### D5.2 Architecture and System Specification

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**Abstract**

This document presents the architectures of ecoTraffic Management and Control systems, applications and components. A hierarchical approach with strategic and tactical elements was chosen. Interface design for domain specific interactions as well as external interactions are discussed based on the ecoTraffic Management and Control system overview. The aim of this document is to set the scope for the implementation work package; however the content of this document is not definitive and should be further detailed in the next phases of research.
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TABLE OF CONTENTS

TABLE OF CONTENTS ...........................................................................................3
TERMS AND ABBREVIATIONS .................................................................................7

1. SCOPE ................................................................................................................8
   1.1. IDENTIFICATION ...........................................................................................8
   1.2. SYSTEM OVERVIEW ...................................................................................8
   1.3. DOCUMENT OVERVIEW ...........................................................................10

2. REFERENCED DOCUMENTS .............................................................................11

3. SYSTEM-WIDE DESIGN DECISIONS ...............................................................12
   3.1. COORDINATE TRAFFIC CONTROLLERS .....................................................14
   3.2. IMPROVE DRIVER INFORMATION ...............................................................16
   3.3. IMPROVE NETWORK USAGE .....................................................................17
   3.4. IMPROVE INTERSECTION CONTROL AND BALANCE INTERSECTION CONTROL
        OBJECTIVES ...................................................................................................19
   3.5. IMPROVE APPROACH VELOCITY ...............................................................22
   3.6. IMPROVE RAMP METERING .....................................................................23
   3.7. SUPPORT MERGING ..................................................................................25
   3.8. IMPROVE PARKING GUIDANCE .................................................................26
   3.9. INCREASE TRAFFIC FLOW STABILITY ........................................................28
   3.10. LEGEND: BUSINESS LAYER DICTIONARY .................................................29
   3.11. CONCLUSIONS AND GUIDE TO THE ARCHITECTURAL DESIGN ..............30

4. SYSTEM ARCHITECTURAL DESIGN ...............................................................31
   4.1. LEGEND: APPLICATION LAYER DICTIONARY ..........................................31
   4.2. LEGEND: TECHNOLOGY LAYER DICTIONARY .........................................32
   4.3. SYSTEM OVERVIEW ..................................................................................33
   4.4. SYSTEM: ecoAdaptive BALANCING AND CONTROL (“ecoABC”) ...............34
   4.5. SYSTEM: ecoMOTORWAY MANAGEMENT (“ecoMM”) ................................37
   4.6. SYSTEM: ecoAdaptive TRAVELLER SUPPORT (“ecoATS”) .........................39
   4.7. APPLICATION: ecoROUTE ADVICE ...........................................................41
   4.8. APPLICATION: ecoPARKING ADVICE .........................................................44
   4.9. APPLICATION: ecoGREEN WAVE ...............................................................46
   4.10. APPLICATION: ecoBALANCED PRIORITY ...............................................49
   4.11. APPLICATION: ecoRAMP METERING .........................................................51
   4.12. APPLICATION: SUPPORT MERGING ........................................................54
   4.13. APPLICATION: ecoSPEED AND HEADWAY MANAGEMENT .....................55
   4.14. APPLICATION: ecoTRUCK PARKING .......................................................59
   4.15. APPLICATION: ecoTOLLING ....................................................................62
   4.16. APPLICATION: ecoAPPROACH ADVICE ................................................65
   4.17. COMPONENT: ecoNETWORK PREDICTION ............................................67
   4.18. COMPONENT: ecoEMISSION ESTIMATION AND PREDICTION ...............70
   4.19. COMPONENT: ecoTRAFFIC STRATEGIES ................................................74
   4.20. COMPONENT: DRIVER INFO SUPPORT MANAGER ..................................76
   4.21. COMPONENT: DRIVER DIALOG MANAGER .............................................78
   4.22. COMPONENT: TCC/TMC ADAPTER ..........................................................80
4.23. COMPONENT: TLC ADAPTER .................................................................82
4.24. COMPONENT: RMC ADAPTER ..............................................................85
4.25. COMPONENT: MS ADAPTER .................................................................87
4.26. CONCLUSIONS AND GUIDE TO THE INTERFACE DESIGN ..................87

5. INTERFACE DESIGN ..................................................................................88
  5.1. INTRODUCTION ......................................................................................88
  5.2. OVERVIEW OF RELEVANT INTERFACES .............................................88
  5.3. PHILOSOPHY OF CROSS-APPLICATION INTEGRATION .........................89
  5.4. UNIFORM CONTROL TARGETS ..............................................................92
  5.5. PHILOSOPHY OF INTERFACE DESIGN .................................................95
  5.6. INTERFACE CLUSTER 1: eCoMove versus roadside systems .................96
  5.7. INTERFACE CLUSTER 2: eCoMove versus master systems .....................99
  5.8. INTERFACE CLUSTER 3: DATA EXCHANGE WITH ecoMAPS AND ecoMODELS101
  5.9. INTERFACE CLUSTER 4: DATA EXCHANGE WITH THE VEHICLE ..........107
  5.10. INTERFACE CLUSTER 5: DATA EXCHANGE WITH OTHER SERVICE CENTRES...110

6. REQUIREMENTS TRACEABILITY ..................................................................111
FIGURES AND TABLES

Figure 1 – Document Scope ...................................................................................................... 8
Figure 2 - Overall system concept ............................................................................................ 9
Figure 3 – Time and area scales of operation ......................................................................... 9
Figure 4: Business Layer Diagram for Coordinate Traffic Controllers ................................. 14
Figure 5: Business Layer Diagram for Improve Driver Information ..................................... 16
Figure 6: Business Layer Diagram for Improve Network Usage ........................................... 18
Figure 7: Business Layer Diagram for Improve Intersection Control and Balanced Intersection Control Objectives .............................................................................................. 20
Figure 8: Business Layer Diagram for Improve Approach Velocity ...................................... 22
Figure 9: Business Layer Diagram for Improve Ramp Metering ........................................... 24
Figure 10: Business Layer Diagram for Support Merging ..................................................... 25
Figure 11: Business Layer Diagram for Improve Parking Guidance .................................... 27
Figure 12: Business Layer Diagram for Increase Traffic Flow Stability .............................. 28
Figure 13: Application Layer Diagram for System Overview ................................................ 33
Figure 14: Application Layer Diagram for the ecoABC system ............................................ 35
Figure 15: Technology Layer Diagram for the ecoABC system ............................................ 36
Figure 16: Application Layer Diagram for the ecoMM system ............................................. 38
Figure 17: Technology Layer Diagram for the ecoMM system ............................................. 39
Figure 18: Application Layer Diagram for the ecoATS system ............................................. 40
Figure 19: Application Layer Diagram for ecoRoute Advice ............................................... 42
Figure 20: Technology Layer Diagram for ecoRoute Advice .............................................. 43
Figure 21: Application Layer Diagram for ecoParking Advice ........................................... 44
Figure 22: Technology Layer Diagram for ecoParking Advice .......................................... 45
Figure 23: Application Layer Diagram for ecoGreen Wave ................................................. 46
Figure 24: Technology Layer Diagram for ecoGreen Wave ................................................ 48
Figure 25: Application Layer Diagram for ecoBalanced Priority ........................................ 49
Figure 26: Technology Layer Diagram for ecoBalanced Priority ......................................... 51
Figure 27: Application Layer Diagram for ecoRamp Metering ............................................ 52
Figure 28: Technology Layer Diagram for ecoRamp Metering ............................................ 53
Figure 29: Application Layer Diagram for ecoSupport Merging .......................................... 54
Figure 30: Technology Layer Diagram for ecoSupport Merging ........................................... 55
Figure 31: Application Layer Diagram for ecoSpeed and Headway Management ............... 56
Figure 32: Technology Layer Diagram for ecoSpeed and Headway Management ............... 58
Figure 33: Application Layer Diagram for ecoTruck Parking .............................................. 59
Figure 34: Technology Layer Diagram for ecoTruck Parking .............................................. 61
Figure 35: Application Layer Diagram for ecoTolling .......................................................... 63
Figure 36: Technology Layer Diagram for ecoTolling .......................................................... 64
Figure 37: Application Layer Diagram for ecoApproach Advice ......................................... 65
Figure 38: Technology Layer Diagram for ecoApproach Advice .......................................... 67
Figure 39: Application Layer Diagram for ecoNetwork Prediction ..................................... 68
Figure 40: Technology Layer Diagram for ecoNetwork Prediction ..................................... 70
Figure 41: Application Layer Diagram for Estimate and Predict Emission (Macro) ............... 71
Figure 42: Application Layer Diagram for Estimate and Predict Emission (Micro) ............... 72
Figure 43: Technology Layer Diagram for ecoEmission Estimation and Prediction ............. 73
Figure 44: Application Layer Diagram for ecoTraffic Strategies ........................................ 74
Figure 45: Technology Layer Diagram for ecoTraffic Strategies ........................................ 75
Figure 46: Application Layer Diagram for Driver Info Support Manager ............................. 76
Figure 47: Technology Layer Diagram for Driver Info Support Manager ............................. 77
Figure 48: Application Layer Diagram for Driver Dialog Manager ....................................... 78
Figure 49: Technology Layer Diagram for Driver Dialog Manager ...................................... 79
Figure 50: Application Layer Diagram for TCC / TMC Adapter ........................................... 80
Figure 51: Technology Layer Diagram for TCC / TMC Adapter .......................................... 81
Figure 52: Application Layer Diagram for TLC Adapter ....................................................... 82
Figure 53: Technology Layer Diagram for TLC Adapter ...................................................... 84
Figure 54: Application Layer Diagram for RMC Adapter ..................................................... 85
Figure 55: Technology Layer Diagram for RMC Adapter ..................................................... 86
Figure 56 – System Overview with all relevant interfaces ..................................................... 88
Figure 57: The position of the Uniform control targets .......................................................... 93

Table 1: The SP5 use cases that are referred to in this chapter............................................... 13
Table 2: Symbols used in Business Layer Diagrams .............................................................. 30
Table 3: Symbols used in Application Layer Diagrams ......................................................... 32
Table 4: Symbols used in Technology Layer Diagrams ......................................................... 32
Table 5: Examples of Uniform Control Targets ..................................................................... 93
TERMS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
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<td>AL</td>
<td>Application Layer</td>
</tr>
<tr>
<td>BL</td>
<td>Business Layer</td>
</tr>
<tr>
<td>CP</td>
<td>Cultural and Political requirement</td>
</tr>
<tr>
<td>F</td>
<td>Functional requirement</td>
</tr>
<tr>
<td>FVD</td>
<td>Floating Vehicle Data</td>
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<td>HGV</td>
<td>Heavy Goods Vehicle</td>
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<td>L</td>
<td>Legal requirement</td>
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<td>LF</td>
<td>Look and Feel requirement</td>
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<tr>
<td>MPV</td>
<td>Multi Purpose Vehicle</td>
</tr>
<tr>
<td>MS</td>
<td>Maintainability and support requirement</td>
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<tr>
<td>OE</td>
<td>Operational and Environmental Requirement</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>P</td>
<td>Performance Requirement</td>
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<td>RSU</td>
<td>Road side unit</td>
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<tr>
<td>S</td>
<td>Security requirement</td>
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<td>SP</td>
<td>Sub-project</td>
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<td>STO</td>
<td>Scientific and Technological Objectives</td>
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<td>TCC</td>
<td>Traffic Control Centre</td>
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<td>TL</td>
<td>Technology Layer</td>
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<tr>
<td>TMC</td>
<td>Traffic Management Centre</td>
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<tr>
<td>UH</td>
<td>Usability and Humanity requirement</td>
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<td>V2I</td>
<td>Vehicle-to-Infrastructure</td>
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<td>Work package</td>
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Term Definition:

ecoMap: The ecoMap serves as the central database for all geo-referenced information that is used or produced by the applications and components. It is in the very centre of the architecture as in almost all cases the exchange of data between components and applications is realised via ecoMap to which they all are connected with. For a more comprehensive specification of the ecoMap see the deliverable D2.3.

Adapters: The eCoMove system has to be integrated in different test sites or simulation environments, where legacy systems with specific interfaces reside. To realise the adaption to these specific environments certain adapters are introduced that can be considered as abstraction layer (one interface side unique and one side environment-specific).

Simulators: Micro/macro simulators substitute the reality in cases where statistics of larger sample sets are required. For evaluation those simulation environments can be seen as a supplement to test sites. For a more comprehensive specification of the micro and macro simulation environments see D.3.
1. Scope

1.1. Identification

This document describes the architecture, system specifications and interfaces specifications of the ecoTraffic Management and Control systems, applications and components. The content of this deliverable is the result of work package 3 and logically extents the use cases and system requirements as defined in work package 2, and provides a clear starting point for the implementation activities in work package 4.

The system and scope of this document can best be understood by means of the Figure below. The Figure illustrates how the technologies and functionalities provided by eCoMove facilitate a connection between infrastructure and vehicles, and ultimately infrastructure systems and vehicle drivers. It is the aim of this document to detail ‘what’ eCoMove does as defined in D5.1, into ‘how’ eCoMove it will do it. That is, building ‘upon’ the current state-of-the-art rather than an independent design on its own.

Figure 1 – Document Scope

A bottom-up approach is used. In this document several components are described which enable data exchange, data collection and data processing to support applications in their task. Applications perform an action and provide significant added value to ecoTraffic Management and Control processes. They are designed in a way that allows collaboration, which leads to integrated systems for the urban and motorway domain.

1.2. System overview

One operation environment for all entities, to reduce fuel consumption in traffic by 20 percent is the purpose of the system. The Figure below summarizes on a high level the domain covered by the system. Three major entities can be indentified: private vehicles, commercial vehicles and logistics, and traffic management and control. This document addressed the latter.
In the context of ecoTraffic Management and Control in relation with the eCoMove system, this document often refers to ‘infrastructure’. Infrastructure refers to the combination of traffic management and control measures independent of their roadside or central physical location. Roadside infrastructure related to roadside units connected to legacy traffic systems such as traffic lights, ramp metering installations, variable message signs, toll gates and others. On the other hand, ‘central’ generally refers to a traffic management centre or elements which are physically stored at or originated from a back-office location. In functional terms this segregation would highlight the distinction between strategic and tactical operations. See also the Figure below.

Figure 2 - Overall system concept

Figure 3 – Time and area scales of operation
Throughout this document it is assumed that roadside and central entities or strategic and tactical operations are linked, and that data objects and operation rules are exchanged between them. In general, operation rules are established on higher levels and distributed to lower levels, while data objects are mostly derived on lower levels and aggregated for use on higher levels. The main user of the system from the traffic management and control perspective is the road operator. With the system the road operator will be provided with the means to influence and monitor a set of functional elements to reduce fuel consumption where and when necessary.

1.3. Document overview

This document is arranged as follows. In chapter 2 the documents used as reference material are listed. Chapter 3 presents the business layers diagrams as derived from the use cases, each followed by a number of system-wide design decisions. Application design and deployment schemes are presented in chapter 4. In chapter 5 the overall system overview is presented and the interfaces are specified. Finally, chapter 6 summarizes by means of identifying traceability of requirements.

Using the eCoMove modelling language based on JSTD-016 standard, this document will provide detailed descriptions of SP4 components on three levels:

- Business Layer: services realized by processes, used by actors with a certain behaviour
- Application Layer: services are described further down in terms of applications and functions
- Technology Layer: on which device or nodes components are deployed

As such, it will serve as basis for application developers to implement the SP4 systems during the WP4 phase.

More details on the eCoMove modelling language can be found in D2.2.
2. Referenced documents

- Ronald van Katwijk and Jaap Vreeswijk, SP5 Use Cases and System Requirements, D5.1, ecoTraffic Management and Control, 2010
- N. Eikelenberg, J. Subbian, S. T’Siobbel, E.P. Neukircher, L. Bersiner, M. Mann and Z. Jeftic, System Concept, Functionality, Requirements and Use Case Description, D2.1, Core Technology Integration, 2010
- eCoMove, Functional Architecture and specifications for ecoSmartDriving and ecoTripPlanning, D3.2, ecoSmart Driving (to be published)
- eCoMove, Functional Architecture and specifications for ecoPostTrip and ecoMonitoring, D3.3, ecoSmart Driving (to be published)
- eCoMove, Functional Architecture and System specifications, D4.2, ecoFreight and Logistics (to be published)
- eCoMove, High Level Architecture, D2.2, Core Technology Integration (to be published)
- IEEE-J STD-016
3. System-wide Design Decisions

The System Architectural Design is the ecoMove concept that focuses on how a structure or system, as viewed by the users, meets their needs and requirements. See also architectural design in chapter 4.

This chapter is dedicated to system-wide design decisions, i.e. decisions about the system's behavioural design (how it will behave, from a user's point of view, in meeting its requirements, ignoring internal implementation) and other decisions affecting the selection and design of system components. This part of the system specification is a deeper, more formalised and comprehensive view on the main use cases that have already been defined in the deliverable D5.1.

The system-wide design decisions will be derived from a special architecture that is tightly use case correlated and is named a “Business Layer Architecture” (BLA). The BLA elaborates about the communication between actors and the sequence of happenings in a particular use case. It herewith illustrates the processes that lead to the offering of products and services to external customers, which are realized in the organization by eCoMove processes performed by eCoMove actors. According to this, all use cases concerned here (each of which has its own sub-chapter) come with a BLA consisting of a diagram, a description of the diagram and one or more design decision together with the reason that has lead to the decision.

In order to come to the relevant design decisions, the following subsequent steps have been carried out:

- Selection of those main eCoMove SP5 use cases (1) where the definition of a behavioural design is desirable and (2) that are closely correlated with relevant design decisions.

- Creation of Business Layer Diagrams based on the “ArchiMate Modelling Language”. Explanation of all objects, data items, interfaces and processes that are crucial to understand the behavioural design.

- Creation of one or more design decisions together with a concise reasoning of the decision.

The table below provides an overview of the BLA diagrams of this chapter and their relationship to use cases as defined in D5.1.
Table 1: The SP5 use cases that are referred to in this chapter

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<td>Improve Parking Guidance</td>
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<td></td>
<td>Improve network usage</td>
<td>Improve Network Usage</td>
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<tr>
<td></td>
<td>Improve driver information</td>
<td>Estimate and Predict Emission</td>
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<tr>
<td>Corridor</td>
<td>Coordinate traffic controllers</td>
<td>Coordinate Traffic Controllers</td>
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<td>Support merging</td>
<td>Support Merging</td>
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<td>Local</td>
<td>Improve intersection control</td>
<td>Improve Intersection Control and Balance</td>
</tr>
<tr>
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<td>Balance intersection control objectives</td>
<td>Intersection Control Objectives</td>
</tr>
<tr>
<td></td>
<td>Improve ramp control</td>
<td>Improve Ramp Metering</td>
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<tr>
<td></td>
<td>Improve lane usage</td>
<td>Improve Lane Usage</td>
</tr>
<tr>
<td></td>
<td>Improve approach velocity</td>
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</tr>
<tr>
<td></td>
<td>Improve traffic flow stability</td>
<td>Improve Traffic Flow Stability</td>
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Business layer diagrams describe the processes that constitute use cases. They may comprise several applications and components. The basis of the diagrams is made up of “business actors” and “business roles”. A “business role” can be regarded as a specific behaviour of a “business actor”, which is usually supported by means of technical systems. Those technical systems behind are sketches in the diagrams by associating them with “business services” and “business processes”. Moreover, the main data items are identified and indicated in form of “data objects”. The corresponding data flows are expressed as “business interfaces”. The interfaces found here in the business layer diagrams are in line with the derived architectural design. For a description of terms and icons see also chapter 3.10.

The following sub-chapters describe the SP5 relevant use cases or scenarios in more detail.
3.1. Coordinate Traffic Controllers

The coordination of subsequent traffic light controllers along a string of intersections owns two innovative features:

1. new objective functions with particular respect to fuel consumption and
2. conducted platoons by means of driver information (speed recommendation).

These two main functions closely cooperate with each other.

The business layer diagram:

- The diagram shows the main subsequent processing steps of the use case which are “Calculate Green Wave Coordination” and “Calculate Speed Advice” together with their input and output data items, the associated services, roles, actors and interfaces. Note that these steps are realised as different applications in the architectural design (see also chapter 4.9 and 4.16).

- The role “TCC/TMC” provides periodically valid strategies (e.g. prioritisation of directions) and control data (e.g. the actual running signal/frame program) as input values to the process “Calculate Green Wave Coordination”.

Figure 4: Business Layer Diagram for Coordinate Traffic Controllers
There are also services “Provide Macroscopic Traffic States” and “Provide Microscopic Traffic States” that provide periodically macroscopic and microscopic traffic states as input values to the process “Calculate Green Wave Coordination”. These services are realised by other functional parts of the SP5 system (partly coming from SP2) and can therefore be regarded as out of scope of this diagram context.

The process “Calculate Green Wave Coordination” calculates optimal coordination of signal control programs along a defined road section of subsequent intersections, which means that it adjusts green windows in a way that the throughput of moving vehicle platoons is maximised. The outcome of this process is a coordination scheme, consisting either of rotation values for signal / frame programs or green window locations and coordination speed data. The aim of the coordination is to let vehicles pass a sequence of controllers without abrupt changes in their speed profile thereby taking into account demand fluctuations.

The coordination schemes are transmitted to the intersection controller (depending on the system environment either directly or via TCC) together with the request to update the signal light control according to the coordination scheme within a defined time frame. The response of the intersection controller is given either directly or via “TCC/TMC” (control data).

The process “Calculate Speed Advice” (see also chapter 4.16) calculates the speed advice information that is expressed in the form of spatial distribution (along the road section) of speed values. The speed advice is optimised such that the moving vehicles platoons are kept together and moves with the speed that fits to the green windows to come.

The speed advice information is received by the vehicle and processed by the ecoDriving Support that decides to which degree it will follow those advices.

System-wide design decisions:

1. **Decision**: The speed advice provided to the vehicles shall be a spatial-temporal distribution that shall be broadcasted. It is not addressed to individual vehicles.

   **Reason**: Each vehicle can derive the part of information that is relevant for its location and special conditions.

2. **Decision**: The coordination control data (signal / frame programs, preferred green windows) shall be provided to the intersection controllers that are used then by the local signal light control.

   **Reason**: Because the application is going to be evaluated and demonstrated at test sites in the Netherlands and Germany. In both countries it is remote control of signal groups from the centre is generally not used.

3. **Decision**: The strategy data (“Uniform Control Targets” coming from the TCC) shall comprise the actual signal / frame programs which are running in the intersection controller at that moment.

   **Reason**: This data also express the current strategy that is pursued by the traffic light control.
4. **Decision**: The processes “Calculate Green Wave Coordination” and “Calculate Speed Advice” can run either in the TCC (traffic control centre) or the TLCs (traffic light controller).

   **Reason**: There are different system architectures of the legacy system in the test sites that has to be taken into account.

5. **Decision**: The coordination schemes can be of different kind, either a set of signal/frame program data for the traffic light intersection control or explicit locations for the next green windows.

   **Reason**: There are different control approaches/methodologies of the legacy system in the test sites that have to be taken into account.

6. **Decision**: Speed advice shall only be generated due to a new coordination scheme if the intersection controller affirms the change of the control parameters.

   **Reason**: Otherwise the speed advice would not be in line with the traffic light timings.

### 3.2. Improve Driver Information

Infrastructure systems provide drivers and vehicles with general and tailored information before and during the trip that is generated by various eCoMove infrastructure applications.

The main goals of “Improve Driver Information” are to provide traffic information to vehicles and drivers and to provide travel and driving advices to vehicles and drivers.

The business layer diagram:

![Diagram](image)

**Figure 5: Business Layer Diagram for Improve Driver Information**

- The diagram shows the main subsequent processing steps of the use case “Improve Driver Information” together with its input and output data items, the associated services, roles,
actors and interfaces. The diagram shows a process that is related to the SP5 system ecoABC which is responsible for calculating network traffic state and prediction and providing eco traffic strategy information.

- The role “Traffic Operator” provides dynamic data like loop data, traffic management strategies and traffic signal information.
- The role ecoABC calculates and provides traffic state and prediction information and traffic management strategies by means of storing this information into the SP2 ecoMap.
- The process “retrieve current and predictive situational data and eco strategy information” requests the most recent information from the ecoMap.
- The process “calculate traffic flow prediction” is reformatting the traffic state and prediction information taking into account the request for “driver information” coming from the driver. This process includes geo-referencing of the data and results in a new set of TPEG-TFP messages.
- The process “calculate traffic events” is reformatting the traffic event and strategy information taking into account the request for “driver information” coming from the driver. This process includes geo-referencing of the data and results in a new set of TPEG-TEC messages.

System-wide design decisions:

1. **Decision**: Every vehicle can request from the ecoATS system tailored (by means of vehicle type and spatial filters) information about traffic state and prediction information as well as on traffic events and traffic management strategies.

   **Reason**: With this information for each vehicle it is possible to calculate the route within the vehicle (or in a routing service) in the most efficient way either by considering the predicted traffic states or by just following traffic management strategies.

3.3. **Improve Network Usage**

Improve Network Usage lays the data basis for various strategies and measures that aim to reduce the overall fuel consumption of the vehicles in the network. The following tasks are part of the Improved Network Usage:

- Determine a macroscopic network traffic state on the basis of available traffic control states, sensor data, traffic incidents, ecoFVD data and vehicles’ current fuel consumption.
- Define the macroscopic network traffic state in terms of travel times, traffic demand, traffic flows and dynamic source-destination route distributions that reflect minimal fuel consumption for the totality of traffic.
- Compute routes which serve the system and the driver requirements (win-win routes).
- Provide a benchmark for optimal fuel consumption in a road network.
The business layer diagram:

- The diagram shows the main subsequent processing steps of the use case which are “Calculate Energy Map”, “Calculate Optimal Route Distribution” and “Generate Route Advice” together with their input and output data items, the associated services, roles, actors and interfaces.

- All input data of the processing steps are retrieved from the ecoMap.

- All result data of the processing steps are stored in the ecoMap.

- The Calculation of the Energy Map is triggered through a timer that provides a cycle time period for the calculation.

- ecoNavigation will provide information whether a route advice is required or not. If no route advice is needed, only the o-d-information will be extracted from the “ecoRoute”.

- The “ecoRoute” requests from individual vehicles will be used to derive or to improve o-d-matrices that are then used for calculating the Energy Map.

- The optimal route distribution is used as input data for the “Generate Route Advice” process.

- The “Generate Route Advice” is provided with route distributions. It has two processing modes: (1) It determines individual route advices as a response to individual vehicle requests. For doing this it processes ecoRoutes coming from the vehicles. (2) It determines on the basis of actual route distributions general information in form of e.g.
link cost values or sub-route recommendations that are broadcasted and can be used to improve the vehicles’ autonomous navigation to reduce fuel consumption.

System-wide design decisions:

1. **Decision**: There are two types of route advice: (1) In case of an individual request an explicit route info will be provided to the requesting vehicle in return. (2) Whenever the desired route distribution changes significantly, general information will be generated and broadcasted that shall support navigation in the vehicle.

   **Reason**: Both cases are possible. The first one allows a more optimal distribution of the traffic over the network, because the transmitted routes reflect more direct the desired route distribution determined in the infrastructure centre. The second case is the basic provision that is available for all vehicles in the communication range.

2. **Decision**: All data that are used within the processing steps stems from the ecoMap.

   **Reason**: This corresponds to a general SP5 design decision that helps to decouple different applications and to minimise the overall number of interfaces.

3. **Decision**: It is all about influencing routes of vehicles. There will be no changes of traffic light control.

   **Reason**: Within the SP5 system there are other applications that are in charge to change link capacities by means of influencing traffic light control parameters.

### 3.4. Improve Intersection Control and Balance Intersection Control Objectives

Intersection controllers can be made more CO₂ efficient by having them adapt to the actual traffic conditions and having them anticipate on the expected traffic conditions. Using information from infrastructure and vehicles, the intersection controller can distribute and assign green times more efficiently to accommodate the expected demand. This information includes, but is not limited to, information regarding the direction of travel, the estimated arrival time, and the CO₂ emission characteristics of the vehicle. An intersection can furthermore reduce inefficiencies caused by the generally conservatively chosen values for minimum green time, yellow time and clearance time by setting them dynamically.

Furthermore, traffic participants can have many different expectations with respect to what can be considered acceptable and desirable. The traffic operator has to find an appropriate balance between all these local expectations and at the same time take into account that the intersection is part of network. This use case presents the different ways through which the traffic operator can prioritize certain target groups and constrain the intersection controller to find a balance between the different interests: prioritizing of vehicles with a large CO₂ footprint or the more environmentally friendly, prioritizing vehicles that are part of a flow of vehicles on a prioritized traffic corridor (i.e. a green wave), and dynamically selecting between a flexible and a fixed signal group. Besides, allowing higher maximum waiting times for traffic participants, even above the normal threshold, to give sufficient green to the various directions prevents gridlock and keeps flows moving when they are in motion.
Business Layer:

The diagram shows the main processes of the use cases ‘Improve intersection control’ and ‘Balance intersection control objectives’, together with their input and output data items, the associated services, roles, actors and interfaces.

- The role “TCC/TMC” provides periodically valid strategies (e.g. prioritisation of directions) as input values to determine Uniform Control Targets.
- The ecoMap is a central feature in the system providing “Macroscopic Traffic States”, “Microscopic Traffic States” and “Uniform Control Targets” periodically. For most processes, ecoMap is the start and end point.
- The process ‘Calculate High Level Control Plan’ calculates optimal green allocation based on the traffic demand in the upcoming minutes, including priority realization for individual vehicles (e.g. public transport and trucks) and vehicle platoons. The outcome of this process is a control plan which is the basis for the final signal plan.
- The process ‘Calculate Low Level Signal Plan’ calculates the actual green allocation, based on the exact signal sequence, timing, clearance times, etc. The outcome of this process is a signal plan which will we adopted by the traffic light controller.
- The process “Calculate Vehicle Recommendation” calculates the speed advice information that is expressed in the form of spatial distribution (along the road section) of speed values. The speed advice is optimised such that vehicles are aware when to arrive at
the stop line for green and to keep vehicle platoons together. Besides, it calculates lane recommendations to prevent unnecessary stops.

- The process ‘Communication Signal States to TLC” broadcasts the signal states to enable vehicles to make their own calculations based on their characteristics.
- The speed advice information is received by the vehicle and processed by the ecoDriving Support that decides to which degree it will follow those advices.

**System-wide design decisions:**

1. **Decision:** Whenever possible, the speed advice provided to the vehicles shall be a spatial-temporal distribution that shall be broadcasted. It is not addressed to individual vehicles.
   **Reason:** Each vehicle can derive the part of information that is relevant for its location and special conditions.

2. **Decision:** Complete signal plans will be approved to the intersection controllers that are then used by the signal light control.
   **Reason:** Because the application is going to be evaluated and demonstrated at test sites in the Netherlands and Germany. In both countries it is remote control of signal groups from the centre is generally not used.

3. **Decision:** The strategy data (coming from the TCC) shall comprise the actual signal / frame programs which are running in the intersection controller at that moment.
   **Reason:** This data also express the current strategy that is pursued by the traffic light control.

4. **Decision:** The processes “Calculate Speed Advice” and “Calculate High Level Control Plan” can run either in the TCC (traffic control centre) or the TLCs (traffic light controller).
   **Reason:** There are different system architectures of the legacy system in the test sites that has to be taken into account.

5. **Decision:** Speed advice shall only be generated due to a new coordination scheme if the intersection controller affirms the change of the control parameters.
   **Reason:** Otherwise the speed advice would not be in line with the traffic light timings.

6. **Decision:** The process “Calculate Low Level Signal Plan” is allowed to deviate from traditional regulations for traffic light control as long as this does not affect traffic safety.
   **Reason:** Minimum and maximum timings, clearance times, amber time, etc. are generally fixed by law. For research purposes and to save on fuel consumption, these rules will be loosened.

7. **Decision:** The traffic operator has the means available to set priority and control objectives that will be reflected in the signal plan. Without strategy input the system will run on neutral default parameters.
   **Reason:** The availability of effective and transparent control variables is of great importance to traffic operators.
3.5. Improve Approach Velocity

Traffic control systems can be informed about approaching traffic so that the trajectories of individual vehicles can be predicted. This allows the traffic control systems to deal with traffic demand as efficiently as possible. The road user can be made aware of the downstream conditions and advised about the best way to approach the discontinuity.

Road users that are approaching a disruption in traffic flow will receive advice on optimal driving speed and timing to anticipate on the downstream traffic conditions and mitigate the disruption in the most energy-efficient way. The source of a disruption in traffic flow can either have a fixed location (i.e., a controlled intersection, a toll plaza or a change in speed limit) or be moving (i.e., in case of a shock wave).

Business Layer:

- The diagram shows a process that is related to many other use cases which involves the approach and passage of certain events in traffic such as traffic light, a green wave, a ramp metering installation, a toll gate, a merging point, a traffic jam, or dynamic speed zone.

- The main processing steps in the diagram are to calculate individual speed recommendations and to calculate general trajectory recommendations (for broadcasting), together with their input and output data items, the associated services, roles, actors and interfaces.

Figure 8: Business Layer Diagram for Improve Approach Velocity
- The roles of TCC/TMC and Traffic Controller are of a providing nature. They provide valid strategies (e.g. speed regulations) and control data (e.g. actual signal program) as input values to calculate the best vehicle trajectory.

- The ecoMap is a central feature in the system providing vehicle related data which trigger other processes. An “Energy Map” is derived out of the ecoMap and provides information about traffic states and fuel consumption levels which are relevant for the computation of vehicle trajectories.

- The process ‘Calculate Optimal Vehicles’ Trajectory determines how vehicle could best cover a certain distance over time from a traffic flow perspective. Such a time-space description explains where vehicles could best be without stating which speed profile they should follow to get there.

- The process ‘Calculate Trajectory Recommendations’ add to the previous process the functionality that provides tailored and individualised advices to vehicles from a traffic management optimal perspective. Vehicle characteristics that affect the fuel use per speed value are not considered. Alternatively, generic recommendations are broadcasted to all vehicles, which enable the vehicles to determine the best speed profile based on their own characteristics.

- The speed advice or trajectory advice information is received by the vehicle and processed by the ecoDriving Support that decides to which degree it will follow those advices.

**System-wide design decisions:**

1. **Decision:** Whenever possible, the speed advice provided to the vehicles shall be a spatial-temporal distribution that shall be broadcasted. It is not addressed to individual vehicles.
   
   **Reason:** Each vehicle can derive the part of information that is relevant for its location and special conditions.

2. **Decision:** A trajectory will be calculated for the period before, during and after passing an event.
   
   **Reason:** Acceleration right after passing an event was not explicitly considered but is of great importance to prevent overreaction of drivers.

**3.6. Improve Ramp Metering**

Ramp metering is a successful measure to prevent traffic jams at a nearly saturated highway by managing the rate of vehicles entering the highway with a traffic signal. A ramp meter allows one vehicle to leave the on-ramp at the time which creates a 5-15 second delay between cars. This gap is sufficient to keep the motorway flow downstream of the on-ramp below capacity, to control the number and severity of disturbance to the mainstream and to enable merging from the on-ramp to the mainstream. However, queuing at ramp metering installation is generally chaotic and leads to many acceleration and deceleration manoeuvres with a negative impact on fuel consumption. Besides, the behaviour of ramp control never seems to change even though the traffic conditions on either the mainstream or the on-ramp changes.
The goal of ecoRamp Metering and Merging is to widen the scope and extend the horizon of ramp control to better anticipate to changes in the traffic situation and traffic demand, and so reduce fuel waste. It takes into consideration multiple control variables, both macroscopic (i.e. traffic flow) and microscopic (i.e. vehicle), applies different strategies for different designs of on-ramps, informs vehicles about the best driving strategy before the ramp meter, and controls in-flow and spillback to the urban network in the optimization process. Green frequencies will vary based on the current conditions, vehicles receive speed recommendations and priority schemes differentiate between light and heavy vehicles.

The business layer diagram:

Figure 9: Business Layer Diagram for Improve Ramp Metering

- The diagram shows the main subsequent processing steps of the use case “Improve Ramp Metering”.
- The need for ramp metering is determined by the traffic flow on the highway and the uniform control target. If a control target is not met, ramp metering will be switched on.
- For determination of the traffic state on the highway, macroscopic data is directly taken from eStram. For the traffic state on the on-ramp, microscopic traffic is required and is taken from eSim.
- When activated, green frequencies are calculated based on the flow characteristics on the highway. From the calculated green frequencies, a signal plan will be derived. This signal is optimised by using the emission prediction components from both eStram and eSim. The optimized signal plan is then send to the Intersection controller (which controls the ramp metering traffic light)
- From the signal plan, a uniform ideal approach speed is calculated and sent to equipped vehicles (SP3&4). This advice is processed by the “ecoDriver Info Support Manager”. The SP3/SP4 application then decides to which degree it will take this speed advice into account.

- If the traffic flow on the on-ramp is such, that not every vehicle can leave the on-ramp without stopping, a virtual stop line will be placed at a strategic location at the on-ramp. Vehicles behind this line will have to stop and can switch off their engines until it is their turn to start moving again. They will only be allowed to do so if they can leave the on-ramp without any more stopping. The stop instructions are sent to the drivers by the “ecoDriver Info Support Manager”.

3.7. Support Merging

Merging at on-ramps, or at a weaving section or lane-drop, driving is complex and the workload on drivers significantly increases, for both mergers and non-mergers. Finding the right cruising speed, a safe following distance, a suitable gap to merge in or to let merge somebody merge in, and the right time for merging is difficult. Advising mergers and non-mergers about these variables can make merging processes easier for drivers.

The business layer diagram:

![Figure 10: Business Layer Diagram for Support Merging](image)

- The diagram shows the main subsequent processing steps of the use case “Support Merging”.
- Inter-SP data exchange: External input data consists of FVD, provided by SP2. Data output is generated for SP3 and SP4; driving advices and merging advices
- At any stretch of road where merging is required, ideal headways are calculated for both approaching and merging traffic, as well as for traffic leaving the merging area.
- In all cases, vehicles get a driving advice in terms of lane, speed and acceleration.
- The merging advice and driving advice information is received by both cars and trucks. It is processed by the ecoDriving Support that decides to which degree it will follow those advices.
- ecoEmission prediction is not used in this case because the communication is mainly between cars. Data exchange with a remote emission prediction application would be too slow, so this is not expected to improve the merging process.

### 3.8. Improve Parking Guidance

Parking Guidance is a successful measure to prevent vehicles adding to congestion when searching for available parking garage space within a City.

Parking Guidance provides the road user with the necessary information to guide him to the correct garage for the area of the City that he wishes to visit, by providing the necessary direction to the road user to indicate which routes are the most suitable to reach his/her destination. The information is dynamic and can either be provided by signing or in-vehicle.

Parking Guidance for the Network Operators provides a valuable tool in controlling the flow of traffic to a particular area of a City dependent on the prevailing traffic situations in the area. This could be due to specific events or environmental issues which cause the network operator to vary the frequency and accessibility to an area of the City. If parking garage capacity has been reached, the network operator can present the road user with an alternative route and destination.
The business layer diagram:

- Driver nominates destination, this is entered into the eCoMove Smart driving interface and requests parking assist from the eCoMove Parking Guidance (EPG), by providing vehicle identification, vehicle parameters, load (Where applicable) and destination from Navigation Data.

- The EPG requests information from the parking garage operator data base for available parking garage space, and from the road operator data base for the current road state.

- The eCoMove parking service receives the information from the road operator and the parking garage and optimizes route choice according to the destination requested.

- The optimal route is delivered to the driver by using the situational model in ecoSmartDriving. The driver accepts the route.

- The route is calculated and navigation instructions are given to the driver by Dynamic ecoNavigation is commenced.

- Guidance for the trip is provided in a mapping form by eCoMove Smart driving product using ecoNavigation service and ecoMap, static and dynamic.

- The optimal route guidance is refreshed utilizing data from both the parking garage database and traffic control database, along with data received from Floating Car Data, and V2V data along with eCoMove junction controller data.
- Changes in route or timing or new messages are provided to the driver on the journey.
- The iteration of the optimal route continues until the final destination is reached.

3.9. Increase Traffic Flow Stability

This use case refers to the scenario where traffic is dense but not yet congested. Small disturbances in traffic flow can potentially lead to bigger disturbances such as a shockwaves and the accompanying drop in capacity. To increase the stability of the traffic flow the road operator can give specific speed or headway advice such that small disturbances will be dampened and not grow in magnitude as they propagate upstream.

The main goals of this scenario are
- to avoid frequent heavy braking and acceleration from vehicles driving too close to each other, and thus reduce fuel consumption, and
- to prevent of shockwaves by ensuring that disturbances in traffic flow do not grow in magnitude as they propagate upstream.

The business layer diagram:

![Diagram](image)

**Figure 12: Business Layer Diagram for Increase Traffic Flow Stability**

- The diagram shows a process that is related to use cases where traffic is dense but not yet congested, causing the speed of one road user to be constrained by the speeds of the vehicles in front of him.
- The main processing steps in the diagram are to calculate speed and headway recommendations as well as trajectory recommendations, together with their input and output data items, the associated services, roles, actors and interfaces.
- The role of TCC/TMC is to determine valid strategies (which can result in dynamic speed limits) and traffic data (e.g. mean speeds or flows) as input values to calculate the best vehicle trajectory.
- The services ‘Determine Traffic States’ and ‘Determine Environmental States’ periodically provide input values that enable to produce a new state estimation, which is used together with the valid traffic control strategies determined by the TCC to produce and update ecoMap.
- The process ‘Calculate Best Vehicle Trajectory’ determines how vehicles could best cover a certain distance over time from a traffic flow perspective. Such a time-space description explains where vehicle could best be without stating which speed profile they should follow to get there.
- The process ‘Calculate Speed / Headway Recommendations’ adds the previous process the functionality that provides tailored and individualised advice to vehicles from a traffic management optimal perspective.
- The process ‘Calculate Trajectory Recommendations’ calculates and broadcasts one generic recommendations to all vehicles, which enable the vehicles to determine the best speed profile based on their own characteristics.
- The speed advice or trajectory advice information is received by the vehicle and processed by the ecoDriving Support (SP3) that decides to which degree it will follow that advice.

System-wide design decisions:
1. **Decision:** Whenever possible, the speed advice provided to the vehicles shall be a spatial-temporal distribution that shall be broadcasted. It is not addressed to individual vehicles.
   
   **Reason:** Each vehicle can derive the part of information that is relevant for its location and special conditions.

2. **Decision:** A trajectory will be calculated for the period before, during and after passing an event.
   
   **Reason:** Acceleration right after passing an event was not explicitly considered but is of great importance to prevent overreaction of drivers.

**3.10. Legend: Business Layer dictionary**

The following table gives an overview about all symbols that were used in the diagrams of this chapter that refer to Business Layer diagrams.
Table 2: Symbols used in Business Layer Diagrams

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business process</td>
<td>A unit of internal behavior or collection of causally related units of internal behavior intended to produce a defined set of products and services.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Business event</td>
<td>Something that happens (internally or externally) and influences behavior.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Business actor</td>
<td>An organizational entity that is capable of performing behavior.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Business role</td>
<td>A named specific behavior of a business actor participating in a particular context.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Business service</td>
<td>An externally visible unit of functionality, which is meaningful to the environment and is provided by a business role.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Business Interface, Provided</td>
<td>Declares how a business role can connect with its environment: provides the interface</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Business Interface, Required</td>
<td>Declares how a business role can connect with its environment: requires a provided interface</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Business object</td>
<td>A unit of information that has relevance from a business perspective.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>Product</td>
<td>A coherent collection of services, accompanied by a contract/set of agreements, which is offered as a whole to (internal or external) customers.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

3.11. Conclusions and Guide to the Architectural Design

The chapter “System-wide design decisions” described the most relevant SP5 use cases that play an outstanding role for demonstration and evaluation in test sites and simulation environments. The diagrams cover the main order of events of these use cases in the respective system environments and sketch on a high level the architectural features associated with them.

The diagrams and descriptions are the basis for a much more extensive architectural and interface design which then has a different granularity as it refers to functional / technical systems, applications and components.

The architectural design is the main issue of the following chapter 1.
4. System Architectural Design

The System Architectural Design is the ecoMove concept that focuses on the components or elements of a structure or system and unifies them into a coherent and functional whole, according to a particular approach in achieving the objectives under the given constraints or limitations.

This chapter provides a more extensive architectural design that is composed of:

- **Functional / technical systems**, which are a set of interacting or interdependent applications, components and databases forming an integrated whole. A sub-system is only the parts integrated at the roadside or vehicle. Example: *ecoAdaptive Balancing and Control*.

- **Applications**, which are entities that perform an action with direct interaction with a system user. It is a functional entity that is perceived from a user as the implementation of one or more use cases. Example: a traffic light that switches to green, a roadside system that is activated, or a speed or route advice that is send to a vehicle.

- **Components**, which are entities that perform an activity without direct interaction with a system user. Components might contain a data base. These are information sources for applications and content providers of databases. Example: Estimation and prediction of traffic state and emissions.

- **Data flows**, which are connections between applications and components and legacy systems that are usually realised by interfaces or gateways.

The System Architectural Design in this chapter (1) identifies the functional and physical components of the system, (2) shows the static relationships of the components, and (3) states the purpose of each component and identifies the system-wide design decisions allocated to it.

This will be done by using different views on the architecture. These views are named layers and defined as follows:

- **Application layer**: supports the business layer with application services which are realized by eCoMove applications.

- **Technology Layer**: offers infrastructure services needed to run applications, realized by computer and communication hardware and system software

4.1. **Legend: Application Layer dictionary**

The following table gives an overview about all symbols that were used in the diagrams of this chapter that refer to Application Layer diagrams.
Table 3: Symbols used in Application Layer Diagrams

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Component</td>
<td>A modular, deployable, and replaceable part of a system that encapsulates its contents and exposes its functionality through a set of interfaces.</td>
<td>![image]</td>
</tr>
<tr>
<td>Application Interface, Provided</td>
<td>An application interface declares how a component can connect with its environment: provides the interface</td>
<td>![image]</td>
</tr>
<tr>
<td>Application Interface, Required</td>
<td>An application interface declares how a component can connect with its environment: requires a provided interface</td>
<td>![image]</td>
</tr>
<tr>
<td>Data Object</td>
<td>A coherent, self-contained piece of information suitable for automated processing.</td>
<td>![image]</td>
</tr>
<tr>
<td>Application Function</td>
<td>A coherent group of internal behavior of a component.</td>
<td>![image]</td>
</tr>
<tr>
<td>Application Service</td>
<td>A unit of behavior jointly performed by two or more collaborating components.</td>
<td>![image]</td>
</tr>
</tbody>
</table>

4.2. Legend: Technology Layer dictionary

The following table gives an overview about all symbols that were used in the diagrams of this chapter that refer to Technology Layer diagrams.

Table 4: Symbols used in Technology Layer Diagrams

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
<th>Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node</td>
<td>A computational resource upon which artifacts may be deployed for execution.</td>
<td>![image]</td>
</tr>
<tr>
<td>Device</td>
<td>A physical computational resource upon which artifacts may be deployed for execution.</td>
<td>![image]</td>
</tr>
<tr>
<td>Network</td>
<td>A physical communication medium between two or more devices.</td>
<td>![image]</td>
</tr>
<tr>
<td>Communication path</td>
<td>A link between two or more nodes, through which these nodes can exchange information.</td>
<td>![image]</td>
</tr>
<tr>
<td>Infrastructure Interface, Provided</td>
<td>A point of access where the functionality offered by a node can be accessed by other nodes and application components: provides the interface</td>
<td>![image]</td>
</tr>
<tr>
<td>Infrastructure Interface, Required</td>
<td>A point of access where the functionality offered by a node can be accessed by other nodes and application components: requires a provided interface</td>
<td>![image]</td>
</tr>
<tr>
<td>System software</td>
<td>A software environment for specific types of components and objects that are deployed on it in the form of artifacts.</td>
<td>![image]</td>
</tr>
<tr>
<td>Infrastructure Service</td>
<td>An externally visible unit of functionality, provided by one or more nodes, exposed through well-defined interfaces, and meaningful to the environment.</td>
<td>![image]</td>
</tr>
<tr>
<td>Artifact</td>
<td>A physical piece of information that is used or produced in a software development process, or by deployment and operation of a system.</td>
<td>![image]</td>
</tr>
</tbody>
</table>
4.3. System Overview

The infrastructure functional system is subdivided into applications and components that are partly connected by means of data flows (interfaces). It comprises everything that is needed to set up the three infrastructure systems:

- ecoABC (see also chapter 4.4)
- ecoMM (see also chapter 4.5)
- ecoATS (see also chapter 4.6)

For the sake of completeness and in particular in order to show the infrastructure external data flows the SP5 system overview also contains external sub-systems (vehicle, test site, simulation environment).

It has been found that there is a considerable overlap between the infrastructure systems. Many components serve for more than one system.

All infrastructure applications and components that are located in the system overview are specified in more detail in subsequent sub-chapters, their interfaces being in line with the ones identified here in the system overview.

Application Layer Diagram:

![Figure 13: Application Layer Diagram for System Overview](image)
Although the application layer diagram is a functional view on the architecture, we indicated the main sub-systems for better orientation:

- **Infrastructure:** All applications and components that is located either at the road- or centre-side.
- **Vehicle:** All components that is located in the vehicle.
- **Test site / sim. environment:** All components or data items that are located in test sites or simulation environments.

The following colours are used to distinguish the different sub-project scope within eCoMove:

- **Blue:** SP5 applications and components
- **Red:** SP2 components
- **Yellow:** SP3/4 applications and components
- **Gray:** Test site or simulation environment

**ecoMap**

The ecoMap serves as the central data base for all geo-referenced information that is used or produced by the applications and components. It is in the very centre of the architecture as in almost all cases the exchange of data between components and applications is realised via ecoMap to which they all are connected with. For a more comprehensive specification of the ecoMap see the deliverable D2.3.

**Adapters**

The eCoMove system has to be integrated in different test sites or simulation environments, where legacy systems with specific interfaces reside. To realise the adaption to these specific environments certain adapters are introduced that can be considered as abstraction layer (one interface side unique and one side environment-specific).

**Communication between vehicles and infrastructure**

The communication between vehicles and infrastructure is essential for the eCoMove system. It is realised by a “communication manager” which is specified and realised in SP2. The “communication manager” either writes incoming data directly into the ecoMap or forwards it to the “Driver Info Support Manager” or “Driver Dialog Manager”. It is also the addressee for all data that is sent to individual vehicles or broadcasted (CALM: 802.11p or 3G). This means that the “Driver Info Support Manager” and “Driver Dialog Manager” can send data to the “communication manager” as a mediator to the vehicles. For a more comprehensive specification of the communication devices the deliverable D2.3 of SP2.

**Micro / macro simulators**

Micro / macro simulators substitute the reality in cases where statistics of larger sample sets are required. For evaluation those simulation environments can be seen as a supplement to test sites. For a more comprehensive specification of the micro and macro simulation environments see D2.3.

### 4.4. System: ecoAdaptive Balancing and Control (“ecoABC”)

The objective of ecoABC is to balance traffic demand and network capacity at network (strategic, i.e. wide area routing), area (tactical, i.e. micro-routing) and local (operational, i.e. ...
speed advice) levels thereby combining vehicle generated data (like positions, speed and real-time fuel consumption) and road-side sensor data. The types of measures can be subdivided into microscopic and macroscopic as they refer to individual road users (e.g. micro routing and balanced Priority) or to traffic streams (e.g. traffic strategies and green wave), respectively. The application areas therefore combine components for route guidance and traffic control.

It addresses the paradigm of travel time versus CO₂, with consideration of traffic safety, comfort, reliability and other pollutions (i.e. noise NOₓ and PM₁₀). The two main stakeholder groups are the road user with individual objectives and the road operators with collective (i.e. system) objectives. The essence in trade-off is setting priorities for example for objectives, modalities and functionalities. The complexity of ecoABC and its component parts, is when to enable and combine functionalities and when not. To determine prerequisites and traffic conditions that is of importance.

In summary the ecoABC objectives are:
- Advice individual vehicles and control traffic flows so that the overall fuel consumption is reduced considerably
- Distributes and balance traffic across the road network to reach better capacity utilization.
- Reduce waiting times and number of stops.
- Smooth traffic flows.
- Advise optimal individual routes to drivers.

Figure 14: Application Layer Diagram for the ecoABC system
- The functional diagram shows the ecoABC system that resides at the infrastructure and test site.
- The yellow colour indicates which application and component is integral functional part of ecoABC, no matter whether it is being implemented in SP5 or elsewhere (SP2).
- The orange colour indicates the ecoATS components that serve as mediator between vehicles and the ecoABC system.

Technology Layer Diagram:

![Technology Layer Diagram for the ecoABC system](image)

- The Technology Layer represents the physical view on the eCoMove system. In particular it distinguishes between road-side and centre-side sub-systems and shows the interfaces in between.
- In order to distribute and aggregate data between the ecoMaps at the road and centre-side a component “Data Aggregator/Distributor” is introduced. The “Data Aggregator/Distributor” aggregates defined data objects (e.g. ecoFVD) from the road-side ecoMap and transmits it to the central ecoMap.

In the other direction certain data objects from the centre ecoMap has to be available at the road-side as well (e.g. coordination schemes for TLCs). This data is also realised by the “Data Aggregator/Distributor”.

Figure 15: Technology Layer Diagram for the ecoABC system
4.5. System: ecoMotorway Management ("ecoMM")

The objective of the ecoMotorway Management system is to reduce fuel consumption and CO$_2$ emissions by smooth traffic control in motorways systems; it combines energy-optimised speed and flow management measures with tools to improve metering and merging assistance at individual vehicle level. This system combines applications for motorway management measures, ramp metering and merging. This system can be considered as a specialized (for motorway environment) version of the eco-ABC system. The main stakeholders of this system are first the road operators that will use the measures to influence the traffic flow, and then the road users to whom these measures will be applied.

Motorway management systems today may have notable benefits for energy efficiency, such as section speed control; however these are implemented today for safety or traffic efficiency purposes, and do not explicitly deal with energy use information; this system will provide manoeuvring-level support for entering and leaving the motorway and for smooth lane management, while for the first time providing the traffic manager with both detailed and aggregated energy use information in real time.

This system coordinates measures that are implemented on a motorway system. It contains a monitoring and state estimation and prediction component, as well as emission estimation and prediction.

The common state on motorway is a free flow at relatively high speeds. When road capacity becomes insufficient, serious congestion with stop-and-go behaviour of a large number of vehicles ensues, causing high CO$_2$ production.

All the measures are expected to reduce stop-and-go traffic and lead to lower fuel consumption and associated emissions. They will also result in a general calming of the traffic flow and a higher efficiency of fuel consumption, and improve road safety.
Application Layer Diagram:

- The functional diagram shows the ecoMM system that resides at the infrastructure and test site.
- The green colour indicates which application and component is integral functional part of ecoMM, no matter whether it is being implemented in SP5 or elsewhere (SP2).
- The orange colour indicates the ecoATS components that serve as mediator between vehicles and the ecoMM system.

Figure 16: Application Layer Diagram for the ecoMM system
The Technology Layer represents the physical view on the eCoMove system. In particular it distinguishes between road-side and centre-side sub-systems and shows the interfaces in between.

In order to distribute and aggregate data between the ecoMaps at the road and centre-side a component “Data Aggregator/Distributor” is introduced. The “Data Aggregator/Distributor” aggregates defined data objects (e.g. ecoFVD) from the road-side ecoMap and transmits it to the central ecoMap.

In the other direction certain data objects from the centre ecoMap has to be available at the road-side either (e.g. coordination schemes for TLCs). This data is also realised by the “Data Aggregator/Distributor”.


The objective of ecoATS is to improve traveller information to enable new or improve existing applications supporting the driver or driver assistance systems. This includes information not only about existing incidents but also on traffic management strategies respectively route recommendations from local authorities, traffic state information and prediction in terms of current and future travel times, speed limits and information on traffic conditions.
light controls. The information can be provided either on a local, non personalised level using car2x communication or on a global level allowing individual tailoring of information. This application therefore offers an information service for route guidance, driving advice or driver assistance.

It addresses the paradigm of lack of information which is often a drawback for applications as routing and navigation, smart driver assistance as green wave assistance systems.

The two main stakeholder groups are the road user with its individual objectives and the road operator with collective objectives. The road operator has an interest in distributing more and accurate traffic related information in order to directly influence the driving behaviour. The complexity of ecoATS is to connect to and collect traffic management and control information and distribute it in a standardised and way (e.g. tailored and in time) using the right communication channels to the driver.

In summary the ecoATS objectives are:
- integration of traffic management and control information
- selection of appropriate standards
- conversion of information and consideration of geo-referencing
- distribution of information to drivers.

In the following description the focus is on describing the ecoATS system and its co-operation with the network related results from ecoABC only. It does not cover individual request for lane or route advice.

**Application Layer Diagram:**

![Application Layer Diagram for the ecoATS system](image)

**Figure 18: Application Layer Diagram for the ecoATS system**
- The diagram shows the main components and function of the ecoATS system in cooperation with ecoABC. Based on ecoABC results regarding traffic state and prediction information as well as traffic messages and traffic strategies ecoATS – represented by “Driver info Support Manager” – provides routing respectively navigation relevant information to driver assistance or information systems as well as to routing service providers.

- The component “Driver info Support Manager” retrieves a request from a single vehicle (navigation system) or a routing service (e.g. fleet operator) for either historical time series (for trip planning) or online traffic state and prediction information or traffic messages including recommendation from the strategic traffic management. The component
  - considers spatial relevance defined by the requesting system
  - transforms the relevant information stored within ecoMap into appropriate messages (TPEG-TEC, TPEG-TFP)
  - takes care about geo referencing the provided information

- The component ecoMap stores the result from ecoABC and provides it (traffic state, traffic forecast, traffic messages, traffic strategies) using well defined interfaces.

- The component “Communication Manager” handles the communication between vehicles, Service Centers provided by logistics operators or routing service providers and the ecoATS system.

**Technology Layer Diagram:**

As the ecoATS system is integral part of the other two systems ecoABC and ecoMM, there is no distinct Technology Layer Diagram and description for ecoATS.

### 4.7. Application: ecoRoute Advice

The ecoRouting macro guides vehicles through a network in the most fuel efficient way. It also includes a re-routing in a small scale (e.g. one block), if this is necessary due to changing traffic conditions. Therefore, it takes into account the current, future and desired traffic state and the route pattern. As an infrastructure-based application, the focus is to optimise fuel consumption in the whole network, by assigning the vehicles to different routes considering the optimal origin-destination route. Besides this, it also can guide the single vehicles by the most fuel efficient journey route through the network. This should reduce the number of congested intersections and minimizing the chance of bottlenecks in the network.
Application Layer Diagram:

- The diagram shows the main components and function of the application “Route Advice” together with input and output data and the associated data receiver.

- The component “Strategic Route Extractor” uses the information from the Unified Control Targets to exclude routes from the Route Advice that traffic operators do not like to be used by the vehicles. The Origin/Destination matrix is reduced by routes which traffic operators do not allow because of the Unified Control Targets.

- The component “Acceptable Route Calculator” takes into account the optimal routes for single vehicles. The O/D matrix is reduced once again by routes those adjectives such as travel time or energy consumption are larger by a certain factor than the optimal route of the vehicle.

- The component “Acceptable ∩ Desired Route Calculator” compares the Acceptable Route matrix with the Desired Route Distribution matrix. The O/D matrix is reduced by the routes which do not belong to the intersection of both matrixes.

- The component “Route Advisor” finally allocates a route to a single vehicle considering his origin and destination.

System-wide design decisions:

1. Decision: Information can be broadcasted for every segment of the O/D matrix that contains only one route. For segments that are containing several routing alternatives the information is given individually.

   Reason: For splitting up the vehicles from a certain origin-destination relation it is not possible to broadcast the information, as the vehicles will then most probably all use the more vehicle optimal route.
2. **Decision:** O/D matrix can be different for different modes of transportation (e.g. cars, trucks).

   **Reason:** There may be different Uniform Control Targets for different modes of transportation.

3. **Decision:** From ecoRoute Advice there is no association with ecoGreen Wave.

   **Reason:** Only the network traffic state and its prediction are taken into account. There may be an association from the other side. As the Green wave may take a changed Route distribution into account for optimization.

4. **Decision:** ecoRoute Advice has no direct Interface to eStraM.

   **Reason:** The goal of ecoRoute Advice is to realize the ecoNetwork Distribution from ecoNetwork State, while considering Uniform Control Targets and the single vehicle optimum. Therefore, it is assumed that optimization is already done by ecoNetwork State which uses eStraM. ecoRoute Advice only takes information from the ecoMaps.

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**Technology Layer Diagram:**

- All five components of the application are at the centre (back end) side.
- There are no interfaces between the different sub-systems.

**Design decisions:**

1. **Decision:** All the components are located at the CIS.

   **Reason:** The application needs to gather information on the network wide view. This data is provided by the CIS ecoMap.
4.8. Application: ecoParking Advice

The ecoParking Advice macro guides vehicles through a network on microscopic level (i.e. from current location to a free parking place close to the destination) in the most fuel efficient way. The ecoParking Advice builds on the advised routes on macro level (from ecoRoute Advice). It includes re-routing on micro level, if necessary due to occupancy rates of public parking locations and/or changing traffic conditions on micro level. Therefore, it takes into account: (i) the current or predicted occupancy rates of public parking locations (both on- and off-street), (ii) the current or predicted network state and emission levels / thresholds and (iii) the preferred routes to be followed on macro level.

As an infrastructure-based application, the focus is to optimise fuel consumption in the whole network, by assigning the vehicles to different available parking locations en routes considering the optimal distribution over the area (and partial network). It hooks in on ecoRoute Advice in guiding single vehicles in a most fuel efficient journey to the place of destination. This should reduce the number of saturated intersections and ‘useless kilometres’ in a search for a free parking place.

Application Layer Diagram:

- The diagram shows the main components and function of the application “ecoParking Advice” together with input and output data and the associated data receiver.
- The application component “Occupancy rate individual parking locations” uses the occupancy related data from both on- and off-street parking locations as gathered in the ecoMap.
The application service “ecoRouting” takes into account the optimal routes for single vehicles on macroscopic level (as defined by the application ecoRoute Advice) details out way points along these routes the optimal routes on microscopic level to preferred parking location.

The application component “Individual parking & route advices passenger / delivery vehicle” matches these way points with the current location of individual vehicles. Based on the applicable match an individual parking & route advices is derived and passed on to the individual passenger / delivery vehicles.

System-wide design decisions:

1. **Decision:** By detailing out the route advice between a way point on the optimal routes on macroscopic level free parking locations are linked to ecoRoute Advice. Free parking location will not be broadcasted, leaving it to the vehicle driver to select a preferred parking location and find a route to this parking location.

   **Reason:** the ambition is that vehicles will use optimal eco-routes, which is not by definition the shortest path between current location and preferred parking location. One step further, the ambition is to distribute vehicles over parking locations in order to gain a balanced use of parking places.

**Technology Layer Diagram:**

Figure 22: Technology Layer Diagram for ecoParking Advice

- ecoParking Advice runs at the centre (back end) side. The application runs on one system.
4.9. Application: ecoGreen Wave

Traditionally green waves are created by establishing a fixed timing relationship between successive intersections such that vehicles, travelling at a predetermined speed, can pass through the green indications at successive signals. This explicit timing relation however limits the flexibility of the system. Ideally green waves emerge and dissolve on demand with elastic coordination speed in reaction to current or expected traffic conditions.

Unlike existing control procedures, the EcoGreen Wave not only synchronizes subsequent signalized intersections but also seeks to influence the spatial-temporal structure of the traffic flows as it forms platoon shapes depending on traffic volume and vehicle characteristics. Moreover, these control measures shall be accompanied by direct driver assistance (e.g. speed advice). The cooperative features of the procedure are crucial for maximal reduction of fuel consumption. By using cooperative technologies ecoGreen Wave will have more information about the spatiotemporal state of moving platoons and their composition (vehicle types) and, as a consequence, it will even incorporate this platoon data in the control mechanisms.

The behaviour of an ecoGreen Wave system therefore depends on the traffic volumes, the smoothness of the traffic flows and the ways in which platoons can be formed, using cooperative technology.

Application Layer Diagram:

Figure 23: Application Layer Diagram for ecoGreen Wave
Components and its interfaces:

- **Strategy Calculator**

  The *Strategy Calculator* reads Uniform Control Targets from the *ecoMap* database and derives a Green Wave strategy out of it.

  **Input data:** Uniform Control Targets. These are strategy guidelines like “Increase Throughput”, “Decrease Throughput” or “Reduce CO2 emissions” that can be translated into green wave relevant strategies.

  **Output data:** Green Wave Strategies. A green wave strategy comprises (1) direction priorities for the stretch of intersections, (2) intersection specific weights for the main green wave direction compared with other conflicting traffic flows, (3) parameters that determine the flexibility or inertia of the dynamic *ecoGreen Wave*, (4) speed ranges within the *ecoGreen Wave* can vary the coordination speed, (5) weights for different *ecoGreen Waves* that cross each other at some intersection and (6) average forecast probabilities for green windows.

- **Coordination Scheme Calculator**

  The main purpose of this component is to calculate the coordination scheme for the *ecoGreen Wave* online. The coordination scheme is calculated in a way that it follows the given green wave strategies and ensures an optimal throughput of vehicles with a minimal number of stops along the green wave section. In order to achieve optimal throughput it therefore takes into account the macroscopic traffic situation (e.g. traffic demand fluctuations) of the road section as well as the trajectories of equipped vehicles. As the eCoMove system is able to inform the drivers about coordination speed or time to green, respectively, the coordination can choose an optimal coordination speed from a given range of values.

  **Input data:** Macroscopic Traffic States. Average traffic related information like travel time, saturation degree and flow per link or traffic demand at certain links of the road network.

  **Input data:** Microscopic Traffic States. The spatial-temporal trajectories of vehicles, together with vehicle characteristics.

  **Input data:** Green Wave Strategies. See explanation above.

  **Output data:** Coordination Scheme. A coordination scheme is a set of parameters that defines the subsequent series of intersection green windows along the road section. According to the chosen approach such coordination scheme could be a set of priority values that favours a timely position of the green windows, or, in case of control frame programs, a set of rotation offset that determines the time offsets of subsequent green windows.

- **ecoMap Services**

  - The *ecoMap* database is the central database either on the road-side or in the infrastructure centre. It contains microscopic as well as macroscopic traffic data that is referred to digital maps.

**Processing sequence:**

The processing is split into two separate activities that can be independently carried out:
1. The component *Strategy Calculator* reads strategy data from a data base and derives green wave strategy information.

2. The component *Coordination Scheme Calculator* uses the green wave strategy data together with other traffic related data to determine optimal coordination parameters (coordination schemes) online.

**Technology Layer Diagram:**

![Technology Layer Diagram for ecoGreen Wave](image)

- All the components of the application are either at the centre (back end) side or at the road-side. There are no interfaces between the different sub-systems.
- The control of the Traffic Light Controller is done by the separate component “TLC Adapter” (see chapter 4.23).

**Design decisions:**

1. **Decision:** There are two different versions of the ecoGreen Wave application. According to these the components that constitute the application are either at the road-side or at the centre side.

   **Reason:** Otherwise, the communication effort would be too expensive to provide the needed input data.
4.10. Application: ecoBalanced Priority

The balanced priority application controls signalised intersections by balancing the needs of the approaching vehicles in a way that minimizes fuel consumption without affecting safety. The approach is based on detailed knowledge about the demands and characteristics of individual vehicles approaching an intersection that are transmitted by means of short-range communication. The algorithm optimises the traffic signal programs for multiple criteria: reliability of public transport travel times, total CO₂ emission of all modes and streams, total time lost for private transport. The strategy is based on the utilisation of remaining capacity in order to balance the demands of road users and road operators with difference interests.

Examples of functionalities are the priority to specific vehicle categories like those who leave a large CO₂ footprint when stopped or public transport, in addition priority to vehicle part of a traffic flow or platoon on a prioritized traffic corridor. Other functionalities aim to improve the operation of traffic light in nearly saturated traffic conditions, in particular by increasing the flexibility of the controller. In such operation mode, available green time goes to the directions that need it most to prevent the intersection and eventually a larger area to become gridlocked.

Measures include introducing variability in the signal group sequence, allow higher maximum waiting times, and dynamic determination of the minimum values for green times, yellow times and clearance time. Within ecoAdaptive Balancing and Control there is strong relation with the application ecoGreen Wave and ecoApproach Advice. In comparison with ecoGreen Wave emphasize is on the optimization of local traffic light control, whereas ecoGreen Wave focuses on traffic light coordination and platoon shaping.

Figure 25: Application Layer Diagram for ecoBalanced Priority
Components and its interfaces:

- Control Plan Calculator

  The Control Plan Calculator reads Uniform Control Targets and Macroscopic Traffic States from the ecoMap and derives a high level signal plan out of it.

  **Input data:** Uniform Control Targets, which are strategy guidelines like “Increase Throughput” and “Decrease Throughput”, but also includes priority demands from applications like ecoGreen Wave. Together, those can be translated into traffic light control constraints. Macroscopic Traffic States, which are traffic flow patterns on relevant routes and links, which allow predicting upcoming traffic volumes.

  **Output data:** A Control Plan, in other words a high level signal plan. The Control Plan indicates a green planning that facilitates the Uniform Control Targets, priorities and major traffic demands. In this way the Control Plan sets the high level constraints for the Signal Plan Calculator.

- Signal Plan Calculator

  The Control Plan Calculator reads Uniform Control Targets and Microscopic Traffic States from the ecoMap and receives a control plan from the Control Plan Calculator, and derives a Signal Plan out of it.

  **Input data:** Uniform Control Targets, which are strategy guidelines like “Increase Throughput” and “Decrease Throughput”, or “Reduce CO2 emissions”, which can be translated into traffic light control constraints. Microscopic Traffic States, providing a representation of the traffic situation near the intersection. These include details of individual vehicles such as position, type, heading and speed. Control Plan, which indicates a green planning which sets the high level constraints for the Signal Plan.

  **Output data:** A Signal Plan, which follows the outline as set by the Control Plan and fills the blanks to anticipate to local conditions. The Signal Plan includes green, red and amber times for all signal groups of the intersection for the next 3 minutes.

- ecoMap

  - The **ecoMap** database is the central database in each ITS station. It contains microscopic data, macroscopic data, as well as Uniform Control Targets which are linked to digital maps.

- ecoSituational Model (eSiM)

  - The **eSiM** is a microscopic model which allows doing real-time evaluation of ecoBalanced Priority strategies. Required inputs are the current traffic state and the application strategies, which produces quantitative evaluation of strategies in terms of travel time and fuel consumption.

- Associations with ecoGreen Wave, ecoRamp Metering and ecoApproach Advice are discussion in chapter 5.
- All the components are at the roadside, and through the TLC adapter directly linked with a traffic light controller.
- ecoMap provides situational data of the area around the intersection, but also includes aggregated situational data of upstream and downstream intersections.

**Design decisions:**

1. **Decisions:** A standardized interface between roadside ITS station and traffic light controller guarantees that the working of ecoBalanced Priority is independent of the legacy system.

   **Reason:** the application would not be interoperable as defined in the high level objectives of the eCoMove project.

**4.11. Application: ecoRamp Metering**

Ramp metering is a successful measure to prevent traffic jams on a nearly saturated highway by managing the rate of vehicles entering the highway with a traffic signal. A ramp meter allows one vehicle to leave the on-ramp at the time which creates a 5-15 second delay between cars. This gap is sufficient to keep the motorway flow downstream of the on-ramp below capacity, to control the number and severity of disturbance to the mainstream and to enable merging from the on-ramp to the mainstream. However, queuing at ramp metering installation is generally chaotic and leads to many acceleration and deceleration manoeuvres with a negative impact on fuel consumption. Besides, the behaviour of ramp control never seems to change even though the traffic conditions on either the mainstream of the on-ramp changes.
The goal of ecoRamp Metering is to widen the scope and extend the horizon of ramp control to better anticipate to changes in the traffic situation and traffic demand, and so reduce fuel waste. EcoRamp Metering takes into consideration multiple control variables, both macroscopic (i.e. traffic flow) and microscopic (i.e. vehicle), it applies different strategies for different designs of on-ramps, it informs vehicles about the best driving strategy before and after the ramp meter, and it controls in-flow and spillback to the urban network in the optimization process. Green frequencies will vary based on the current conditions, vehicles receive speed recommendations and priority schemes differentiate between light and heavy vehicles.

**Application Layer Diagram:**

![Application Layer Diagram for ecoRamp Metering](image)

- The diagram shows the main components and functions of the motorway application “Improve Ramp Metering”, together with their input and output data objects, and the associated services.
- The component “Traffic data processor” gets the current traffic state and retrieves the current flow status, information about approaching vehicles and queue information from this data.

- The component “Ramp metering strategy processor” reads the Uniform Control Targets and translates these to a control strategy, suitable for ramp metering. It also takes into account the possible presence of vehicles that need to be prioritized.

- The component “Signal Plan calculator” calculates a signal plan, based on the current traffic state on the highway and prioritization of certain vehicle classes present at the onramp. The signal plan is sent to the ecoMap that sends it on to the Ramp meter controller (adapter) and to a component called “Advice calculator”.

- The component “Flexible stop line strategy processor” chooses the optimal stop line strategy, which can control any number of virtual stop lines separately on multiple lanes. This component will act when the traffic flow on the on-ramp is such, that not every vehicle can leave the on-ramp without stopping. In that case, a virtual stop line will be placed at a strategic location at the on-ramp. Vehicles behind this line will have to stop and can switch off their engines until it is their turn to start moving again. They will only be allowed to do so if the area between the ramp meter and the virtual stop line is (almost) empty.

- The component “Advice calculator” translates the signal plan and the queue info on the onramp into speed advices. These are to the Driver dialog manager. This component also advises specific vehicles about the flexible stop line measures.

- The component ecoMap is a communication gateway between the application and the Ramp Metering Adapter.

Figure 28: Technology Layer Diagram for ecoRamp Metering
- All the components of the application are at the road-side. There are no interfaces between the different sub-systems.

- The control of the Traffic Light Controller is done by the separate component “RMC Adapter” (see chapter 4.23).

- The Driver dialog Manager, which is the interface to the driver of the vehicle, is part of SP3/4.


When merging at on-ramps, or at a weaving section or a lane-drop, driving is complex and the workload on drivers significantly increases, for both mergers and non-mergers. Finding the right cruising speed, a safe following distance, a suitable gap to merge in or to let merge somebody merge in, and the right time for merging is difficult. Advising mergers and non-mergers about these variables can make merging processes much easier for drivers.

By using roadside sensors and collecting ecoFVD, ecoSupport Merging monitors traffic flows at merging points on their traffic volumes, density, relative speeds of vehicles and following distances. Using vehicle trajectory data, the number of lane changes at merging sections is estimated. First the overall traffic flow performance in terms of flow, speed and density is optimised which results in general speed and headway advices while approaching the merging point. In this process, the importance of the different traffic flows is carefully weighted. Next, near the merging point, advices will be adapted to the number of mergers at that time, while the mergers themselves receive individualised recommendations for their speed and merging instant. Right after the merging point drivers will receive an advice that stimulates them accelerate in order to best use the available road capacity.

Application Layer Diagram:

![Figure 29: Application Layer Diagram for ecoSupport Merging](image-url)
- The diagram shows the main components and functions of the motorway application “Support Merging”, together with their input and output data objects, and the associated services.

- The component “Traffic data processor” gets the current traffic state and retrieves the current flow status from this data. Especially current V2V data.

- The component “Headway calculator” determines every vehicle’s ideal headway before, during and after merging. The data output is a list with the headways.

- From these headways, driving advice in terms of headway, lane, speed and acceleration is calculated by the component “Driving advice calculator”. This advice is sent to the Sp3/Sp4 DrivingSupport.

- For the vehicles that actually have to merge, the ideal merging instant is calculated by the component “Merging calculator”. The actual gaps are retrieved from V2V data. When an acceptable gap is detected, a sign is given to merge. The value of the acceptable gap can be different at every location (due to general driving style, road geometry).

Technology Layer Diagram:

Figure 30: Technology Layer Diagram for ecoSupport Merging

- All the components of the application are at the vehicle-side. There are no interfaces between the different sub-systems.

4.13. Application: ecoSpeed and Headway Management

In dense but not yet congested traffic people drive at different speeds and headways, resulting in frequent braking, possibly stops and followed by accelerations. Speed and Headway Management gathers information about speeds and headways of vehicles in the traffic flow. Based on this information the stability of the traffic flow is judged. Globally it monitors traffic flows and traffic density and more specifically vehicle speed, vehicle headway, and speed and headway variation. In particular in unstable conditions, the system recommends speeds and headways for certain road sections or road users individually, which
allows drivers to adapt to smoother, more comfortable and fuel efficient driving behaviour. The aim is to prevent disturbances in traffic that could lead to congestion as they propagate upstream. Its application is essential near bottlenecks, dynamic speed sections, on-ramps, etc. where anticipation to upcoming traffic conditions is generally poor.

Application Layer:

Figure 31: Application Layer Diagram for ecoSpeed and Headway Management

Components and its interfaces:
- Traffic Flow Performance Calculator

The Traffic Flow Performance Calculator read Uniform Control Targets, Microscopic and Macroscopic Traffic States from the ecoMap. It analyses the traffic situation and determines the cause and severity of the traffic flow instabilities. Based on measured traffic intensities it determines spatial-temporal road capacity which, if obeyed, will temper the instability.

Input data: Uniform Control Targets, which are strategy guidelines like “Increase Throughput” and “Decrease Throughput”, ” or “Reduce CO2 emissions”, which can be translated into relevant speed and headway strategies. Macroscopic Traffic States for traffic flow patterns and upcoming traffic demand, and microscopic traffic states to analyze local vehicle interactions.

Output data: Intensity/Capacity ratios per road segment. These indicate the available road capacity in anticipation to the instability. Speed and density values can be derived from these which allow calculating trajectories and headways.
- **Trajectory Calculator**
  
  The Trajectory Calculator receives the Intensity/Capacity ratios and derives vehicle trajectories and appropriate headways out of them.

  *Input data:* Geographical map data to derive an internal picture of the road and its state. Intensity/Capacity ratios per road segment, which indicate the available road capacity in anticipation to the instability. Speed and density values can be derived from these which allow calculating trajectories and headways.

  *Output data:* Vehicle Trajectories represented by a series of positions referenced to time. It is up to the vehicle to determine the most fuel efficient speed to traverse from one point to the other. Besides, the Trajectory Calculator indicates the most appropriate headway in the current road capacity to maximize traffic flow stability.

- **Driver Dialog Manager/Driver Info Support Manager**
  
  The Driver Dialog Manager receives optimal Vehicle Trajectories and Vehicles Headways per road segment and derives appropriate recommendations out of them.

  *Input data:* Vehicle Trajectories represented by a series of positions referenced to time. Vehicle Headways per road segment which correspond to the current road capacity.

  *Output data:* Speed and Headway recommendations represented by a series of positions referenced to time. It is up to the vehicle to determine the exact most fuel efficient speed to traverse from one point to the other. Recommendations are support by indices for the most appropriate headway in the current road capacity to maximize traffic flow stability.

- **ecoMap**
  
  - The *ecoMap* database is the central database in each ITS station. It contains microscopic data, macroscopic data, as well as Uniform Control Targets which are linked to digital maps.

- Association with ecoRamp Metering in described in chapter 5.
Technology Layer:

- The Traffic Flow Performance Calculator is either at the Central ITS Station or at the Roadside ITS Station. This will depend on the amount of data that is required to run the algorithms and the amount of communication effort this involves.

- The Trajectory Calculator is either at the Central ITS Station or at the Roadside ITS Station. This will depend on the effectiveness of very detailed local trajectory recommendations as compared to more high level centrally distributed trajectory recommendations. The final decision affects the way recommendations are communicated to vehicles: short-range versus long-range communication, and unicast versus broadcast.

- The central ecoMap provides aggregated situational data, whereas the local ecoMap provides raw detailed situational data. There is an interface between the two for synchronisation purposes. In case the ecoSpeed and Headway Management components are Central, the Roadside ITS Stations solely serve as data collectors and data aggregators to feed the central ecoMap.

**Design decisions:**

1. **Decisions:** the Vehicle ITS Station should be capable of processing specific Speed and Headway Recommendations as well as derive such recommendations from a recommended trajectory.

   **Reason:** with the vehicles supporting such functionalities there is no use of sending recommendations.

Road user perspective: Frequently the availability of spaces for trucks to park along motorways (truck park area available in rest areas) is not known, and the truck is not allowed to park on the side of the motorway. The result is that the process of finding a place to park is very inefficient for a truck driver as he/she has to drive unnecessary kilometres looking for a parking facility that has space available, or having to exit the motorway to find a place to park. This inefficient search for free parking lots leads to unnecessary fuel consumption for the truck. Moreover, at the same time some truck park areas are oversaturated, and the next ones are half empty along the same motorway, or in the nearby motorway network.

When the parking is an urban parking for cars, with a well known number of car spaces, and with a controlled access, it is easy to decide if there are available spaces. On the contrary, Truck parking areas on Motorway are generally not closed parking areas with controlled access. The total number of place is not simple to define: it depends on the length of trucks and the way they stay. Some spaces can be used if all the “official” places are used. Sometimes car drivers use places for trucks. In order to indicate availability, the ASFA component has to evaluate if the parking is “full enough”. Several methods must be compared: counting the number of vehicles which enter and exit (with difficulties on an “open” space), or measuring which places are in fact occupied.

Application Layer Diagram:

Figure 33: Application Layer Diagram for ecoTruck Parking

- Parking place data collector
  
  This component “counts” a number of empty/full spaces or a number of vehicles in entrance and exit (method to be determined).
Parking place data manager

This component calculates if the parking area is considered as full or not. It uses characteristics of the space area (to which level the capacity could be “adjusted” in case of high occupancy), and the date and hour (with the history of the use of this space area will this rest area be more full or is it going to empty).

It also produces regularly a map on the whole motorway network of the truck parking and their availability. The list of available park area is calculated every \(x\) minutes, and sent to the traffic control centre. The TCC could disseminate information about truck parking through other motorway tools. In addition, the TCC indicates whether a parking is closed (for roadwork for instance).

**Input data:**
- Occupancy of park area (in real time)
- Characteristics and history of park area (periodically adjusted)
- Indication of closed parking.

**Output data:**
- A status for the park area: free / full or closed
- A map of all park area status

MapMatching

This component determines on which motorway trunk is the vehicle and in which direction it is moving on this trunk.

**Input data:**
- The last three positions of the vehicle in WGS84 coordinate

**Output data:**
- Axis (motorway trunk), “kilometric point” (motorway system of location along a motorway), and direction of the vehicle

Available parking search engine

It receives a location (Axis, “kilometric point”, and direction of the vehicle), and determines truck parks area located downstream from the vehicle's position with their status: free, full or closed.

**Input data:**
- Axis, kilometric point on the motorway, direction

**Output data:**
- The list of the rest areas on this motorway trunk and the status (free/full) of the truck park area
Vehicle station:
Out of EcoTruckParking scope; data for a specific vehicle is provided to the eco-Truck Parking Central Station, in order to be sent to other applications (input; see document about interfaces).

Park station:
The road operator is free to choose any type of sensors for data collection regarding the context of its parking area and real time occupation of the local level. As the goal is to determine a status of the park area (free / full), there's no necessary in every cases need to monitor the whole area but only some truck dedicated places (the less attractive ones). The processor requirements for this local level are small: a standard computer can be deployed to collect the sensors information, with internet access to send these to the central station.

Central station:
Is composed of several servers located in the ASF motorway management back office, and able to:
- treat the map-matching
- determine each occupation status of all the parking places monitored
- get the information from the traffic management system in case of parking area closure (if available)
- broadcast the real time information to the different targets

Information could also be accessed with a login/password through a web access.

- Roadside ITS station:
  No Ecotruck Parking application. The application is a centralized server, there is no local treatment.

- Traffic management centre applications:
  Out of eCoMove scope, provides data to ecoTruckParking and receives data.

### 4.15. Application: ecoTolling

Monitoring and management of a better traffic distribution to fuel efficient lanes on existing toll gates to mitigate stop and go CO2 emissions. Passing tolling stations requires each vehicle to decelerate, choose a lane, stop and accelerate again. To improve fuel efficiency, the purpose of ecoTolling is to deploy dedicated toll lanes that allows passing at a nominal speed which compromises between stop-and-go behaviour and fuel efficiency. The aim is threefold: improvement of travel time, decrease CO2 emissions, and decrease toll congestion through higher traffic distribution. To achieve these goals vehicle drivers will be informed about which lane and speed to choose, while electronic toll tag detection takes care of registration aspects.

Special attention will be paid to driver behaviour, inefficient lane usage, wrong driven, no electronic toll tag detection – in such situation; the system operates in degraded mode, i.e. normal toll collection with stop-and-go – through indicators analysis. ecoTolling will be available for all vehicles equipped with electronic toll tag. Upstream, the driver is lead to slow down with signalling approach reminding the nominal speed expected is 30km/h. When approaching the toll barrier, specific dynamic signs will display information for non-stop-and-go lane choice.

Both corridor entrance and exit barriers will be equipped with toll tag detection on the one hand to open the barrier at toll tag detection, on the other to monitor the exit barrier opening when driving at 30 km/h nominal speed.
Components and its interfaces:

- **Toll tag**
  - The equipment in the vehicle that is detected when approaching the toll barrier through DSRC communication (5.8 MHz communications).

- **Upstream barrier**
  - This is composed of an antenna whose input is the signal detection of toll tag inside the vehicle.

- The upstream barrier: it is composed of
  - An antenna
  - A closing/opening barrier
  - Vehicle detection/classification system

*Input / output data:* the signal detection from the vehicle tag is verified by the lane management system that checks authorisation crossing.

- **Lane Management System:** it communicates with the back office toll Information System to checks authorisation crossing and computes toll transactions.

It manages barrier opening/crossing, communications radio messages from the vehicle toll tag.
Processing sequence:
The device is based on the early detection of vehicle toll tag reaching the upstream toll barrier thanks to an antenna. Permanently, 2 pictograms display in real-time the working state of the lane (i.e., working, careful, and closed) and the advised nominal lane crossing speed in operating mode.

Once the vehicle toll tag is detected, the lane management system checks crossing authorisation. If crossing is granted, the downstream barrier opens to allow crossing at 30km/h nominal speed. Then the lane management system role is to:
- Classify the vehicle thanks to a detection device to identify the class billing.
- Compute toll transaction (billing)
- Action the crossing green light to the green colour to indicate the driver to exit without stopping.

As soon as the vehicle exits the lane, the crossing green light is red and the downstream barrier closes. If the vehicle toll tag is not detected at the upstream barrier (not in the vehicle or invalid subscription), the lane management system toggles to safe mode. The dynamic pictogram displays the careful symbol to alert arriving vehicles to choose another lane because crossing will not be 30 km/h. Then, the vehicle toll tag detection is done thanks to the downstream antenna.

The linked lane management system and Back Office Manager periodically allows the computation of CO2 gain emission with regard to the number of vehicles that crossed the lane through mail messages to be defined.

**Technology Layer Diagram:**

![Technology Layer Diagram](image)

- The eCoTolling is interfaced with the ESCOTA back Office Manager. For security reasons, toll data cannot be sent outside the ESCOTA network.
To test this application, we should consider the eCoTolling to be a “component” that will allow the project to evaluate how it contributes to decrease fuel consumption if a vehicle crosses the toll barrier driving the eCoTolling lane or not.

- eCoMove vehicles driving through the eCoTolling lane as compared to eCoMove vehicles driving through a usual toll lane will allow the project to evaluate reduction of fuel consumption.

- The eCoMove vehicle must embed both eCoMove ITS system and toll tag.

4.16. Application: ecoApproach Advice

The main functionality of ecoApproach Advice is the short-term prediction of vehicle trajectories in conjunction with the optimal determination of lane choice and the computation of optimal speed profiles for vehicles that approach intersections. All this is important for energy efficient driving, as there is the potential to reduce fuel consumption and emissions by adjusting the vehicles' speed on a temporally very detailed level.

The goal of the application is to minimize the number of stops, unnecessary acceleration and deceleration, resulting in continuous rather than stop-and-go traffic in order to minimize fuel consumption.

Application Layer Diagram:
- The diagram shows the main components and function of the urban application “ecoApproach Advice” including the vehicle trajectory prediction, together with input and output data and the associated data receiver.

- The component “Saturation Flow Estimator” retrieves up to date saturation flow data together with recent control data. This information serves as input for the current and predictive saturation flow.

- The component “Approach Traffic Demand Estimator” retrieves up to date traffic state and prediction data. This information serves as input for the current and future traffic demand calculation.

- The component “Vehicle Trajectory Prediction” receives single vehicle data. This information serves as input for the calculation of a predictive vehicle trajectory (as a set of space-time points) that describes the most probable path a vehicle will take to pass the observed part of a network.

- The component “Queue Time Computer” calculates the queue per approach and lane per lane. It also includes a prediction of the queue. It serves as input for the Vehicle lane and time slot allocation.

- The “Vehicle Lane Allocator” is the core component of the ecoApproach Advice application. Using the above mentioned information it calculates an optimal lane distribution for the vehicles. Together with the component “Vehicle Lane and Time Slot Advisor” an advice for each approaching vehicle is calculated in order to form an optimal platoon passing the upcoming bottleneck.

- The “Feedback Calculator” calculates whether driver follow the given advice or not. This feedback is used for further traffic state prediction and for giving better advices for following vehicles.

System-wide design decisions:

1. **Decision**: Every vehicle will get a timeslot in which it should be at the stop lane. The advice consists of a lane and a time slot for each vehicle individually.
   
   **Reason**: With this information for each vehicle it is possible to have a dense platoon at the stop line (where this is needed) and therefore a high saturation flow. On the other hand each vehicle is free to choose its speed profile to get there in the most fuel efficient way.

2. **Decision**: The advice for lane and time will take into account spill back length and uncertain due to actuated control.
   
   **Reason**: Not concerning these issues will lead to a not optimal platoon at the stop line and therefore will lead to extra stops and delay and therefore an additional waste of fuel.

3. **Decision**: Associations are taken into account by the ‘Control Event Data’ for ecoTolling, ecoRamp Metering, ecoBalanced Priority and ecoGreen Wave.
   
   **Reason**: Control data provides sufficient input for ecoApproach Advice.

4. **Decision**: ecoApproach Advice has not direct interface to eSiM.
   
   **Reason**: ecoApproach Advice is not optimizing, only distributing time slots to vehicles. The optimization of the trajectory is done within the vehicle. Therefore the application only needs information regarding the microscopic traffic state which can be taken from ecoMaps.
All components of the application are at the Roadside ITS Station (RIS).

There are no interfaces between the different sub-systems.

Design decisions:

1. **Decision:** All the components are located at the RIS.
   
   **Reason:** The application needs to gather information on a local view around the intersection.

4.17. **Component: ecoNetwork Prediction**

Based on various static network attributes, dynamic capacity related information, road side sensor data and - above all - vehicle generated data (positions, speed, routes), the current, future and desired traffic state for the road network is estimated by this “ecoNetwork Prediction” component. The estimation of current and future states is being carried out for urban as well as motorway networks by taking into account user optimal objective functions. In the case of the desired traffic states, the optimisation follows a system optimum strategy that reflects the system operator’s view by minimising the overall fuel consumption / CO2 emission.
Application Layer Diagram:

**Figure 39: Application Layer Diagram for ecoNetwork Prediction**

**Components and its interfaces:**

- **ecoMap Services**
  - The *ecoMap* database is the central database either on the road-side or in the infrastructure centre. It contains microscopic as well as macroscopic traffic data that is referred to digital maps.

- **Energy Map Calculator**
  
  The main purpose of this component is to estimate the current fuel consumption in the road network per link. For doing this it firstly estimates the current o-d-matrix on the basis of the existing static o-d-matrix and situational data (ecoFCD). Then it computes the current traffic state of the network in terms of travel times and traffic flows per link. Together with the *situational data*, that is transmitted from the vehicles to the infrastructure and amongst others contains individual fuel consumption data, the component calculates a more refined picture of the fuel consumption per link.

**Input data:** Static Map. The road network (origins, destinations, links and nodes) together with all relevant dynamic traffic attributes (like saturation flows, number of lanes, etc.).

**Input data:** Situational Data. Raw or aggregated ecoFVD data in conjunction with detailed fuel consumption data from vehicles along routes.

**Input data:** Traffic Information. All traffic information that comes from existing traffic management or traffic information centre and is available in the central ecoMap database.
This data comprises data from road side sensors. Usually consists of travel times or traffic flow values per link.

*Input data:* Link Capacities (Signal Plans). Link Capacities for all links of the network part of interest. The link capacities changes can be caused by changing traffic light control parameters or traffic incidents.

*Output data:* Traffic States. A detailed description of the current and future (short-term) traffic state of the road network in terms of travel times, traffic demand and traffic flow values per link.

*Output data:* Fuel Consumption per Link. A more refined calculation of the fuel consumption that takes into account all available information (ecoFVD, other infrastructure traffic information).

- Route Distribution Calculator

  The Route Distribution Calculator component is in charge with the calculation of a desired network route pattern (a distribution of origin-destination routes) that reflects the prospective of the system provider (minimisation of the totality of fuel consumption in the network). The desired network route pattern, which usually differs from the real one, serves as a basis for subsequent traffic management and routing support.

  *Input data:* Static Map. See above “Energy Map Calculator”.

  *Input data:* Network Fuel Consumption. The refined estimation of the total network fuel consumption as is calculated through the “Energy Map Calculator”.

  *Input data:* Traffic Information. See above “Energy Map Calculator”.

  *Input data:* Link Capacities (Signal Plans). See above “Energy Map Calculator”.

  *Output data:* Desired Route Distribution.

**Processing sequence:**

The processing is split into two separate activities that can be independently carried out:

1. The component *Energy Map Calculator* reads traffic state and vehicle state related data from the central ecoMap database and computes a detailed and more comprehensive picture of the current and future traffic state including fuel consumption per link.

2. The component Route Distribution Calculator uses the traffic state and vehicle state related data from the central ecoMap database (which is already enriched through the component Energy Map Calculator, and derives an optimal route distribution that is again stored in the eCoMove database.
Technology Layer Diagram:

- All the components of the component ecoNetwork Prediction reside at the centre side. There are no interfaces between the different sub-systems.
- The ecoMap involved here is the centre ecoMap.

Design decisions:
- **Decision**: The ecoNetwork Prediction component is located at the centre side.
  
  **Reason**: The center side is the place where all the network related information concerning traffic and control states are present and accessible in one local data base (the centre ecoMap).


The estimation of the emissions produced by traffic is foreseen to be carried out by at least two separate functional components.

One of these components considers data from individual vehicles (i.e. data that is typically, but not exclusively, collected by vehicle bound monitoring stations) and will typically be used within applications that are able to influence vehicles on an individual level and are hosted by a vehicle or a road side controller.

Another component considers aggregated data (i.e. data that is typically collected by infrastructure bound monitoring stations such as average speeds, flows, travel times etc.) and will typically be used within applications that try to influence traffic flows on a network level and are hosted by a traffic management centre.

In the remainder of this section the component that considers data on a microscopic level is referred to as the “ecoEmission Estimation Micro” component, whereas the component that
considers data on a macroscopic level is referred to as the “ecoEmmision Estimation Macro” component.

The ecoEmission Micro and Macro functional components are foreseen to be used as both evaluation tools for use in combination with a microscopic or macroscopic traffic models (such as VISSIM and DynaSMART) and for use in applications optimizing for instance route choice, speed choice, signal control, etc.

When used as an evaluation tool a selection of the data will typically be actively retrieved (pulled) from a data store that is filled as a result of a simulation run. When used in an optimization context data will typically be actively fed (pushed) to the emission estimation component. These different usage scenarios are reflected in the application layer diagrams below.

The application layer diagram (Macro):

- The diagram shows the application layer of the ecoEmission Estimation and Calculation component which is able to calculate emissions on the macro level
- The diagram shows the ‘Calculate Emission’ service which can be initiated by a component or an application in eCoMove.
- The process ‘Calculate Emission’ uses Static Map Data and Network State Data (TSD) from the ecoMap to calculate emissions.

- The data object: ‘Vehicle Type Distributions’ can be used when there is no information about vehicle types available. This data object contains vehicle type distributions for fleet compositions per country or region.

- The ‘Calculate Emission’ process can also be triggered by the event ‘Update TSD’ in case there is new data available. After updating the TSD, the emissions can be calculated.

- The ‘Calculate Emission’ process produces the data object Network Emission Data (NED) which will be fed into the ecoMap.

The application layer diagram (Micro):

![Application Layer Diagram](image)

**Figure 42: Application Layer Diagram for Estimate and Predict Emission (Micro)**

- The diagram shows the application layer of the ecoEmission Estimation and Calculation component which is able to calculate emissions on the micro level

- The diagram shows the ‘Calculate Emission’ service which can be initiated by a component or an application in eCoMove.
- The process ‘Calculate Emission’ uses Static Map Data and Vehicle State Data (VSD) from the ecoMap to calculate emissions.

- The data object: ‘Vehicle Type Distributions’ can be used when there is no information about vehicle types available. This data object contains vehicle type distributions for fleet compositions per country or region.

- The ‘Calculate Emission’ process can also be triggered by the event ‘Update VSD’ in case there is new data available. After updating the VSD, the emissions can be calculated.

- The ‘Calculate Emission’ process produces the data object Network Emission Data (VED) which will be fed into the ecoMap.

**System-wide design decisions:**

1. **Decision:** ecoEmission Estimation and Prediction is situated as a separate component. It has been decided that this component can be initiated from every other component or application either on Vehicle State Data or Network State Data.  
   **Reason:** It is important that every application or component can evaluate its strategy based on emissions on the micro and/or macro level.

**Technology Layer Diagram:**

- The ecoEmission Estimation and Prediction resides at the Central ITS Station as Micro and Macro component and at the Roadside and Vehicle ITS station as Micro component. For the calculation process relevant raw data (VSD) and aggregated data (TSD) are
required. The required data is queried from the ecoMap and the calculation results are written into the ecoMap.

Design decisions:

1. **Decisions:** Calculation results (VED and NED) are written into the ecoMap.

   **Reason:** Different applications are interested in the results of the emission calculation. The concept of the ecoMap as conceptual data store for an ITS station providing common information using a standard interface to access the data suites these requirement of the applications.


The traffic strategies component serves as the link between regional-strategic operations and local eco traffic control measures. It establishes a traffic strategy tailored to the eCoMove objectives and provides sector or local traffic control targets. Fuel-efficiency serves as the main criterion for balancing the road network load while maintaining network efficiency and meeting users’ demand. Control targets for the eco traffic control measures are uniform in order to provide various applications on this level, like traffic light control, route guidance and speed recommendations, with harmonized strategies which they can align with their control measures. A vital element for ecoTraffic Strategies is the interface between the strategy level and the various control applications. Examples of Uniform Control Targets are: increase throughput, hold traffic, etc.

**Application Layer:**

![Application Layer Diagram for ecoTraffic Strategies](image)

**Figure 44: Application Layer Diagram for ecoTraffic Strategies**

**Components and its interfaces:**

- **TCC/TMC Adapter**

  The TCC/TCM Adapter receives Predefined Strategies from the Strategy Provider and processes them to make them available to other entities in the eCoMove system.
Input data: Predefined Strategies like “public transport vehicles have green priority”, “cycle times of traffic light must be as short as possible” or “traffic volume on route A must not exceed x”. An automated process is needed to translate policy objectives road operator demands into control variables.

Output data: Predefined Targets and Constraints which reflect the requirements of the road operator in a way that they are usable for other eCoMove entities.

- Traffic Strategy Compiler

The Traffic Strategy Compiler receives Predefined Targets and Constraints and Macroscopic Traffic States, and derives Uniform Control Targets for infrastructure applications out of them.

Input data: Predefined Targets and Constraints reflect the requirements of the road operator as quantitative as possible. Macroscopic Traffic States describe the network traffic states as well as emission estimates.

Output data: Uniform Control Targets, which are strategy guidelines like “Increase Throughput” and “Decrease Throughput”, ” or “Reduce CO2 emissions”, which can be translated into relevant local control strategies.

- ecoMap

  - The ecoMap database is the central database in each ITS station. It contains microscopic data, macroscopic data, as well as Uniform Control Targets which are linked to digital maps.

Technology Layer:

![Technology Layer Diagram for ecoTraffic Strategies](image)

- The Traffic Strategy Compiler is at the Central ITS Station and distributes its outputs to Roadside ITS Stations via ecoMap service.
There is an interface between the ecoMap in the Central ITS Station and the ecoMap in the Roadside ITS Station. The Uniform Control Targets set by the Traffic Strategy Compiler are stored and distributed by means of the ecoMap.

**Design decisions:**

1. **Decisions:** Uniform Control Targets are written in and read from the ecoMap, both centrally and locally.  
   **Reason:** ecoMap is the one and only data source for applications.

2. **Decisions:** ecoTraffic Strategies follow as top-down approach, where strategic measures are translated into Uniform Control Targets which enable tactical measures to be activities.  
   **Reason:** this provides an open and transparent way of distributed traffic management.

**4.20. Component: Driver Info Support Manager**

The driver support manager component serves as the link between the vehicle and the infrastructure. Information residing within the ecoMap component is extracted following given rules, geo-referenced and formatted into a suitable transmission protocol. This information is provided as broadcast – no individual tailoring – to the vehicles.

**Application Layer Diagram:**

![Application Layer Diagram for Driver Info Support Manager](image)

*Figure 46: Application Layer Diagram for Driver Info Support Manager*
Components and its interfaces:

- The component “Driver Support Manager” coordinates the update of provided ecoMap information. It requests data from the ecoMap and converts it into the convenient formats.

- The component “Communication Manager Infrastructure” receives the information in a binary format and broadcasts this information.

- On the vehicle “Communication Manager Vehicle” receives different infrastructure information as Traffic Flow Prediction information, Traffic Event Compact information, Traffic Signal Information or Speed Information. This information will be decoded and provided to the appropriate applications or stored within the vehicle ecoMap.

- The ecoMap database is the central database in each ITS station. It contains microscopic data, macroscopic data, as well as Uniform Control Targets which are linked to digital maps.

Technology Layer Diagram:

![Technology Layer Diagram for Driver Info Support Manager](image)

Figure 47: Technology Layer Diagram for Driver Info Support Manager

- The Driver Support Manager is at the Central ITS Station as well as at the Roadside ITS station and provides information to the vehicles using broadcast mechanisms.

Design decisions:

1. **Decisions:** All information provided from infrastructure to vehicles is stored within the ecoMap.

   **Reason:** ecoMap is the one and only data source for applications.
2. **Decisions: Driver Support Manager** is a service offering non tailored information to the driver and thus acts as a kind of broadcast service providing information which can be used in any application which knows to handle the transmitted data. Broadcast is not necessarily meant as communication related information distribution service this can also be realised as a web service without tailoring functionality

   *Reason:* As long as bandwidth is not relevant it is important, that traffic related information is made available in general.

### 4.21. Component: Driver Dialog Manager

The driver dialog manager component serves as the link between the vehicle and the infrastructure. It is complementary to the driver info support manager as now a dialog between vehicle and infrastructure is available (unicast service) in order to request and provide individually tailored information which is basically calculated by different applications on the infrastructure side.

**Application Layer Diagram:**

![Application Layer Diagram for Driver Dialog Manager](image)

**Figure 48: Application Layer Diagram for Driver Dialog Manager**

**Components and its interfaces:**

- The component “Driver Dialog Manager” coordinates the information exchange between vehicle and infrastructure. This is done by interpreting incoming information from vehicles and providing, if necessary, an answer or by sending infrastructure information to the vehicles and, if necessary, interpreting the incoming response. This component takes also care about converting the information into the appropriate data exchange formats. The “Driver Dialog Manager” directly interacts with the components providing information to or interpreting information from the vehicles (e.g. “ecoTruck Parking”, “ecoTolling”)
- The component “Communication Manager Infrastructure” sends and receives information in a binary format.

- On the vehicle “Communication Manager Vehicle” receives infrastructure information and/or provides vehicle information. The ecoMap database is the central database in each ITS station. It contains microscopic data, macroscopic data, as well as Uniform Control Targets which are linked to digital maps.

- The ecoMap database is the central database in each ITS station. It contains microscopic data, macroscopic data, as well as Uniform Control Targets which are linked to digital maps.

Technology Layer Diagram:

![Diagram](image)

Figure 49: Technology Layer Diagram for Driver Dialog Manager

- The Driver Dialog Manager is at the Central ITS Station as well as at the Roadside ITS station and provides information to the vehicles using unicast service mechanisms.

Design decisions:

1. **Decisions:** All information provided from infrastructure to vehicles is requested and provided using an interface provided by the appropriate application.

   **Reason:** The driver dialog manager enables the communication between vehicle and infrastructure using the communication manager, but the information is application specific and thus is provided by the application.

2. **Decisions:** Driver Dialog Manager is a service offering tailored information to the driver and thus acts as a kind of unicast service.
Reason: Depending on the application needs, the amount of data to be transmitted, such a unicast service offers the possibility to exchange only information which is needed in a very situation and limited time by an individual vehicle.

4.22. Component: TCC/TMC Adapter

The TCC/TMC adapter is the connection between central aggregated data and the ecoMap component. A special case of aggregated data is the network strategies. These are supplied by the traffic manager and will be forwarded to the ecoTraffic Strategies component instead. An important aspect of this adapter is that it should accept data from different kinds of sources and translate them all to the same format readable for the ecoMap and ecoTraffic Strategies components.

Application Layer Diagram:

Figure 50: Application Layer Diagram for TCC / TMC Adapter

Components and its interfaces:
- ecoMap Service
  - The ecoMap database is the central database either on the road-side or in the infrastructure centre. It contains various kinds of data about the traffic and the environment.

- TMC Gateway
  The TMC Gateway is a mediator between various data sources and the EcoMap. This way data from different kinds of sensors, brands, etc. can be sent to the EcoMap in a uniform way. The predefined network strategies supplied by the traffic manager are a specific case. These are forwarded to the Eco Traffic Strategies.

Input / output data: Network Strategies. As supplied by the traffic manager, these can include but are not limited to emission targets, throughput and traffic distribution.

Input / output data: Aggregated signal states. This is basically how long every signal group on a certain intersection had green light over a certain time interval. The best way
to communicate this is to send the number of green phases in an interval and the average length.

**Input / output data:** Aggregated traffic states. This is average queues, capacities, and saturation flows.

**Input / output data:** Aggregated sensor data. This is average speeds, flows and other traffic measures, but they will all be translated into a small uniform set of data types that will be sent to the EcoMap.

**Processing sequence:**

Basically to flow in the diagram is from the left to the right. Information is only transported one way.

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**Technology Layer Diagram:**

![Technology Layer Diagram](image-url)

**Figure 51: Technology Layer Diagram for TCC / TMC Adapter**

- The component ecoMap service is located at both the central level and the road-side level which is locally connected with the Traffic Light Controller by Ethernet communication. This same Ethernet communication can be used to reach the central ITS station where the central ecoMap and the TMC gateway are. At the central level there is direct communication between TMC gateway and the Eco Traffic Strategies component.

**Computer hardware resources:**

- The TMC adapter software shall run on the central station. The memory (RAM) and processor requirements are dependent on the size of the traffic network. It is recommended for scaling purposes to use a virtual machine that can be easily extended once the network is expanded or more data sources become available.

- The systems that send their information to the TMC are not necessarily ECoMove systems. Therefore the resources for those systems are already defined elsewhere or possibly in other applications or subprojects.
Software development:
- The TMC adapter software shall be in line with the general eCoMove software platform requirements.
- The TMC software platform is specific. Possible enhancements shall be performed by the OEM.

Design decisions:
1. **Decision**: The TMC Adapter will be implemented at the central level.
   **Reason**: The adapter receives information from everywhere and there is only one instance for the entire network, therefore it is a logical choice to put it on the central level. Moreover, the communication network load will be more evenly distributed and the entire system will not fail once the RSU responsible for the TMC adapter is unreachable.

2. **Decision**: The gateway is not responsible for giving the proper regional dissections of the aggregated data it receives.
   **Reason**: The EcoMap is present at both the central and the local level and should be able to do this in a better way.

### 4.23. Component: TLC Adapter

The Traffic Light Controller (TLC) Adapter is a bidirectional connector between eCoMove system and traffic light controllers in test sites. It can be regarded as an abstraction layer for the test site that allows embedding the eCoMove system into various existing infrastructure system environments.

**Application Layer Diagram:**

![Application Layer Diagram for TLC Adapter](image-url)
Components and its interfaces:

- **ecoMap Service**
  - The *ecoMap* database is the central database either on the road-side or in the infrastructure centre. It contains inter alia traffic control states of traffic light controllers.

- **TLC Gateway**
  
The task of the TLC Gateway is to mediate between the TLC and the ecoMap of the eCoMove system. It is also responsible to convert data structures between ecoMap and TLC.

  **Input / output data:** Signal Program. The Signal Program contains the data that is necessary to change the traffic light control strategy of the intersection controller according to new parameters.

  **Input / output data:** Coordination Scheme. The “Coordination Scheme” contains the data that is needed to coordinate a traffic light controller according to a broader coordination scheme (Green Wave).

  **Input / output data:** TLC State. Contains all information to describe the inner state of the intersection controller including a short-term prediction of the traffic light states (green residual times).

- **Traffic Light Controller**
  
The Traffic Light Controllers in test sites are legacy systems at the road-side infrastructure that is in charge with the local traffic light control.

Processing sequence:

The processing is split into two separate activities that correspond to the direction of data flows (towards or from the TLC).

1. Data transport from the TLC: The TLC state is received from the TLC by using the specific TLC interfaces and forwarded to the ecoMap.

2. Data transport towards the TLC: Signal programs and coordination schemes are read from the ecoMap and forwarded to the TLC by using the specific TLC interfaces.
Technology Layer Diagram:

- The component ecoMap service and TLC Gateway are located at the road-side in a road-side unit that is locally connected with the Traffic Light Controller by ETHERNET communication.
- The Traffic Light Controller is a legacy sub-system whose characteristic depends on the test site.

**Computer hardware resources:**
- The TLC adapter software shall run on the road-side station. The memory (RAM) requirements are rather small (< 50 MB). The processor requirements are small.
- The TLC itself is legacy. It should already be designed to meet all possible requirements.

**Software development:**
- The TLC adapter software shall be in line with the general eCoMove software platform requirements.
- The TLC software platform is specific. Possible enhancements shall be performed by the OEM.

**Design decisions:**
1. **Decision:** The TLC Adapter will be implemented at the road-side.
   
   **Reason:** The adapter needs a fast and direct connection to the TLC that can only be guaranteed by an ETHERNET or serial interface.

2. **Decision:** The gateway between the TLC and the eCoMove system will be reused from the previous European projects CVIS and SAFESPOT.
**Reason:** The gateway is proven to be fully functioning. It covers more than 90% of the data flows required in eCoMove.

### 4.24. Component: RMC Adapter

The Ramp Metering Controller (RMC) Adapter is a bidirectional connector between eCoMove system and ramp metering traffic light controllers in test sites. It can be regarded as an abstraction layer for the test site that allows embedding the eCoMove system into various existing infrastructure system environments. Note that the RMC adapter is a simplified version of the TLC adapter.

**Application Layer Diagram:**

![Application Layer Diagram for RMC Adapter](image)

**Figure 54: Application Layer Diagram for RMC Adapter**

**Components and its interfaces:**

- **ecoMap Service**
  - The *ecoMap* database is the central database either on the road-side or in the infrastructure centre. It contains inter alia traffic control states of traffic light controllers.

- **RMC Adapter**
  
The task of the RMC Adapter is to translate the signalplan provided by the ecoMap of the eCoMove system to an understandable signal plan in the language of the RMC.

**Input / output data:** Signal Program. The Signal Program contains the data that is necessary to change the traffic light control strategy of the ramp metering controller according to new parameters.

**Input / output data:** RMC State. Contains all information to describe the inner state of the intersection controller including a short-term prediction of the traffic light states (green residual times).
Ramp Meter Controller

The Ramp Meter Controllers in test sites are legacy systems at the road-side infrastructure that is in charge with the local traffic light control.

Processing sequence:

The processing is split into two separate activities that correspond to the direction of data flows (towards or from the RMC).

1. Data transport from the RMC: The RMC state is received from the RMC by using the specific RMC interfaces, translated and forwarded to the ecoMap.
2. Data transport towards the RMC: Signal programs are read from the ecoMap, translated and forwarded to the RMC by using the specific RMC interfaces.

Technology Layer Diagram:

- The component ecoMap service and RMC Adapter are located at the road-side in a road-side unit that is locally connected with the Ramp Meter Controller by a fast and stable communication method (serial line or ETHERNET).
- The Ramp Meter Controller is a legacy sub-system whose characteristic depends on the test site.

Computer hardware resources:

- The RMC adapter software shall run on the road-side station. The memory (RAM) requirements are rather small (< 50 MB). The processor requirements are small.
- The RMC itself is legacy. It should already be designed to meet all possible requirements.

Software development:
- The RMC adapter software shall be in line with the general eCoMove software platform requirements.
- The RMC software platform is specific. Possible enhancements shall be performed by the OEM.

**Design decisions:**

1. **Decision:** The RMC Adapter will be implemented at the road-side.
   
   **Reason:** The adapter needs a fast and direct connection to the TLC that can only be guaranteed by an ETHERNET or serial interface.

2. **Decision:** The gateway between the RMC and the eCoMove system will be reused from the previous European projects CVIS and SAFESPOT.
   
   **Reason:** The gateway is proven to be fully functioning. It covers more than 90% of the data flows required in eCoMove.

### 4.25. Component: MS Adapter

The specification of the MS adapter will be subject of D5.3 “Extension of Simulation Functionalities and Test Site Modelling” (M12).

This deliverable will contain the following:

- Description of the use of the simulation environment for testing the SP5 applications.
- Detailed description of the extensions of the simulation environment for eCoMove.


The chapter “System architectural design” described the functional ecoTraffic Management and Control architecture in terms of systems, applications, components and data flows. Here the overall system has been defined and in particular all applications and components has been identified and described in form of application and technology diagrams.

All major interfaces that are identified in this chapter are now subject of the next chapter 5 (Interface Design).
5. Interface Design

5.1. Introduction
The aim of this chapter is to define the interfaces which are relevant for the infrastructure subsystem. This includes internal interfaces, i.e. within the infrastructure environment, and external interfaces for example with traffic systems and vehicles. The definitions in this chapter are not definitive and need to be further detailed in the next work-package, when the limitations and opportunities become clear. This requires the involvement of other disciplines such as ecoCore Technologies and ecoSmart Driving.

5.2. Overview of relevant interfaces
Basis for the design of interfaces is the system overview as discussed in the previous chapters and shown in the Figure below. ecoTraffic Management and Control (i.e. eCoMove sub-project 5) elements are in blue, ecoCore Technologies elements in red (i.e. eCoMove sub-project 2), ecoSmart Driving-ecoFreight and Logistics elements (i.e. eCoMove sub-projects 3 and 4) are yellow, and elements external from an eCoMove perspective are grey.

Figure 56 – System Overview with all relevant interfaces

Based on the application designs discussed in chapter 4, the associations between different applications are in white and number 81 to 86 as seen in the Figure above. Section 5.3 describes the philosophy of cross-application integration as intended by this sub-project. It
explains how applications anticipate and influence each other, and through cooperation reach higher goals.

Interfaces are yellow and numbered. In section 5.4 the interfaces are discussed on the basis of five clusters: (1) Interfaces between eCoMove and roadside systems, (2) Interfaces between eCoMove and Master systems, (3) Interfaces to bring data into and retrieve data from the ecoMaps and ecoModels, (4) Interfaces to bring data into and retrieve data from the vehicle, (5) Interface to exchange data with other Service centers. Next the interfaces are discussed one by one. Their name is derived from the element that provides the interface, while the specification is written from the perspective of the providing element. The description of each interface is two-fold. The first part refers to the interface as a whole, the second one to the specification of the data objects that will be exchanged over the interface.

5.3. **Philosophy of cross-application integration**

The philosophy of cross-application integration is illustrated via a series of cases. The exact integration of application and its implications and opportunities need to be further detailed in WP4.

5.3.1. **Association 81 – ecoRoute Advice versus ecoGreen Wave**

Association 81 will be used for on-line interaction between ecoRoute Advice and ecoGreen Wave. The following example illustrates the usage of the association:

- Given the network state, emission levels and available parking places in destination areas, ecoRoute Advice sets out the preferred routes. These are routes along which road traffic can be guided with an optimal (given circumstances) travel time and burden of emissions on the surroundings. To realize an optimal travel time, the preferred routes are communicated to ecoGreen Wave, including an estimation of the additional traffic volumes to be expected;

- ecoGreen Wave creates dynamically a green wave that supports the required minimum of travel time loss along the preferred routes. In case the conditions are such that ecoGreen Wave is not capable of creating an appropriate green wave, the additional loss in travel time is communicated back to ecoRoute Advice.

- It is up to ecoRoute Advice to decide whether it needs to find an alternative preferred route or it accepts the additional loss in travel time.

5.3.1. **Association 82 – ecoRoute Advice versus ecoPark Advice**

Association 82 will be used for on-line interaction between ecoRoute Advice and ecoPark Advice. The following example illustrates the usage of the association:

- ecoPark Advice presents an overview of available parking places (on-street, off-street and at P&R locations) in destination areas;

- Given the network state, the emission levels and available parking places in destination areas, ecoRoute Advice sets out the preferred routes. To assure an optimal travel time, the preferred routes are communicated to ecoPark Advice, including an estimation of the additional traffic volumes to be expected in the destination areas;

- Within the destination areas ecoPark Advice details out the preferred routes from entrance point of the destination area to preferred parking location. In doing so eco Parking monitors the level of saturation of both the parking locations and/or ‘capillary’ roads in the destination areas;
- In case the parking locations and/or ‘capillary’ roads in the destination areas grow towards a pre-define level of saturation, ecoPark Advice communicates so to ecoRoute Advice;
- ecoRoute Advice might decide to divert traffic by changing one or more of the preferred routes and/or bring the P&R opportunities to the attention of approaching vehicle drivers.

5.3.2. Association 83 – ecoGreen Wave versus ecoBalanced Priority

Association 83 will be used for on-line interaction between ecoGreen Wave and ecoBalanced Priority. The following example illustrates the usage of the association:
- ecoGreen Wave creates dynamically green waves along preferred routes (see association 82). For a reality check ecoGreen Wave communicates to ecoBalanced Priority the intersection green windows of the individual traffic light controllers coming with the proposed coordination in the form of:
  o a set of priority values that favours a timely position of the green windows, or
  o in case of control frame programs, a set of rotation offset that determines the time offsets of subsequent green windows.
- ecoBalanced Priority assesses the proposed intersection green windows in the local context of traffic volumes and possibly intersecting green waves. ecoBalanced Priority fine-tunes the proposed intersection green windows and communicates the fine tuned intersection green windows back to ecoGreen Wave;
- ecoGreen Wave (in its turn) assesses the fine tuned intersection green windows in the context of the full green wave. This interaction between ecoGreen Wave and ecoBalanced Priority can be done a pre-defined number of times. At the end of the iteration the coordination schema along a trajectory and thus the intersection green windows of the individual traffic light controller are fixed by ecoGreen Wave and communicated to ecoBalanced Priority;
- ecoBalanced Priority assures that the fixed intersection green windows are adopted in the control plan of the individual traffic light controllers.

5.3.3. Association 84 – ecoBalanced Priority versus ecoRamp Metering and Merging

Association 83 will be used for on-line interaction between ecoBalanced Priority and ecoRamp Metering. The following example illustrates the usage of the association:
- queuing vehicles on and on ramp or off ramp to / from the motorway might cause blocking back effects on the intersections in the urban area or on the traffic lanes off the motorway. In such cases tuning of control plans between traffic light controllers in the vicinity of the ramp and (in case of an on-ramp) the ramp meter controller is required.
  - On-ramp:
    o ecoRamp Metering monitors the queuing length on the on ramp;
    o in case the queuing length exceeds the threshold, ecoRamp Metering assesses whether it can adjust the ramp meter control plan. If this is possible the ramp meter control plan will be tuned by ecoRamp Metering. If not, ecoRamp Metering informs ecoBalanced Priorities on the limitations in ‘outflow’ of vehicles to the on ramp;
    o ecoBalanced Priorities tunes the control plan of the specific intersection, such that the ‘outflow’ of vehicles to the on ramp is limited and vehicles are buffered on the road segment;
ecoBalanced Priorities monitors the queuing lengths before the intersections. In case the queuing lengths exceed their threshold, ecoBalanced Priorities assesses whether it can adjust the traffic controller plan. If this is possible the control plan will be tuned by ecoBalanced Priorities. If not, ecoBalanced Priorities assess the limitations in ‘outflow’ of vehicles to the road segment and tunes the control plans of the downstream intersections.

5.3.4. Association 85 – ecoRamp Metering and Merging versus eco Speed and Headway Management

Association 86 will be used for on-line interaction between ecoRamp Metering and Merging versus ecoSpeed and Headway Management. The following example illustrates the usage of the association:
- To prevent crystallization’ of the traffic flow at a merging section, ecoRamp Metering and Merging monitors the density on and around this merging section and establishes an optimal distribution of vehicles over the road section such that merging can be done fluently;
- ecoRamp Metering and Merging communicates this optimal distribution of vehicles to ecoSpeed and Headway Management, which translates the distribution into a speed for and headway between vehicles. ecoSpeed and Headway Management communicates the speed and headway advice to vehicles;
- In case the traffic density does not allow a near to free flow speed and headway advice anymore (without violating road safety standards), ecoApproach Advice communicates this to ecoRamp Metering and Merging;
- ecoRamp Metering and Merging might stretch the road segment for which it establishes the traffic distribution;
- (In case the stretched road segment exceeds a certain threshold, ecoRamp Metering and Merging starts to interact with ecoApproach Advice).

5.3.5. Association 86 – ecoTolling, ecoGreen Wave, ecoBalanced Priority and ecoRamp Metering and Merging versus ecoApproach Advice

Association 86 will be used for on-line interaction between ecoApproach Advice and subsequently ecoTolling, ecoGreen Wave, ecoBalanced Priority and ecoRamp Metering. The following examples illustrate the usage of the association:
- Toll road, toll lanes:
  o Free flow tolling requires on-the-fly detection, identification and classification of the approaching vehicles. This process requires a certain time. In case the toll lane is closed off with a barrier, moving the barrier up- and downwards takes a certain time also.
  o ecoTolling assess the traffic conditions in front of the toll plaza, as well as the time needed for detection-identification-classification and moving of the barrier under the defined traffic conditions. It communicates these figures to ecoApproach Advice.
  o As a first step, ecoApproach Advice allocates vehicles to a free flow tolling lane;
  o As a second step ecoApproach Advice establishes per free flow toll lane an optimal approach speed and headway of the vehicle(s);
  o ecoApproach Advice translates the latency into an optimal speed advice for the vehicles approaching the toll plaza and communicates this speed advice to both the approaching vehicles and ecoSpeed and Headway management.
Depending on the traffic volume, ecoApproach Advice might have to spread out its advices to approaching vehicles over a growing road length. In case the road length grows above a certain threshold, ecoApproach Advice will communicate this to ecoTolling;

- ecoTolling might open more free flow toll lanes in case the ecoApproach Advice cannot prevent queuing any more.

Road trajectories:
- ecoGreen Wave has defined green windows for certain vehicles / traffic flows. It communicates these green windows to ecoApproach Advice.
- ecoApproach Advice translates the green windows into a speed and traffic lane advice for the targeted vehicles;
- (ecoBalanced Priorities tunes the control plans such that it meets with the defined green windows as good as possible (given local circumstances). It communicates slight deviations from the green windows as set by ecoGreen Wave, to ecoSpeed and Headway Management;
- ecoSpeed and Headway Management tunes the speed and headway advice for the targeted vehicles to these slight deviations);
- In case the traffic density does not allow a near to free flow speed and headway advice anymore (without violating road safety standards), ecoApproach Advice communicates this to ecoGreen Wave;
- ecoGreen Wave assesses whether it can tune the green wave to the emerged traffic situation.

On and off ramps:
- ecoRamp Metering defines an optimal clustering of vehicles in order to: (on ramp) smoothly merging of vehicles in the traffic flow on the motorway, or (off ramp) prevent queuing in front of the intersection at the end of the off-ramp. It communicates this optimal clustering of vehicles to ecoApproach Advice.
- ecoApproach Advice translates the proposed clustering in an speed and headway advice for the vehicles on the considered road sections (on ramp, off ramp, traffic lanes leading to off ramp). It communicates the speed and headway advice to the vehicles;
- in case the traffic density does not allow a decent clustering anymore, ecoRamp Metering and ecoApproach Advice might decide to start managing queuing on the on- or off ramp.

5.4. Uniform Control Targets
As discussed in the previous section, eCoMove ecoTraffic Management and Control builds upon previous European project by combining applications in a structured manner to amplify their potential. Coordination on a strategic level of the various applications will prevent counter-productive combination and will exploit the benefits of effective combinations as much as possible. This coordination is one of the main goals of ecoAdaptive Balancing and Control and ecoMotorway Management.

Uniform Control Targets build upon a bi-level approach, with the ecoTraffic Strategies component serving as a link between regional-strategic operations and local traffic control measures. It establishes a traffic strategy tailored to the eCoMove objectives and provides sector or local traffic control targets. Control targets for the traffic control measures are uniform in order to provide the various applications on this level, like traffic light control,
local route diversions and speed recommendations, with harmonized strategies with which they can align their control measures.

The control targets basically connect multiple strategic components to multiple control applications. A target can therefore be composed by a combination of strategies and affect several control components. To ensure good coordination between the control applications in order to fulfil all activated strategies, a careful specification is required. A vital element for ecoTraffic Strategies is the interface with Uniform Control Targets between the strategy level and the various control applications. The position of this interface is shown in the figure below.

![Figure 57: The position of the Uniform control targets](image)

The Uniform Control Targets can be based on several underlying factors like environment, travel time, encourage or discourage road usage in a certain area, etc. In the following table the control targets are specified.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce CO₂ emissions</td>
<td>This target aims to reduce CO₂ emissions and can basically affect any component and application.</td>
</tr>
<tr>
<td>Reduce smog emission</td>
<td>Similar to CO₂ emissions although the major causes of smog are relatively more present in acceleration of vehicles.</td>
</tr>
<tr>
<td>Increase Throughput</td>
<td>Trying to increase the traffic throughput can be network-wide or local.</td>
</tr>
<tr>
<td>Target</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Decrease Throughput</td>
<td>This can create traffic jams and thus more emissions, but sometimes it is used to influence the route choice of vehicles. Traffic jams can be avoided when sufficient alternative routes are present (for example with increase throughput target active).</td>
</tr>
<tr>
<td>Increase road usage in certain area/route</td>
<td>With this strategy guidance and advices for road users is given to stimulate road usage in certain areas/routes.</td>
</tr>
<tr>
<td>Decrease road usage in certain area/route</td>
<td>A certain route/area is discouraged again with guidance and advices. This is less imperative as the decrease throughput target.</td>
</tr>
<tr>
<td>Increase travel time</td>
<td>Although travel time and throughput are related there is a difference. For example a red wave can drastically increase travel time while the throughput remains almost equal given that queues don’t reach so far that they influence the capacity of an upstream intersection. Although this is quite an imperative target, it can help to balance the network load between a short low capacity route and a long high capacity route.</td>
</tr>
<tr>
<td>Decrease travel time</td>
<td>The opposite of increase travel time.</td>
</tr>
<tr>
<td>Hold Traffic / gating</td>
<td>Hold traffic should not be confused with decrease throughput. Instead of aiming at reduction of throughput, it can steer where long queues will be present in the network. When traffic demand is higher than the capacity at some point in the network the gating target tries to hold the traffic at upstream point(s) where the impact of a long queue is less severe.</td>
</tr>
<tr>
<td>Prevent jams</td>
<td>The opposite of hold traffic / gating. This target can tell where traffic jams would have a more severe impact and prevent them from forming there.</td>
</tr>
</tbody>
</table>

As can be seen from the table certain targets overlap each other or have similar effects. Especially increase/decrease road usage, increase/decrease travel time and increase/decrease throughput are related when the overall policy is to encourage or discourage a certain area/route. However, which target or set of targets is activated tells the system how far it can go. For example when decrease road usage, decrease travel time and decrease throughput are active, it implies that all means can be used even unethical ones like deliberately creating a traffic jam. It is also important to note that policies (see top of Figure 58) are different from Uniform Control Targets. The policy to encourage a certain area can be fulfilled in different manners and the combination of active Uniform Control Targets defines that manner.

Just giving a list of all Uniform Control Targets will not be sufficient for the ecoTraffic strategies component. Specification of the location, importance and conditions is important.
for proper functioning. The following functional parameters can be supplied for each control target:

- **Importance** - Value between 0 and 10 indicating how important the control target is. The ecoTraffic strategies component will use this value to blend conflicting targets which are active.
- **Location** - This can be either global (i.e. network wide) or local. In case of local, a clear description of the route or area should be supplied on the interface according to standards from SP2.
- **Conditions** - This means that the target can have several conditions like, only activate the target when a certain conditions are satisfied. This can include several traffic parameters like flow, saturation level and travel time or time constraints to only have a target in the peak hours for example.
- **Relative or absolute** - A relative target will try to improve to current value no matter what the state currently is. An absolute target will try to achieve a target value but will stop steering further when the target is achieved.
- **Actual implementation of Uniform Control Targets is not trivial and needs to be further discussed in WP4. Nonetheless, it is clear that this approach support the philosophy of cross-application integration.**

### 5.5. Philosophy of interface design

An interface enables an interaction between functions and components. Such interaction has its own historical background, its own requirements towards latency and its own requirements towards the validity of data:

- The historical background determines whether eCoMove can set a ‘standard’ for the interface or should accept a legacy interface as it is;
- The maximum latency in the interaction requires a communication path and communication bearer that can meet with the requirements;
- The validity of data should express the moment of generation of the data and the use-by date of the data.

The interfaces in eCoMove can be clustered along these phenomena:

- **Cluster 1 and 2. Interfaces to gather data from road side systems, data warehouses, master systems and simulators and into eCoMove:**
  - **Nature:** since eCoMove has to dovetail with legacy systems, the available interfaces’ of the legacy systems should be used. This can be a supplier proprietary protocol or a country specific standardised protocol.
  - **Latency:** the tolerable latency is defined by the eCoMove function or component. However, the nature of legacy systems requires that eCoMove functions or components should be designed such that they can interface with legacy systems whose interface simply cannot meet the latency requirements;
  - **Validity of data:** data from the real world should be date&time stamped to enable eCoMove functions and components to assess the validity of the data.

- **Cluster 3. Interfaces to bring data into and retrieve data from the ecoMaps and ecoModels:**
  - **Nature:** ecoMaps is a core technology of eCoMove and will be define strictly following the requirements of the functions and components of eCoMove;
  - **Latency:** the latency of ecoMaps should meet with: (i) the timing and frequency with which the data sets are delivered, (ii) the duration of the control loop of the
eCoMove functions or components and (iii) the number of interface situ has to handle in parallel;

- **Validity**: data from the real world should keep its date/time stamp to enable eCoMove functions and components to assess the validity of the data. Data from eCoMove functions and components should come with a validity stamp that tells users what the use-by date is of this data;

- **Cluster 4**: Interfaces to bring data into and retrieve data from the vehicle:
  - **Nature**: eCoMove adopts standardised wireless communication protocols for broadcasting, cellular communication and mobile WiFi;
  - **Latency**: the tolerable latency for information transfer determines the interface to be used. For instance, information needed for a trip plan can be broadcasted or send via 3G, whereas information for instant choices might require 802.11p.
  - **Validity**: data from the vehicles (real world) should be date/time stamped to enable eCoMove functions and components to assess the validity of the data. Data sent to the vehicles should come with a validity stamp that tells users what the use-by date is of this data;

- **Cluster 5**: Interface to exchange data with other Service Centers:
  - **Nature**: eCoMove adopts standardised wired communication protocols for exchange of data between service centres;
  - **Latency**: the tolerable latency is defined by the eCoMove function or component. However, the nature of the standardised wired communication protocols requires that eCoMove functions or components should be designed such that they can deal with the latency coming with these protocols;
  - **Validity**: Data exchanged between service centres should come with a validity stamp that tells users what the use-by date is of this data;

In WP3 the first step is to define the interfaces. In WP4 the defined interfaces need to be detailed out along the axes: nature, latency and validity of data.

### 5.6. Interface cluster 1: eCoMove versus roadside systems

eCoMove works with legacy systems and simulators, that are operational, planned or available on the market. The implication is that the interface between legacy systems and simulators and eCoMove is a system supplier proprietary or country specific interface. Nonetheless, standards such as DATEX-II will be used as much as possible to facilitate interoperability.

#### 5.6.1. Interface 61 – Parking location controller

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>Parking Adapter, ecoPark Advice, ecoTruck Parking</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Parking location controller specific</td>
</tr>
<tr>
<td>Protocol:</td>
<td>A supplier proprietary protocol or a country specific standardised protocol, following standardization as much as possible.</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>1 minute intervals</td>
</tr>
<tr>
<td>Security/privacy constraints:</td>
<td>Secure access to parking controller</td>
</tr>
</tbody>
</table>
Objects required by Application/Components:
- Inner state of the parking controller (i.e. controller status, detector data);
- Configuration data coming from ecoPark Advice and ecoTruck Parking.

Objects produced by Application/Component:
- Capacity of the parking location, number of parked cars, occupancy rate.

5.6.2. Interface 62 – Ramp meter controller

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>RMC Adapter, eco Ramp Metering and Merging</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Ramp meter controller specific</td>
</tr>
<tr>
<td>Protocol:</td>
<td>A supplier proprietary protocol or a country specific standardized protocol, following standardization as much as possible.</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>Real-time</td>
</tr>
<tr>
<td>Security/privacy constraints:</td>
<td>Secure access to traffic light controller</td>
</tr>
</tbody>
</table>

Objects required by Application/Components:
- Inner state of the ramp meter controller (i.e. controller status, traffic light status, detector data, RMC application data);
- Configuration data coming from ecoBalanced Priorities and ecoRamp Metering and Merging.

Objects produced by Application/Component:
- Signal program;
- A short-term prediction of the traffic light states (green residual times).

5.6.3. Interface 63 – Local traffic light controller

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>TLC Adapter, ecoBalanced Priorities and ecoGreenWave</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Traffic light controller specific</td>
</tr>
<tr>
<td>Protocol:</td>
<td>A supplier proprietary protocol or a country specific standardised protocol, following standardization as much as possible.</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>Real-time</td>
</tr>
</tbody>
</table>

Security/privacy constraints:  
- Secure access to traffic light controller;
- The internal security monitor of the traffic light will always check whether the signal plan is consistent with for instance minimum clearance timers.
Objects required by Application/Components:
- Inner state of the intersection controller (i.e. controller status, traffic light status, detector data, green wave data, TLC application data);
- Configuration data coming from ecoBalanced Priorities and ecoGreenWave.

Objects produced by Application/Components:
- A signal program (i.e. signal time program, frame program, preferred green windows);
- A short-term prediction of the traffic light states (green residual times).

5.6.4. Interface 64 – Roadside sensor data processor

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read</td>
</tr>
<tr>
<td>Data sources:</td>
<td>Sensor Adapter</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Road side unit specific</td>
</tr>
<tr>
<td>Protocol:</td>
<td>A supplier proprietary protocol or a country specific standardized protocol, following standardization as much as possible.</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>1 minute intervals</td>
</tr>
</tbody>
</table>

Objects required by Application/Components:
- Inner state of the road side unit and its sensors.

Objects produced by Application/Components:
- In case of point sensors (e.g. physical or virtual induction loops) traffic density (expressed in intensity, average speed and corresponding standard deviation);
- In case of trajectory based sensors (e.g. ANPR camera’s, Bluetooth) travel times (travel speeds over fixed trajectory lengths).

5.6.5. Interface 65 – Micro simulator

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>MS Adapter</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Micro simulator specific</td>
</tr>
<tr>
<td>Protocol:</td>
<td>A supplier proprietary protocol</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>Interval of a simulation run</td>
</tr>
</tbody>
</table>

Objects required by Application/Components:
- Current controller states and signal plans of the controllers (traffic light and ramp meter controllers);
- Current “coordination scheme” (i.e. the data that is needed to coordinate a virtual intersection controller in the simulation environment e.g. for dynamic Green Waves);
- Current “vehicle state” of vehicles in real life;
- Input requests by ecoApplications.

Objects produced by Application/Components:
- Probe vehicle dataset;
- Microscopic Traffic State dataset;
- Specific input requested by ecoApplications (e.g. microscopic route choice, speed choice, signal control, etc.).

5.7. Interface cluster 2: eCoMove versus master systems

eCoMove traffic management and control consist of a strategic and tactical level. On tactical level operate local application and components, typically in a roadside unit. Strategic operations generally take place centrally, for example in a traffic management centre or back-office. Based on aggregated data from many different sources, these operations determine a high level view of the traffic state and define control strategies for local operations.

5.7.1. Interface 51 – Macro simulator

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>TCC / TMC Adapter</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Road side unit specific</td>
</tr>
<tr>
<td>Protocol:</td>
<td>A macro simulator proprietary protocol</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>Interval of a simulation run</td>
</tr>
</tbody>
</table>

Objects required by Application/Components:
- Current signal plans of the controllers (traffic light and ramp meter controllers);
- Current “coordination scheme” (i.e. the data that is needed to coordinate a virtual intersection controller in the simulation environment e.g. for dynamic Green Waves);
- Input requests by ecoApplications.

Objects produced by Application/Components:
- Macroscopic Traffic State dataset;
- Specific input requested by ecoApplications (e.g. macroscopic route choice).

5.7.2. Interface 52 – Predefined strategies network

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read</td>
</tr>
<tr>
<td>Data sources:</td>
<td>TCC / TMC Adapter</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>XML</td>
</tr>
<tr>
<td>Protocol:</td>
<td>SOAP</td>
</tr>
</tbody>
</table>


Objects required by Application/Components: n/a

Objects produced by Application/Components:
- Predefined Strategies (e.g. “public transport vehicles have green priority”, “cycle times of traffic light must be as short as possible” or “traffic volume on route A must not exceed x”).

5.7.3. Interface 53 – Actual aggregated network traffic states

Interface type: Storage and retrieval data
Operation: Read
Data sources: TCC / TMC Adapter
Physical storage: XML
Protocol: SOAP
Kind of access: Subscription
Timing and Frequency: Every 10 minutes

Objects required by Application/Components: n/a

Objects produced by Application/Components:
- External qualification of the actual aggregated network states e.g. captured as actual state in the fundamental diagram (i.e. traffic flow, speed, and density) for the distinguished segment, trajectories and partial road networks.

5.7.4. Interface 54 – Actual aggregated network sensor data

Interface type: Storage and retrieval data
Operation: Read
Data sources: TCC / TMC Adapter
Physical storage: DATEX II
Protocol: DATEX II
Kind of access: Subscription
Timing and Frequency: Event based (every time a predefined strategy changes or is added)

Objects required by Application/Components: n/a

Objects produced by Application/Components:
- MeasuredDataPublication (processed measurement data from sensors).

5.7.5. Interface 55 – Actual aggregated network signal control states

Interface type: Storage and retrieval data
Operation: Read
Data sources: TCC / TMC Adapter
Objects produced by Application/Components:
- External qualification of the actual utility factor of the signal control states. This minimally includes average cycles time and average waiting time per signal group.

### 5.7.6. Interface 41 – ecoTraffic Strategies

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read</td>
</tr>
<tr>
<td>Data sources:</td>
<td>TCC / TMC Adapter</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>XML</td>
</tr>
<tr>
<td>Protocol:</td>
<td>SOAP</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>Every 10 minutes</td>
</tr>
</tbody>
</table>

Objects produced by Application/Components:
- Predefined strategies (see interface 52);
- Actual aggregated network state (see interface 32);
- Actual aggregated signal state (see interface 32).

### 5.8. Interface cluster 3: data exchange with ecoMaps and ecoModels

ecoMove works with an ecoMap to build one, unambiguous and complete representation of the traffic state that is shared and used by all eco-applications. The implication is that the interface definition fully relies on the ecoMap definition. One important assumption is that there are two different ecoMaps at the infrastructure side, one centrally and one locally. The local ecoMaps contains detailed data, while the central ecoMaps contains aggregated data.

#### 5.8.1. Interface 31 – ecoMaps for simulator

This interface is the counterpart of interface 65 as described in cluster 1. The design is identical only seen from a different perspective. The aim of both interfaces is to make simulation data available in ecoMaps as if it concerns a real-life test site.

#### 5.8.2. Interface 32 – ecoMaps for applications

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>ecoTraffic Strategies, Adapters</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>XML-file</td>
</tr>
</tbody>
</table>
Protocol: SOAP
Kind of access: Subscription/API call
Timing and Frequency: From real-time to 30 minute intervals

Objects required by ecoApplications/Components:
- Static Map Information (i.e. network topology, link attributes, road equipment)
- Uniform Control Targets – Strategy and Priority Values (e.g. control targets (reduce CO₂ emissions, increase/decrease throughput, increase/decrease travel time), excluded routes, favoured routes);
- Actual and Predicted Microscopic Traffic States (i.e. vehicle state and movement (e.g. type, position, vehicle fuel consumption, distance to stop line, lane, speed, acceleration, vehicle movement/planned further route), signal state, geography);
- Actual and Predicted Macroscopic Traffic States (i.e. travel time, traffic flow and fuel use per link of the network, waiting queue per intersection);
- Dynamic speed limits;
- Link Capacities (i.e. capacity, link id, time stamp)
- Parking (i.e. parking name, location and status parking, preferred route);
- Signal Plan (i.e. SG colour, SG next colour, SG residual time, SG next colour duration);
- Coordination Scheme (i.e. cycle time, offset time, next optimal green window, Coordination speed);
- Control Event Data (i.e. frame signal plan, stage change, PT logon, cycle time, toll gate status information, mode of payment);
- Toll / road user charging schemes;
- Desired Route Distribution Matrix (i.e. origin id, destination id, weight);
- Position of vehicles and vehicle states;
- Traffic demand (i.e. vehicle Origin/Destination)

Objects produced by ecoApplications/Components:
- ecoSpeed and Headway Management: speed recommendation, trajectory recommendation, headway recommendation;
- ecoTruck Parking: available parking area for trucks, parking area status;
- ecoRamp Metering and Merging: speed Advice, phase cycle schedule;
- eco Park Advice: available parking locations, parking location status;
- eco Route Advice: route advice;
- eco Approach Advice: trajectory advice, speed advice;
- ecoGreen Wave: coordination scheme;
- ecoBalanced Priorities: traffic signal plans;

5.8.3. **Interface 33 – ecoMaps for master systems**

Interface type: Storage and retrieval data
Operation: Read and write
Data sources: Aggregated network signal control states, aggregated network
sensor data, aggregated network traffic states, predefined strategies network, macro simulator, eStram

Physical storage: XML-file
Protocol: SOAP
Kind of access: Subscription/API call
Timing and Frequency: From one minute to 30 minute intervals

Objects required by ecoApplications/Components:
- eStram - Aggregated network signal control states (see interface 55);
- eStram - Aggregated network sensor data (see interface 54);
- eStram - Aggregated network traffic states Objects required by roadside systems (see interface 53).
- eStram - Uniform Control Targets
- ecoTraffic Strategies – Predefined traffic strategies
- ecoTraffic Strategies – Actual and predicated traffic network state

Objects produced by Applications/Component:
- ecoTraffic Strategies – Uniform Control Targets

5.8.4. Interface 34 – ecoMaps for roadside systems

Interface type: Storage and retrieval data
Operation: Read and write
Data sources: Road side systems (ramp meter controllers, traffic light controllers, road side sensors and parking locations), ecoRamp Metering and Merging, ecoGreen Wave, ecoBalanced Priority

Physical storage: XML-file
Protocol: SOAP
Kind of access: Subscription/API call
Timing and Frequency: From real-time to 30 minute intervals

Objects required by Applications/Components:
- Ramp Meter Controller (see interface 61): Controller State Signal Program and Coordination Scheme;
- Traffic Light Controller (see interface 62): Controller State, Signal Program and Coordination Scheme;
- Road side sensors:
  - in case of point sensors (e.g. physical or virtual induction loops) traffic density (expressed in intensity, average speed and corresponding standard deviation);
  - in case of trajectory based sensors (e.g. ANPR camera’s, Bluetooth) travel times (travel speeds over fixed trajectory lengths).
- Parking locations: number of free parking locations and occupancy rate.

Objects required by Applications/Components:
- Configuration data for ramp meter and traffic light controllers.
5.8.5. **Interface 35 – ecoMaps for driver info support manager**

Interface type: Storage and retrieval data  
Operation: Read  
Data sources: ecoApplications (respond)  
Physical storage: XML-file  
Protocol: SOAP  
Kind of access: Request  
Timing and Frequency: One to 30 minutes

Objects available broadcast service:  
- ecoSpeed and Headway Management: speed recommendation, trajectory recommendation, headway recommendation;  
- ecoTruck Parking: available parking area for trucks, parking area status;  
- ecoRamp Metering and Merging: speed advice, phase cycle schedule;  
- eco ParkAdvice: available parking locations, parking location status;  
- eco Route Advice: route advice;  
- eco Approach Advice: trajectory advice, speed advice;  
- ecoBalanced Priorities: traffic signal states;  
- ecoEmission Estimation: environmental states;  
- ecoNetwork State: traffic state and forecast information, dynamic speed limits;

Objects required from by Service Centres WP3 & WP4:  
- See D3.2, D3.3 and D4.2

5.8.6. **Interface 36 – ecoMaps for communication manager**

It is foreseen to write specifications for a Cooperative Awareness Message (CAM) for roadside systems. The difference with the TPEG protocol described in interface 35 and 2 is that no involvement of a functional application is required. This activity is part of the development of ecoTraffic Situational Data (ecoTSD) in the ecoCore Technologies sub-project (SP2).

5.8.7. **Interface 37 – ecoMaps for ecoModels**

Interface type: Storage and retrieval data  
Operation: Read and write  
Data sources: eSim, eStram  
Physical storage: XML-file  
Protocol: SOAP  
Kind of access: Subscription/API call  
Timing and Frequency: From real-time to 30 minute intervals

Objects required by ecoApplications/Components:  
- Static Map Information (i.e. network topology, link attributes, road equipment)
- Uniform Control Targets – Strategy and Priority Values (e.g. control targets (reduce 
  CO₂ emissions, increase/decrease throughput, increase/decrease travel time), 
  excluded routes, favoured routes);
- Dynamic speed limits;
- Link Capacities (i.e. capacity, link id, time stamp)
- Parking (i.e. parking name, location and status parking, preferred route);
- Signal Plan (i.e. SG colour, SG next colour, SG residual time, SG next colour 
  duration);
- Coordination Scheme (i.e. cycle time, offset time, next optimal green window, 
  Coordination speed);
- Control Event Data (i.e. frame signal plan, stage change, PT logon, cycle time, toll 
  gate status information, mode of payment);
- Toll / road user charging schemes;
- Position of vehicles and vehicle states;
- Traffic demand (i.e. vehicle Origin/Destination)
- Implemented application strategies;

Objects produced by ecoApplications/Components:
- Actual and Predicted Microscopic Traffic States (i.e. vehicle state and movement 
  (e.g. type, position, vehicle fuel consumption, distance to stop line, lane, speed, 
  acceleration, vehicle movement/planned further route), signal state, geography);
- Actual and Predicated Macroscopic Traffic and Emission States (i.e. travel time, traffic flow and 
  fuel use per link of the network, waiting queue per intersection);
- Desired Route Distribution Matrix (i.e. origin id, destination id, weight);

5.8.8. Interface 38 – data exchange central to local ecoMaps

Interface type: Storage and retrieval data
Operation: Read and write
Data sources: ecoMaps central, ecoMaps local
Physical storage: XML-file
Protocol: SOAP
Kind of access: Subscription/API call
Timing and Frequency: From real-time to 30 minute intervals

Objects required by ecoApplications/Components:
- Uniform Control Targets – Strategy and Priority Values (e.g. control targets (reduce 
  CO₂ emissions, increase/decrease throughput, increase/decrease travel time), 
  excluded routes, favoured routes);
- Coordination Scheme (i.e. cycle time, offset time, next optimal green window, 
  Coordination speed);
- Actual and Predicated Macroscopic Traffic and Emission States (i.e. travel time, 
  traffic flow and fuel use per link of the network, waiting queue per intersection);
- Traffic demand (i.e. vehicle Origin/Destination)
- Dynamic speed limits;
- Toll / road user charging schemes;

Objects produced by ecoApplications/Components: n/a

### 5.8.9. Interface 39 – data exchange local to central ecoMaps

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>ecoMaps</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>XML-file</td>
</tr>
<tr>
<td>Protocol:</td>
<td>SOAP</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription/API call</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>From real-time to 30 minute intervals</td>
</tr>
</tbody>
</table>

Objects required by ecoApplications/Components:
- Aggregated Actual and Predicted Microscopic Traffic and Emission States (i.e. vehicle state and movement (e.g. type, position, vehicle fuel consumption, distance to stop line, lane, speed, acceleration, vehicle movement/planned further route), signal state, geography);
- Aggregated Traffic Signal Plan Data;
- Aggregated Control Event Data (i.e. frame signal plan, stage change, PT logon, cycle time, toll gate status information, mode of payment);

Objects produced by ecoApplications/Components: n/a

### 5.8.10. Interface 71 – ecoModels for Applications (micro)

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Storage and retrieval data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Read and write</td>
</tr>
<tr>
<td>Data sources:</td>
<td>ecoMaps</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>XML-file</td>
</tr>
<tr>
<td>Protocol:</td>
<td>SOAP</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Subscription/API call</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>From real-time to 30 minute intervals</td>
</tr>
</tbody>
</table>

Objects required by ecoApplications/Components:
- Actual and Predicted Microscopic Traffic and Emission States (i.e. vehicle state and movement (e.g. type, position, vehicle fuel consumption, distance to stop line, lane, speed, acceleration, vehicle movement/planned further route), signal state, geography);
- Tactical Application Strategies:
- ecoSpeed and Headway Management: speed recommendation, trajectory recommendation, headway recommendation;
- ecoRamp Metering and Merging: speed Advice, phase cycle schedule;
- eco Approach Advice: trajectory advice, speed advice;
- ecoBalanced Priorities: traffic signal plans;

Objects produced by ecoApplications/Components:
- Traffic and emission state indicators for the evaluation of different strategies ex-ant and ex-post of implementation.

5.8.11. Interface 72 – ecoModels for Applications (macro)

Object type: Storage and retrieval data
Operation: Read and write
Data sources: ecoMaps
Physical storage: XML-file
Protocol: SOAP
Kind of access: Subscription/API call
Timing and Frequency: From real-time to 30 minute intervals

Objects required by ecoApplications/Components:
- Actual and Predicated Macroscopic Traffic and Emission States (i.e. travel time, traffic flow and fuel use per link of the network, waiting queue per intersection);
- Desired Route Distribution Matrix (i.e. origin id, destination id, weight);
- Strategic Application Strategies (i.e. route advice, park advice, speed advice, etc.)
- ecoSpeed and Headway Management: speed recommendation, trajectory recommendation, headway recommendation;
- ecoTruck Parking: available parking area for trucks, parking area status;
- eco Park Advice: available parking locations, parking location status;
- eco Route Advice: route advice;
- ecoGreen Wave: coordination scheme;

Objects produced by ecoApplications/Components:
- Traffic and emission state indicators for the evaluation of different strategies ex-ant and ex-post of implementation.

5.9. Interface cluster 4: data exchange with the vehicle

eCoMove brings data (representing information, advices, warnings and instructions) to vehicles drivers and service centres via wireless (vehicle) and wired (service centres) communication bearers. Here international standards will be followed.

5.9.1. Interface 11 – Driver dialog manager

Object type: Storage and retrieval data
Operation: Read
Data sources: Communication manager for unicast (request), ecoApplications (respond)
Physical storage: XML-file
Protocol: SOAP
Objects required by ecoApplications/Components:
- Vehicle data – notification (i.e. the last three positions of the vehicle in WGS84 coordinate);
- Vehicle data – information request.

Objects produced by ecoApplications/Components:
- ecoSpeed and Headway Management: Vehicle Trajectory (a series of points reference to time) and vehicle headway;
- ecoTruck Parking: parking opportunities (i.e. locations of truck parks area located downstream from the vehicle's position with their status: free, full or closed);
- ecoTolling: speed advice and payment transactions;
- ecoRamp Metering and Merging:
  - ramp metering: actual signal plans and cycle times in ramp meter controllers, and speed advice;
  - merging: driving advice (speed, acceleration, headway, lane)
- ecoPark Advice: parking opportunities (i.e. locations of public parking locations located downstream from the vehicle's position and close to vehicle’s destination with their number of free parking places);
- ecoRoute Advice: individual “Route Advice” for a specific vehicle;
- ecoApproach Advice: vehicle lane advice and a time slot when to pass the stop line for this specific vehicle;
- ecoBalanced Priorities: actual signal plans and cycle times in traffic light controllers.

5.9.2. Interface 12 – Driver Info Support Manager

Interface type: Storage and retrieval data
Operation: Read
Data sources: Communication manager for broadcast (request), EcoApplications (respond)
Physical storage: XML-file
Protocol: SOAP
Kind of access: Request
Timing and Frequency: Event based

Objects required by ecoApplications/Components:
- Vehicle data – notification (i.e. the last three positions of the vehicle in WGS84 coordinate);
- Vehicle data – information request.

Objects produced by ecoApplications/Components:
- ecoTruck Parking: parking opportunities (i.e. locations of truck parks area located downstream from the vehicle's position with their status: free, full or closed);
- ecoPark Advice: parking opportunities (i.e. locations of public parking locations located downstream from the vehicle's position and close to vehicle’s destination with their number of free parking places);
- ecoRoute Advice: individual “Route Advice” for a specific vehicle;

5.9.3. Interface 2 – Communication manager for unicast

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Real-time data transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Receive and pass on</td>
</tr>
<tr>
<td>Data sources:</td>
<td>Vehicles (delivery of ecoFVD, request for information), EcoApplications (respond)</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Binary (CEN/ISO TC 18234)</td>
</tr>
<tr>
<td>Protocol:</td>
<td>802.11p WAVE</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>Write</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>Event based</td>
</tr>
</tbody>
</table>

Objects required by ecoApplications/Components:
- Vehicle data – notification (i.e. the last three positions of the vehicle in WGS84 coordinate) that triggers one or more of the applications to send data, or;
- Specific information request from the vehicle (see interface 1).

Objects produced by ecoApplications/Components:
- See interface 11 – Driver dialog manager.

5.9.4. Interface 3 – Communication manager for broadcast

<table>
<thead>
<tr>
<th>Interface type:</th>
<th>Real-time data transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation:</td>
<td>Receive and pass on</td>
</tr>
<tr>
<td>Data sources:</td>
<td>Vehicles (request), ecoApplications (respond)</td>
</tr>
<tr>
<td>Physical storage:</td>
<td>Binary (CEN/ISO TC 18234)</td>
</tr>
<tr>
<td>Protocol:</td>
<td>TPEG over IP (http) or 802.11p WAVE (local broadcast)</td>
</tr>
<tr>
<td>Kind of access:</td>
<td>n/a</td>
</tr>
<tr>
<td>Timing and Frequency:</td>
<td>Event based</td>
</tr>
</tbody>
</table>

Objects produced by ecoApplications/Components:
- Road Traffic Message (RTM): current traffic state and prediction (TPEG-TFP), Traffic events including diversion information (TPEG-TEC);
- Parking Information (TPEG-PKI);
- Traffic Event Compact - Congestion and Travel-Time (TPEG-TEC);
- Weather information for travellers (WEA);
- Traffic Signal States (TPEG-TSI).

5.9.5. Interface 1 – Communication manager for ecoFVD
Interface type: Real-time data transfer  
Operation: Receive and pass on  
Data sources: Vehicles (delivery of ecoFVD, request for information), ecoApplications (respond)  
Physical storage: Binary (CEN/ISO TC 18234)  
Protocol: CAM over 802.11p WAVE  
Kind of access: Read  
Timing and Frequency: Event based  

Objects required by ecoApplications/Components:  
- Vehicle data – notification (i.e. the last three positions of the vehicle in WGS84 coordinate) or specific information request;  
- ecoFVD (Floating Vehicle Data) (i.e. vehicle trajectory data)  

Objects produced by ecoApplications/Components:  
- see interface 2 and 3  

5.10. Interface cluster 5: data exchange with other Service Centres  
5.10.1. Interface 22 – Driver info support manager  
Interface type: Storage and retrieval data  
Operation: Read  
Data sources: SP3/SP4-Service Center, Driver Info Support Manager  
Physical storage: XML or binary  
Protocol: TPEG  
Kind of access: Subscription  
Timing and Frequency: From real-time to 30 minute intervals  

Objects required by other service centre:  
- See D3.2, D3.3 and D4.2  

Objects produced by other service centre:  
- See D3.2, D3.3 and D4.2  

5.10.2. Interface 4 – Communication Manager for service centre  
The design of this interface is under the responsibility of the SP2, 3 and 4.
### 6. Requirements traceability

<table>
<thead>
<tr>
<th>ID</th>
<th>SP5 Subject</th>
<th>Requirement</th>
<th>BL</th>
<th>TL</th>
<th>AL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP5-1-0001</td>
<td>ecoRouteAdvice</td>
<td>Take into account capacity restrictions (incidents, accidents, road work, etc.)</td>
<td>AL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-1-0002</td>
<td>ecoRouteAdvice</td>
<td>Overall benefits do not come at unacceptable cost for some individuals</td>
<td>AL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-1-0003</td>
<td>ecoRouteAdvice</td>
<td>The infrastructure system provides ecoMessages (TBD) to the vehicles and fleet operators or navigation service providers.</td>
<td>To SP2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-1-0004</td>
<td>ecoRouteAdvice</td>
<td>A goal of route optimization is needed</td>
<td>AL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-1-0005</td>
<td>ecoRouteAdvice</td>
<td>Route advices should reflect local traffic conditions, or should be updated based on them</td>
<td>AL</td>
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<tr>
<td>SP5-2-0006</td>
<td>ecoParkAdvice</td>
<td>Vehicles and drivers are guided in the most energy efficient way to parking areas with available parking places near to their destination.</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-2-0007</td>
<td>ecoParkAdvice</td>
<td>Vehicles and drivers are guided to available parking spaces in the most energy efficient way</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-2-0008</td>
<td>ecoParkAdvice</td>
<td>Guidance of vehicles to parking locations is based on dynamic partial network route distribution (in the considered parking area) that reflects minimal total fuel consumption and takes into account capacity restrictions (incidents, accidents, road work, etc.)</td>
<td>BL</td>
<td>AL</td>
<td></td>
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<tr>
<td>SP5-2-0009</td>
<td>ecoParkAdvice</td>
<td>In case parking areas near destination are near to saturation and/or the trunk roads to these parking areas are near to saturation, vehicles will be guided to Park&amp;Ride (P&amp;R) locations.</td>
<td>BL</td>
<td>AL</td>
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<tr>
<td>SP5-2-0010</td>
<td>ecoParkAdvice</td>
<td>ecoParking Advice connects to the parking locations and their systems as they are present in municipalities.</td>
<td>AL</td>
<td>TL</td>
<td></td>
</tr>
<tr>
<td>SP5-2-0011</td>
<td>ecoParkAdvice</td>
<td>ecoParking Advice is accepted and supported by the owners of the parking locations.</td>
<td></td>
<td></td>
<td>AL</td>
</tr>
<tr>
<td>SP5-2-0012</td>
<td>ecoParkAdvice</td>
<td>ecoParking Advice should operate in a closed communication network.</td>
<td></td>
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<tr>
<td>SP5-2-0013</td>
<td>ecoParkAdvice</td>
<td>ecoParking Advice provides information to vehicles drivers that is in line with the actual situation.</td>
<td>BL</td>
<td></td>
<td>AL</td>
</tr>
<tr>
<td>SP5-3-0014</td>
<td>ecoGreenWave</td>
<td>The road section of the green wave should at least cover three subsequent signal controlled intersections with traffic flows in both directions and different distances between the intersections.</td>
<td>BL</td>
<td></td>
<td>AL</td>
</tr>
<tr>
<td>SP5-3-0015</td>
<td>ecoGreenWave</td>
<td>The average ratio of green wave vehicles passing intersections without stops over both directions shall significantly be higher than for a green wave without link specific coordination speed and i2v communication (speed advices).</td>
<td>BL</td>
<td></td>
<td>AL</td>
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<tr>
<td>SP5-3-0016</td>
<td>ecoGreenWave</td>
<td>The update period of the ecoGreenWave parameters shall not be larger than 15 minutes.</td>
<td>BL</td>
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<td>AL</td>
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<tr>
<td>SP5-3-0017</td>
<td>ecoGreenWave</td>
<td>Demand fluctuations are reflected in the control strategy, i.e. there is a functional dependency between traffic demand along the green wave and the coordination weights of the green wave (compared to those weights from other green waves or directions).</td>
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<tr>
<td>SP5-3-0018</td>
<td>ecoGreenWave</td>
<td>Vehicles that are driving in the road section of the green wave shall be provided permanently with speed recommendations.</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-3-0019</td>
<td>ecoGreenWave</td>
<td>Determine and update dynamically link coordination speeds for green waves according to traffic demands.</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-3-0020</td>
<td>ecoGreenWave</td>
<td>Use vehicle generated data (CAM) to estimate accurate traffic states for the road section of the green wave.</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-3-0021</td>
<td>ecoGreenWave</td>
<td>The procedure can take into account additional strategic data from central systems (Uniform Control Targets).</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-4-0022</td>
<td>ecoBalancedPriority</td>
<td>The control strategy facilitates coordination schemes to enable green waves</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-4-0023</td>
<td>ecoBalancedPriority</td>
<td>The control strategy anticipates to control targets derived from a strategic level</td>
<td>BL</td>
<td>AL</td>
<td>TL</td>
</tr>
<tr>
<td>SP5-4-0024</td>
<td>ecoBalancedPriority</td>
<td>The control strategy takes into consideration ecoFVD and local sensor data</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-4-0025</td>
<td>ecoBalancedPriority</td>
<td>The control strategy is not restricted to traditional control principles, and therefore fully flexible</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-4-0026</td>
<td>ecoBalancedPriority</td>
<td>The control strategy progressively aims to meet fuel reduction goals, disregarding mobility and accessibility constraints</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-4-0027</td>
<td>ecoBalancedPriority</td>
<td>Individual vehicles, platoons and traffic flows are weighed differently based on their importance to control objectives</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-4-0028</td>
<td>ecoBalancedPriority</td>
<td>Outcome of the control strategy should remain with the acceptability boundaries of individual travellers</td>
<td>To SP6</td>
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<td>ID</td>
<td>SP5 Subject</td>
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<tr>
<td>SP5-4-0029</td>
<td>ecoBalancedPriority</td>
<td>With the control strategy the use of intersection capacity increases, possibly to nearly its maximum</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-4-0030</td>
<td>ecoBalancedPriority</td>
<td>The control strategy should be able to run real-time on a low-cost (e.g. 200 euro) industrial PC for one intersection</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-4-0031</td>
<td>ecoBalancedPriority</td>
<td>The control strategy anticipates to traffic conditions at upstream and downstream traffic controllers</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-5-0032</td>
<td>ecoApproach Advice</td>
<td>Vehicles are able to pass a sequences of controllers without abrupt changes in their speed profile</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-5-0033</td>
<td>ecoApproach Advice</td>
<td>Determine and update dynamically coordination speeds for green waves according to traffic demands.</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-5-0034</td>
<td>ecoApproach Advice</td>
<td>Prevent unnecessary queuing and traffic jams from happening</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-5-0035</td>
<td>ecoApproach Advice</td>
<td>The infrastructure system provides ecoMessages (TBD) to the vehicles and fleet operators or navigation service providers.</td>
<td>To SP2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-5-0036</td>
<td>ecoApproach Advice</td>
<td>Normal traffic rules like the legal speed limit remain valid</td>
<td>AL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-5-0037</td>
<td>ecoApproach Advice</td>
<td>Information about speed, acceleration, lane and destination from the vehicle is available</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-6-0038</td>
<td>ecoRamp Metering</td>
<td>Improve Ramp metering should be capable of reducing fuel usage of all traffic surrounding the relevant on-ramp in rush-hour conditions with 10%.</td>
<td>BL</td>
<td>AL</td>
<td>TL</td>
</tr>
<tr>
<td>ID</td>
<td>SP5 Subject</td>
<td>Requirement</td>
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<tr>
<td>SP5-6-0039</td>
<td>ecoRamp Metering</td>
<td>Improve Ramp metering should be capable of reducing the number of stops of all traffic surrounding the relevant on-ramp in rush-hour conditions with 10%.</td>
<td>BL</td>
<td>AL</td>
<td>TL</td>
</tr>
<tr>
<td>SP5-6-0040</td>
<td>ecoRamp Metering</td>
<td>Improve Ramp metering should be capable of reducing the number of acceleration movements of all traffic surrounding the relevant on-ramp in rush-hour conditions with 10%.</td>
<td>BL</td>
<td>AL</td>
<td>TL</td>
</tr>
<tr>
<td>SP5-6-0041</td>
<td>ecoRamp Metering</td>
<td>The strategy reduces the amount of stop-and-go movements on on-ramps</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-6-0042</td>
<td>ecoRamp Metering</td>
<td>The strategy reduces the fuel consumption of heavy and/or polluting vehicles on on-ramps</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-6-0043</td>
<td>ecoRamp Metering</td>
<td>The strategy is able to discriminate between different lanes and branches</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-6-0044</td>
<td>ecoRamp Metering</td>
<td>Outcome of the control strategy should remain within the acceptability boundaries of individual travellers</td>
<td>To SP6</td>
<td></td>
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</tr>
<tr>
<td>SP5-6-0045</td>
<td>ecoRamp Metering</td>
<td>The control strategy anticipates to traffic conditions at upstream and downstream traffic controllers</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-6-0046</td>
<td>ecoRamp Metering</td>
<td>The strategy reduces the total amount of fuel used on the onramp without disproportional increase in fuel use on the main road</td>
<td>BL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-7-0047</td>
<td>ecoSupport Merging</td>
<td>Improve Ramp metering should be capable of reducing fuel usage of all traffic surrounding the relevant merging location in rush-hour conditions with 10%.</td>
<td>BL</td>
<td>AL</td>
<td>TL</td>
</tr>
<tr>
<td>ID</td>
<td>SP5 Subject</td>
<td>Requirement</td>
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<tr>
<td>SP5-7-0048</td>
<td>ecoSupport Merging</td>
<td>Improve Ramp metering should be capable of reducing the number of stops of all traffic surrounding the relevant merging location in rush-hour conditions with 10%.</td>
<td>BL</td>
<td>AL</td>
<td>TL</td>
</tr>
<tr>
<td>SP5-8-0049</td>
<td>ecoSpeed and Headway Management</td>
<td>The control strategy anticipates to control targets derived from a strategic level</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-8-0050</td>
<td>ecoSpeed and Headway Management</td>
<td>Excessive speed, stop-and-go traffic, unnecessary queuing and traffic jams on motorways are minimized</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-8-0051</td>
<td>ecoSpeed and Headway Management</td>
<td>The strategy distributes information to vehicles, which enables them to plan their most fuel efficient trajectory</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-8-0052</td>
<td>ecoSpeed and Headway Management</td>
<td>Small disturbances in traffic flows are absorbed through anticipation by vehicles</td>
<td>BL</td>
<td>AL</td>
<td></td>
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<tr>
<td>SP5-8-0053</td>
<td>ecoSpeed and Headway Management</td>
<td>Normal traffic rules like the legal speed limit remain valid</td>
<td>BL</td>
<td>AL</td>
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</tr>
<tr>
<td>SP5-8-0054</td>
<td>ecoSpeed and Headway Management</td>
<td>Information and advices are in line with the traffic conditions in the environment of the vehicle</td>
<td>BL</td>
<td></td>
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</tr>
<tr>
<td>SP5-9-0055</td>
<td>ecoTruck Parking</td>
<td>The number of places available on the park must be properly assessed</td>
<td>AL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-9-0056</td>
<td>ecoTruck Parking</td>
<td>Status of the truck parking area must correspond to reality</td>
<td>AL</td>
<td></td>
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<tr>
<td>SP5-9-0057</td>
<td>ecoTruck Parking</td>
<td>The vehicle must be correctly map matched</td>
<td>AL</td>
<td></td>
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</tr>
<tr>
<td>SP5-9-0058</td>
<td>ecoTruck Parking</td>
<td>The available parking search engine must return truck parking area located downstream from the vehicle's position</td>
<td>AL</td>
<td></td>
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<tr>
<td>SP5-9-0059</td>
<td>ecoTruck Parking</td>
<td>The system should give the TruckParking information to the relevant truck</td>
<td>AL</td>
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<tr>
<td>SP5-10-0060</td>
<td>ecoTolling</td>
<td>The number of stops will be lower driving through the ecoLane rather than a conventional lane</td>
<td></td>
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<td>AL</td>
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<tr>
<td>SP5-10-0061</td>
<td>ecoTolling</td>
<td>The fuel consumption will be improved for those vehicles that use &quot;Desired Route Distribution&quot; supported routing compared to navigation (without this support).</td>
<td></td>
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<td>AL</td>
</tr>
<tr>
<td>SP5-10-0062</td>
<td>ecoTolling</td>
<td>the drivers will follow the speed recommendations</td>
<td></td>
<td></td>
<td>AL</td>
</tr>
<tr>
<td>SP5-10-0063</td>
<td>ecoTolling</td>
<td>The average travel time will be improved compared to a &quot;conventional&quot; toll crossing. It is assumed here that the drivers will follow the speed recommendations on the pictogram on the entrance eCoTolling lane.</td>
<td></td>
<td></td>
<td>AL</td>
</tr>
<tr>
<td>SP5-11-0064</td>
<td>ecoNetwork State</td>
<td>The system is based on a representation of a road network which minimally consists of origins, destinations, links and nodes.</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-11-0065</td>
<td>ecoNetwork State</td>
<td>The traffic demand on a particular road/route should be calculated based on the available origin-destination relations?</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-11-0066</td>
<td>ecoNetwork State</td>
<td>Traffic demand is derived from ecoFVD and completed with historic data and infrastructure sensor data</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-11-0067</td>
<td>ecoNetwork State</td>
<td>Provide ideal / desired network route distribution that reflects minimal total fuel consumption in the network.</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-11-0068</td>
<td>ecoNetwork State</td>
<td>Take into account capacity restrictions (incidents, accidents, road work, etc.)</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-11-0069</td>
<td>ecoNetwork State</td>
<td>Network state should reflect local traffic conditions</td>
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<tr>
<td>SP5-11-0070</td>
<td>ecoNetwork State</td>
<td>Route distribution should consider local route alternatives</td>
<td>AL</td>
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<tr>
<td>SP5-12-0071</td>
<td>ecoTraffic Strategies</td>
<td>Convert policies of the local traffic manager into Uniform control targets</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-12-0072</td>
<td>ecoTraffic Strategies</td>
<td>A location referencing system should be available from the ecoMap that enables the traffic light control application, the policies of the traffic manager and this system to operate with the same referencing system</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-12-0073</td>
<td>ecoTraffic Strategies</td>
<td>The resulting Uniform Control Targets contribute to less CO2 emissions and help achieving the policy goals set by a traffic manager</td>
<td>BL</td>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>SP5-12-0074</td>
<td>ecoTraffic Strategies</td>
<td>Usage and degree of usage of cooperative applications should be steered effectively by the ecoTrafficStrategies component</td>
<td>BL</td>
<td></td>
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</tr>
<tr>
<td>SP5-12-0075</td>
<td>ecoTraffic Strategies</td>
<td>The required processing capacity with updates at least every 5 minutes should not exceed the capacity of a contemporary quad core machine with the network of a testsite</td>
<td>n/a</td>
<td></td>
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</tr>
<tr>
<td>SP5-13-0076</td>
<td>ecoEmission Estimation and Prediction</td>
<td>Emissions can be calculated on the basis of the trajectories of individual vehicles</td>
<td>AL</td>
<td></td>
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<tr>
<td>SP5-13-0077</td>
<td>ecoEmission Estimation and Prediction</td>
<td>Emissions can be calculated on the basis of traffic flow variables</td>
<td>AL</td>
<td></td>
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</tr>
<tr>
<td>SP5-13-0078</td>
<td>ecoEmission Estimation and Prediction</td>
<td>Emissions estimated reflect the average vehicle mix in each country when this mix is known</td>
<td>AL</td>
<td></td>
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</tr>
<tr>
<td>SP5-13-0079</td>
<td>ecoEmission Estimation and Prediction</td>
<td>Input to the ecoEmission Component can both be pushed or be pulled (i.e. from the ecoMap)</td>
<td>AL</td>
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<tr>
<td>SP5-13-0080</td>
<td>ecoEmission Estimation and Prediction</td>
<td>Output from the ecoEmission Component can be delivered directly or indirectly (i.e. via the ecoMap)</td>
<td>AL</td>
<td></td>
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</tr>
<tr>
<td>SP5-14-0081</td>
<td>ecoAdaptive Traveller Support</td>
<td>The infrastructure system provides traffic and signal states to the vehicles</td>
<td>TL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-14-0082</td>
<td>ecoAdaptive Traveller Support</td>
<td>The infrastructure (traffic operator) provides forecast information to the vehicles and other service provider</td>
<td>TL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP5-14-0083</td>
<td>ecoAdaptive Traveller Support</td>
<td>The infrastructure (traffic operator) should provide tailored information to the vehicles</td>
<td>TL</td>
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<tr>
<td>SP5-14-0084</td>
<td>ecoAdaptive Traveller Support</td>
<td>ecoTraffic state can be converted to ecoMessages (TBD)</td>
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<td>SP5-14-0085</td>
<td>ecoAdaptive Traveller Support</td>
<td>ecoTraffic forecast can be converted to ecoMessages (TBD)</td>
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<td>SP5-14-0086</td>
<td>ecoAdaptive Traveller Support</td>
<td>ecoStrategies can be converted to ecoMessages (TBD)</td>
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<td>SP5-14-0087</td>
<td>ecoAdaptive Traveller Support</td>
<td>traffic light control information can be converted to ecoMessages (TBD)</td>
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<td>SP5-14-0088</td>
<td>ecoAdaptive Traveller Support</td>
<td>traffic control information (e.g. speed limit) can be converted into ecoMessages (TBD)</td>
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<td>SP5-14-0089</td>
<td>ecoAdaptive Traveller Support</td>
<td>The infrastructure system provides ecoMessages (TBD) to the vehicles and fleet operators or navigation service providers.</td>
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<td>SP5-14-0090</td>
<td>ecoAdaptive Traveller Support</td>
<td>The vehicle and fleet operators or navigation service providers can request tailored information (ecoMessages TBD) from the infrastructure system</td>
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<td>SP5-14-0091</td>
<td>ecoAdaptive Traveller Support</td>
<td>The location reference of the information provided by the infrastructure system is map independent, unambiguous and accurate regarding the position</td>
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<td>SP5-14-0092</td>
<td>ecoAdaptive Traveller Support</td>
<td>In-car information and roadside information must be synchronised in real-time</td>
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<td>SP5-14-0093</td>
<td>ecoAdaptive Traveller Support</td>
<td>ecoMessages are map independently referenced (TBD)</td>
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<td>SP5-15-0094</td>
<td>ecoAdaptive Balancing and Control</td>
<td>Multiple applications cooperate in an urban environment to balance network load and reduce network fuel consumption</td>
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<td>SP5-15-0095</td>
<td>ecoAdaptive Balancing and Control</td>
<td>The system discriminates between strategic and tactical operations and realizes traffic management strategies accordingly</td>
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<td>SP5-15-0096</td>
<td>ecoAdaptive Balancing and Control</td>
<td>Applications take into consideration strategic data from central systems</td>
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<td>SP5-16-0097</td>
<td>ecoMotorway Management</td>
<td>Applications take into consideration strategic data from central systems</td>
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<td>SP5-16-0098</td>
<td>ecoMotorway Management</td>
<td>Multiple applications cooperate in an urban environment to balance network load and reduce network fuel consumption</td>
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<td>SP5-17-0099</td>
<td>General eCoMove system</td>
<td>The eCoMove platform minimally should be CVIS compliant</td>
<td>To SP2</td>
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<td>SP5-17-0100</td>
<td>General eCoMove system</td>
<td>Vehicle systems should be capable of transmitting vehicle information to infrastructure following the CAM standard</td>
<td>To SP2</td>
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<td>SP5-17-0101</td>
<td>General eCoMove system</td>
<td>The vehicles and fleet operators or navigation service providers provide destination and route information (TBD) to the infrastructure system.</td>
<td>To SP2</td>
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<td>SP5-17-0102</td>
<td>General eCoMove system</td>
<td>Infrastructure systems should be capable of transmitting infrastructure information to vehicle</td>
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<td>SP5-17-0103</td>
<td>General eCoMove system</td>
<td>Vehicle systems should be capable of processing infrastructure information as well as tailored advices and display them to the driver</td>
<td>To SP3/4</td>
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<td>SP5-17-0104</td>
<td>General eCoMove system</td>
<td>The application should be able to receive the ecoFVD messages from all vehicles within a TBD distance from the application unit</td>
<td>To SP2</td>
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<td>SP5-17-0105</td>
<td>General eCoMove system</td>
<td>Recommendations from infrastructure systems should not affect traffic safety</td>
<td>To SP6</td>
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<td>SP5-17-0106</td>
<td>General eCoMove system</td>
<td>A sufficient number of vehicles broadcasting ecoFVD should be present to ensure significant effects</td>
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<td>SP5-17-0107</td>
<td>General eCoMove system</td>
<td>Advices from infrastructure system should be conform the acceptance of drivers</td>
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<td>SP5-18-0108</td>
<td>Simulation Environment</td>
<td>Modelling of driver behaviour for eCoMove equipped and non vehicles</td>
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<td>SP5-18-0109</td>
<td>Simulation Environment</td>
<td>The micro simulation models should be capable of modelling traffic movements, its inefficiencies and the eCoMove applications and components in a realistic way</td>
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<td>SP5-18-0110</td>
<td>Simulation Environment</td>
<td>The macro simulation models should be capable of modelling traffic movements, its inefficiencies and the eCoMove applications and components in a realistic way</td>
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<td>SP5-18-0111</td>
<td>Simulation Environment</td>
<td>The simulation environment support developers in testing their applications and components.</td>
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<td>Environment support roads operators in determining the effects of traffic</td>
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<td>Environment support roads operators in determining the effects of traffic</td>
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