge of

	incoming traffic conditions.
Relationship with other requirements	Child of: - SP3_REQ_Int_CMC_6_v1.0: CMC shall support PT optimisation functionalities - SP3_REQ_Int_CMC_8_v1.0: CMC shall optimise traffic control taking into account traditional and innovative parameters - SP3_REQ_Int_CMC_12_v1.0: CMC shall interface with other TEAM applications
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met: - Poor level of accuracy of other TEAM applications - Degraded operation of collaborative CMC functionalities (e.g. SPaT provisioning) Requirement met: - Need of a very robust communication layer to support the amount of data exchanged - Need of scalable computational resources, in order to run the forecast algorithms on large data sets
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_8_v1.0
Name of requirement	Traffic control optimisation
Created by	Swarco Mizar - marco.bottero@swarco.com
Assigned partner	CMC developers

Source (TEAM application or enabler)	CMC
Requirement category	Functional: - Application requirements
Goal	CMC shall optimise traffic control taking into account traditional and innovative parameters

Definition	The CMC application will be able to optimize collaborative traffic control both on the TMC side, by running pro-active traffic light control algorithms, and on the vehicle side, by enabling DIALOGUE V2I applications for intersection (e.g. collaborative GLOSA – SPaT provisioning) and lane (e.g. dynamic speed limit) assistance.
	
	Pro-active traffic control will be able to optimise strategy in real-time during the execution of the cycle by modifying timing and phases. Pro-active traffic control shall be able to optimize traffic lights operation by taking into account traffic parameters forecasts and policies coming from the local authorities, considering as part of optimization function parameters such as:
	
	- Traditional parameters:
	  o Queues
	  o Number of stops
	  o Travel time
	  o PT priority
	
	- Innovative parameters:
	  o Energy consumption
	  o Pollutants emissions
	  o Vehicles duty cycle

Critical level (priority)	High
Validation Method (tests,	Performance tests of TEAM traffic control functionalities

indicators, performance bounds)	in terms of:
	- Road network improvements in terms of:
	  ○ Capacity
	  ○ Travel time (classified)
	  ○ Delay (classified)
	  ○ Energy consumption
	  ○ Pollutants emissions
	- Collaborative functionalities reliability

Acceptance criteria	If the CMC application will carry out collaborative traffic control optimisation, all the other FLEX and DIALOGUE collaborative V2I applications will be enabled and/or their functionalities will be improved – therefore with significant benefits from the overall users' experience in TEAM. Requirement accepted if information exchange is set up and working with CMC and the specific vertical application.
Relationship with other requirements	Parent of: - SP3_REQ_Int_CMC_10_v1.0: CMC shall publish processed traffic info/events data for B2C applications - SP3_REQ_Int_CMC_15_v1.0: Collaborative traffic control shall be based on SPaT protocol - SP3_REQ_Int_CMC_17_v1.0: CMC shall support SIRI, TPEG and DATEX2 standards
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met: - Poor level of accuracy of other TEAM applications - Degraded operation of collaborative CMC functionalities

	Requirement met: - Need of a very robust communication layer to support the amount of data exchanged - Need of scalable computational resources, in order to run the optimisation algorithms on large areas and/or considering multiple variables - Data exchange standards-protocols will be needed (e.g. SPaT, DATEX2, TPEG)
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_9_v1.0
Name of requirement	Multi-layered policies support
Created by	INFOTRIP - tgiannopoulos@infotrip.gr
Assigned partner	CMC developers
Source (TEAM application or enabler)	CMC Application
Requirement category	Functional - Application Requirements
Goal	Defined multi-layered area-wide traffic control policies are supported and taken into account by the CMC Application both at a tactical and a strategic level (as detailed in deliverable "D1.0 TEAM users, stakeholders and use cases" version 1.5).
Definition	The CMC application has to support and take into account a number of multi – layered traffic control

	policies that are defined by the TMC. By doing so the CMC application will utilize commands given by the policies (both at tactical and strategic level) benefiting from the resulting optimization of the performance of the transportation network. • Strategic level refers to the management of the estimated operations of the Origin/Destination matrix and of traffic volumes assignment on the road system, according to the current and forecasted traffic conditions; these estimations are based on a larger calculation time interval. • Tactical level refers to the management of operations related to the on-line estimation on the status of the monitored network. Data validation and data fusion are implemented in this level, which provides also historical data (profiles) and elaborates predictions. The outcomes of these two levels are a number of multi-layered (strategic and tactical) policies that are applied to collaborative traffic control systems.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Performance indicators for network optimization. Benchmarking analyses based on: ○ Capacity ○ Travel time (calssified) ○ Delay (classified) ○ Energy consumption ○ Pollutants emissions
Acceptance criteria	TMC should verify: a) the correct implementation of multilayered policies support and

	b) the correctness and validity of the results by the use of the policies within the CMC application.
Relationship with other requirements	Parent of: - SP3_REQ_Int_CMC_7_v1.0: traffic flow forecast - SP3_REQ_Int_CMC_8_v1.0: traffic control optimisation
Potential conflicts	Not foreseen at this stage
Risk analysis	Risks for meeting the requirement: - Integration of different goals for traffic management within a city area (public vs private transport for example). Risks if requirement is not met: - Collaborative traffic management goals will not be met in full. In this case, local optimisation and related demonstrations will still be possible.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_10_v1.0
Name of requirement	Processed traffic info/events data publication for B2C applications
Created by	INFOTRIP - tgiannopoulos@infotrip.gr
Assigned partner	CMC developers
Source (TEAM application or enabler)	CMC
Requirement category	Functional: - Connectivity and communication requirements

Goal	CMC shall publish processed traffic info/events data for B2C applications.
Definition	CMC application will be able to publish processed traffic information and /or events in order to be used by B2C applications through standardized interfaces such as DATEX. Further clarification is required in whether this requirement is considered as a tool for the CMC application functionality or whether it is simply a side requirement.
Critical level (priority)	Medium The criticality depends on whether the published traffic information is considered as a tool for the CMC application or simply as a side deliverable. If it is part of the CMC application functionality (I.e. it is used for collaborative management) then this requirement is very critical. To be determined.
Validation Method (tests, indicators, performance bounds)	Connectivity Tests. Requirement accepted if information exchange is set up and working with CMC and the specific vertical application.
Acceptance criteria	The CMC application should provide easily understandable real-time information about nearby traffic events (such as: accidents, road closures, maintenance work, hazards etc) to B2C Applications. Coverage of the events and delay in B2B publication parameters shall be identified later in the project, in agreement with working groups of other applications.
Relationship with other requirements	Parent of: - SP3_REQ_Int_CMC_7_v1.0: traffic flow forecast
Potential conflicts	SP3_REQ_Int_CMC_9_v1.0:

	- Published information should be supporting the multi-layered traffic control policies and not come in conflict with them in any way.
Risk analysis	Risks for meeting the requirement: - Management of trusted (B2C) organizations. Risks if the requirement is not met: - In the case where published information is meant for the objectives of the CMC application, a management tool will be missing. - Poor impact of vertical FLEX applications
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_11_v1.0
Name of requirement	Degraded-mode Information support
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	CMC developers
Source (TEAM application or enabler)	CMC application
Requirement category	Non-Functional: - Security requirements
Goal	CMC will shift into degraded-mode in case of poor reliability of information
Definition	• CMC will issue messages to connected systems (e.g. SPaT prediction messages to RIS, or DENM messages to VIS) with the collected information containing a quality metric for the reliability of the

	provided information, e.g. QM_reliability = {good, poor, unknown}. When a quality metric is available in the standard message specification (e.g. "confidence" field in the SPaT message, as from SAE J2735 standard), it will be used for identifying degraded mode operation.
	• CMC will evaluate the information source in different ways:
	  ○ by requesting validity / reliability certificates (e.g. is the provided information certified to be true to a given degree?)
	  ○ by testing for data consistency over periodic requests, e.g. CMC will have to evaluate whether the source has noise, changes with given trend, or its data is random and thus unreliable
	• CMC will check the communication link by issuing test messages over the service bridge. If the link is unstable CMC will look for alternative information sources providing similar information.
	• After evaluation of the information, CMC will determine what information to deliver. If the data is very noisy but still has a certain degree of reliability, it will issue a message to the requesting application having the requested information. It will provide appropriate quality metrics labelling the information: QM_reliability = {good, poor, unknown}, QM_std_deviation = {figure} (if applicable), etc.
	• If the link is not reliable, CMC might decide to reduce the refresh rate of the information (by periodic information requests) and inform the requesting service with appropriate quality metric (e.g.

	QM_period = {figure}, QM_degraded_mode = {on,off}) or a specific message (e.g. CMC_UNRELIABLE_DATA, etc.)
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Test for the above functionality. Load test for the communication architecture. Test cases will be specifically defined.
Acceptance criteria	CMC effectively implements a degraded-reliability mode and is able to inform requesting applications when the mode is active. Applications are able to deal correctly with the degraded-reliability mode.
Relationship with other requirements	No
Potential conflicts	N/A
Risk analysis	It is foreseen that reliability issues regarding the many different information sources and how they convey and gather these information will be common. Therefore, CMC and other TEAM applications relying on this data need to assess the quality of the provided information. The proposed implementation will endow TEAM with graceful degradation capabilities. Failure to address this requirement can seriously deteriorate the quality and confidence of TEAM services.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_12_v1.0
Name of requirement	Vertical TEAM applications interface
Created by	Swarco Mizar - marco.bottero@swarco.com

Assigned partner	CMC developers
Source (TEAM application or enabler)	CMC
Requirement category	Non-functional: - General architectural and equipment requirements
Goal	The CMC Application will give B2B information services to other vertical TEAM applications
Definition	Self-explanatory
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Availability of information services for other TEAM applications (e.g. SPaT, dynamic speed limit info, PT priority policies, …)
Acceptance criteria	If the CMC application outcomes (mainly TMC-related information) will be available for other vertical TEAM applications, all of them will be enabled and/or their functionalities will be improved – therefore with significant benefits from the overall users' experience in TEAM
Relationship with other requirements	Parent of: - SP3_REQ_Int_CMC_13_v1.0: The TMC database defined in CMC application shall interface with LDM++ - SP3_REQ_Int_CMC_17_v1.0: CMC shall support SIRI, TPEG and DATEX2 standards
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met: - Low integration of the TEAM system - Poor level of accuracy of other TEAM applications

	Requirement met: - Need of a very robust communication layer to support the amount of data exchanged - Data exchange standards-protocols will be needed (e.g. SPaT, DATEX2, TPEG) - LDM++ - TMC interface shall be deployed
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_13_v1.0
Name of requirement	Database to LDM++ interface
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	CMC developers
Source (TEAM application or enabler)	CMC
Requirement category	Non-functional: - General architectural and equipment requirements
Goal	The TMC database defined in CMC application shall interface with LDM++
Definition	Self-explanatory
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Availability of information through LDM++. Load test for the communication architecture. Test cases will be specifically defined.
Acceptance criteria	Reliable data exchange with LDM++ enables different vertical TEAM applications to cooperate properly without

	counteracting each other, hence improving the performance of all.
Relationship with other requirements	Child of: - SP3_REQ_Int_CMC_12_v1.0: CMC shall interface with other TEAM applications
Potential conflicts	N/A
Risk analysis	Requirement not met: - Low integration of the TEAM system - Poor level of accuracy of other TEAM applications - Need of a parallel common database
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CMC_14_v1.0
Name of requirement:	MAP Protocol
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	STS
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Non-Functional - Connectivity and communication requirements
Goal	Protocol for sending topology information continuously as broadcast
Definition:	The MAP message set will be specified with all relevant information based on the SAE J2735 data elements under

	development with ISO
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Document review, functional review, optional ETSI conformance tests
Acceptance criteria	Project relevant ETSI conformance requirements
Relationship with other requirements	**Bases on:** Intersection topology **Is base for:** I2V communication
Potential conflicts	None
Risk analysis	Minor risk, as project members are involved in the on-going standardisation process and can try to adapt to the requirements.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CMC_15_v1.0
Name of requirement:	SPaT Protocol
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	STS (additional partners to be defined)
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Connectivity and communication requirements
Goal	Protocol for sending signal phase and time continuously as broadcast
Definition:	The SPaT message set will be specified with all relevant

	information based on the SAE J2735 data elements under development with ISO
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Document review, functional review, optional ETSI conformance tests
Acceptance criteria	Project relevant ETSI conformance requirements
Relationship with other requirements	**Bases on:** Time reference, Traffic lights prediction, Prediction update, green wave, traffic control application, prioritisation management **Is base for:** I2V communication
Potential conflicts	None
Risk analysis	Minor risk, as project members are involved in the on-going standardisation process and can try to adapt to the requirements.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CMC_16_v1.0
Name of requirement:	CAM protocol
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	CMC development group
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Connectivity and communication requirements

Goal	The request information is available from the information received from the vehicles.
Definition:	The optional data element for prioritisation request in the CAM message must be available and filled with data.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Document review, functional review, optional ETSI conformance tests
Acceptance criteria	Project relevant ETSI conformance requirements
Relationship with other requirements	**Bases on:** V2I communication **Is base for:** prediction update, Vehicle localisation
Potential conflicts	None
Risk analysis	TBD
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CMC_17_v1.0
Name of requirement	SIRI, TPEG and DATEX2 standards support
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	CMC developers
Source (TEAM application or enabler)	CMC
Requirement category	Non-functional: - Connectivity and communication requirements
Goal	The CMC Application will use standardized interfaces and protocols to all communication partners (applications)

	within TEAM
Definition	The standardized protocols SIRI for public transport, TPEG for traveller and vehicles info and DATEX2 for B2B communication units will be integrated within the TEAM-requirements and eventually they will be used and implemented or extended in the sense of the standards.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Availability of information services for other TEAM applications (e.g. SPaT, traffic events, dynamic speed limit info, PT priority policies, ...)
Acceptance criteria	If the CMC application outcomes (mainly TMC-related information) will be available for other vertical TEAM applications, all of them will be enabled and/or their functionalities will be improved – therefore with significant benefits from the overall users' experience in TEAM
Relationship with other requirements	Child of: - SP3_REQ_Int_CMC_12_v1.0: CMC shall interface with other TEAM applications
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met: - Low integration of the TEAM system - Using proprietary integration interfaces instead misses the chance to assess / confirm interoperability with the missed standards - Poor level of accuracy of other TEAM applications Requirement met: - Need of a very robust communication layer to support the amount of data exchanged

	- Data exchange standards-protocols will be needed (e.g. SPaT, DATEX2, TPEG)
Status	New
Other	No

B) Collaborative co-modal route planning

The COPLAN requirements briefly highlighted in section 3.2 will be provided in more detail in the following by filling in the tabular template presented in Table 1-1.

Requirement ID	SP3_REQ_Int_COPLAN_1_v1.0
Name of requirement	Input of User preferences for COPLAN
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs user's preferences to compute routes
Definition	The COPLAN end-user application part shall be able to accept the necessary input regarding the user preferences (origin, destination, time of travel, preferences regarding the number of modes' change, transportation type etc.), and shall be able to propagate it to the rest of the COPLAN functions so that it can be further processed. COPLAN does not need a formal user interface, it only requires the definition of a number of parameters that can be input through abstract ways, e.g. through TEAM messages.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	• Test ability to understand user preferences entered in a number of formats and to different completion degrees.

	• Tests should proof that COPLAN is able to deal with partial or incomplete information. • COPLAN should understand in a flexible way a number of variations on user inputs.
Acceptance criteria	For a defined number of user inputs detailing preferences, the system will understand partial or incomplete information in different formats. The system will complete using a best-guess approach extracting ancillary/missing information from the context.
Relationship with other requirements	
Potential conflicts	None
Risk analysis	Partial or even total application malfunctioning.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_2_v1.0
Name of requirement	COPLAN's output format of route calculation
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN 's results should be formatted as to be readable by the requesting user

Definition	The COPLAN end-user application part shall be able to present the COPLAN results to the user in a readable, user friendly format. A routing request to COPLAN is also associated to the type of user being made the request (field ***user_type***), so that COPLAN generates an adequate, readable format intended for that specific user type or class. For instance, if the results are to be read directly by a human resource, a textual, verbose description will be issued, if the results are to be used by another application, a compact description is preferred.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Tests will involve different user_types (human users, TEAM applications, non-TEAM applications) and a given route.
Acceptance criteria	COPLAN will generate a route description according to the intended user type. The resulting system-generated answer will be compared to a number of golden patterns, resulting from a number of routes whose system output is known.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Non-critical requirement but with imminent practical use.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_3_v1.0
Name of requirement	COPLAN's application layer connectivity interfaces

Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs to connect to a number of external services in order to get information for route computation
Definition	The COPLAN application server shall have application layer connectivity interfaces with specific external servers/applications (i.e. through SP3_CMC) in order to exchange information with 3rd parties such as: 1. The road operators: providing information about the traffic conditions in specific road segments (either directly from their application servers or through an interconnection with the CMC application) 2. Public Safety Answering Points (PSAP), police or fire brigade: providing information about an emergency incident that took place on the road, or at a specific location, 3. Municipality services, road operators etc.: e.g. providing information regarding planned civil works that will be performed on a part of the road at specific dates, thus rendering specific roads or lanes inaccessible. 4. Historical traffic related information data bases (e.g. any kind of info gathered from TEAM users). 5. Public transport operators: providing time based data

	related to the public transport vehicle fleet such as timetables, routes, current location of means, availability, load (linked to the data modules of CPTO application). 6. Parking owners/infrastructures: providing data regarding parking space availability at certain locations (link to SP4's COPARK).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving different sources through appropriate interfacing to the SP3_MCM application. Each case above will be selected and individually tested by generating a number of specific requests, whose answers are known apriori.
Acceptance criteria	COPLAN should classify and process answers correctly. Slight variations on the requests and answers should be correctly classified also, thus showing resilience against "noise".
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Critical requirement for successful app operation. . Failure to comply can lead to lack of information to take informed decisions on the part of the TMC, i.e. the main user of COPLAN, or any other users relying on the service.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_4_v1.0
Name of requirement	External parties to provide info to COPLAN

Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs real-time access to information provided by third parties in order to compute optimal routes
Definition	3rd parties (road operators, PSAPs, Municipality services, public transport operators, parking owners etc.) should provide real-time access to the needed data to the CPTO application (as well as the whole TEAM Framework, including SP4 CONAV). COPLAN will leverage this information as provided by the SP3_CPTO application. Other TEAM applications such as CONAV, COPARK, etc will also provide to COPLAN information on request.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests will involve a number of requests to SP3_CPTO and other SP4 applications (CONAV, COPARK). Answers are known apriori.
Acceptance criteria	COPLAN should correctly classify and process answers from different SP3 and SP4 applications, also in the presence of noise (slight input / output variations).
Relationship with other requirements	N/A
Potential conflicts	None

Risk analysis	Critical requirement for successful app operation. Lack of compliance might lead to wrong decisions taken by the users of the service.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_5_v1.0
Name of requirement	Common data exchange and communication scheme between TEAM applications, the TEAM infrastructure and third parties.
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN relies extensively on the exchange of information among TEAM applications and third parties (e.g. through CPTO and CMC). This can be achieved by adopting a common communication scheme as proposed by the TEAM Messaging Protocol.
Definition	A common information exchange and communication scheme is the fundament for the effective cooperation and interaction between applications. To this end, a scheme such as proposed by the TEAM Messaging Protocol can be employed.
Critical level (priority)	High

Validation Method (tests, indicators, performance bounds)	Tests involving communication among different applications and third parties, e.g. through CPTO and CMC employing the TEAM Messaging Protocol (TMP). These will include data exchange as well as commands.
Acceptance criteria	Applications will be able to exchange data with COPLAN using TMP. Test coverage should include most common protocol sequences showing behaviour before errors.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Critical requirement for successful app operation. . Lack of compliance could lead to synchronization problems due to difficulties in the data exchange between parties (e.g. COPLAN and other applications).
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_6_v1.0
Name of requirement	Storage of user data
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs historical user data on preferences in order to make optimal guesses in case requests are

	incomplete or ambiguous.
Definition	The COPLAN application server shall be able to store (historical) user information related to user transport preferences regarding e.g. usual origin, destination, time of travel, preferences regarding the number of mode's changes, transportation type etc. The storage of information shall not be persistent in order to comply with privacy schemes. That is, information will have a well-defined life-cycle with appropriate mechanisms to protect user's privacy.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's user data focusing on privacy issues. Data life-cycle will be shown to work by providing user data and synthetically accelerating all process to enable for accelerated tests.
Acceptance criteria	User data goes through all data life-cycle phases and is finally terminated. Privacy issues along the data life cycle are demonstrated.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Critical requirement for successful app operation. Lack of compliance could lead to ambiguous situations where the application will take on default values which might not be applicable for a particular user, and thus lead to results that are subsequently disregarded.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_7_v1.0
Name of requirement	Storage of data on traffic conditions
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs traffic data to compute optimal routes based on historical information
Definition	• (Historical) information regarding e.g. traffic load and conditions etc. per road segment and for specific timeframes, usual public transport availability/time schedules, parking availability etc. shall be stored (either by COPLAN or by other linked applications). • Historical data should be stored a common TEAM format, as proposed for the LDM++ database. Historical data for COPLAN will include information in a number of time frames and spatial scales. Historical data will include a number of statistical information (average, standard deviation, etc.) associated with classes of events associated with specific geo-locations or geometrical shapes (circles, polygons, lines, points, etc.)
Critical level (priority)	High
Validation Method (tests, indicators, performance	Tests will involve COPLAN accessing to historical data as well as the generation of statistical information. Historical / statistical data layers will be created in the LDM++

bounds)	database.
Acceptance criteria	COPLAN is able to generate statistical data out of historical data. It is also capable of providing and presenting this information in an adequate, usable way.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Critical requirement for successful app operation. Lack of compliance might lead to wrong decisions taken by the application or its users.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_8_v1.0
Name of requirement	Real-time assessment of road/traffic status
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs to assess traffic and road status on a real-time basis in order to compute an optimal route for requesting applications
Definition	COPLAN shall be able to assess the real time roads'

	status regarding their availability, traffic load etc.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to assess traffic and road status, these will include determining an optimal route in the presence of a number of road, traffic and weather situations. The cases are staggered according to increasing difficulty up to non-solvable solutions, where the system should provide adequate advice as how to proceed (in view of not accomplishing the request according to the current situations, i.e. either wait, or take a proper action).
Acceptance criteria	COPLAN deals with most situations in a proper manner. Scores are assigned to each route according to a number of factors, like difficulty, context, solution time, etc.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Non-critical requirement for successful app operation. Lack of compliance could lead to wrong decisions taken by the Ideal Routing Engine, as parameters to this enabler could be based on false premises.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_9_v1.0
Name of requirement	Real-time assessment of transport modes availability and conditions
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team

Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs to assess the availability and conditions of the different transport modes that a user might choose from
Definition	COPLAN shall be able to assess the real-time availability and conditions of a number of various transportation modes for various routes/route segments.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to assess transport modes depending on availability, conditions and a number of user preferences. Selected "problems" will be fed to COPLAN, whose solution is known apriori.
Acceptance criteria	COPLAN is able to route actors according to presented conditions. Scores are assigned to the calculated routes as compared to the golden solutions.
Relationship with other requirements	N/A
Potential conflicts	Unavailability of real-time data: if this is the case, COPLAN will use historical data or regular schedules (e.g. for public transport) to make a best guess and thus always deliver an answer to the user's request.
Risk analysis	Critical requirement for successful app operation. However an alternative plan sees the use of historical data and regular schedules to guarantee a functional system. The user will be warned that the information being currently delivered (i.e. route) is based on historical

	data or a schedule and not real-time data, and thus it is prone to entail errors. The system will however try to provide enough buffer time between mode changes as to enable flexibility and allow for an error margin.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_10_v1.0
Name of requirement	Predictive behaviour of transport modes
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs to assess the availability and conditions of the different transport modes and thereby involve predictions of the evolution at different time scales.
Definition	COPLAN shall analyse/process historical data related to traffic load of various transport modes as well as to traffic conditions for a number of road segments and for specific timeframes so that short/long term predictions regarding characteristics such as efficiency, availability, etc. and its behaviour (evolution) of various transport modes for various road segment/route can be made. The ability to predict behaviour and characteristics of transport modes is essential to COPLAN and its

	acceptance by the users. COPLAN will produce routes combining different transport modes and these must be available at the right moment in the right place. Public transportation is predictable, but other transportation modes present challenges. Further, the influence of external factors like peak hour traffic, road works and weather conditions, to name a few, play a very important role and must be included for an optimal service quality.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to predict traffic conditions and behaviour for a number of transport modes under different conditions. Selected cases will be generated with increasing solution difficulty. Solutions are known apriori.
Acceptance criteria	COPLAN deals with most presented situations and provides solutions which favourably compares (figure of merit) to the golden solutions.
Relationship with other requirements	None
Potential conflicts	Potential risks and conflicts related to legal implications as discussed in D3.3.1 and D1.2
Risk analysis	Critical requirement for successful app operation. Lack of compliance of this requirement could lead to wrong decisions taken by the application.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_11_v1.0
Name of requirement	Predictive demand of transport modes
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com

Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN needs to assess the demand of transport modes in order to assess their availability.
Definition	COPLAN shall be able to process historical data related to the actual demand for various transport modes per road segment and for specific timeframes and predict future demand for each transport mode, per road segment and for specific timeframes. Similar to requirement 10, but focused on availability prediction.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to predict transport mode availability under a number of conditions and at different time scales. Selected cases spanning different time frames and scales will be presented to COPLAN. Taking a particular point in time, COPLAN should generate predictive information that matches the actual behaviour.
Acceptance criteria	COPLAN should predict traffic behaviour to an acceptable extent. Acceptance level is achieved by introducing quality metrics (figures of merit) that compare predicted to actual behaviour over a given time frame at certain time scale.
Relationship with other requirements	N/A

Potential conflicts	None
Risk analysis	Critical requirement for successful app operation. Lack of compliance with this requirement could lead to wrong decisions taken by the application.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_12_v1.0
Name of requirement	Impact of using transport modes on different route segments
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN must be able to assess the impact of using different transportation modes in different segments of a given route.
Definition	COPLAN shall be able to identify the impact of using each transportation mode for various routes/route segments to the total user travel time, to the total number of transportation mode changes of the user, the environmental impact etc. taking into account the travellers' transport preferences, the traffic/transport related information provided by the 3rd parties, and the prediction processes results

Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to assess the use of transportation modes on a number of road segments for a statistically significant number of computed routes. Selected cases with increasing difficulty and whose answer is known apriori, will be fed to COPLAN.
Acceptance criteria	Through the introduction of figures of merit, COPLAN is able to produce results that favourably compare to the golden solutions.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Critical requirement for successful app operation. Lack of compliance with this requirement could lead to wrong decisions taken by the application in subsequent service requests.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_13_v1.0
Name of requirement	Alternative multi-modal routing ability
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement

	- Application requirement
Goal	COPLAN must be able to compute different / alternative multi-modal routes upon user request
Definition	COPLAN shall be able to calculate alternative multi-modal routing solutions for a user wishing to travel from a certain origin to a certain destination depending on various optimisation criteria such as: travel time, modes' changes, environmental impact etc.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to generate alternative routes depending on user preferences and/or wishes. To this end, COPLAN will be asked to produce different results (through change in the user preferences) for selected cases.
Acceptance criteria	COPLAN is able to generate different routes which fulfil user preferences and requirements for one and the same starting and ending points.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Critical requirement for successful app operation.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_14_v1.0
Name of requirement	Real-time re-computation of routes
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team

Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN must be able to change a route in real-time according to changing situations / information altering original (traffic / transportation mode / etc) conditions.
Definition	COPLAN shall be able to evaluate real-time information, and accordingly, provide changes to the initial recommendations to the users. The ability to provide enhanced routes according to changing situations plays also a critical role in the acceptance of the service.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to generate new routes based on the real-time evaluation of new information affecting the originally suggested route. A number of cases will be presented to COPLAN, and COPLAN will solve these cases for the current conditions. Then, during the navigation process, random changes will be introduced and selected information will be fed to COPLAN. COPLAN must be able to reconsider routed actors and suggest new routes that deal with the new situation.
Acceptance criteria	COPLAN successfully reroutes TEAM actors in real-time. Appropriate figures of merit are created to evaluate level of success.
Relationship with other requirements	N/A

Potential conflicts	None
Risk analysis	Critical requirement for successful app operation.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_15_v1.0
Name of requirement	Multi-vehicle routing ability
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	COPLAN must be able to route vehicles considering traffic conditions and already routed TEAM users in order to achieve more collaboration (in the co-modality sense) and a better load balance of available resources.
Definition	COPLAN shall be able to perform multi-vehicle routing for global optimisation of a fleet collaborating to compute individual routes in a coordinated way – link to SP4's CONAV.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Tests involving COPLAN's ability to route TEAM users in a coordinated way in order to achieve global goals such as optimal resource utilization (road network, transportation modes, etc) and enhance TEAM collaboration. Selected cases will be generated where a large number of

	TEAM actors has been routed. Additional actors will introduce changes in priorities that COPLAN should successfully route achieving a global optimal point according to internal system metrics. These metrics will be public to the purposes of the test. COPLAN will be requested to explicitly show the reasoning behind the global optimization decisions.
Acceptance criteria	COPLAN is able to achieve global optimization fulfilling most TEAM actor requests. Optimization metrics are shown and the reasoning behind decisions must clearly corroborate these.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Critical requirement for successful app operation.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_16_v1.0
Name of requirement	Data Update and Synchronisation between COPLAN Application Server and User Application Parts
Created by	COSMOTE - imesogiti@cosmote.gr
Assigned partner	COPLAN team
Source (TEAM application or enabler)	COPLAN application
Requirement category	Functional - Connectivity and communication requirement - Application requirement

Goal	COPLAN application related data (stored/processed) at the Application Server and at the User Application Part shall be always synchronized.
Definition	The User Part of the COPLAN application shall be linked to the COPLAN Application Server, and COPLAN related data stored/processed at these two parts shall be always synchronised/continuously updated (application layer connection).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Testing/Verification of the linking between the COPLAN User and Application Server Parts through network connectivity. Testing of the data exchange-update/synchronization process between the COPLAN User and Application Server Parts in terms of: • reliability (do both sides possess the same data/results after synchronization?), • speed (is the duration acceptable?), • efficiency (is the process performed efficiently in terms of algorithms?), • flexibility (how easy it is to control the synchronisation period, time etc?), etc.
Acceptance criteria	When the COPLAN User Application Part is up and running at the user terminal device, the User Application Part is continuously linked to the COPLAN application server. Data stored/processed/presented at these two parts (at Server & User sides) is continuously updated through a (continuous or periodic) synchronisation process so that the information stored/processed/presented is always the same at both sides (Server-User).

Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Partial or even total application malfunctioning. The application may provide some basic functionality to users but some "application results"/"application proposals" may not be valid/efficient, and may cause further distress to users and even problems to real world traffic situations. Depending on the Server-User Parts' synchronization period, and the number of physical events that have taken place during this period, the volume of synchronization data that shall be exchanged may be considerably large, thus requiring high speed network connectivity (e.g. through LTE). COPLAN provides basic access control based on validation of the TEAM ID, performed in a subjacent service layer provided by SP2 EMPOWER (and thus not handled by COPLAN). Failure to validate the ID will result in a denial-of-service error.
Status	New
Other	No

Requirement ID	SP3_REQ_ Int_COPLAN_17_v1.0
Name of requirement	Data Update and Synchronisation between COPLAN Application Server and 3rd Parties' Systems
Created by	COSMOTE - imesogiti@cosmote.gr
Assigned partner	COPLAN team

Source (TEAM application or enabler)	COPLAN
Requirement category	Functional - Connectivity and communication requirements - Application requirements
Goal	COPLAN application related data (e.g. related to the transport means' time schedules/availability, traffic conditions, road segments' availability, parking vacancies etc.) at the Application Server shall be always synchronised with the 3rd Parties' systems.
Definition	The 3rd Parties' information sent to the COPLAN Application Server shall be continuously updated so that information stored/processed by the two entities (3rd Parties and COPLAN application) is always synchronised.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Testing/Verification of the linking between the COPLAN Application Server and 3rd Parties systems through network connectivity. Testing of the data exchange-update/synchronization process between the COPLAN Application Server and 3rd Parties systems in terms of: • reliability (do both sides possess the same data/results after synchronization?), • speed (is the duration acceptable?), • efficiency (is the process performed efficiently in terms of algorithms? How does it respond to rapid changes?), • flexibility (how easy is it to control the synchronisation period, time etc?), etc.
Acceptance criteria	Optimally an always on communication connection

	between the COPLAN Application Server and the 3rd Parties' systems shall exist. Alternatively it shall be possible to have a communication link established whenever data shall be exchanged between those two entities. Data sent by the 3rd Parties to the COPLAN Application Server is continuously updated through a (continuous or periodic) synchronisation process so that the COPLAN related information (e.g. the transport means' time schedules/availability, traffic conditions, road segments' availability, parking vacancies etc.) stored/processed is always the same at both sides.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Partial or even total application malfunctioning. The application may provide some basic functionality to users but some "application results"/"application proposals" may not be valid/efficient, and may cause further distress to users and even problems to real world traffic situations. Depending on the synchronization period, and the number of physical events that have taken place during this period, the volume of synchronization data that shall be exchanged may be considerably large, thus requiring very high speed network connectivity (e.g. through high speed fixed line communications, LTE etc.).
Status	New
Other	No

C) Co-modal coaching with support from virtual/avatar users

The CCA requirements briefly highlighted in section 3.3 will be provided in more detail in the following by filling in the tabular template presented in Table 1-1.

Requirement ID	SP3_REQ_Int_CCA_1.1_v1.0
Name of requirement	Most Probable Activities
Created by	F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	- Application requirements
Goal	CCA shall provide information of the most probably activities
Definition	CCA shall provide information of the most probably activities of the user given the time of day and the possibly the present activity state of the user
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Function availability
Acceptance criteria	The CCA shall be able to provide information on activity of the user.
Relationship with other requirements	Other parallel 1.X requirements
Potential conflicts	N/A
Risk analysis	The requirement is relevant for the application; if not present application will provide reduced functionalities for what specifically concerns O/D recognition. Other

	functionalities will still be available.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_1.2_v1.0
Name of requirement	Social Network Connectivity
Created by	F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	- Application requirements
Goal	CCA shall connect to one or more social network media
Definition	CCA shall connect to one or more social network media accounts of the user to extend the information on activity
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Function availability
Acceptance criteria	The CCA shall be able to connect to at least one social media to interact with the TEAM user.
Relationship with other requirements	Other parallel 1.X requirements
Potential conflicts	N/A
Risk analysis	The requirement is relevant for the application; if not present application will provide reduced functionalities for what concerns social media integration. Core

	functionalities will not be affected.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_1.3_v1.0
Name of requirement	Activity info
Created by	F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	- Application requirements
Goal	CCA shall provide location, time, duration and type of activity associated with each activity
Definition	CCA shall provide location, time, duration and type of activity associated with each activity
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Information availability
Acceptance criteria	Information on the activity shall be available.
Relationship with other requirements	Other parallel 1.X requirements
Potential conflicts	N/A
Risk analysis	The requirement is relevant for the application; if not present application will provide reduced functionalities. If activities will not be available, alternative logics will have

	to be implemented.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_1.4_v1.0
Name of requirement	User position
Created by	F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	- Application requirements
Goal	CCA shall connect to the positioning system to collect the position and time of the user movement
Definition	CCA shall connect to the positioning system to collect the position and time of the user movement
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Information availability
Acceptance criteria	Information on the use position shall be available.
Relationship with other requirements	Other parallel 1.X requirements
Potential conflicts	N/A
Risk analysis	The requirement is relevant for the application; since it impacts core functionalities. User position will come from SP2 TLPM component

Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_1.5_v1.0
Name of requirement	Social Media Update
Created by	F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	- Application requirements
Goal	CCA could allow the user to update social network media based on its current location and activity
Definition	CCA could allow the user to update social network media based on its current location and activity
Critical level (priority)	Low
Validation Method (tests, indicators, performance bounds)	Information availability
Acceptance criteria	Information on the use position shall be available.
Relationship with other requirements	Other parallel 1.X requirements
Potential conflicts	N/A
Risk analysis	The requirement is relevant for the application; if not present application will provide reduced functionalities.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_1.6_v1.0
Name of requirement	Activity Input
Created by	F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	- Application requirements
Goal	CCA shall provide a way to the user to input the current activity
Definition	CCA shall provide a way to the user to input the current activity. Direct input of the activity allows improved accuracy.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Information availability
Acceptance criteria	Information on the use position shall be available.
Relationship with other requirements	Other parallel 1.X requirements
Potential conflicts	N/A
Risk analysis	The requirement is relevant for the application; if not present application will provide reduced functionalities.
Status	New
Other	For what concerns in-vehicle coaching, integration with DIALOGUE HMI will be analysed. Therefore this requirement will define how the CCA collects and uses

	the input provided by the user through in-vehicle HMI when in case.

Requirement ID	SP3_REQ_Int_CCA_1.7_v1.0
Name of requirement	Destination Imputation
Created by	F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	- Application requirements
Goal	CCA could estimate the destination and the activity type of the user even for time periods at which historical data are not provided
Definition	See above
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Information availability
Acceptance criteria	Information on the use position shall be available.
Relationship with other requirements	Other parallel 1.X requirements
Potential conflicts	N/A
Risk analysis	The requirement is relevant for the application; if not present application will provide reduced functionalities.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_2_v1.0
Name of requirement	User preferences for optimisation
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	CCA developers
Source (TEAM application or enabler)	CCA
Requirement category	Functional
Goal	Closely related to the CONAV application, the CCA shall consider user preferences. In CCA, it means that the application looks for alternative routes (that were not taken) but would suit to the user preferences. One example may help: Assume a user does not like complex crossing and has defined that those should be avoided. In consequence, the CCA application will consider those (better) alternatives in a special way, which includes such crossings.
Definition	CCA shall be able to take into account the preferences of the user to calculate his "tailored" optimal trip. See also goal section.
Critical level (priority)	Low
Validation Method (tests, indicators, performance bounds)	• Functional tests • User acceptance tests
Acceptance criteria	The implementation of this requirement is optional, but it

	is expected, that the implementation increases user acceptance.
Relationship with other requirements	Requirements from CONAV and COPLAN, which address personal preferences.
Potential conflicts	Not known at this stage.
Risk analysis	No risks expected. In case requirements will be met, need for a robust and reliable communication infrastructure to support the data exchange between the two applications.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_3_v1.0
Name of requirement	On-co-modal trip traveller coaching
Created by	Sebastian Stiller - sebastian.stiller@tu-berlin.de
Assigned partner	CCA developers
Source (TEAM application or enabler)	CCA
Requirement category	Functional: - Application requirements
Goal	Give multi-criteria rated assessment of trip chosen and its alternatives.
Definition	The CCA shall provide a seemingly constant feedback on the choices of the traveller in the co-modal environment. To this is end CCA communicates the performance of the travellers' trip compared to the CCA suggestion and optimal solutions for other calibrations of the objective function.

Critical level (priority)	Low
Validation Method (tests, indicators, performance bounds)	Subjectively convincing assessment of alternatives for the user through multi-criteria evaluation.
Acceptance criteria	This requirement builds on most other requirements. Acceptance depends on subjective impact on test users.
Relationship with other requirements	Parent of: • SP3_REQ_Int_CCA_1_v1.0: CCA shall learn and identify most probable O/D locations • SP3_REQ_Int_CCA_2_v1.0: CCA shall consider user preferences for optimisation • SP3_REQ_Int_CCA_5_v1.0: CCA shall assess the impact • SP3_REQ_Int_CCA_6_v1.0: CCA shall update its simulations at a specified rate
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement is not met in case of: • Failure to define convincing criteria model • Update rate too low for successful coaching Requirement met: • Traveller can seemingly constantly assess his choice and ponder alternatives.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_4_v1.0
Name of requirement	Simulated optimal trip calculation

Created by	Swarco Mizar - marco.bottero@swarco.com
Assigned partner	CCA developers
Source (TEAM application or enabler)	CCA
Requirement category	Functional: - Application requirements
Goal	Define in space and time the optimal trip to be virtually followed by the Avatar user
Definition	The CCA application shall be able to use optimal trip as a benchmark item for coaching the travellers and for giving estimations about potential savings. Optimal trip shall be computed according to: • Availability of different co-modal transport solutions • Preferences defined by the user • Real-time traffic information coming from the CMC application
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Availability of optimal trip solutions in the CCA application, to be used for travellers' coaching
Acceptance criteria	This requirement represent the core of the CCA application, since it deals with the possibility of having a reliable estimation of the optimal co-modal trip, to be followed by (or at least suggested to) coached TEAM community travellers. An accurate simulation will improve the benefits of coaching.
Relationship with other requirements	Parent of: • SP3_REQ_Int_CCA_2_v1.0: CCA shall consider user preferences for optimisation

	• SP3_REQ_Int_CCA_6_v1.0: CCA shall update its simulations at a specified rate (e.g. every 5 minutes) • SP3_REQ_Int_CCA_10_v1.0: CCA shall link with CMC to get real-time traffic info • SP3_REQ_Int_CCA_13_v1.0: Co-modal coaching shall be supported (CPTO app integration)
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met: • Optimal trip is not available for coaching • CCA application cannot coach the traveller Requirement met: • Need of appropriate computational resources in order to run the simulation • Need of a scalable system in order to supply peak-hour potential demand
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_5_v1.0
Name of requirement	Traveller trip impact assessment
Created by	Swarco Mizar - marco.bottero@swarco.com
Assigned partner	CCA developers
Source (TEAM application or enabler)	CCA
Requirement category	Functional: - Application requirements

Goal	To assess to impact of the traveller's trip taking into consideration relevant variables
Definition	CCA shall assess the impact (e.g. for what concerns fuel consumption, pollutants emissions, time spent, cost, ...) of the traveller trip considering his modal choice and related impacts, according to environmental and time/economy parameters to be further defined.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Estimations about the impact of the co-modal trip to be followed by the Avatar are available
Acceptance criteria	In order to give advices and to evaluate the traveller's behaviour, CCA application shall be able to estimate the impact of the traveller. Once this impact is estimated, the traveller can be coached in his co-modal trip.
Relationship with other requirements	Child of: • SP3_REQ_Int_CCA_3_v1.0: CCA shall coach the traveller during his co-modal trip • SP3_REQ_Int_CCA_6_v1.0: CCA shall update its simulations at a specified rate (e.g. every 5 minutes) • SP3_REQ_Int_CCA_7_v1.0: CCA shall coach the traveller at specific waypoints • SP3_REQ_Int_CCA_8_v1.0: CCA shall coach the traveller at the end of the trip Parent of: • SP3_REQ_Int_CCA_12_v1.0: CCA parameters shall be based on time and economy figures
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met:

	• Traveller behaviour cannot be assessed • Traveller impact is unknown • Coaching is not accurate Requirement met: • Need of adequate impact evaluation models
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_6_v1.0
Name of requirement	Regular simulations update
Created by	Lorenzo Maggi (CREATE-NET) - lorenzo.maggi@create-net.org
Assigned partner	CCA development group
Source (TEAM application or enabler)	CCA
Requirement category	Functional - General architectural and equipment requirements
Goal	Providing an estimate of the journey duration, cost, and CO_2 emission for all possible alternative routes on a regular basis
Definition	CCA shall update its simulations at a specified rate (e.g. every 5 minutes), to be further defined in the next phases of the Project
Critical level (priority)	High
Validation Method (tests, indicators, performance	Comparison between the estimated and the real triple (journey duration, cost, CO_2 emission), for each

bounds)	alternative route, computed with different rates of simulation update.
Acceptance criteria	For each alternative route, the estimated triple (journey duration, cost, CO_2 emission) has to be close enough to the real one for the selected simulation refresh rate.
Relationship with other requirements	Directly linked with REQ4, and needed for all requirements
Potential conflicts	Not foreseen at this stage
Risk analysis	If the requirement is not met, then the virtual avatar cannot effectively coach the user. Long-term coaching will still be possible thanks to post-trip analysis.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_7_v1.0
Name of requirement	Specific way points coaching
Created by	Sebastian Stiller - sebastian.stiller@tu-berlin.de
Assigned partner	CCA developers
Source (TEAM application or enabler)	CCA
Requirement category	Functional: - Application requirements
Goal	Give updated suggestion and assessment at specific way points.
Definition	At specific way points that connect reasonable subpaths the traveller might reconsider again using or deviating from CCA suggestions. The requirement is to support this

	decision.
Critical level (priority)	Low
Validation Method (tests, indicators, performance bounds)	Subjectively convincing assessment of alternatives for the user at waypoints.
Acceptance criteria	This requirement builds on most other requirements. Acceptance depends on subjective impact on test users.
Relationship with other requirements	Parent of: • SP3_REQ_Int_CCA_1_v1.0: CCA shall learn and identify most probable O/D locations • SP3_REQ_Int_CCA_2_v1.0: CCA shall consider user preferences for optimisation • SP3_REQ_Int_CCA_5_v1.0: CCA shall assess the impact • SP3_REQ_Int_CCA_6_v1.0: CCA shall update its simulations at a specified rate
Potential conflicts	Not foreseen at this stage
Risk analysis	The requirement is not met if: • Failure to identify waypoints. • Suggestions are not adjusted fast enough. The requirement is met: • The traveller can make his choice at waypoints with the right assessment of the qualities of alternative paths in the co-modal environment. • Long-term coaching will still be possible thanks to post-trip analysis.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_8_v1.0
Name of requirement	User coaching at the end of the trip
Created by	Lorenzo Maggi (CREATE-NET) - lorenzo.maggi@create-net.org
Assigned partner	CREATE-NET
Source (TEAM application or enabler)	CCA
Requirement category	Functional - Application requirements
Goal	Coaching the user about the route to choose in the next round
Definition	CCA shall coach the traveller at the end of the trip
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	TEAM should provide at the end of the trip a recommendation to the user on the route to follow in the next trip
Acceptance criteria	The recommendation on the route to follow has to allow the whole transportation system to reach a suitable equilibrium state
Relationship with other requirements	Necessary to fulfil most of the other requirements
Potential conflicts	Not foreseen at this stage
Risk analysis	If the requirement is not met, then the user does not obtain any recommendation on the route to follow. Hence, in this case the virtual avatar cannot coach the user in the next trip

Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_9_v1.0
Name of requirement	Statistics on last usage period
Created by	Lorenzo Maggi (CREATE-NET) - lorenzo.maggi@create-net.org
Assigned partner	CCA development group
Source (TEAM application or enabler)	CCA
Requirement category	Functional - General architectural and equipment requirements
Goal	Providing to the user the statistics on the duration, cost, and CO_2 emission of the recent journeys
Definition	CCA shall be able to give stats about the last period of usage
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Assessment of the truthfulness of the provided statistics
Acceptance criteria	The statistics on the duration, cost, and CO_2 emission of the recent journeys should be correct
Relationship with other requirements	Directly linked with SP3_REQ_Int_CCA_8_v1.0, and fundamental for all requirements
Potential conflicts	None
Risk analysis	If the requirement is not met, then the user cannot compare the utility associated with the realized journey

	with the one of all the alternative routes. In such a case, the virtual avatar cannot coach the user.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_10_v1.0
Name of requirement	CCA-CMC link
Created by	Swarco Mizar - marco.bottero@swarco.com
Assigned partner	CCA developers
Source (TEAM application or enabler)	CCA
Requirement category	Non-functional - General architectural and equipment requirements
Goal	CCA shall link with CMC to get real-time traffic info to be used in simulations and impact evaluations
Definition	CCA application shall be able to use elaborated information coming from the CMC application about current and forecasted traffic conditions as a basis for travellers' coaching
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	CMC application traffic information are available for CCA application
Acceptance criteria	If CMC information will be available, the functionalities of the CCA application will be improved, thanks to the knowledge of the current and forecasted status of the co-modal transport network

Relationship with other requirements	Child of: • SP3_REQ_Int_CCA_13_v1.0: Co-modal coaching shall be supported (CPTO app integration)
Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met: • Coaching functionalities of the CCA application are based on a weak data set • Coaching is not accurate Requirement met: • Need of a robust communication architecture • Need of a degraded mode definition in case CCA-CMC link is temporarily unavailable
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_11_v1.0
Name of requirement	CCA – CONAV link
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	CCA and CONAV Application group
Source (TEAM application or enabler)	CCA
Requirement category	Technological and development requirements
Goal	To integrate CCA and CONAV applications in the in-vehicle phase
Definition	Self-explanatory
Critical level (priority)	Low

Validation Method (tests, indicators, performance bounds)	Test of interfaces
Acceptance criteria	Not applicable
Relationship with other requirements	Related to all CONAV requirements. In case public transport should play a role, COPLAN needs to be integrated as well. It is expected that then, CONAV is considered by connecting to COPLAN (as we assume, that COPLAN integrates CONAV for the vehicle routing part).
Potential conflicts	Conflicts with other requirements
Risk analysis	If CONAV is not used, the vehicle routing would need to be implemented one more time. CCA-COPLAN-CONAV relationship to be defined into details in the development phase.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_12_v1.0
Name of requirement	Trip impact assessment parameters
Created by	Swarco Mizar - marco.bottero@swarco.com
Assigned partner	CCA developers
Source (TEAM application or enabler)	CCA
Requirement category	Non-functional: - Application requirements
Goal	CCA parameters shall be based on environmental, time

	and economy parameters

Definition	The impact assessment of traveller and Avatar trip shall be based on a number of defined parameters belonging to three different categories:
	• Environmental:
	  ○ Pollutants emissions
	  ○ Impact on traffic (contribution in creating congestion of the single trip)
	• Time:
	  ○ Total travel time
	  ○ Travel time share on preferred mean of transport
	  ○ Delay (actual travel time / free flow travel time)
	• Economy:
	  ○ Fuel consumption
	  ○ Highways tolls
	  ○ LTZ access fees

Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Different parameters are included in the sub-optimal problem to be solved by the CCA application and can be used for optimal trip calculation The traveller can choose weights for the available parameters according to his/her preferences
Acceptance criteria	The traveller will be able to choose the parameters the will be used by the Avatar in order to coach the driver in the optimal trip – in this way the suggested path will be tailored to the preferences of the user (expresses by relative weights to the abovementioned parameters)
Relationship with other requirements	Child of: SP3_REQ_Int_CCA_5_v1.0: Traveller trip impact assessment

Potential conflicts	Not foreseen at this stage
Risk analysis	Requirement not met: • Traveller impact estimation is not accurate • Coaching is not reliable • Poor user acceptance (user cannot choose optimization parameters)
Status	New
Other	To be integrated with corresponding requirement for CONAV application for what concern the trip planned in the pre-trip phase

Requirement ID	SP3_REQ_Int_CCA_13_v1.0
Name of requirement	Integration with CPTO
Created by	NEC - F. Alesiani - Francesco.Alesiani@neclab.eu
Assigned partner	CCA development group
Source (TEAM application or enabler)	SP3/CCA
Requirement category	Non-functional: - Application requirements
Goal	Co-modal coaching shall be supported (CPTO app integration)
Definition	See above
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Integration between the two system working

Acceptance criteria	The information from the CPTO can be used in the CCA
Relationship with other requirements	N/A
Potential conflicts	When not implementing the requirement, then the CCA cannot used PT information.
Risk analysis	If this requirement will not met, CCA application will not be able to use information coming from CPTO application. Co-modal coaching with real-time information will not be available. Coaching overall quality will be very poor.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CCA_14_v1.0
Name of requirement	TPEG protocol for information exchange
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	SP2 Group
Source (TEAM application or enabler)	CCA
Requirement category	Technological and development requirements
Goal	TPEG is a well-established technology to exchange traffic information. The TPEG standard shall be considered, when low bandwidth requirements are there and when exchanged information relate to standard traffic events7infromation, for which TPEG codes are defined.
Definition	TPEG codes shall be considered whenever applicable. This is when information about standard traffic events are to be exchanged.

Critical level (priority)	Low
Validation Method (tests, indicators, performance bounds)	Functional test
Acceptance criteria	Not applicable
Relationship with other requirements	Shall be integrated with other requirements, which target information exchange concerning standard traffic events/information.
Potential conflicts	No
Risk analysis	The use of TPEG will help deploying protocols as TPEG is a well-established standard.
Status	New
Other	No

D) Collaborative smart intersection for intelligent priorities

The CSI requirements briefly highlighted in section 3.4 will be provided in more detail in the following by filling in the tabular template presented in Table 1-1.

Requirement ID:	SP3_REQ_Int_CSI_01_v1.0
Name of requirement:	Signalling History
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	STS
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Non-Functional - Equipment requirements

Goal	Historical data is accessible for planning time and phase for the traffic lights
Definition:	Logged data is recorded from the intersections for a time long enough to calculate reliable prediction values
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	visual review of the logged historic signal phases
Acceptance criteria	All relevant elements available for a pre-defined period of time, precision of data is less than 2 seconds.
Relationship with other requirements	**Bases on:** time reference, traffic control application, external traffic **Is base for:** Traffic lights prediction and prediction update.
Potential conflicts	none
Risk analysis	Without historical data a prediction of signals is not possible and the information cannot be transmitted. In order to still be able to test GLOSA functionality fixed signal phase traffic lights would have to be used.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_02_v1.0
Name of requirement:	Intersection Topology
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	STS SH-Hellas

Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Non-functional - Equipment requirements
Goal	Traffic controller knows the topology of the intersection and is able to provide it
Definition:	Data content for the MAP message must be measured and provided on the road side unit (e.g. relevant lanes, allowed manoeuvres, linked signals, ...)
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	use of visualisation tool and visual review
Acceptance criteria	All relevant elements available, precision of coordinates is better than x meter. "x" has to be specified based in the application, but the preliminary value is 1 meter
Relationship with other requirements	**Bases on:** External input **Is base for:** MAP protocol and for vehicle localisation
Potential conflicts	none
Risk analysis	The application depends on the topological data, dynamic update is not relevant for the application. In order to be able to deploy on intersections where several signal groups is used, this data is essential in order for the vehicles to be able to determine the relevant signal group. If the data is not available, it would still be possible to do tests on single signal group intersections.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_03_v1.0
Name of requirement:	MAP Protocol
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	STS, NEC?
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Connectivity and communication requirements
Goal	Protocol for sending topology information continuously as broadcast
Definition:	The MAP message set will be specified with all relevant information based on the SAE J2735 data elements under development with ISO
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	document review, functional review, optional ETSI conformance tests
Acceptance criteria	project relevant ETSI conformance requirements
Relationship with other requirements	**Bases on:** Intersection topology **Is base for:** I2V communication
Potential conflicts	none
Risk analysis	Minor risk, as project members are involved in the on-going standardisation process and can try to adapt to the requirements.

Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_04_v1.0
Name of requirement:	SPaT Protocol
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	STS, NEC?
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Connectivity and communication requirements
Goal	Protocol for sending signal phase and time continuously as broadcast
Definition:	The SPaT message set will be specified with all relevant information based on the SAE J2735 data elements under development with ISO
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	document review, functional review, optional ETSI conformance tests
Acceptance criteria	project relevant ETSI conformance requirements
Relationship with other requirements	**Bases on:** Time reference, Traffic lights prediction, Prediction update, green wave, traffic control application, prioritisation management **Is base for:** I2V communication
Potential conflicts	none

Risk analysis	Minor risk, as project members are involved in the on-going standardisation process and can try to adapt to the requirements.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_05_v1.0
Name of requirement:	Authentication access
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	Fraunhofer FOKUS
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Security requirements
Goal	Module for prioritisation is able to prove the permission level for prioritisation
Definition:	The authentication system provides a service that enables the access to the authentication data the vehicle has sent. Either the permitted vehicles like bus or emergency vehicle carries an allowed level in their identification or the prioritisation module knows the level of each authentication ID
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Module tests with test patterns and functional tests with visual review

Acceptance criteria	All relevant parameters are accessible and module works according to definition
Relationship with other requirements	**Bases on:** V2I communication, Authentication provision **Is base for:** Prioritisation management
Potential conflicts	none
Risk analysis	Critical for the project, as it is not possible to decide if a vehicle is allowed to request priority if this requirement is not fulfilled. An alternative approach would however be possible, where the infrastructure based on information received in CAM messages is able to perform prioritization based on vehicle categories, in order to be able to give priority, for example to buses or emergency vehicles.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_06_v1.0
Name of requirement:	Controller unit
Created by	5T - massimo.cocozza@5t.torino.it
Assigned partner	CSI development group
Source (TEAM application or enabler)	Smart Intersection
Requirement category	Functional or non-functional - General architectural and equipment requirements
Goal	Hosting of Smart Intersection application
Definition:	Smart Intersection application needs to run locally at the traffic light intersection and requires adequate hardware to respect planned performances. The controller unit has

	to be able to manage connection with external devices (sensors and transmission module).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Hardware availability and performance level measurement
Acceptance criteria	The controller unit has to allow the application to run respecting the performance defined. (time to calculate output)
Relationship with other requirements	Self-explanatory Same level relationship or hierarchical relationship
Potential conflicts	Conflicts with local admitted traffic light regulation; Smart intersection behaviour can be not compliant with national and local regulation.
Risk analysis	Major critical: low level of performance of intersection application and/ or communication rate with external devices
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_07_v1.0
Name of requirement:	Detectors
Created by	5T - massimo.cocozza@5t.torino.it
Assigned partner	CSI development group
Source (TEAM application or enabler)	Smart Intersection
Requirement category	Functional or non-functional

	- General architectural and equipment requirements - Application requirements
Goal	External event detectors – traffic, pedestrian etc.
Definition:	The Smart intersection application needs to acquire information (traffic flow, queue, pedestrian request etc.) from the environment around the traffic light. This requirement should be accomplished preferably by receiving the data from existing systems.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Detectors availability and their integrations with controller unit
Acceptance criteria	Detectors data is available for the application with the minimum frequency required of 1 second
Relationship with other requirements	Same level relationship or hierarchical relationship
Potential conflicts	None
Risk analysis	The absence of detectors can reduce effectiveness of smart intersection application. The reduction of effectiveness depends on the specific missing detector.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_08_v1.0
Name of requirement:	Traffic lights prediction
Created by	STS - Juergen.Weingart@swarco.de

Assigned partner	CSI development group
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Technological and development requirements
Goal	Time and confidence of signal phases are available for the upcoming changes of traffic signals
Definition:	Based on historical data and the actual events a prediction is calculated for the next two phase changes of each traffic light group. Content of data to predict is under standardization at CEN/ISO and specified in the SPaT message.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Module tests with test patterns and integration tests with logged historical data for statistical evaluation
Acceptance criteria	Algorithm running at an embedded system, generic to traffic applications, based on historical data, extended by real-time detection events. Content as specified in the standard for SPaT, 95% correct messages.
Relationship with other requirements	**Bases on:** signalling history **Is base for:** prediction update
Potential conflicts	Prediction of signalling will be affected by requests to influence signalling.
Risk analysis	This requirement is necessary for the application. Risks are possibility and quality of prediction in case of traffic actuated control and influence of pre-emption and prioritization to the prediction.
Status	New

Other	No

Requirement ID:	SP3_REQ_Int_CSI_09_v1.0
Name of requirement:	Prioritisation configuration
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	CSI development group
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Application requirements - Security requirements
Goal	The traffic authority is able to fine tune the prioritization based on different parameters, such as congestion, public transport, emergency vehicles etc.
Definition:	A tool for reconfiguration is necessary; this tool should work local at the controller and remote from a central side. The tool for configuration needs a database for the archiving of the local configurations.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	functional test, Black box test
Acceptance criteria	All project relevant parameters can be configured and are resulting in the expected way. The minimum parameters are congestion and type of vehicle for priority.
Relationship with other requirements	**Bases on:** External Input **Is base for:** Prioritisation management, Authentication

	provision (The tool for prioritisation configuration shall also handle the management of the authentication Information)
Potential conflicts	none
Risk analysis	Critical for the project is the local functionality of configuration. Static priority configuration could be used as a fall back on test sites, where a closed track environment is used.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_10_v1.0
Name of requirement:	Prioritisation management
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	CSI development group
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Application requirements - Security requirements
Goal	The intersection must be able to receive and process information received from the vehicles, such as vehicle type, load, weight, number of passengers, schedule, position, CACC platoon information etc.
Definition:	Out of the parameter set for priority the prioritisation actions are calculated. The results are provided to the traffic application. The status of prioritisation is

	distributed to the vehicles via SPaT optional fields.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Module tests with test patterns and functional tests with visual review
Acceptance criteria	The intersection receives the relevant parameters from the vehicles. Minimum set of parameters is vehicle type, position and speed.
Relationship with other requirements	**Bases on:** Authentication access, Prioritisation configuration, vehicle localisation, CAM protocol. **Is base for:** traffic control application, SPaT protocol.
Potential conflicts	none
Risk analysis	Without fulfilling this requirement no prioritization at all can be made and thus the intersection could not really be considered as "smart" anymore.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_11_v1.0
Name of requirement:	Prediction Update
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	CSI development group
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Technological and development requirements

Goal	The intersection must be able to broadcast the updated signal phase and time
Definition:	Dependent on the requests the prediction out of historical data needs to be extended by reactions to requests
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Module tests with test patterns and integration tests with logged historical data, additional with test patterns for requests.
Acceptance criteria	Precision as specified in the standard for SPaT, better than 95% correct messages
Relationship with other requirements	**Bases on:** Traffic lights prediction, CAM protocol, Time reference, Signalling history **Is base for:** prioritisation management, SPaT protocol
Potential conflicts	None
Risk analysis	This functionality is critical in realisation; at least the provided traffic application needs to be known in its logical structure or must be adapted to a special predictable mode.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_12_v1.0
Name of requirement:	Traffic control application
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	STS SH-Hellas

Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Application requirements
Goal	Intersection is able to control the traffic lights phase and time
Definition:	The traffic application needs to have different strategies for different levels of adaptation requests. It must be extended by access to the prioritisation levels out of the prioritisation management
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	functional test, conformance tests and release by the customer
Acceptance criteria	Functional requirements of the customer are fulfilled. Requirements of the Project are fulfilled. Safety assessment for road traffic systems are fulfilled
Relationship with other requirements	**Bases on:** prioritisation management, Time reference, external Traffic **Is base for:** green wave, Traffic lights prediction, prediction update, SPaT protocol
Potential conflicts	none
Risk analysis	This is a core mandatory requirement.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_13_v1.0

Name of requirement:	Access to transport information
Created by	VOLVO - rafael.basso@volvo.com
Assigned partner	CSI development group
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Application requirements
Goal	To provide the applications with information about transport tasks, such as planned itinerary and schedule.
Definition:	An API is available where the application can request information such as schedule for distribution trucks and public transport (stops, time behind or ahead, etc.)
Critical level (priority)	Low
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	Information about schedule and itinerary of vehicles is available for the application
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	The main use cases of the CSI application can still be demonstrated even without access to transport schedules for the individual vehicles approaching the intersection.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_CSI_14_v1.0

Name of requirement:	Green wave
Created by	STS - Juergen.Weingart@swarco.de
Assigned partner	CSI development group
Source (TEAM application or enabler)	Collaborative Smart Intersections for Intelligent Priorities
Requirement category	Functional - Application requirements
Goal	Traffic controller can plan a green wave across multiple intersections and send the recommended speed to the vehicles.
Definition:	For at least some hours of the day the traffic controllers will run in a time coordinated mode which is planed providing a green wave. The green wave speed and the direction may differ over the time of day. If there are adaptations from the controller to prioritisation request destroying the green wave, this information shall not be sent for this time.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Visual review of the logged signal phases
Acceptance criteria	Difference is less than 4 seconds to calculated value
Relationship with other requirements	**Bases on:** traffic control application and on time reference. **Is base for:** SPaT protocol
Potential conflicts	none
Risk analysis	Not critical in realisation
Status	New

Other	No

E) Collaborative public transport optimization

The CPTO requirements briefly highlighted in section 3.5 will be provided in more detail in the following by filling in the tabular template presented in Table 1-1.

Requirement ID	SP3_REQ_Int_CPTO_1_v1.0
Name of requirement	User Input
Created by	AIT - Matthias.Prandtstetter@ait.ac.at
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Functional - General architectural and equipment requirements
Goal	The aim is to gather the relevant information (origin, destination, departure time, etc.) provided by the user such that the application can be realized.
Definition	The CPTO should be able to get all information relevant for optimization purposes (as defined by the different use cases).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Unit tests should be performed for general validation. In addition user tests (i.e. test performed by applicants) should be performed to test the user interface.
Acceptance criteria	Obviously, this requirement is crucial since otherwise no user information is available. Optimization would not be possible in that case. TEAM has to be able to gather all relevant information. The end user has to be able to

	provide all information relevant for her (e.g. preference on departure time, etc.).
Relationship with other requirements	SP3_REQ_Int_CPTO_2_v1.0, SP3_REQ_Int_CPTO_4_v1.0, SP3_REQ_Int_CPTO_7_v1.0, SP3_REQ_Int_CPTO_11_v1.0, SP3_REQ_Int_CPTO_12_v1.0, SP3_REQ_Int_CPTO_21_v1.0
Potential conflicts	None at this time
Risk analysis	If this requirement is not fulfilled information as needed by other requirements cannot be provided. Even more, meaningful operations are quite unrealistic since essential information would be missing. To avoid this risk CPTO HMI will demand some basic minimum user input before allowing them to use the application.
Status	New
Other	None

Requirement ID	SP3_REQ_Int_CPTO_2_v1.0
Name of requirement	Output to user
Created by	AIT - Matthias.Prandtstetter@ait.ac.at
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Functional - General architectural and equipment requirements
Goal	The aim is to provide all relevant information to the user (e.g. the next stop, the estimated arrival time, etc.).
Definition	The CPTO should be able to provide relevant information to the user (e.g. bus rider).

Critical level (priority)	High (to medium)
Validation Method (tests, indicators, performance bounds)	Unit tests as well as usability tests have to be performed.
Acceptance criteria	The functionality is accepted if a) the CPTO can provide relevant information to the user and b) the user interface is designed such that all information is properly displayed.
Relationship with other requirements	SP3_REQ_Int_CPTO_2_v1.0, SP3_REQ_Int_CPTO_4_v1.0, SP3_REQ_Int_CPTO_7_v1.0, SP3_REQ_Int_CPTO_11_v1.0, SP3_REQ_Int_CPTO_12_v1.0, SP3_REQ_Int_CPTO_21_v1.0
Potential conflicts	None at this time
Risk analysis	If this requirement is not met, no/not all information can be provided to the customer. Since this requirement is the final step of CPTO, all other requirements have to be met such that the relevant information can be provided.
Status	New
Other	A close collaboration will be established with the HMI working group in SP4 for meeting this requirement. Relevant requirements have been addressed to SP4 which are included in D4.3.1.

Requirement ID	SP3_REQ_Int_CPTO_3_v1.0
Name of requirement	Application layer connectivity interfaces
Created by	SWARCO MIZAR - marco.bottero@swarco.com
Assigned partner	CPTO development group
Source (TEAM application or	Collaborative Public Transport Optimization (CPTO)

enabler)	
Requirement category	Non-functional - General architectural and equipment requirements
Goal	Effective information exchange between all the applications interacting with CPTO
Definition	The CPTO application server shall have application layer connectivity interfaces with specific external servers/applications in order to exchange information with: a. The public transport operator's infrastructure (e.g. application server) b. The road operators' infrastructure (either directly from their application servers or through an interconnection with the CMC application).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Communications/handshake tests between applications involved with CPTO functionalities and/or data, CMC application (that acts in this case as a B2B horizontal data handling & processing layer), and CPTO application itself
Acceptance criteria	Functionalities of applications interacting with CPTO and functionalities of CPTO itself are operated in an efficient, integrated and reliable way. The interfaces are functional and the exchange of relevant data is successfully performed.
Relationship with other requirements	Child of: - SP3_REQ_Int_CPTO_6_v1.0: Information regarding the road conditions and availability shall be provided in a readable format to the CPTO application (either directly by their road operators' application servers or through an interconnection with the CMC application) - SP3_REQ_Int_CPTO_8_v1.0: (Historical) information

	regarding the traffic load and conditions etc. per road segment and for specific timeframes shall be stored (either by CPTO or by another linked application)
Potential conflicts	Not foreseen in this stage of requirements definition
Risk analysis	Requirement not met: - Poor integration among applications - Duplication of functionalities in diverse applications - Functionalities of dependent applications will not be available Requirement met: - Need of a very robust communication layer to support the amount of data exchanged - Data exchange standards will be needed (e.g. SIRI, DATEX2) To minimise the risk of bad connectivity CPTO central servers will be most probably located close to PT Operator facilities.
Status	New
Other	To be further refined after the definition of the corresponding requirements for the CMC application

Requirement ID	SP3_REQ_Int_CPTO_4_v1.0
Name of requirement	Public transport data access
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Connectivity and communication requirements

	Data requirements
Goal	In order to integrate public transport information into TEAM application it is required that relevant data is available. This will be implemented with help of the LDM++.
Definition	The public transport operator should provide real-time access to the needed data to the CPTO application (as well as the whole TEAM Framework) such as: a. Current location of each public transport unit (bus, train), b. Availability, c. Load, d. Bus sizes, e. Fixed/Mutable Timetable schedules of transport means (bus, train), f. Mixed/mutual routes of transport means (bus, train), h. Event organisation (e.g. conference, football game etc.) and relevant requirements (e.g. opening/closing hours, amount of people expected, available bus fleet etc.). In order to have real-time access, the relevant TEAM component (LDM++) requires interfaces to infrastructure operators' systems.
Critical level (priority)	High priority In general, the requirement is mandatory to be implemented. But in detail, it depends on the relevant data: a. Current location of each public transport unit (bus, train): important b. Availability: critical c. Load: desired d. Bus sizes: optional

	e. Fixed/Mutable Timetable schedules of transport means (bus, train): critical f. Mixed/mutual routes of transport means (bus, train): critical g. Event organisation and relevant requirements: important
Validation Method (tests, indicators, performance bounds)	Data correctness Update time
Acceptance criteria	The acceptance criteria is implicitly given through the application in general. Features of the application are dependent on data quantity and quality. Availability of the abovementioned data in the LDM++ within a reasonable update rate (to be defined in the final specifications).
Relationship with other requirements	Related to SP3_REQ_Int_CPTO_3_v1.0, SP3_REQ_Int_CPTO_5_v1.0
Potential conflicts	None
Risk analysis	If this requirement is not met then the whole CPTO functionality will be at risk. The availability of public transport data is crucial for the successful operation of this application.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_5_v1.0
Name of requirement	Public transport data format
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de

Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Technical / data format / communication
Goal	The data provided by the public transport operator shall be in a readable format by the CPTO application.
Definition	All given data needs to be processed by the LDM++. Since TEAM will interface multiple system, it is required that the data will be provided in standard formats. Examples for that is GTFS.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Conformance tests
Acceptance criteria	Conformance Successful reception of PT data
Relationship with other requirements	SP3_REQ_Int_CPTO_3_v1.0, SP3_REQ_Int_CPTO_4_v1.0
Potential conflicts	None
Risk analysis	Work overhead increases in case multiple adapters needs to implemented. Mistakes could be made here. Some data might not be considered in TEAM if the format is different. This requirement does not place a big risk since PT data adaptation for the TEAM CPTO pilot sites will take place in either case, irrespective of the possible overhead.
Status	New
Other	None

Requirement ID	SP3_REQ_Int_CPTO_6_v1.0
Name of requirement	Infrastructure information data format
Created by	SWARCO MIZAR - marco.bottero@swarco.com
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Non-functional - General architectural and equipment requirements
Goal	Infrastructure information are available to CPTO application
Definition	Information regarding the road conditions (traffic data, accidents etc.) and availability shall be provided in a readable format to the CPTO application (either directly by their road operators' application servers or through an interconnection with the CMC application)
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Communications/handshake tests between CMC application (processed static & dynamic data provider in this case) and CPTO application
Acceptance criteria	Functionalities of CPTO will have a stronger impact on travellers' experience if they will be coordinated with real-time infrastructure information coming from the CMC application. Successful reception of the needed information from the infrastructure side.
Relationship with other requirements	Parent of: ● SP3_REQ_Int_CPTO_3_v1.0: The CPTO application server shall have application layer connectivity interfaces with specific external servers/applications in

	order to exchange information with: - The public transport operator's infrastructure (e.g. application server) - The road operators' infrastructure (either directly from their application servers or through an interconnection with the CMC application)
Potential conflicts	Not foreseen in this stage of requirements definition
Risk analysis	Requirement not met: - Low reliability of CPTO functionalities - Low integration of CPTO and CMC traffic control strategies - CPTO/CMC-dependent applications (e.g. CSI) functionalities will not be available (e.g. PT priority) Requirement met: - Need of a very robust communication layer to support the amount of data exchanged - Data exchange standards will be needed (e.g. SIRI, DATEX2, TPEG) This requirement risk mainly concerns CMC and TMC enablers, as CPTO and particularly algorithmic enablers that serve CPTO will be customers of this type of data.
Status	New
Other	To be further refined after the definition of the corresponding requirements for the CMC application

Requirement ID	SP3_REQ_Int_CPTO_7_v1.0
Name of requirement	User Data Storage
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	CPTO development group

Source (TEAM application or enabler)	Collaborative Public Transport Optimisation (CPTO)
Requirement category	Technological and development requirements
Goal	To ensure the availability of user specific data (incl. historic data) regarding public transport.
Definition	The CPTO application server shall be able to store user information related to user transport preferences - demand for public transport means (origin, destination, time of travel, preferences regarding the means of transport etc.). Also historic user data will be stored.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Test that the needed information is stored successfully on the CPTO application server. LDM++ features/tables available.
Acceptance criteria	Proper use of the collected data will improve the user experience (quality of service) of public transport. The needed information are successfully stored in the relevant LDM++ tables.
Relationship with other requirements	This requirement is necessary for SP3_REQ_Int_CPTO_19_v1.0 (Historic User Data Processing)
Potential conflicts	None
Risk analysis	Absence of this data will block some CPTO functionalities and decrease the overall efficiency of the CPTO application. The risk CPTO servers and LDM++ to not have the necessary data storage capacity is small.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_8_v1.0
Name of requirement	Traffic Data Storage
Created by	TUB - sebastian.stiller@tu-berlin.de
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimisation (CPTO)
Requirement category	Technological and development requirements
Goal	To ensure the availability of road segment specific (historic) data regarding traffic load and the road conditions.
Definition	Information regarding the traffic load and conditions etc. per road segment and for specific timeframes shall be stored (either by CPTO or by another linked application). Also historic traffic information will be stored.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Test that the historical information is stored successfully on the CPTO application server. LDM++ features/tables available.
Acceptance criteria	Proper use of the traffic data will improve the user experience (quality of service) of public transport. The needed information are successfully stored in the relevant LDM++ tables.
Relationship with other requirements	This requirement is necessary for SP3_REQ_Int_CPTO_20_v1.0 (Historic Data on Traffic Load)
Potential conflicts	None
Risk analysis	Absence of this data will block some CPTO functionalities and decrease the overall efficiency of the CPTO application. CPTO will be user of traffic data, so this risk

	mainly concerns well functioning of related enablers.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_9_v1.0
Name of requirement	Road status assessment
Created by	CREATE-NET - lorenzo.maggi@create-net.org
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	- Application requirements - Technological and development requirements
Goal	Assessing the roads' traffic status
Definition	The CPTO shall be able to assess the roads' status regarding their availability, traffic load etc.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	The validation test should involve the real time gathering of information about road status and cross-checking of the validity of the outcome of the road status assessment algorithm
Acceptance criteria	TEAM has to be able to gather information about road status Correctness of the road status assessment outcome
Relationship with other requirements	See "Risk analysis"
Potential conflicts	Not foreseen at the moment
Risk analysis	If this requirement is not met, the optimization of public

	transport routes and schedules will not be able to account for traffic congestion. Hence, the efficiency of the route planning would decrease. This risk should be handled by the relevant enablers providing input to CPTO. In this case, the functionality of SP3_REQ_Int_CPTO_4_v1.0, SP3_REQ_Int_CPTO_10_v1.0, SP3_REQ_Int_CPTO_11_v1.0, SP3_REQ_Int_CPTO_21_v1.0 would be seriously affected.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_10_v1.0
Name of requirement	Affected bus routes
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	- Application requirements - Technological and development requirements
Goal	To ensure that bus routes which are affected by the current traffic situation are identified in order to proceed with the dynamic route planning and adaptation.
Definition	The CPTO shall be able to identify the bus routes that are affected by "difficult" conditions experienced in specific road segments.
Critical level (priority)	High
Validation Method (tests,	Check that all the affected bus routes are properly

indicators, performance bounds)	identified and stored in a format that could be processed by the route planning algorithms.
Acceptance criteria	Affected bus routes are identified correctly. The fact that the affected bus routes are identified in a timely manner (to be defined during specification) will promote the use of the CPTO application.
Relationship with other requirements	This requirement is dependent on the fulfilment of the previous requirement (SP3_REQ_Int_CPTO_9_v1.0) and on the Data Provisioning Related Requirements, that is SP3_REQ_Int_CPTO_4_v1.0, SP3_REQ_Int_CPTO_5_v1.0, SP3_REQ_Int_CPTO_6_v1.0, SP3_REQ_Int_CPTO_7_v1.0, SP3_REQ_Int_CPTO_8_v1.0
Potential conflicts	Not yet identified
Risk analysis	In case this requirement is not fulfilled the CPTO application will not function properly and will not serve its goal. To meet this requirement the current traffic situation and its forecast should be accurately estimated. This depends on TEAM traffic forecast enablers operation and update rate, assuming that intercommunication between TEAM components will be good.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_11_v1.0
Name of requirement	Alternative route calculation
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	CPTO development group

Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	- Application requirements - Technological and development requirements
Goal	To ensure that an alternative bus route can be calculated in case a specific road segment is blocked/unavailable.
Definition	The CPTO should be able to calculate dynamically an alternative route in case of unavailability of a specific road segment (e.g. in case an accident happens, civil works take place etc.).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Check that the provided alternative route can serve the origin/destination (O/D) pairs of the travellers and that the transport service is performed undisrupted.
Acceptance criteria	The fact that the alternative route calculation is performed in a timely, smooth and sensible manner will promote the use of the CPTO application. The calculated alternative routes should be valid.
Relationship with other requirements	This requirement is dependent on the fulfilment of the previous two requirements that is SP3_REQ_Int_CPTO_9_v1.0 & SP3_REQ_Int_CPTO_10_v1.0 and on the Data Provisioning Related Requirements, that is SP3_REQ_Int_CPTO_4_v1.0, SP3_REQ_Int_CPTO_5_v1.0, SP3_REQ_Int_CPTO_6_v1.0, SP3_REQ_Int_CPTO_7_v1.0, SP3_REQ_Int_CPTO_8_v1.0
Potential conflicts	Not yet identified
Risk analysis	In case this requirement is not fulfilled the CPTO application will not function properly and will not serve its goal.

	To meet this requirement the current traffic situation and its forecast should be accurately estimated as well as the affected buses and bus routes. Moreover CPTO algorithm should calculate in real time the necessary parameters. In case initial tests demonstrate delays then optimum and fast solutions will be investigated by CPTO algorithms group.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_12_v1.0
Name of requirement	Public transport stops handling
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimisation (CPTO)
Requirement category	- Application requirements - Technological and development requirements
Goal	To enable CPTO to assess the need for public transport stops and dispatch public transport vehicles.
Definition	The CPTO should take into account the transport preferences (origin, destination, time of travel, preferences regarding the means of transport etc.) from the travellers and dynamically make recommendations to the public transport operator in order to: a. add and/or skip stops b. add and/or skip complete scheduled itineraries.
Critical level (priority)	High (to medium)

Validation Method (tests, indicators, performance bounds)	Test algorithms in sample scenarios and simulation.
Acceptance criteria	Efficient public transport networks increase passenger throughput and allow faster service.
Relationship with other requirements	This requirement builds upon SP3_REQ_Int_CPTO_6_v1.0, SP3_REQ_Int_CPTO_7_v1.0 and SP3_REQ_Int_CPTO_8_v1.0 and may cooperate with SP3_REQ_Int_CPTO_11_v1.0, SP3_REQ_Int_CPTO_14_v1.0 and SP3_REQ_Int_CPTO_15_v1.0.
Potential conflicts	Updating the public transport network may interfere with route planning algorithms.
Risk analysis	Lack of the ability to change to change the public transport network will degrade the performance of the CPTO application. The risk of achieving this requirement is high because of legislative and other issues raised by local authorities and PT operators. CPTO will try to negotiate with them in the TEAM pilot sites and find realistic real traffic scenarios where part of CPTO use cases could be demonstrated. In any case simulation scenarios are also considered.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_13_v1.0
Name of requirement	Public transport operator adaptation
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	CPTO development group
Source (TEAM application or	Collaborative Public Transport Optimisation (CPTO)

enabler)	
Requirement category	- Application requirements - Connectivity and communication requirements
Goal	To ensure that the PT operator will adapt the public transport schedule based on the current demand and the outcome of the relevant CPTO algorithms
Definition	It shall be possible for the public transport operator to support this dynamic adaptation of the schedule/routes etc., to update the relevant information of the public transport means, and propagate this information to the CPTO application.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional and interoperability tests that there is two-way communication between the PT operator and the CPTO application
Acceptance criteria	The PT operator adapts its schedule timely (e.g. every 1 min? to be defined in the final specifications) based on the outcome of CPTO algorithms and travellers are served well
Relationship with other requirements	Relationship with SP3_REQ_Int_CPTO_4_v1.0
Potential conflicts	Due to the dynamic nature of this application there might be conflicts with other functionalities within the TEAM system
Risk analysis	In case the PT operator is not willing or not able to adapt the transport schedule based on the outcome of CPTO the core functionality of this application cannot be fulfilled. To avoid this risk CPTO will provide real time information on application suggestions to the PT Operator so he/she can decide in real time whether accepts or not. However, communication between

	Operator and Bus driver is an issue covered by the Operator. If this is not the case then an extra risk may arise and possible extra overhead for the implementation.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_14_v1.0
Name of requirement	Speed recommendations to the bus driver
Created by	FOKUS - florian.haeusler@fokus.fraunhofer.de
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimisation (CPTO)
Requirement category	Functional - Application requirements
Goal	Increase efficiency of the transport network
Definition	The CPTO application shall provide speed recommendations to the bus driver in a way that it increases the efficiency of the network. The application is closely related to the driving and merging application and collaborative adaptive cruise control, where similar requirements are expected.
Critical level (priority)	Low
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	Functional tests User acceptance

Relationship with other requirements	The application is closely related to the driving and merging application and collaborative adaptive cruise control, where similar requirements are expected.
Potential conflicts	None
Risk analysis	Small risks concerning the correctness of algorithmic calculation of speeds. However the risk of local authorities acceptance for such a use case or the quality of communication between operator and drivers is relevantly high depending on pilot sites facilities.
Status	New
Other	None

Requirement ID	SP3_REQ_Int_CPTO_15_v1.0
Name of requirement	Bus stop recommendations
Created by	TUB - sebastian.stiller@tu-berlin.de
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimisation (CPTO)
Requirement category	- Application requirements - Technological and development requirements
Goal	To enable CPTO to assess preferable time slots in which the buses handle the passengers at the bus stops in order to prevent undesirable headways.
Definition	The CPTO should take into account the transport preferences (origin, destination, time of travel, preferences regarding the means of transport etc.) from the travellers, current road conditions, as well as historical user data and historical road data, and the current status

	of all buses in the network in order to dynamically make recommendations to the bus drivers such that good headways are maintained. To this end, the CPTO communicates to the bus drivers in which time window the passengers at a specific bus stop shall be handled.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Test algorithms in sample scenarios and simulation.
Acceptance criteria	Preferable time windows for handling the passengers at the bus stops increase the passenger throughput and allow an overall faster service.
Relationship with other requirements	This requirement builds upon SP3_REQ_Int_CPTO_4_v1.0, SP3_REQ_Int_CPTO_5_v1.0, SP3_REQ_Int_CPTO_6_v1.0, SP3_REQ_Int_CPTO_7_v1.0 and SP3_REQ_Int_CPTO_8_v1.0 and may cooperate with SP3_REQ_Int_CPTO_11_v1.0, SP3_REQ_Int_CPTO_12_v1.0 and SP3_REQ_Int_CPTO_14_v1.0. It is linked also with SP3_REQ_Int_CPTO_17_v1.0.
Potential conflicts	Updating the recommended time windows for handling passengers at the bus stops may interfere with the dynamic route calculation, and the dynamic reaction on user demands.
Risk analysis	Lack of the ability recommend preferable time windows to the bus drivers may lead to undesirable headways of the buses and, thus, to a degradation of the performance of the CPTO application. This requirement again depends on the willingness and the ability of PT operator to accept such recommendations.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_16_v1.0
Name of requirement	Scheduling in case of an event
Created by	ICCS -panagiotis.lytrivis@iccs.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	- Application requirements - Technological and development requirements
Goal	The aim is to gather the relevant information from the public transport operator about the event and the fleet availability and serve in the best possible way the attendees of an event.
Definition	The CPTO application shall be able to calculate the best alternative routes and frequencies for buses to head to or out of an organised event after a relevant request from the Public transport operator.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Check that the provided bus routes and frequencies can sufficiently serve the attendees of the event and that the transport service is performed undisrupted.
Acceptance criteria	The fact that the new bus schedules are performed in a timely, smooth and sensible manner without affecting the normal everyday traffic will promote the use of the CPTO application.
Relationship with other requirements	This requirement builds upon SP3_REQ_Int_CPTO_3_v1.0 and SP3_REQ_Int_CPTO_4_v1.0 and cooperates with SP3_REQ_Int_CPTO_11_v1.0, SP3_REQ_Int_CPTO_12_v1.0

	and SP3_REQ_Int_CPTO_17_v1.0.
Potential conflicts	There might be the case that for serving that specific event the demand of everyday travellers could not be sufficiently served and/or delays might be caused.
Risk analysis	If this requirement is not met then there will be not specific planning for supporting the arrival/departure from the event which might cause traffic congestions and problems in the nearby area especially during the opening/closing hours of the event. The unexpectedness of the event can cause extra problems.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_17_v1.0
Name of requirement	Headway adaptation
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	- Application requirements - Technological and development requirements
Goal	To dynamically adapt the headway of two or more consecutive buses and thus provide a better transport service to the travellers.
Definition	The CPTO application shall be able to monitor the headway between two or more consecutive buses and in case these buses are getting too close together or too far apart to dynamically adapt their headway taking into

	account the current traffic situation and other information (e.g. the passenger load, the travellers' demand). Then the application notifies the bus drivers to adapt their distance by choosing speed or waiting times etc.
Critical level (priority)	High (to medium)
Validation Method (tests, indicators, performance bounds)	Check that the headway between two or more consecutive buses is dynamically adapted and that there are no buses moving too close together or too far apart. The needs of both the travellers and the public transport operators should be served.
Acceptance criteria	The fact that the new bus service with dynamically adapting the headway is performed in a timely, smooth and sensible manner thus promoting the use of the CPTO application.
Relationship with other requirements	Linked with SP3_REQ_Int_CPTO_15_v1.0.
Potential conflicts	Due to the dynamic nature of the transport environment there might be a conflict with the interests of other means of transport or with other bus lines.
Risk analysis	If this requirement is not met then the bus schedules will remain static without the possibility of adapting to the needs of modern cities and their citizens which will result in an obsolete public transport service. The risk of not correctly calculating the cases that an adaptation is needed is also important. This can be caused by small penetration rate of CPTO between those travellers or perhaps deliberately false usage of the application. CPTO should elaborate and test the rules for suggesting headway adaptations to eliminate these risks.
Status	New

Other	No

Requirement ID	SP3_REQ_Int_CPTO_18_v1.0
Name of requirement	Traveller and bus association
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	- Technological and development requirements
Goal	To associate a traveller with the specific bus that he/she is onboard.
Definition	The CPTO application shall be able to associate a traveller with a specific bus. This way the information that will be pushed to the traveller will be relevant not only to his/her position but also to the current bus route and schedule.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Check that the association is done correctly and the traveller is associated with the correct bus that he is actually on board and not another nearby bus.
Acceptance criteria	The correct association with significantly low false rate
Relationship with other requirements	Support the correct functionality of the CPTO application and is related to most of the application requirements in this list.
Potential conflicts	Not foreseen at the moment
Risk analysis	If this requirement is not met then there will be several false associations degrading significantly the performance of the CPTO application averting the users from actually using it. This requirement depends on the

	accuracy of the traveller and bus positioning. In TEAM smart approaches to enhance vehicle positioning are being implemented. Tests will lead to the optimum algorithm for this association.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_19_v1.0
Name of requirement	Historic User Data Processing
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimisation (CPTO)
Requirement category	Technological and development requirements
Goal	To predict future traffic user demand on the public transport system.
Definition	The CPTO application shall be able to process historical data related to demand for public transport means etc. per road segment and for specific timeframes and predict future demand per road segment and for specific timeframes.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Test prediction on samples of historic data, or data generated from simulations.
Acceptance criteria	Accurate prediction of user demand allows to provide appropriate amounts of public transport. This increases user experience and public transport efficiency.

Relationship with other requirements	This requirement builds on SP3_REQ_Int_CPTO_7_v1.0.
Potential conflicts	None
Risk analysis	Lack of accurate prediction will force the CPTO to reactive behaviour instead and take away superior proactive actions. This risk arises of other TEAM enablers whose input is used by CPTO.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_20_v1.0
Name of requirement	Historical data on traffic load
Created by	CREATE-NET - lorenzo.maggi@create-net.org
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Non-functional General architectural and equipment requirements
Goal	Predict the future traffic load in the short/long term.
Definition	Historical data related to traffic load shall be processed so that possible short (i.e. within hours) and long (within days or weeks) term changes in stops and/or complete scheduled itineraries can be predicted.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Historical data on traffic conditions should be stored and processed. The predictive models should be available.
Acceptance criteria	The accuracy of the traffic load prediction is above a fixed

	threshold. One could measure the accuracy as the difference (in absolute value) between the real traffic load, i.e. the sum of traffic loads in each road, and the predicted one.
Relationship with other requirements	This requirement builds on SP3_REQ_Int_CPTO_8_v1.0. See also "Risk analysis"
Potential conflicts	None
Risk analysis	If this requirement is not met, then the traffic load cannot be predicted, hence the functionality of SP3_REQ_Int_CPTO_11_v1.0, SP3_REQ_Int_CPTO_14_v1.0, SP3_REQ_Int_CPTO_21_v1.0 would be seriously affected. CPTO will be a user of this type of data and does not implement methods to minimise this risk.
Status	New
Other	This requirement strongly depends on the availability of large amounts of data, samples over various contextual conditions (e.g., different streets, hours of the day, days of the week, etc.)

Requirement ID	SP3_REQ_Int_CPTO_21_v1.0
Name of requirement	Real-time information to the traveller
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	- Application requirements - Technological and development requirements

Goal	To ensure that the travellers receive the needed information in a timely manner.
Definition	The CPTO application (as the majority of TEAM applications) should provide real-time information to the traveller such as the following: a. the current location of the bus of interest, b. the time they have to wait at the stop for the bus, c. info on the forthcoming stations, d. the estimated time to their destination, e. considerable delays on the route of interest, f. suggestions on alternative routes
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Test that the smartphones of the travellers are working as expected providing real-time information related to the their current location, forthcoming stops, connections, alternative routes etc.
Acceptance criteria	The information of interest are provided to each traveller (personalisation) in real-time and in a sensible manner that can be usable.
Relationship with other requirements	All the CPTO requirements should be satisfied in order to have reasonable outcomes to present to the travellers. There will be also a strong connection with SP4 DIALOGUE requirements related to the HMI aspects of the smartphones.
Potential conflicts	Not yet identified
Risk analysis	In case this requirement is not fulfilled the CPTO application will be useless for the travellers. To meet this requirement the described functionality of the CPTO application should be met (e.g. identification of affected bus routes, dynamic route adaptation etc.) as

	well as a close cooperation with SP4 should be established. This requirement is heavily based on traveller connectivity to the internet, an issue beyond CPTO development group actions. CPTO calculations should be fast to eliminate delays in sending the information.
Status	New
Other	Input from SP4 is expected for fulfilling this requirement and especially from the HMI working group

Requirement ID	SP3_REQ_Int_CPTO_22_v1.0
Name of requirement	Application layer connectivity with CPTO end-user
Created by	COSMOTE - imesogiti@cosmote.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Functional - Connectivity and communication requirement - Application requirement
Goal	CPTO application related data (stored/processed) at the Application Server and at the User Application Part shall be always synchronized.
Definition	The User Part of the CPTO application shall be linked to the CPTO Application Server, and CPTO related data stored/processed at these two parts shall be always synchronised/continuously updated (application layer connection).
Critical level (priority)	High
Validation Method (tests,	Testing/Verification of the linking between the CPTO User

indicators, performance bounds)	and Application Server Parts through network connectivity. Testing of the data exchange-update/synchronization process between the CPTO User and Application Server Parts in terms of: • reliability (do both sides possess the same data/results after synchronization?), • speed (is the duration acceptable?), • efficiency (is the process performed efficiently in terms of algorithms?), • flexibility (how easy it is to control the synchronisation period, time etc?), etc.
Acceptance criteria	When the CPTO User Application Part is up and running at the user terminal device, the User Application Part is continuously linked to the CPTO application server. Data stored/processed/presented at these two parts (at Server & User sides) is continuously updated through a (continuous or periodic) synchronisation process so that the information stored/processed/presented is always the same at both sides (Server-User).
Relationship with other requirements	Linked to SP3_REQ_Int_CPTO_23_v1.0 and SP3_REQ_Int_CPTO_24_v1.0 (application layer connectivity requirements)
Potential conflicts	None
Risk analysis	Partial or even total application malfunctioning. The application may provide some basic functionality to users but some "application results"/"application proposals" may not be valid/efficient, and may cause further distress to users and even problems to real world traffic situations. Depending on the Server-User Parts' synchronization

	period, and the number of physical events that have taken place during this period, the volume of synchronization data that shall be exchanged may be considerably large, thus requiring high speed network connectivity (e.g. through LTE).
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_23_v1.0
Name of requirement	Application layer connectivity with PT operator
Created by	COSMOTE - imesogiti@cosmote.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Functional - Connectivity and communication requirements - Application requirements
Goal	CPTO application related data (e.g. related to the transport means' time schedules/availability etc.) at the Application Server shall be always synchronised with the public transport operator systems.
Definition	The public transport operator information sent to the CPTO Application Server shall be continuously updated so that information stored/processed by the two entities (public transport operator servers and CPTO application) is always synchronised.
Critical level (priority)	High
Validation Method (tests,	Testing/Verification of the linking between the CPTO

indicators, performance bounds)	Application Server and public transport operator systems through network connectivity. Testing of the data exchange-update/synchronization process between the CPTO Application Server and public transport operator systems in terms of: • reliability (do both sides possess the same data/results after synchronization?), • speed (is the duration acceptable?), • efficiency (is the process performed efficiently in terms of algorithms? How does it respond to rapid changes?), • flexibility (how easy is it to control the synchronisation period, time etc?), etc.
Acceptance criteria	Optimally an always on communication connection between the CPTO Application Server and the public transport operator systems shall exist. Alternatively it shall be possible to have a communication link established whenever data shall be exchanged between those two entities. Data sent by the public transport operator systems to the CPTO Application Server is continuously updated through a (continuous or periodic) synchronisation process so that the CPTO related information (e.g. regarding the transport means' time schedules/availability etc.) stored/processed is always the same at both sides.
Relationship with other requirements	Linked to SP3_REQ_Int_CPTO_22_v1.0 and SP3_REQ_Int_CPTO_24_v1.0 (application layer connectivity requirements)
Potential conflicts	None
Risk analysis	Partial or even total application malfunctioning. The application may provide some basic functionality to users but some "application results"/"application

	proposals" may not be valid/efficient, and may cause further distress to users and even problems to real world traffic situations. Depending on the synchronization period, and the number of physical events that have taken place during this period, the volume of synchronization data that shall be exchanged may be considerably large, thus requiring very high speed network connectivity (e.g. through high speed fixed line communications, LTE etc.).
Status	New
Other	No

Requirement ID	SP3_REQ_Int_CPTO_24_v1.0
Name of requirement	Application layer connectivity with road operator
Created by	COSMOTE - imesogiti@cosmote.gr
Assigned partner	CPTO development group
Source (TEAM application or enabler)	Collaborative Public Transport Optimization (CPTO)
Requirement category	Functional - Connectivity and communication requirements - Application requirements
Goal	CPTO application related data (e.g. related to the road segment availability and traffic load information/data etc.) at the Application Server shall be always synchronised with the road operators' systems.
Definition	The road operators' information sent to the CPTO Application Server shall be continuously updated so that information stored/processed at the two entities (road

	operators' systems and CPTO application) is always synchronised.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Testing/Verification of the linking between the CPTO Application Server and road operators' systems through network connectivity. Testing of the data exchange-update/synchronization process between the CPTO Application Server road operators' systems in terms of: • reliability (do both sides possess the same data/results after synchronization?), • speed (is the duration acceptable?), • efficiency (is the process performed efficiently in terms of algorithms? How does it respond to rapid changes?), • flexibility (how easy is it to control the synchronisation period, time etc?), etc.
Acceptance criteria	Optimally an always on communication connection between the CPTO Application Server and the road operators' systems shall exist. Alternatively it shall be possible to have a communication link established whenever data shall be exchanged between those two entities. Data sent by the road operators' systems to the CPTO Application Server is continuously updated through a (continuous or periodic) synchronisation process so that the CPTO related information (e.g. related to the road segment availability and traffic load information/data etc.) stored/processed is always the same at both sides.
Relationship with other requirements	Linked to SP3_REQ_Int_CPTO_22_v1.0 and SP3_REQ_Int_CPTO_23_v1.0 (application layer connectivity requirements)

Potential conflicts	None
Risk analysis	The communication between CPTO and the road operator is not of significant importance, and possibly is not necesssary. The relevant risk is small.
Status	New
Other	The link with the road operator could be done indirectly through the CMC application. This has to be investigated during the specification and design phase.

F) Dynamic collaborative corridors

The DC requirements briefly highlighted in section 3.6 will be provided in more detail in the following by filling in the tabular template presented in Table 1-1.

Requirement ID:	SP3_REQ_Int_DC_01_v1.0
Name of requirement:	Warn driver when vehicle is about to enter a dedicated lane where it's not allowed being.
Created by	Claes Pihl (VTEC) - rafael.basso@volvo.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Dynamic Corridors (DC)
Requirement category	Collaborative Dynamic Corridors
Goal	Ensure that the driver is informed when the vehicle is about to enter a dedicated lane that the vehicle is not allowed using.
Definition:	The driver shall receive a warning when the vehicle is about to enter a lane that is dedicated to another traffic or vehicle type. The driver shall receive the warning in advance, so it's

	possible to change lane in a safe way. The ideal position (or time) for when this information shall be presented is TBD. It could depend on the speed, the traffic situation etc., and is something that has to be evaluated during the project. The driver shall receive a new warning if the vehicle is entering the dedicated lane. This warning shall probably be of a higher priority (like go from yellow to red). New warnings could be received if the driver persists driving in the wrong lane. How often is TBD. The form in which this information shall be presented is TBD.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Integration in the on-board unit and roadside/central infrastructure
Acceptance criteria	Warnings correctly displayed preferably before the driver enters the lane or with a tolerance of 10 seconds after crossing the lane boundaries.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	System will not have information on all available dedicated lanes. The lanes will be dynamic, so the information has to be fresh. There is a special case where a lane is shifting status while the truck is using it. This must also be handled. If the requirement is not fulfilled, the application could still be implemented, but the driver would not be warned if he/she is about to break the rules.

Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_02_v1.0
Name of requirement:	Recommend driver to shift lane when alternative dedicated lane is available.
Created by	Claes Pihl (VTEC) - rafael.basso@volvo.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Dynamic Corridors (DC)
Requirement category	Collaborative Dynamic Corridors
Goal	To ensure that the driver is aware that there is an alternative dedicate lane available.
Definition:	The system shall inform the driver when there is a suitable alternative dedicated lane available. This information shall not be presented before the dedicated lane is available, in contrast to the warning of driving into a dedicated lane where the vehicle is not allowed being. If the driver does not change to the dedicated lane, reminders shall be given. How often and how many times is TBD. The form in which this information shall be presented is TBD.
Critical level (priority)	High
Validation Method (tests, indicators, performance	System implemented in the on-board and roadside/central stations

bounds)	
Acceptance criteria	Recommendation presented according to availability of dedicated lanes
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	The positioning system has to be very exact, so the system knows in what lane the truck is driving. The lanes will be dynamic, so the information has to be fresh.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_03_v1.0
Name of requirement:	The system shall have knowledge of regulations and restrictions for all dedicated lanes in the area near the current vehicle position.
Created by	Claes Pihl (VTEC) - rafael.basso@volvo.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Dynamic Corridors (DC)
Requirement category	Collaborative Dynamic Corridors
Goal	The system shall know about all the dedicated lanes, and their regulations and restrictions, to be able to give the driver information, advices, and warnings regarding the use of dedicated lanes.
Definition:	The system shall know about regulations and restrictions for all dedicated lanes surrounding the vehicle.

Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	System integration with roadside/central stations
Acceptance criteria	Correct regulations available for the lanes surrounding the vehicle at any given time.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	The system must have access to correct and updated information. This is not static data, so the current status has to be transmitted to the vehicles when a lane is changing status. This is a core requirement for this application, with no workarounds foreseen.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_04_v1.0
Name of requirement:	The vehicle shall know about the current regulations in the area where it operates such as noise, emission or speed
Created by	Claes Pihl (VTEC) - rafael.basso@volvo.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Dynamic Corridors (DC)
Requirement category	Collaborative Dynamic Corridors
Goal	The vehicle shall know about the current regulations in the area where it operates so that it can automatically

	adapt to these.
Definition:	The vehicle shall know about the current regulations in the area (the current road) where it operates.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Integration with central/roadside and vehicle stations
Acceptance criteria	Correct regulations available for the system before the vehicle enters the specially regulated area. The regulations should be available for the complete itinerary of the vehicle.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	The system must have access to correct and updated information. This is dynamic data, so the current regulations have to be transmitted to the vehicles
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_05_v1.0
Name of requirement:	Computation of performance metrics
Created by	UniGe - franz@elios.unige.it
Assigned partner	DC development group
Source (TEAM application or enabler)	Dynamic Corridors (DC)
Requirement category	Serious gaming (SG)/Community building (CB)

Goal	To ensure that the DC application can take benefit of the SG/CB
Definition:	Every TEAM application should compute some user performance evaluation metrics that can be fed to the SG/CB application so that it can incentive proper usage of the application. The SG/CB application shall convert the user feedback coming from the SP3 (and 4) applications into virtual coins that, in turn, could be spent on acquiring higher quality of services in the SP3 (and 4) applications, thus building a virtuous cycle. In the DC application case, good metrics (to be computed in real time during a DC drive) could involve: • Keeping right speed • Keeping right distance • Keeping low fuel consumption • Respect the dynamic local regulations Actually, a penalty function should be defined, penalizing drivers whose behaviour deviates from the optimal behaviour. Parameters, such as weather, and road conditions will also be considered. Moreover, the actual use of the dynamic lanes, when available, will be considered as a merit parameter. Normalization will also be necessary to keep into account the fact that a driver could drive through the corridor more or less frequently and could drive through different corridors. Also, different vehicle models should be considered. Since different vehicles have inherently different behaviours (e.g., fuel consumption levels and other dynamic features) and the driver performance should be evaluated in a vehicle-independent way, it is important to

	decouple the driver assessment from the actual raw data (e.g., plain consumption).
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Verify the quality/relevance of DC application user performance assessment during the drive (in a DC case)
Acceptance criteria	Performance evaluation available for the Gaming framework.
Relationship with other requirements	SP3_REQ_Int_DC_06
Potential conflicts	None
Risk analysis	Lack of link to the SG/CB application would prevent the driver from a compelling way of continuously verifying and improving his performance using the DC application
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_06_v1.0
Name of requirement:	Spending virtual coins on application quality levels
Created by	UniGe - franz@elios.unige.it
Assigned partner	DC development group
Source (TEAM application or enabler)	Dynamic Corridors (DC)
Requirement category	Serious Gaming (SG)/ Community Building (CB)
Goal	To ensure that the DC application interacts with the SG
Definition:	Every SP3 application should be able to provide different levels of services (e.g., in terms of contents, look & feel,

	quality of information, etc.) so that the user can spend virtual coins on it. For the DC application, we can foresee that virtual coins could be spent to enter the (reserved) dynamic corridors, or could benefit from the assistance services for lane merging. Different quality/levels of feedback to a driven in a dynamic corridor may be provided based on the virtual coins spent by the driver. Moreover, information about available dynamic corridor in an area could be provided earlier to people having more coins.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Verify the quality/relevance of the differentiation among the various access levels within the DC application
Acceptance criteria	Different DC levels are available for different virtual coin expenditures
Relationship with other requirements	SP3_REQ_Int_DC_05_v1.0
Potential conflicts	None
Risk analysis	Lack of link to the SG/CB application would prevent the driver from having a compelling way of continuously verifying and improving his performance using the DC application
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_07_v1.0
Name of requirement:	The infrastructure shall be able to receive information about vehicle, goods, and type of operation.
Created by	Claes Pihl (VTEC) - rafael.basso@volvo.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Dynamic Corridors (DC)
Requirement category	Collaborative Dynamic Corridors
Goal	The system shall have knowledge of vehicle, goods and type of operation to be able to perform access control.
Definition:	The application shall be able to get information about vehicle, goods, and type of operation.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Integration with central station
Acceptance criteria	Correct information available for the system, including at least vehicle type, load and type of operation.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	To secure that the data is correct has a potential to be far more complex that just setting the data. At least if we aiming for a system that could be accepted as some kind of legal standard.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_DC_08_v1.0
Name of requirement	Dedicated lanes
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Functional (traffic management perspective)
Goal	The application via the traffic operator shall have the ability to change the operation of certain road lanes.
Definition	The traffic operator shall be able to dedicate a lane to a certain traffic or vehicle type. This should either be made momentarily, or scheduled so that for example a lane is dedicated to bus traffic every working-day between 7 to 9 am and 4 to 6 pm.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	This requirement can be tested by measuring time delays or traffic congestions with and without modular lanes operated by the application.
Acceptance criteria	Lanes can be dynamically allocated according to schedule or congestion.
Relationship with other requirements	N/A
Potential conflicts	N/A
Risk analysis	Drivers may refuse or because they are used, drivers may fail to comply with changes in certain roads. The changes if not thoroughly elaborated or well predicted may lead to the opposite of the desired results.

Status	New
Other	No

Requirement ID	SP3_REQ_Int_DC_09_v1.0
Name of requirement	Enforce regulations on certain areas
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Functional (traffic management perspective)
Goal	Specific road and traffic regulations should be enforced in certain defined geographic areas.
Definition	It shall be possible for a traffic manager to define areas to which regulations can be applied. An area is either defined as a geographic area (rectangle, circle etc.) or as a road segments.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	This requirement can be tested by measuring time delays or traffic congestions with and without the ability to dynamically enforce rules in geographic areas by the application.
Acceptance criteria	Specially regulated areas can be created in certain geographic areas according to criteria. The areas should have clear points of entry/exit.
Relationship with other requirements	Parent requirement of SP3_REQ_Int_DC_10_v1.0
Potential conflicts	Maybe merge with SP3_REQ_Int_DC_10_v1.0

Risk analysis	Enforcing regulation in a large area is a complicated issue to decide and to accomplish reducing undesired effects, such as erroneous decisions, failure for drivers to be aware of the dynamic changes.
Status	New
Other	No

Requirement ID	SP3_REQ_Int_DC_10_v1.0
Name of requirement	Apply regulations to an area
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Functional (traffic management perspective)
Goal	Specific road and traffic regulations should be enforced in certain defined geographic areas.
Definition	The following regulations shall be possible to apply to an area • Max noise. Expressed as a number of abstract levels (e.g. high, medium, low), or as measurable values [db] • Max emission. Expressed as a number of abstract levels or a measurable value, e.g. CO2/km. • Max speed. [km/h] • Safety level.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance	This requirement can be tested by measuring time delays, maximum noise, maximum emission or traffic flow with

bounds)	and without the ability to dynamically enforce rules in geographic areas by the application.
Acceptance criteria	The minimum four criteria should be available for applying to a regulated area.
Relationship with other requirements	Child requirement of SP3_REQ_Int_DC_09_v1.0
Potential conflicts	Maybe merged with SP3_REQ_Int_DC_09_v1.0
Risk analysis	Enforcing regulation in a large area is a complicated issue to decide and to accomplish reducing undesired effects, such as erroneous decisions, failure for drivers to be aware the dynamic changes. Also there might be an issue on measuring some values e.g. noise in some areas within the framework of the project (specific equipment is needed).
Status	New
Other	No

Requirement ID	SP3_REQ_Int_DC_11_v1.0
Name of requirement	Inform about the effect of enforced regulations
Created by	ICCS - panagiotis.lytrivis@iccs.gr
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Functional (traffic management perspective)
Goal	The traffic manager shall have feedback on the imposed regulations.
Definition	The system shall be able to inform the traffic manager

	about the effect of regulations. It shall be possible to understand what kind of vehicles can and cannot adapt to the given regulations. It shall also be able to estimate the expected impact of certain regulations, e.g. on emissions, noise, traffic flow etc.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	No particular validation method is needed for this requirement.
Acceptance criteria	Logged data match the expected impact at least 90% of the time.
Relationship with other requirements	N/A
Potential conflicts	N/A
Risk analysis	A big application penetration rate is required to conclude to reliable assessment of the application.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_12_v1.0
Name of requirement:	Traffic state data collection
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Application requirements
Goal	To have information on current traffic state

Definition:	The TEAM infrastructure will be able to deliver the following information to the SP3_DC application: • Information on current traffic state at different spatial scales. • Information on current traffic state at different temporal scales (but considering the time horizon of the DC application –seconds / minutes-). • The spatial / temporal information is adapted and filtered to the requirements of the current vehicle according to the desired routing / driving requirements. That is, only information is delivered that directly affects the vehicle using the DC application and / or is related to the currently selected route. • Low-granularity information (i.e. seconds or meters) is locally gained (i.e. in the vehicle) by evaluating data coming from other vehicles and the lowest-level infrastructure.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	Current traffic state for relevant areas is available with precision of at least 10 meters at least every 1 minute to the DC application.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	This requirement is compulsory for the application.
Status	New

Other	No

Requirement ID:	SP3_REQ_Int_DC_13_v1.0
Name of requirement:	Traffic state prediction I
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Application requirements
Goal	To have information on future traffic state that directly affects the DC application
Definition:	• The TEAM infrastructure will deliver information on traffic state to the vehicles using the DC application. • The delivered information is filtered and adapted to the needs of the current vehicle being routed / whose route is known. • The vehicle running the DC application will make a request for predictive traffic information according to a best-guess / intended route.
Critical level (priority)	Medium
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	The logged data matches at least 90% of the predictions.
Relationship with other requirements	N/A
Potential conflicts	None

Risk analysis	This requirement is not critical but it would add an innovative aspect to the TEAM overall concept. The main risk is to provide inaccurate predictions and affect traffic based on these false predictions. Solution: weight traffic predictions in combination with real-time measurements (e.g. information from other vehicles). Upon accurate / successful predictions, weights can be dynamically changed.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_14_v1.0
Name of requirement:	Traffic state prediction II
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Application requirements
Goal	Lane organization
Definition:	The system shall be able to "understand" how dedicated lanes affects the traffic situation, so that it could decide when they shall be used and not. • The DC application will issue event- or time-triggered requests demanding lane organization information • The TEAM infrastructure will issue lane organization information in a unified format (similar to that of traffic rules information) that the DC application will be able to understand.

	• The DC application will be able to make sense of lane organization information by feeding it to a local / in-vehicle "Traffic Management Unit".
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	The logged date matches at least 90% of the predictions.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	This requirement is compulsory for the DC application.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_15_v1.0
Name of requirement:	Access control to active corridor area
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Application requirements
Goal	The traffic manager shall be able to define areas where access control is required. An area is either defined as a geographic area (rectangle, circle etc.) or as one or more road segments.

Definition:	• The DC application will send periodic requests to the local Traffic Management Centre to check for validity / permission of the DC application in the requested area. • Whenever a new lane change is detected or predicted, a request for authorization for the DC application will be issued. • If authorization from the TMC is granted the DC application will be active for the requested area. • Areas might involve geometric shapes (square, circle, etc) • Roads and road segments should be also individually addressable.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	Area generated correctly, with clear entry/exit points.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	This requirement is compulsory for the DC application. This requirement defines DC-enabled areas where there is no danger to use the DC application or its infrastructure. Misuse of the DC application with no authorization of the TMC might lead to traffic accidents.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_16_v1.0
Name of requirement:	Access Control Criteria
Created by	Nicolas Gay (INTEL) - nicolas.a.gay@intel.com
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Application requirements
Goal	It shall be possible to set criteria for when a vehicle is permitted to enter an area or not.
Definition:	Criteria (examples): • Vehicle (weight and dimensions, engine type, emission or noise level etc.), • Load (dangerous goods could for example be not allowed) • Type of operation (commercial transport, public transportation etc.). • Certifications • Membership in organizations.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	Criteria set for access control is available for the application, with at least control by vehicle type.
Relationship with other requirements	N/A
Potential conflicts	None

Risk analysis	This requirement is relevant but no compulsory for the DC application. Since DC involves safety issues regarding traffic management at lane / corridor level, the ability to manage traffic by restricting access to certain areas of the city or particular streets plays also an important role. SP3 COPLAN implements mechanisms to manage traffic in the sense described in this requirement, which will be entirely operated by the TMC (Traffic Management Centre). DC will use this ability of SP3 COPLAN indirectly, and thus the requirement can be considered fulfilled. Improper implementation of this functionality might lead to detriment of the quality of service provided by DC.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_17_v1.0
Name of requirement:	Lane necessary
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Functional requirements
Goal	Determine the necessity of dedicated lanes
Definition:	The system shall be able to understand when, and when not, the total traffic situation would benefit from having lanes dedicated to certain traffic or vehicle types. Lanes will automatically be dedicated according to this understanding.
Critical level (priority)	High

Validation Method (tests, indicators, performance bounds)	Functional tests, simulations
Acceptance criteria	Lanes created only when necessary. Logged data should show a benefit in terms of traffic flow, either for specific types of vehicles (e.g. buses) or for the overall traffic.
Relationship with other requirements	N/A
Potential conflicts	This requirement changes the traffic density and thus interacts with any requirement that uses traffic density information.
Risk analysis	Lack of the ability to detect need for designated lanes and the ability to assign them automatically will disable the dynamic corridors application.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_18_v1.0
Name of requirement:	Vehicle participation detection
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Technical requirements
Goal	To know when vehicles enter an access control area
Definition:	The system shall be able to know when a vehicle is about to enter an area with access control, as well as the vehicles that are already inside the area. The main

	objective is to monitor and control occupancy and priorities.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests, simulations
Acceptance criteria	Vehicles are correctly identified.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	Accurate positioning and route data for all participants is necessary. If this is not available, the application performance will be decreased.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_19_v1.0
Name of requirement:	Vehicle self-information
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Technical requirements
Goal	The infrastructure should be able to gather information about participants.
Definition:	The vehicles shall be able to identify themselves and give information about the type (truck, bus, car, taxi, etc), the

	goods, passengers, type of operation etc.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests
Acceptance criteria	Accurate information allows optimal operation from a system point of view and to treat individual vehicles according to its needs. The minimum information necessary is the vehicle type.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	In order to optimize infrastructure utilization this requirement is essential. The core functionality of the application could still be demonstrated without fulfilling this requirement.
Status	New
Other	No

Requirement ID:	SP3_REQ_Int_DC_20_v1.0
Name of requirement:	Admission control
Created by	NUIM - Arieh.Schlote@nuim.ie
Assigned partner	DC development group
Source (TEAM application or enabler)	Collaborative Dynamic Corridors
Requirement category	Technical requirements
Goal	To evaluate permission on a per vehicle basis.

Definition:	The system shall be able to evaluate if the vehicle is allowed to enter the area. When a vehicle approaches a controlled area the system should be able to evaluate if the vehicle is allowed to enter and communicate the access granted/denied in good time.
Critical level (priority)	High
Validation Method (tests, indicators, performance bounds)	Functional tests, simulations
Acceptance criteria	Traffic in the area is close to ideal. Vehicles who are not allowed in the area will need some additional incentive to obey.
Relationship with other requirements	N/A
Potential conflicts	None
Risk analysis	This is a core requirement for the DC application.
Status	New
Other	No