## Abstract
The deliverable D3.1 defines the architecture of the VIAJEO open platform, specifies common interfaces and the core process of the platform.

## Keyword list
- Interface
- Open platform
- Data flow

## Nature of deliverable
- Report

## Dissemination
- PU

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![European Commission DG Research](image)

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# Deliverable 3.1

## Detailed Design of the Integrated Open Platform

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1 Introduction

The open platform to be designed in VIAJEO shall support the data exchange among existing data sources and future processes by defining interfaces according to current European Standards to generate an open platform. To ensure the success of the concept and its value beyond the project’s runtime, it is essential to focus on an open architecture with standardized and extensible interfaces and a number of well defined core functionalities. Flexibility is a core prerequisite for the platform, since the open platform not only aims at connecting existing services but also new data sources and new services.

Interfaces to facilitate using and exchange data from floating car data (using the SiMONE protocol), roadside sensor data (using DATEX2), elaborated traffic data (using Datex 2 as well), public transport data (using the VDV 452 for static and SIRI for dynamic data), routing data (using the interface defined by the IN TIME project) and traffic data for services (using TPEG UML) shall be provided or exchanged. Moreover, the VIAJEO open platform features a number of well defined core functionalities centred around the essential core process to generate vital traffic data based on real time data.

1.1 Target audience

The target audience of this deliverable are all entities, which wish to implement an open platform for the standardised exchange of traffic related data featuring decisive core functionalities and thus create a flexible platform for the coordinated implementation of ITS in areas in- and outside of Europe. Of course, this deliverable is also especially provided for WP4 of VIAJEO in which the platform concept is implemented in the test sites Shanghai, Beijing, Sao Paolo and Athens.

1.2 Structure of the document

Chapter 1 is general introduction. Chapter 2 describes the methodology applied in the design of the platform, a summary of the results of the Work Package 2 and the common processed derived from this information.

Chapter 3 provides an overview about the FRAME methodology and the mapping of the VIAJEO use cases onto the FRAME methodology. Also, Chapter 3 provides an overview on the interfaces defined by VIAJEO based on the common processes described in Chapter 2 and provides a view on the system boundaries.

Chapter 4 provides detailed definitions of the common interfaces and chapter 5 provides detailed definitions of the core processes of the VIAJEO open platform.

Chapter 6 provides some recommendations to the test sites of VIAJEO on how to best implement the open platform concept in WP4.

The appendices hold UML models for several of the different interfaces and also xsd schemas.
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1.3 Objective of the report

This report provides the specification of the open platform including functionalities, system boundary and interface specifications as well as recommendations for the implementation of the design within the project’s test sites in Athens (GR), Beijing (CH), Shanghai (CH) and Sao Paolo (BR). This design shall provide the grounds for the demonstration executed within WP4.
2 Methodology for the Design of the open platform

To provide a high value of the project results which shall be fully usable after the VIAJEO project ends it was agreed by the consortium that the open platform should feature a flexible design and should allow existing processes (e.g. services, data collection processes such as roadside detectors etc.) to be integrated into the concept.

To understand the requirements towards the open platform, the user needs and actors for each use case should be defined. The use cases are derived from the existing systems in the test sites. A user case is a process which delivers specified data allowing for an interface based on European standards and whose functionalities are required to be covered by the open platform design.

2.1 Methodology of the Open Platform design

2.1.1 Definition of the Open Platform in VIAJEO

- “Open platform” is neither an official standard nor does a universal valid definition exist. Therefore the partners of the VIAJEO project agreed a definition which forms the basis of the overall validation plan as well as of the following validation and impact assessment: A well defined set of core processes accessible via published open external interfaces which are accessible by external parties.

- Standardised, openly described interfaces for data exchange between processes in the realm of the open platform. This set of interfaces is to be used by any new functionality implemented within the open platform concept.

- An “Open Platform” does not mean it is “Open Source”.

- Related to Open Standards, an open platform means the platform is publicly available and has various rights to use associated with it.

2.1.2 Approach

As such, the open platform is a concept which allows existing systems to provide (and accept) data in standardized way and which allows platform-external functionalities to be connected via the platform and also provide/accept standardized data sets. To this purpose, the existing, proprietary interfaces of the existing processes are to be replaced by interfaces following commonly agreed, European (or international) standards to provide their data to subsequent processes.

To explain the approach, an exemplary service is used to illustrate the open platform approach for roadsite traffic data. The first figure below illustrates the existing processes (white arrows) with their proprietary interfaces (small grey arrows):
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![Figure 1: Existing processes in exemplary service](image)

In this example, the real time traffic data collected at the roadside are provided to the traffic data processing and the resulting estimated traffic volumes are provided to the routing service which would, in turn, provide it’s results to subsequent processes. None of the interfaces in between the processes is standardized (hence the term “proprietary”), as the interface the routes would be provided.

Within VIAJEO, a new service (Traffic Information Distribution) and a new client (Mobile Client) shall be implemented using the open platform concept. The process chain would then look like:

![Figure 2: Existing and new processes in exemplary service](image)

The interfaces standardized within VIAJEO would be implemented between the existing processes (blue arrows). As the core process defined within VIAJEO is defined to cover the functionality of the traffic information elaboration, the existing traffic data processing process is, in this example, seen as part of the VIAJEO core process (depending on which specific functionalities the existing process provides). As it becomes evident in this example, VIAJEO does not standardize all interfaces between all imaginable potential processes in a business process chain (see chapter 4 for specified interfaces).

In the example above, the interface between traffic information distribution centre and mobile clients remains a non-standardized interface. This is the case, because there are, among others, numerous technical issues, such as screen size and operating system of the handheld device if it is e.g. a mobile phone, but also organisational issues such as distinction of a given service providers end user service delivered through the mobile client from competing services as basis of his business concept involved in the question of how to transfer data to a client. Also, the data volume which has to be transferred over the air is an issue, as charges of mobile phone network operators apply normally according to the transmitted data volume.

However, TPEG TEC is in the process of becoming a well established standard in the European automotive community, hence VIAJEO recommends (see chapter 4.10 for details) TPEG TEC if automotive systems are involved.

In other words: a service provider operating the traffic information distribution centre may not use a standardized interface since he wants to streamline his service exactly according to his wishes (e.g. because of specific handheld devices) and thus would rather use a proprietary solution. For automotives however, TPEG TEC is a widely used standard. Hence VIAJEO does not standardize this very interface as shown in this example.
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In principle, VIAJEO standardized interfaces between those processes which form the backbone of a service, but the provision of information to mobile clients is not part of the scope of the definition.

Of course, the standardized interfaces are applicable to a variety of processes. For example, a Datex 2 interface specified for roadside traffic count data is applied to loop and radar detectors alike, the SIMONE interface specification defined for FCD can be applied to the provision of single-vehicle-data or the data sets generated by a FCD centre providing a bunch of them at once. Also, the core service does not only supply data to one existing process but to all which require those data sets (or different data sets to different processes, according to the requirements).

2.1.3 Available European Standards and their Applications in Europe and Worldwide

Main European Standards currently applicable to the open platform design are DATEX 2 and TPEG, both related to road traffic data, as well as SIRI for dynamic public transport data. While DATEX 2 is primarily designed for the communication between centres and thus does not care for bandwidth questions (as the connection is expected to provide sufficient bandwidth), the TPEG standard is focussed on information provision to end clients such as mobile units using an over-the-air interface and thus is tailored to use only limited bandwidth. VIAJEO however is defining the interface towards a given broadcaster or service provider on basis of the TPEG RTM interface as the data sets transmitted over this interface are easily convertible to other TPEG standards by a given service provider and easy to handle on centre side. SIRI features the capability to provide highly actual public transport information but, unfortunately, not to model static public transport data such as stop locations or static time tables.

Other standards, such as for the provision of roadside traffic data or FCD, are only in place on national level. For example, Germany features a common national standard according to which RSUs have to provide traffic data. Within the VIAJEO open platform design, all interfaces shall be defined according to European standards, but, in absence of these, widespread and well received solutions (by the market) are chosen to allow for a standardized data exchange. Thus, the Italian approach SIMONE is, for example, chosen for floating car data since it is currently implemented as one of the first standards of its kind in Europe and is compatible to other approaches such as the one developed in the GST project and the German VDV 452 standard is chosen for static public transport data as it enjoys a widespread and growing application in Europe.

As described already by WP2, related national standards in China are, despite featuring quite a variety, not yet active and are all still in a development stage. Also in Brazil, no national standards are currently implemented meaning that in all three Europe-external test sites no prerequisites can be considered. Thus, the standards chosen by VIAJEO are not adapted to local peculiarities apart of having to be suitable to serve as applicable solution for the data transmitted in the test sites.
2.2 Main Outcomes of WP2

2.2.1 Approach and Constraints of WP2

WP2 has the task to understand, which systems are currently available and which systems shall additionally be implemented in the test sites in the future. Not only the functionality of the specific processes (as e.g. traffic message generation) is important here, but also if any mandatory standards are in place in the test sites to exchange the data and information sets in between those processes.

WP2 thus devised a questionnaire in which frame also a principle structuring concerning the currently available systems was devised (see below).

*Figure 3: A draft architecture of the intermediate data structure of the Viajeo projet*

This structure defines five basic Function Groups (abbreviated FG – these are data collection, processing, applications, services and devices) which reflect a basic frame into which any ITS application should be integrable. The interfaces between those function groups are of importance, since they form the sound basis for the design of suitable interfaces in WP3 providing a significant share of the open platform definition.
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The questionnaire allowed the test sites to describe their system in a harmonized way and the results form a first basis on which WP3 can discuss the principle layout of the VIAJEO open platform. Additionally, the expected functionalities were also defined, among others in the frame of dedicated workshops (applying a specific methodology), and can thus be considered within the design of the open platform.

2.2.2 Preliminary Results from investigation by WP2

The current inputs from the test sites describe the systems to be considered within the open platform design. The preliminary results show, that the interfaces between the processes are not yet standardized (however it is currently investigated, if national standards are to be considered which are not yet in place in the test sites, e.g. as the systems exist longer than the standards themselves). According to the current knowledge there are no standards and guidelines in China and Brazil which need to be considered, the open platform design can set up upon the requirements from the test sites only. This means that the data currently exchanged between the processes must be analysed and corresponding interfaces defined according to European standards.

2.3 Common Processes

In all test sites, similar business process chains are established for similar functionalities. This means, that the processes leading to similar data/information sets and or offering similar functionalities are similar if the service is present in more than one test site. Thus these process chains can be abstracted and common interfaces as well as the widely used VIAJEO core process (traffic information processing) can be identified. The following figures display the abstracted business chains for several processes, deep blue lean arrows mark interfaces standardized within VIAJEO (see chapter 4 for details) while the VIAJEO core process, the traffic data processing step, is the sole process of any chain commonly defined within VIAJEO (see chapter 5 for a description of its functionality) and hence marked in deep blue as well.

2.3.1 Roadside Traffic Data with Routing application

This abstracted process covers the provision of roadside traffic count data with its use in the traffic data processing step (which is the VIAJEO core process). Subsequently, this information is provided to a routing engine which is providing the routes to a traffic information distribution centre feeding mobile clients or websites with this information.

![Figure 4: Common Process Chain – Roadside Traffic Data used for Dynamic Routing with Distribution to Mobile Clients](image)

As already described in chapter 2.1.2 (this common business process chain was provided as an example there), the sole interface not standardized by VIAJEO within this chain is the one to mobile clients (marked
in grey) or websites. As VIAJEO defines TPEG RTM as data exchange standard mainly towards service providers, here represented by the traffic information distribution centre, it could be a sound solution to implement TPEG TEC for the non-standardised interface as this standard is suitable for this task and TPEG RTM can easily be converted into TPEG TEC (see chapter 4.10 for details).

2.3.2 Roadside Traffic Data with Traffic Data Provision

In contrary to the abstracted business process depicted above, no routes are computed in this chain but the traffic information is directly provided to a mobile client or website. This may be the case e.g. with mobile traffic information services “just” showing the current traffic state.

![Figure 5: Common Process Chain – Roadside Traffic Data with Distribution to Mobile Clients](image)

2.3.3 Single Vehicle Floating Car Data with Routing application

Another common process chain is the provision of dynamic routes based on traffic information generated on basis of single vehicle floating car data (FCD). This is the only distinction between this chain and the one mentioned in chapter 2.3.1 (the VIAJEO core process actually is able to handle both kinds of raw data, roadside traffic data and single vehicle floating car data).

![Figure 6: Common Process Chain – Floating Car Data used for Dynamic Routing with Distribution to Mobile Clients](image)

2.3.4 Aggregated Floating Car Data with Routing application

Similar to the common process chain mentioned above, the dynamic routes are in this case also computed on basis of traffic information (provided by the VIAJEO core process). The single vehicle floating car data (FCD) are pre-processed by an existing FCD centre and, after this step, fed into the VIAJEO core process instead being fed in directly.
Actually, this common process is, in reality, more applicable to a given site than the assumption, that single vehicle FCD are available, since there has to be a kind of FCD centre in place if FCD are used at a given site.

2.3.5 Public Transport Data with Routing Application

This abstracted process illustrates the use of public transport data in the frame of a routing service provided to mobile clients. The difference between this business process and the business processes described in the chapters 2.3.1, 2.3.3 and 2.3.4 is, that the data used for routing is now originating from the public transport sector. This means, that the information generation process would either be calculating sheer public transport routes or, if the process also, as in the mentioned chapters, also considers roads and thus would provide co-modal routes. In the latter case, the VIAJEO core process (traffic data processing) would also feed its results into the information generation process which is not displayed in the figure below.

Of course, also static data like time tables and stop positions are required for the generation of public transport or co-modal routes. In this case, the positions of the public transport positions (PT positions) would be replaced by time tables and stop positions instead.

2.3.6 Public Transport Data with Display on Signs

The last of the common processes is showing either dynamic or static data on on-board signs in buses or other public transport vehicles or at stations. The following figure displays this business process,
In contrary to the business process explained in the last chapter, the interface between the traffic information distribution centre and the signs can be standardized (VIAJEO defines the interface according to the international SIRI standard, see chapter 4.9 for details).
3 Data Flow and Data Processes

3.1 Introduction

The architecture approach of VIAJEIO is based on KAREN and FRAME methodology. A special focus is given to the traffic information collection on infrastructure and floating vehicle data basis. The use of standardized interfaces for the data acquisition and the dispatch of traffic and travel information/services are the most important aspect in the project. Further areas of importance for the completion of this information chain on architecture level and according to the FRAME Functional Area Diagram are:

- Area 3: Manage Traffic
- Area 4: Manage Public Transport Operations
- Area 5: Provide Advanced Driver Assistance Systems
- Area 6: Provide Travel Journey Assistance
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Figure 10: FRAME Functional Area Diagram
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Each area contains functions for its purpose. There are two types of functions that may be found in these areas – high-level and low-level functions. High-level functions are very complex and for this reason they consist of lower-level functions to fulfil the user needs. The Manage Traffic area is responsible for managing the flow of traffic through the road network served by the System. The functionality that the Area contains will enable the traffic flow to be managed in a way that encourages efficient use of the road space and minimises the impact of vehicles on the environment. The Manage Public Transport Operations area is responsible for managing the operation of Public Transport services in the geographic area served by the System. The Functions that the Area contains will provide facilities that enable Public Transport services to be planned and operated in a way that meets the needs of Travellers. The other goal of the Functions will be to ensure that the services are provided in ways that make the most efficient use of the Public Transport vehicle fleet and of the inter-urban and urban road networks.

The Provide Advanced Driver Assistance System area shall provide communications facilities between the vehicle’s systems and both the road infrastructure and/or other vehicles. It should be noted that the vehicle’s systems themselves are outside the scope of the Framework Architecture.

The Provide Traveller Journey Assistance area shall provide functionality that enables Travellers to plan and complete trips and request travel information. Once a trip is in progress, the contents of its plan (the itinerary) can be adjusted if changes (perturbations) in the condition of the travel network occur. The implementation of the trip plan can include the provision of driving instructions to the Traveller as a Driver, otherwise known as “dynamic route guidance”.

3.2 The FRAME Methodology

The Functional Viewpoint in FRAME defines the functionality for the ITS System for realising the user needs and interfaces to the outside world. The input and output data used by the system are defined. There are functional areas, which are divided into functions. The data flow diagrams show how the functions relate to each other, to data stores and to the terminators (the outside world) through the data flows.

The physical viewpoint is describing the next layer to the functional architecture where the functionalities are grouped into physical locations. If user needs contain physical requirements, they have to be linked to this viewpoint. The resulting physical modules and sub-systems are the basis for procurement and development of components while the physical data flows represent the actual, physical links within the VIAJEO system.

The communications viewpoint describes the kind of communications links needed in a system in order to support its physical data flows. It may include some requirements from the User Needs, where they relate to specific communication requirements. It consists of an analysis of the communications requirements of the reference system which is described in the physical viewpoint. Furthermore, it describes the communication technologies and standards.

The user handbook of the FRAME Selection Tool provides a step-by-step guideline to build up the own functional architecture:

- Identify the user needs that define the services to be provided
- Select functions form the trace table, which provide a cross reference from user needs to the functions that help to satisfy them.
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- Identify their functional areas or sub-functional group.
- Confirm that the selected functions are reasonable.
- Select the data flows needed by the selected functions.
- Select the data stores needed by the selected data flows.
- Select the additional data flows needed by the selected data stores.
- Identify the terminators (node to outside world) with all these data flows.

Figure 11: FRAME Methodology

For the development of the physical viewpoint on basis of the defined functional viewpoint following steps are necessary:
- Allocate the functions and data stores to physical locations.
- Define the physical data flows between the sub-systems, modules and the outside world.

More information about the methodology and an explanation of the terms used in this context can be found in the Selection Tool Reference manual.
### 3.3 Mapping of VIAJEO User Needs on FRAME User Needs

The following table provides the mapping of the User Needs (UN) identified in WP2 of VIAJEO onto the standardised user needs defined by the FRAME concept. Detailed description of User Needs identified by WP2 of Viajeo can be found in Appendix A.

<table>
<thead>
<tr>
<th>Allocation</th>
<th>No.</th>
<th>Description</th>
<th>VIAJEO UN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.1 Architectural Properties</strong></td>
<td>1.1</td>
<td>The Framework Architecture description shall include functional, information, physical and communication perspectives.</td>
<td>Basic principles applicable to all UNs</td>
</tr>
<tr>
<td></td>
<td>1.3</td>
<td>The Framework Architecture description shall include a glossary to explain all the main concepts described in the architecture.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>The Framework Architecture shall be technology independent.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.6</td>
<td>The Framework Architecture shall facilitate the creation of modular and flexible designs, so that manufacturers can produce their own versions of equipment.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.7</td>
<td>The Framework Architecture shall allow equipment performing the same service to be provided by various suppliers.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>The Framework Architecture shall allow the same service to be provided by various service providers.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.9</td>
<td>The Framework Architecture shall allow the user to select from one of a number of suppliers of the same service.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.10</td>
<td>The Framework Architecture shall support interaction between services provided by private and public bodies.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.14</td>
<td>The Framework Architecture shall support the integration of Traffic Information Centres and Traffic Control Centres into national and international networks.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.15</td>
<td>The Framework Architecture description shall identify clearly the relevant interfaces to other modes of transport.</td>
<td>See above</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Allocation</th>
<th>No.</th>
<th>Description</th>
<th>VIAJE UN UN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 Data Exchange</td>
<td>1.2.1</td>
<td>The Framework Architecture shall provide a high level description of the message sets and data communication protocols to be used in data transfers.</td>
<td>Basic principles applicable to all UNs</td>
</tr>
<tr>
<td></td>
<td>1.2.2</td>
<td>The Framework Architecture shall provide a high level description of data stores and data flows, and shall have a single data dictionary.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.2.3</td>
<td>Systems that conform to the Framework Architecture shall exchange information in a manner that permits a given geographic location to be understood by all parties.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.2.4</td>
<td>Systems that conform to the Framework Architecture shall exchange information in a manner that permits road and traffic conditions to be understood by all parties.</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>1.2.5</td>
<td>The Framework Architecture shall provide a high level description of the message sets used to exchange data with external interfaces.</td>
<td>See above</td>
</tr>
<tr>
<td>2.1.0 Objectives</td>
<td>2.1.0.1</td>
<td>The system shall be able to exchange traffic and travel information between adjacent TICs to enhance local information and to improve strategic planning.</td>
<td>UN28, 37</td>
</tr>
<tr>
<td>2.1.1 Information Management</td>
<td>2.1.1.1</td>
<td>The system shall be able to produce information for travellers on the traffic and travel conditions of all transport modes relevant to the geographical area covered.</td>
<td>UN 1,2,3,12,13,14,15,20,29,30,34</td>
</tr>
<tr>
<td></td>
<td>2.1.1.2</td>
<td>The system shall be able to provide links to non-transport information systems using &quot;open&quot; communication protocols.</td>
<td>UN 4,5,6,7,9</td>
</tr>
<tr>
<td></td>
<td>2.1.1.3</td>
<td>The system shall be able to collect traffic data for road network use analysis and prediction calculations.</td>
<td>UN 12,14,19,24,29,32,34,35</td>
</tr>
<tr>
<td></td>
<td>2.1.2.3</td>
<td>The system shall be able to assist in the planning of (inter-modal) routes.</td>
<td>UN 24,25</td>
</tr>
</tbody>
</table>
## Deliverable 3.1
### Detailed Design of the Integrated Open Platform

<table>
<thead>
<tr>
<th>Allocation</th>
<th>No.</th>
<th>Description</th>
<th>VIAJE UN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2.2.2 Monitoring</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2.2.1</td>
<td></td>
<td>The system shall be able to receive infrastructure equipment status data remotely.</td>
<td></td>
</tr>
<tr>
<td>6.1.0.3</td>
<td></td>
<td>The system shall be able to provide accurate, credible, timely, and easy to comprehend traffic and travel information where it may be of benefit to the user.</td>
<td></td>
</tr>
<tr>
<td>6.1.0.4</td>
<td></td>
<td>The system shall be able to provide information on alternative routes, e.g. where they are quicker, cheaper, shorter, scenic, etc.</td>
<td></td>
</tr>
<tr>
<td>6.1.0.5</td>
<td></td>
<td>The system shall enable travellers to plan their trip using their own travel criteria, e.g. modes of transport, time of departure/arrival, road selection criteria, etc.</td>
<td></td>
</tr>
<tr>
<td>6.1.1.3</td>
<td></td>
<td>The system shall be able to provide current and forecast traffic and travel information for all modes at local, regional, national and international levels.</td>
<td></td>
</tr>
<tr>
<td>6.1.1.4</td>
<td></td>
<td>The system shall be able to provide extensive multi-modal trip information, e.g. prices, fares, routes, forecast &amp; current traffic situations, traffic control, demand mgt measures, local warnings, special events, weather conditions, hotels etc.</td>
<td>See above (note: pricing is not applicable)</td>
</tr>
<tr>
<td>6.1.2.5</td>
<td></td>
<td>The system shall be able to analyse, process and retrieve data from different combinations of sources (including floating car).</td>
<td></td>
</tr>
<tr>
<td>6.1.2.6</td>
<td></td>
<td>The system shall be able to provide road and traffic information adapted to different classes of users, e.g. travellers, radio broadcasters, service operators.</td>
<td></td>
</tr>
<tr>
<td>6.1.2.7</td>
<td></td>
<td>The system shall provide information using graphical representation or text. Graphical form shall include the use of maps as well as text.</td>
<td></td>
</tr>
<tr>
<td>6.1.2.8</td>
<td></td>
<td>The system shall provide information in the native language at the output location, and/or from a user selected choice of other appropriate foreign languages.</td>
<td></td>
</tr>
<tr>
<td>6.1.2.9</td>
<td></td>
<td>The system shall provide Information Management tools for the operator.</td>
<td></td>
</tr>
</tbody>
</table>
## Deliverable 3.1
Detailed Design of the Integrated Open Platform

<table>
<thead>
<tr>
<th>Allocation</th>
<th>No.</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.1.3.8</td>
<td>The system shall be able to provide customised pre-trip information to hand-held and in-vehicle devices.</td>
<td>UN 4, 23</td>
</tr>
<tr>
<td></td>
<td>6.1.3.9</td>
<td>The system shall communicate with other information systems using &quot;open&quot; standard protocols.</td>
<td>Basic principle applicable to all UN</td>
</tr>
<tr>
<td></td>
<td>6.1.3.10</td>
<td>The system shall provide information for fixed and mobile terminals using &quot;open&quot; standard communication protocols.</td>
<td>UN 4,23</td>
</tr>
<tr>
<td></td>
<td>6.2.1.3</td>
<td>The system shall be able to provide information about other transport modes: e.g. location of P+R areas, PT timetable, etc.</td>
<td>UN 13, 21</td>
</tr>
<tr>
<td></td>
<td>6.2.2.1</td>
<td>The system shall be able to inform travellers on the current average travel time between fixed points.</td>
<td>UN 12, 14, 19</td>
</tr>
<tr>
<td></td>
<td>6.2.2.4</td>
<td>The system shall provide road and traffic safety advice based on current weather and traffic conditions.</td>
<td>UN 29, 32, 33</td>
</tr>
<tr>
<td></td>
<td>6.2.2.5</td>
<td>The system shall be able to provide all drivers with information on current road travel conditions, e.g. route restrictions, travel times, etc.</td>
<td>UN 29, 32, 33</td>
</tr>
<tr>
<td></td>
<td>6.2.2.6</td>
<td>The system shall be able to provide routing information for Commercial traffic to/from a (cargo) modal interchange.</td>
<td>UN 36 for caps</td>
</tr>
<tr>
<td></td>
<td>6.2.2.10</td>
<td>The system shall be able to collect data from a variety of different sources, e.g. road/traffic management, police, weather services, floating car etc.</td>
<td>UN 28, 37</td>
</tr>
<tr>
<td></td>
<td>6.2.2.11</td>
<td>The system shall be able to provide operators with an overall view of all active events in an area.</td>
<td>UN UN 29, 30, 31, 32, 33, 34,35</td>
</tr>
<tr>
<td></td>
<td>6.2.2.12</td>
<td>The system shall provide Information Management tools for the operator.</td>
<td>UN UN 29, 30, 31, 32, 33, 34,35</td>
</tr>
</tbody>
</table>
## Deliverable 3.1
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<table>
<thead>
<tr>
<th>Allocation</th>
<th>No.</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2.3 Traveller Interaction</td>
<td>6.2.3.1</td>
<td>The system within the vehicle, or in the centre, shall support various types of presentation to the user, e.g. text, graphics, symbols, speech, etc.</td>
<td>UN 4,5,6,7,9</td>
</tr>
<tr>
<td></td>
<td>6.2.3.4</td>
<td>The system shall provide information using &quot;open&quot; standard communication protocols.</td>
<td>Basic principle</td>
</tr>
<tr>
<td></td>
<td>6.2.3.5</td>
<td>The system shall be able to provide customised on-trip information to hand-held and in-vehicle devices.</td>
<td>UN 10, 11</td>
</tr>
<tr>
<td></td>
<td>6.2.3.8</td>
<td>The system shall be able to provide road and traffic information using road-side equipment, e.g. VMS.</td>
<td>UN 22</td>
</tr>
<tr>
<td>7.1.0.3</td>
<td></td>
<td>The system shall not do anything to reduce road safety.</td>
<td>UN 28, 37</td>
</tr>
<tr>
<td>7.1.0.6</td>
<td></td>
<td>The system shall be able to help co-ordinate the activities of TICs and TCCs.</td>
<td>UN 28, 37</td>
</tr>
<tr>
<td>7.1.0.8</td>
<td></td>
<td>The system shall enable the data that it stores to be extracted by an operator onto a variety of media and used for other purposes, or by other organisations.</td>
<td>UN 28, 37</td>
</tr>
<tr>
<td>7.1.0.9</td>
<td></td>
<td>The system shall ensure that traveller information service providers are aware of the traffic management strategy, so that they can provide information that conforms to it.</td>
<td>UN 28, 37</td>
</tr>
<tr>
<td>7.1.1.1</td>
<td></td>
<td>The system shall be able to monitor sections of the road network to provide the current traffic conditions (e.g. flows, occupancies, speed and travel times etc.) as real time data.</td>
<td>UN 29, 30, 32,34</td>
</tr>
<tr>
<td>7.1.1.2</td>
<td></td>
<td>The system shall monitor urban roads and traffic.</td>
<td>Basic principle</td>
</tr>
<tr>
<td>7.1.1.3</td>
<td></td>
<td>The system shall monitor inter-urban roads and traffic.</td>
<td>Basic principle</td>
</tr>
<tr>
<td>7.1.2.1</td>
<td></td>
<td>The system shall be able to use consistent historical data to complement real-time data, when necessary.</td>
<td>Basic principle</td>
</tr>
<tr>
<td>7.1.2.2</td>
<td></td>
<td>The system shall be able to predict short, medium, and long-term traffic conditions, e.g. for minutes, hours and days ahead.</td>
<td>UN 34</td>
</tr>
<tr>
<td>7.1.2.3</td>
<td></td>
<td>The system shall be able to use historical data to complement predicted data, when necessary.</td>
<td>UN 34</td>
</tr>
<tr>
<td>7.1.2.7</td>
<td></td>
<td>The system shall be able to provide historical and predicted data.</td>
<td>UN 34</td>
</tr>
</tbody>
</table>
## Deliverable 3.1
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<table>
<thead>
<tr>
<th>Allocation</th>
<th>No.</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7.1.3 Traffic Control Centres</strong></td>
<td>7.1.3.1</td>
<td>The system shall enable a TCC operator to control, possibly remotely, infrastructure elements (e.g. traffic lights, VMS).</td>
<td>Test Site specific</td>
</tr>
<tr>
<td></td>
<td>7.1.3.2</td>
<td>The system shall enable a TCC operator to log all significant events and to record free text messages prior to their output to travellers.</td>
<td>Basic principle</td>
</tr>
<tr>
<td></td>
<td>7.1.3.3</td>
<td>The system shall be able to provide a graphical representation of the road network which includes relevant features (e.g. equipment, events, traffic condition etc.) to TCC operators.</td>
<td>Basic principle</td>
</tr>
<tr>
<td></td>
<td>7.1.3.4</td>
<td>The system shall be able to activate control devices (e.g. traffic lights, VMS), either individually or in groups.</td>
<td>Test Site specific</td>
</tr>
<tr>
<td></td>
<td>7.1.3.7</td>
<td>The system shall be able to support a database of all known (future) events.</td>
<td>Basic principle</td>
</tr>
<tr>
<td><strong>7.1.6 O/D Computations</strong></td>
<td>7.1.6.1</td>
<td>The system shall be able to provide Origin/Destination computations, and route assignment estimations, for the road network.</td>
<td>UN 24</td>
</tr>
<tr>
<td></td>
<td>7.2.0.2</td>
<td>The system shall not do anything to reduce road safety.</td>
<td>Basic principle</td>
</tr>
<tr>
<td></td>
<td>7.2.0.3</td>
<td>The system shall not do anything that might aggravate, or cause, an incident.</td>
<td>Basic principle</td>
</tr>
<tr>
<td></td>
<td>9.5.2.10</td>
<td>The system shall be able to predict a time of arrival.</td>
<td>UN 14</td>
</tr>
<tr>
<td></td>
<td>9.5.2.12</td>
<td>The system shall be able to provide a driver with a suitable alternative route, when the original planned route becomes unavailable.</td>
<td>UN 24</td>
</tr>
</tbody>
</table>
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3.4 Identification of Common Interfaces based on Common Data Flows and Processes

Based on the data flows in the test sites and the common abstracted business processes (see chapter 2.3), the location of the interfaces which shall be standardized among the test sites within the abstracted business processes and thus be part of the open platform can be identified. Lean arrow depict interfaces, processes are depicted as wide arrows. For interfaces, the transmitted data are provided as abbreviated list. The specification of the interfaces is provided in chapter 4. The components marked in blue (including the grey/blue interface, see chapter 2.1.2 and below) are located within the system boundary of VIAJEO.

The first figure, depicted below, shows the interfaces which are applied when traffic data (roadside or FCD) are used to generate a route provided to mobile clients. For the latter VIAJEO recommends TPEG TEC if applicable on board units are in place. Service providers operating the traffic info distribution centre might rather utilise proprietary interfaces here due to business case and technical (depending on mobile device) constraints (see chapter 2.1.2 for details).

![Figure 12: Interfaces and transmitted data for roadside data used for routes delivered to mobile clients and websites](image)
The following table (also provided in chapter 4.2) gives another overview on the interfaces:

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>Designation</th>
<th>Chapter in Document</th>
<th>Data Typically Transmitted</th>
<th>Standard to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCD</td>
<td>I1</td>
<td>4.3</td>
<td>Vehicle ID Time Stamp Position Speed</td>
<td>SIMONE</td>
</tr>
<tr>
<td>Roadside Traffic Count Data</td>
<td>I2</td>
<td>4.4</td>
<td>Detector ID Lane N° Direction Traffic Count (passenger cars) Traffic Count (lorries) Time Gap (between vehicles)</td>
<td>DATEX 2</td>
</tr>
<tr>
<td>Roadside Environmental Data</td>
<td>I3</td>
<td>4.5</td>
<td>Detector ID Direction Measurement CO2 Measurement NOx</td>
<td>DATEX 2</td>
</tr>
<tr>
<td>Centre Road Traffic Data Interface</td>
<td>I4</td>
<td>4.6</td>
<td>Traffic Events Traffic Load per Segment</td>
<td>DATEX 2</td>
</tr>
<tr>
<td>Static Public Transport Information</td>
<td>I5</td>
<td>4.8</td>
<td>Timetables Stop Positions</td>
<td>VDV 452</td>
</tr>
<tr>
<td>Dynamic Public Transport Information</td>
<td>I6</td>
<td>4.9</td>
<td>Update Time Tables (?) Vehicle ID Time Stamp Vehicle Position Vehicle Speed Delays (line,vehicle)</td>
<td>SIRI</td>
</tr>
<tr>
<td>Traffic Information over TPEG</td>
<td>I7</td>
<td>4.10</td>
<td>Traffic Messages Traffic Load</td>
<td>TPEG RTM/TEC</td>
</tr>
<tr>
<td>Co modal Routes</td>
<td>I8</td>
<td>4.7</td>
<td>Waypoints Travel Time on Links Traffic Mode</td>
<td>IN TIME / eMotion</td>
</tr>
</tbody>
</table>

The following figure shows the chain for traffic information (traffic messages, traffic load) distribution. In contrary to the first figure, there are no routes compiled.
The following figure shows a typical process chain with static public transport information involved in a routing case (a comodal routing engine would also have information on the road traffic provided over interface I4):

Figure 14: Interfaces and transmitted data for roadside data delivered to mobile clients and websites
The following common business process chain, as depicted in the following figure, shows the use of dynamic public transport data used for routing:
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Figure 16: Interfaces and transmitted data for Dynamic Public Transport Data used for Routing

Finally, the final common process chain depicts the use of the VIAJEO interfaces for the delivery of dynamic public transport information to signs at public transport stations or onboard a vehicle:
3.5 System Boundary

The Viajeo platform shall be ubiquitously applicable in different settings and under different ancillary conditions. Hence the platform shall provide a set of well defined interfaces for the exchange/management of specific data sets and core functionalities required as basis to operate the platform’s functionalities.
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The detailed specifications of the interfaces and the core process is contained in the next chapters with chapter 4 describing the common interfaces and chapter 5 describing the functionalities of the core platform.
4 Definition of common interfaces

4.1 Introduction

This chapter describes those interfaces which are standardized within the VIAJEQ platform. As the mission of the project is to define common interfaces based on international and European standards, the project considered common specifications above other approaches. However, floating car data (FCD) are not sufficiently standardized on international level and another highly important interface for the provision of route data (e.g. used for the exchange of mono- and intermodal routes between independent systems) is not standardized at all. Hence the project selected a national standard (from Italy) which is already established in the market for FCD and the interface specified by the IN TIME project for co modal routes, as they are suitable and the best choice for the task at hand. The respective chapters contain a sound reasoning to justify these choices.

Each interface is described in detail within the next chapters. It should be noted, that the implementation decisions, e.g. DATEX 2 profiling, is left to the test sites which will specify the details in WP4. Only in this way, sufficient flexibility is provided to the test sites to adapt the implementation specification of the local platforms to the ancillary conditions prevailing in the specific sites.

Concerning the DATEX 2 standard, the release candidate 2.0 (2.0 RC 1) was used for the specification.
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## 4.2 Overview of the Standardized Interfaces of the VIAJEO Platform

As per the definition of the system boundary, the following interfaces are defined in VIAJEO:

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>Designation</th>
<th>Chapter in Document</th>
<th>Data Typically Transmitted</th>
<th>Standard to be used</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCD</td>
<td>I1</td>
<td>4.3</td>
<td>Vehicle ID, Time Stamp, Position, Speed</td>
<td>SIMONE</td>
<td>SIMONE does not count as an European Standard (see chapter 4.3 for explanation) but is used in the market</td>
</tr>
<tr>
<td>Roadside Traffic Count Data</td>
<td>I2</td>
<td>4.4</td>
<td>Detector ID, Lane N°, Direction, Traffic Count (passenger cars), Traffic Count (lorries), Time Gap (between vehicles)</td>
<td>DATEX 2</td>
<td>Roadside units (especially in case of older systems) may feature low computing power and low bandwidth connections. DATEX 2 is designed for centre to centre communication and rather heavy, hence a level 3 compliant interface is used.</td>
</tr>
<tr>
<td>Roadside Environmental Data</td>
<td>I3</td>
<td>4.5</td>
<td>Detector ID, Direction, Measurement, CO2, Measurement NOx</td>
<td>DATEX 2</td>
<td></td>
</tr>
<tr>
<td>Centre Road Traffic Data Interface</td>
<td>I4</td>
<td>4.6</td>
<td>Traffic Events, Traffic Load per Segment</td>
<td>DATEX 2</td>
<td>Classic DATEX application</td>
</tr>
<tr>
<td>Static Public Transport Information</td>
<td>I5</td>
<td>4.8</td>
<td>Timetables, Stop Positions</td>
<td>VDV 452</td>
<td>SIRI does not cover static data, the German VDV 452 standard is based on the same principles and widely used in Europe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>Designation</th>
<th>Chapter in Document</th>
<th>Data Typically Transmitted</th>
<th>Standard to be used</th>
<th>Remark</th>
</tr>
</thead>
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<tr>
<td><strong>Interface Name</strong></td>
<td><strong>Designation</strong></td>
<td><strong>Chapter in Document</strong></td>
<td><strong>Data Typically Transmitted</strong></td>
<td><strong>Standard to be used</strong></td>
<td><strong>Remark</strong></td>
</tr>
<tr>
<td>FCD</td>
<td>I1</td>
<td>4.3</td>
<td>Vehicle ID, Time Stamp, Position, Speed</td>
<td>SIMONE</td>
<td>SIMONE does not count as an European Standard (see chapter 4.3 for explanation) but is used in the market</td>
</tr>
<tr>
<td>Roadside Traffic Count Data</td>
<td>I2</td>
<td>4.4</td>
<td>Detector ID, Lane N°, Direction, Traffic Count (passenger cars), Traffic Count (lorries), Time Gap (between vehicles)</td>
<td>DATEX 2</td>
<td>Roadside units (especially in case of older systems) may feature low computing power and low bandwidth connections. DATEX 2 is designed for centre to centre communication and rather heavy, hence a level 3 compliant interface is used.</td>
</tr>
<tr>
<td>Roadside Environmental Data</td>
<td>I3</td>
<td>4.5</td>
<td>Detector ID, Direction, Measurement, CO2, Measurement NOx</td>
<td>DATEX 2</td>
<td></td>
</tr>
<tr>
<td>Centre Road Traffic Data Interface</td>
<td>I4</td>
<td>4.6</td>
<td>Traffic Events, Traffic Load per Segment</td>
<td>DATEX 2</td>
<td>Classic DATEX application</td>
</tr>
<tr>
<td>Static Public Transport Information</td>
<td>I5</td>
<td>4.8</td>
<td>Timetables, Stop Positions</td>
<td>VDV 452</td>
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</table>
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<table>
<thead>
<tr>
<th>Dynamic Public Transport Information</th>
<th>I6</th>
<th>4.9</th>
<th>Update Time Tables (?) Vehicle ID Time Stamp Vehicle Position Vehicle Speed Delays (line,vehicle)</th>
<th>SIRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Information over TPEG</td>
<td>I7</td>
<td>4.10</td>
<td>Traffic Messages Traffic Load TPEG RTM/TEC TPEG RTM defined as widely used standard to provide information to centres of mobile service providers as conversion into TPEG TEC is extremely easy and widely used, TPEG TEC recommended for provision to mobile clients since it is widely used in the European automotive sector.</td>
<td></td>
</tr>
<tr>
<td>Comodal Routes</td>
<td>I8</td>
<td>4.7</td>
<td>Waypoints Travel Time on Links Traffic Mode IN TIME / eMotion IN TIME / eMotion defined a well received approach (see chapter 4.7 for explanation).</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 19: Interfaces defined in VIAJE</i>**

The following chapters describe the interfaces in detail.

### 4.3 FCD Interface

#### 4.3.1 Introduction

The idea of using moving vehicles on the road network to obtain information on traffic is more than 10 years old. Beyond the problems associated with data acquisition on board and the transmission to the data centre, the main difficulty in the past was linked to the possibility to have an “amount” of equipped vehicles to ensure an accurate detection.
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Today, the technology and the market trends for on-board devices ensure that the number of equipped vehicles is appropriate and, therefore, that the method of FCD collection is a valid alternative, or rather an excellent support to the data traditionally obtained via fixed sensors (loops, radar, etc.).

Hereafter some useful information for the evaluation of the level of accuracy of traffic information obtained by processing FCD data.

First of all it is essential to distinguish the two objectives that are usually addressed by using of FCD data collection techniques. The first refers to the estimation of the Travel Time (TT) on predefined road sections, the second to the ability to detect "congestion events" in the shortest possible time.

By considering the first objective, it is reasonable to assume that the goodness of the estimation is influenced mainly by four variables: the intrinsic variability of the measure, the level of service on the road section, the amount of FCD (% of flow) available and the time slot. The result is expressed in percentage.

The following chart puts in relation these variables. The value is in percentage that is easily readable.

![Figure 20: Relation of FCD Vehicle Percentage, Vehicle flow and Confidence](image)

Based on the curves drawn in Figure 20 we can assert that considering a penetration of 2% of FCD and an observation period of 15’ the width of the confidence interval of the average estimation is less than 20% with flows higher than 430 [v/h] and less than 10% with flows slightly above the 1700 [v/h] threshold.

The second objective is quite complex to achieve. The aim is to detect traffic events based on FCD measurements. This means that it should be evaluated the probability to detect a “random event” that occurs within the road network by means of FCD. The figures below show the probability to observe at least 2 FC on one lane according to the traffic flow. The hypothesis is to have a penetration of FCs of 2%, an observation period of 15’ and the length of the road section of 500m.
Assuming the above pre-conditions, the probability to detect 2 FC on a 500 m road section within 15’ and by considering a traffic flow of 600 [v/h] is about 80% (stable flow). Up to 90% in “not-stable” conditions (congested). In order to give the reader a better understanding of the above mentioned figures please note that in a large city like Turin (Italy) the average traffic flow during the day (7am – 8 pm) is about 300 [v/h] while during rush hour it’s about 500 [v/h].

4.3.2 State of the Art

Europe is a hotbed of probe vehicle activity for both passenger car and taxi based systems. Probe vehicle systems have also been a part of early telematics offerings -- this work in passenger car probe data is driven strongly by the auto manufacturers, as they see these services as one aspect of enhancing the customer relationship. At the same time, governments are facilitating probe data projects because of the benefits to road management and society overall. The European term for probe data is Floating Car Data systems, or FCD. Current activity can be framed in terms of a) current commercial FCD offerings and b) Research and Development towards next-generation FCD systems. Examples of current commercial FCD systems are described below.
ITIS entered the telematics and traffic business in the United Kingdom (U.K.) in 1997, initially to serve trucking companies and now serving travellers in general. They ventured quite early into the probe vehicle field by designing an in-vehicle device which logs, stores, and transmits vehicle position, speed, and direction information. The information collected enables traffic flow rates to be known in real-time, and flows can also be predicted based on historical and other data. Their customers serve as both the data providers and data consumers. Their probe vehicle coverage extends across motorways in several British cities, and plans call for coverage over the entire trunk road network of England, Scotland and Wales. ITIS is also collecting real time traffic flow based on anonymously sampling the positions of mobile phones in moving vehicles. Main case studies are deployed in Belgium (Be-Mobile), UK (BMW, HAMPSHIRE COUNTY COUNCIL, Hyder Consulting), USA (MARYLAND DEPARTMENT OF TRANSPORTATION), Scotland (TRANSPORT SCOTLAND), TelMap and Vodafone.

TomTom HD Traffic

The core sources of traffic data collection systems are probe data from cell phone operators in the various countries as well as GPS probes from the installed base TomTom connected devices and commercial fleets with TomTom WORK navigation systems. The existing installed base of these sources, including all GPS probe vehicles and cell phone handsets from the cooperating telecommunication operators, is huge, and guarantees enhanced data and service coverage that is not limited to highways, but also covers secondary and arterial urban roads. This greatly improves both travel time and the delay time measurements along a planned route or through traffic, respectively. An additional advantage is the improved routing due to time specific data. So far, routes may vary with respect to the day of the week, time of the day, traffic information delays or other major dependencies by weather or events, for example. The data fusion engine is responsible for delivering reliable speed information for every road stretch of the underlying map, based on available data sources. Every data source has an ‘a-priori’ reliability measure, a measure indicating confidence in the speed measurement. The most reliable carries more weight, and so on. Measurements are compared with historic data to come to verified ‘ground truth’ speeds. For this ground truth, the most reliable are loop detector speeds, which have a sufficiently high density of data (incl. an appropriate travel
time assignment model). GPS-based probe measurements are even better, where available in an adequate penetration. TomTom is collecting its own highly accurate ground truth using GPS probe data from the TomTom installed base. Every day, more than one billion probe data are collected. The reliability measure for each data source takes into account the deviation against the ground truth in a number of parameters, such as the speed, the delay in reporting a jam, changes in a jam or positive and false traffic jam measures when the ground truth indicates a traffic jam. In the fusion process a number of other parameters are used beside the reliability measure, like the age of the measurement and the number of independent probe measurements. So far the contribution to the final speed is weighted according to the parameter vector described above. The result is that the speed in the network that corresponds to available real-time data is calculated and assigned to the related TMC Location points. In order to increase the TMC coverage for road stretches without these, TomTom has added additional its own TMC points. This strategy allows the delivery of traffic information in a bandwidth efficient manner across the whole network.

In Figure 23, a set of time distance diagrams is plotted showing the single probe data contribution to the data fusion process and the result output of the incident detection process for HD Traffic. For comparison reasons, the public TMC messages broadcast in the same area are plotted as well. The x-axis shows a highway section of the A3 in Germany between junction “Seligenstädter Dreieck” and “Wiesbadener Kreuz” where the y-axis show the time through the day of 6th March 2009. The speed is indicated by various colours, blue for speeds close to 0 and green for free flowing traffic. The example shows the existing high coverage of probe data, both from GPS and GSM sources. The calculated incident measures are far more accurate and precise compared to the TMC messages which are broadcast in the same area. Furthermore, the delay time, time of reporting the delay and modelling of the jam are far more realistic, assuming that the GPS probe can be seen as a ground truth.
Trafficmaster

Trafficmaster was established in 1988 in the U.K. as a private company collecting and processing traffic data to offer traffic information services. The major part of their data comes from stationary sensors which are supplemented with probe vehicle data. Their probe vehicle approach requires subscribers to mount units in their cars to transmit and receive the traffic information. Trafficmaster is now active across Europe, particularly in Germany and Italy (20,000 vehicles).

DDG

The German firm DDG initially provided traffic information services based upon deployment of thousands of road-based traffic sensors. Via separate agreements with BMW and VW, they are now collecting probe vehicle data as well. Approximately 40,000 probe vehicles (close to 1% of total passenger cars in Germany) are reporting data. DDG is currently processing 30M records daily from reporting vehicles. As a first generation system, the DDG approach is hampered by high communications costs, as vehicles are reporting at regular intervals whether data is needed or not. As will be discussed in the following section, BMW is addressing this issue in their current R&D.

Taxi-FCD System

The Institute of Transport within the German Aerospace Center has implemented the Taxi-FCD System in 2300 taxis operating in several European cities. Because they are capitalizing on fleet management information, there are no on-board expenses for data collection nor are there additional communication expenses. The data structure is simple, with Vehicle ID, timestamp, position, and taxi status being transmitted at intervals between 15 and 120 seconds. This approach yields excellent information on traffic.

Mediamobile

Today, Mediamobile develops its floating cars fleet. Mediamobile’s FCD module follows 150,000 vehicles/month (100,000 vehicles 6 months ago) and treats 300,000 million positions/month. The goal is to reach 400,000 followed vehicles/month by the end of 2010. Data from the French road administration and supplemented with FCD from Taxis.

Figure 24: Level of Service and Vehicles in Network at Mediamobile system
4.3.4 Research and Development towards next-generation FCD systems

**Road Traffic Advisor**

The Road Traffic Advisor project in the U.K. was an early foray into vehicle-roadside communications for evaluation purposes. Sponsored by the UK Highways Agency, 350 km of the motorway M4 from the London airports to Swansea was instrumented with 80 5.8 GHz beacons. The goal was to develop the necessary in-vehicle electronics and an open architecture to support a variety of applications. Among the applications investigated, probe vehicle data was shown to be technically viable.

**Sweden OPTIS Probe Vehicle Data Pilot**

OPTIS (Optimized Traffic in Sweden) was a project with the purpose of developing cost effective methods of collecting traffic data in order to provide high quality traveller information. Major partners in OPTIS were SAAB Automobiles, Scania Commercial Vehicles, Volvo Cars, Volvo Truck Corporation, and the Swedish National Road Administration. At a high level, the OPTIS goal was to show the feasibility of obtaining a quality picture of the traffic status in a metropolis with wide geographical coverage, given a reasonable number of FCD vehicles. The project also sought to establish that FCD is a cost effective alternative to stationary sensors that FCD provides a cost-efficient means of collecting data in more situations and locations than with other methods, and that FCD can be implemented in such a way that it is commercially attractive to telematics service providers. The specific objectives of OPTIS were to build a server solution for FCD, verify it through simulations, perform a realistic field trial to verify the simulations, and establish an action program for deployment. Field trials with 250 vehicles took place in Gothenburg during a six month period in 2002. The data concept was based on travel time. The cars in the study were equipped with Volvo Oncall units modified with OPTIS algorithms. Position data was transmitted to the OPTIS centre where the data was processed into travel times. Map matching was performed at the centre, so that the cars did not need an on-board digital map. Travel times were calculated at the road link level for each probe by determining a position in the road network and identifying when a vehicle passes the beginning and end of a link. The difference in the two times constituted the measured travel time for the link. 

OPTIS evaluations indicated that high quality travel information could indeed be produced with this system approach. The data allowed drivers to choose alternative routes at major incidents, saving as much as 25 minutes on their trip. This was in turn related to emissions reductions if such a system were deployed widely. Overall, the probe vehicle data was shown to offer a better overall picture of the traffic situation as compared to road-based sensors. Further, the installation cost of the probe vehicle solution was estimated to be half that of a fixed detector system. Communications costs were assessed at a high level. Simplicity at the vehicle level resulted in higher communication loads between the probe and server, compared to an implementation in which the probe vehicle calculates link travel time. Short Message Service (SMS) over the GSM cellular network was used in the pilot, but this is not seen as feasible for deployment due to cost. The General Packet Radio Service (GPRS), a commercial radio service becoming available in Europe, is seen as an attractive alternative. Generating probe data via GPRS is expected to be 1/10 the price of SMS.

The OPTIS final report called for OPTIS to be followed by a large-scale demonstration project in Gothenburg and Stockholm. The recommendation called for a total of 3% of all vehicles in Gothenburg and Stockholm to be equipped with probe vehicle equipment. The cost was estimated at approximately €4M. Deployment activity along these lines is underway.
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Smart FCD: Floating Car Data Collection via Satellite

The European Space Agency has completed a feasibility test with a small number of vehicles in the Rotterdam area using satellite communication to collect FCD data from vehicles. The advantage of the satellite approach, of course, is that the entire road network is covered by the satellite footprint. Researchers concluded that this approach to the collection of traffic information is technically feasible. Even though shadowing by large buildings was a concern, the data gathered shows that the coverage of the satellite system is adequate, even in densely urbanized areas. Further, analysis showed that traffic jams were detected effectively with the algorithms used. The project team noted that, compared to conventional detection methods, this concept offers better coverage and better data at competitive costs.

BMW Extended Floating Car Data R&D

Some 40,000 probe BMW vehicles are currently operating on German roads, reporting data through the DDG service described above. Their approach to second-generation probe data systems, called Extended Floating Car Data (XFCD), is based on reporting by exception, data management, advanced event detection algorithms, and data cleansing. The key to exception reporting is the presence of an on-board database which is frequently refreshed by new data. Although this data refreshment requires communications airtime, it can be transmitted in a broadcast mode which is much less costly. XFCD applications implemented by BMW include traffic, weather (precipitation, visibility), and road conditions. Data elements collected include speed, acceleration, windshield wiper status, ABS signals, headlight status, and navigation data.

BMW researchers have performed extensive analyses to understand the tradeoffs between the quality of traffic information and the necessary penetration rates of equipped XFCD vehicles. They assumed a period of 10 minutes for detection of a traffic incident, which is seen as satisfactory precision for reporting on traffic conditions. One factor affecting needed penetration rates is traffic volume. For example, mean passenger car volumes of 1000 cars/hour require penetration rates of 3.8% in order to reliably detect an incident (reports from at least three XFCD vehicles) within 10 minutes. The necessary penetration rates are halved if a 20-minute detection period is allowed. The researchers applied their methodology to the Munich road network as a case study. Results showed that, at a penetration rate of 9%, traffic conditions on 50% of the secondary network are detected. If only the primary network is analyzed, a penetration rate of only 5% is sufficient to cover two-thirds of that network. Overall, the analysis showed that an XFCD-capable fleet of 7.3% of the total number of passenger cars is sufficient to detect traffic conditions for over 80% of the main road network. For the overall German federal motorway network, analyses showed that penetration rates of at least 2% are required for good incident detection at peak traffic times, and that satisfactory traffic information can be generated on 80% of the motorway network at penetration rates of around 4%.

DaimlerChrysler CityFCD

Daimler is similarly focused on reducing message frequency through on-board measurement of link travel time and exception reporting based on an on-board link time database. Researchers have concluded that only two to four probe vehicle messages are necessary to detect the congestion fronts, and their analysis of necessary equipped-vehicle penetration rates yielded results similar to those of BMW: a 1.5% probe vehicle penetration rate gives sufficient service quality in urban traffic. This relies also on the traffic centre employing a predictive interpolation algorithm to process the data in the most efficient way and broadcast
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the predicted link information to the all other probe vehicles to update their databases. Each CityFCD vehicle measures its travel time on a network section and makes a decision as to whether to transmit this data to the probe service centre or not, based on the previous information received via broadcast. In terms of communications factors, this optimized message generation process was shown to reduce the amount of messages by factor of 40. Candidate communication channels for data outbound from the vehicle are GSM point-to-point, SMS, Digital Audio Broadcast, and GPRS. Data inbound to the vehicle would be transmitted via broadcast.

CVIS

Based on the interaction between the three involved entities cars, infrastructure and operation centre the figure below is showing the space for innovation within COMO. In a first development stage FCD approaches used the speed-profile for data gathering as well as for the event detection. The communication was limited to transmission of data from the car to the centre. In order to improve the information quality GST/EFCD is connecting the vehicle-bus for a multi-sensor data processing and detection inside the car. Furthermore the communication between the car and Centre is bidirectional to enable a detection control inside the car. The EFCD approach is supporting the communication with the infrastructure to forward messages to the service centre. But the infrastructure is only a communication hop without any intelligence for data processing methods.

Figure 25: FCD and EFCD Approaches

4.3.5 Standards related to FCD

TC 204 – WG16 works on ISO22837 - Configuration of vehicle probe data for wide area communications. ISO TC204 WG16 is developing a family of International Standards based on the CALM (Communications access for land mobiles) concept. This family of standards specifies a common architecture, network
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protocols and communication interface definitions for wired and wireless communications using various access technologies including cellular 2nd generation, cellular 3rd generation, satellite, infra-red, 5 GHz micro-wave, 60 GHz millimetre-wave, and mobile wireless broadband. These and other access technologies that can be incorporated are designed to provide broadcast, unicast and multicast communications between mobile stations, between mobile and fixed stations and between fixed stations in the "Intelligent Transport Systems" (ITS) sector.

A probe data system (Figure 32) is a system that consists of a group of vehicles that collect and transmit various types of data using medium and wide area radio communication, and centre functions for statistical processing of the received data to acquire information concerning traffic, road and environment is called a 'probe vehicle system'. Probe data is the data sent from on-board systems in the vehicle to the centres and other external systems. The speed and other basic data elements in the probe data are called 'probe data elements' and a compilation of multiple data elements is called a 'probe message'. Probe messages always contain position and time stamps. This SWG is in charge of standardization of data dictionary for probe vehicle system and standardization of the instructions for the probe data reporting management that is sent from the centre side to the group of vehicles when collecting probe data.

Figure 26: Probe Data System

For probe data, standardization of the following is in progress:

- **Basic work frame**: Specifies the methods of defining probe data elements and probe messages. Expansion and revision of the standard will be performed in accordance with this framework.
- **Reference architecture**: Defines the structure of the probe data system covered by this standard and the semantic structure of probe data.
- **Core data element**: Defines a group of probe data elements showing the position and time stamps included in all probe messages.
- **Initial set of probe messages**: Defines a group of typical probe messages.

Figure 27: Scope of Probe Data Standardisation
4.3.6 Detailed description of SIMONE protocol

4.3.6.1 Data Type

This section defines the nomenclature of data types, their contents and the reference systems used for geo-referenced data.

The protocol provides for 5 types of data:

- RD (Raw Data)
- MRD (Map-matched Raw Data)
- TT (Travel time)
- OD (Origin Destination Matrices)
- TE (Traffic Events)
- LTZ (limited traffic zone)

Raw Data (RD)

Such data consists mainly of speed and position information associated with time to which they refer. The RD data are defined from the PVT (position, velocity, time) information made available in the standard NMEA 0183 from GPS receivers. The OBU in order to reduce transmission costs (GPRS) send only part of the data produced by GPS: PVT data, the direction and the index of precision HDOP. The basic data obtained from GPS are integrated with the information that the OBU is able to calculate or retrieve by further on board measurement systems (odometer) recorded upon the acquisition of GPS position. The RD data may refer to the FCD data from private vehicles (cars), fleet generated by means of public transport (bus) and commercial fleets.

The type of vehicles is distinguished by the attribute vehicle_type this makes it possible to treat data for homogeneous classes (e.g. private transport, freight and public transport). Particular emphasis is given to the possibility of collecting data from fleets of public transport because of the increasing deployment of AVM.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veh</td>
<td>Anonymous vehicle ID</td>
</tr>
<tr>
<td>Timestamp</td>
<td>Time with reference to the GMT</td>
</tr>
<tr>
<td>Lat</td>
<td>Latitude WGS84</td>
</tr>
<tr>
<td>Lng</td>
<td>Longitude WGS84</td>
</tr>
<tr>
<td>Alt</td>
<td>Altitude</td>
</tr>
<tr>
<td>Heading</td>
<td>Direction respect to the geographic north</td>
</tr>
<tr>
<td>Speed</td>
<td>Instantaneous Speed km/h</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Name</th>
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</tr>
<tr>
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<td>Time with reference to the GMT</td>
</tr>
<tr>
<td>Lat</td>
<td>Latitude WGS84</td>
</tr>
<tr>
<td>Lng</td>
<td>Longitude WGS84</td>
</tr>
<tr>
<td>Alt</td>
<td>Altitude</td>
</tr>
<tr>
<td>LCD 1</td>
<td>Location reference code of start location</td>
</tr>
<tr>
<td>LCD 2</td>
<td>Location reference code of end location</td>
</tr>
<tr>
<td>Offset</td>
<td>Distance travelled on the arc from lcd1 [m]</td>
</tr>
<tr>
<td>Speed</td>
<td>Instantaneous Speed km/h</td>
</tr>
<tr>
<td>Event</td>
<td>Triggering event (e.g. sampling, keyOn, keyOff, door opening etc.)</td>
</tr>
<tr>
<td>Tracking_distance</td>
<td>Odometric distance respect to the previous measure [m]</td>
</tr>
<tr>
<td>Global_distance</td>
<td>Total odometric distance [m]</td>
</tr>
<tr>
<td>Tracking_type</td>
<td>Type of Sampling: time, space, mixed</td>
</tr>
<tr>
<td>Vehicle_type</td>
<td>Vehicle type: car, truck, bus, tram etc.</td>
</tr>
<tr>
<td>Vehicle_information</td>
<td>Various parameters: engine type, kW, class etc.</td>
</tr>
</tbody>
</table>

**Map-matched Raw Data (MRD)**

Such data shall consist of position, velocity and time already partially processed: the GPS data is in fact associated with data from a reference map. The position calculated by the GPS receiver is basically "correct" projecting it on an element of the graph. This methodology is commonly known as "map matching". The information thus includes the PVT data and its cartographic element. The following table gives the list of information conveyed by the protocol.
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<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle_type</td>
<td>Vehicle type: car, truck, bus, tram etc.</td>
</tr>
<tr>
<td>Vehicle_info</td>
<td>Various parameters: engine type, kW, class etc.</td>
</tr>
</tbody>
</table>

**Figure 29: FCD Map Matched Raw Data in SIMONE**

**Travel Time (TT)**

The information consists of compiled and aggregated data. A travel time on an arc of the reference graph will be communicated instead of the single location of a vehicle.

There are two different TT data / speed: The first is an effective "measure", characterized by three fundamental parameters of the statistics distribution (mean, standard deviation and number of samples). The second is "estimation" based on the proprietary methodology of the fleet owner characterized by a value "Estimated" and a quality indicator of the estimate.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCD 1</td>
<td>Location reference code of start location</td>
</tr>
<tr>
<td>LCD 2</td>
<td>Location reference code of end location</td>
</tr>
<tr>
<td>start_time</td>
<td>starting time to which data are reported</td>
</tr>
<tr>
<td>stop_time</td>
<td>End time to which data are reported</td>
</tr>
<tr>
<td>time</td>
<td>average travel time [s]</td>
</tr>
<tr>
<td>speed</td>
<td>Instantaneous Speed km/h</td>
</tr>
<tr>
<td>n_vehicles</td>
<td>Number of vehicles that contributed to the calculation</td>
</tr>
<tr>
<td>std_dev</td>
<td>Standard deviation of the sample distribution</td>
</tr>
<tr>
<td>accuracy</td>
<td>Shows, in percentage, the validity of the data.</td>
</tr>
<tr>
<td>estimated_speed</td>
<td>estimate of the speed [km/h]</td>
</tr>
<tr>
<td>q_idx</td>
<td>quality index of the estimate (1 = min, max = 5)</td>
</tr>
</tbody>
</table>

**Figure 30: FCD Travel Time Data in SIMONE**

**Travel Origin Destination (OD)**

The information is the number of trips for each origin-destination pair defined within the OD matrix. The following table lists the information that the protocol must carry.
Deliverable 3.1
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<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCD 1</td>
<td>Location reference code of start location</td>
</tr>
<tr>
<td>LCD 2</td>
<td>Location reference code of end location</td>
</tr>
<tr>
<td>start_time</td>
<td>starting time to which data are reported</td>
</tr>
<tr>
<td>stop_time</td>
<td>End time to which data are reported</td>
</tr>
<tr>
<td>vehicle_type</td>
<td>vehicle category</td>
</tr>
<tr>
<td>trips</td>
<td>number of trips on the OD pair</td>
</tr>
</tbody>
</table>

Figure 31: FCD Origin-Destination Data in SIMONE
4.4 Interface for the provision of Roadside Traffic Count Data

4.4.1 Introduction

Several national standards for the provision of roadside traffic count data from the roadside units to centre units are currently established in Europe, for example UTMC in the UK. These standards, however, have not been adopted on European level. As VIAJEO has the goal to provide standardized interfaces to allow streamlined tendering on the one hand and efficient product development on the other, national specifications should not be applied.

DATEX II, a European standard developed within the Euroregional Project EASYWAY and its predecessors, is commonly used for centre to centre communication, meaning that most European system suppliers adopted this technology. Although DATEX II is designed with inter-centre perspective in mind (e.g. bandwidth is not specifically considered), it allows to model “raw” roadside traffic data and elaborated data as well. As DATEX II is designed to be extensible it is, per se, a good option for use in the VIAJEO open platform. The full DATEX II specification is available under http://www.datex2.eu/. For the VIAJEO open platform, the Version 2.0 Release Candidate 1 is used. The DATEX II V2.0 User Guide can be found under http://www.datex2.eu/archived-document/16 and provides some good overview and details on the DATEX II standard.

4.4.2 Interface Specification

There are two different kinds of roadside detectors which have to be taken into account in the test sites of the VIAJEO project, namely those located at motorways and other interurban high level links and those which operate in urban areas. The first normally are providing their data for traffic state estimation and infrastructure control (such as line control systems showing mandatory speed limits and warning messages etc.), the data of the second type are usually used for traffic light or signal control. Unfortunately, not all urban detectors are, as their primary use is requiring them to be located very close to traffic lights, suitable for traffic status analysis. Based on the different use types, different data are collected.

The data provided by the detectors in the VIAJEO test sites are provided below:

Urban detectors for signal control:
- Vehicle type
- Speed
- Occupancy
- Position of detector
- Driving direction which is covered by the detector
- Timestamp

Interurban detectors:
- Detector ID
4.5 Interface for the provision of Roadside Environmental Data

4.5.1 Data to be Transmitted

The data to be transmitted originate from the test site Shanghai, where pollution sensors are mounted on dedicated vehicles to collect those data. The data collected are:

- CO₂
- NOₓ
- O₃

The unit the data are currently provided in is mg/m³.

4.5.2 Interface Specification

DATEX 2 provides the possibility to model pollution values within its normal procedure. The annex holds UML diagrams which are taken from the DATEX 2 specification to describe the modelling (see the annex, for a UML model).

4.6 Interface for the Exchange of Road Traffic Data between Centres

The full DATEX 2 specification is available under [http://www.datex2.eu/](http://www.datex2.eu/). For the VIAJE0 open platform, the Version 2.0 Release Candidate 1 is used.

4.7 Routing Interface for Centre-to-Centre Communication

4.7.1 Introduction

Routing services are extremely common today and applications range from private handheld systems to professional routing engines integrated into dispatching environments. However, the exchange of route
information, be it between centres or between a centre and a handheld/mobile system is mostly based on proprietary solutions up to now. This, however, limits the accessibility of a given service since any user of the systems’ information must adapt to the proprietary technology. In case of a very lively business environment, where routing engines only cover a specific geographical area, a service provider must collect the data from various systems to provide services at a “critical mass level”, meaning that enough users use this information that the service is economically viable. Thus, if standardized interfaces are used and the same interfaces can be used for all regional services to retrieve information, service providers can more easily establish their business model due to reduced costs for data collection.

The project IN TIME defined an interface for routes to be exchanged between central systems on basis of the results of eMotion, a predecessor project.

VIAJEKO decided to use this interface, since it is based on standardized procedures and is one of the first agreed definitions. Also, current experience shows, that the interface design meets high interest in the market, on provider as well as on consumer side.

### 4.7.2 Interface Specification

The interface specification is based on the results of the European research project IN TIME project which again is using the results of the European predecessor project eMotion. The eMotion data model was extended where found necessary.

The In-Time/eMOTION specification defines two interfaces for Journey Planning:

1. The main and most complete interface is based on the JourneyWeb protocol
2. Another interface uses a profile of the OpenLS [OGC-OpenLS, 2005] Routing service

The focus was placed on JourneyWeb for the further specification within IN TIME.

JourneyWeb is an extensible protocol and open XML-schema for dynamic data exchange over the Internet between multimodal public transport journey planners. The protocol enables one journey planner to send questions to another, and to receive answers back, so that journeys can be planned beyond the boundary of the first journey planning system. The protocol can be used with journey planners used in telephone call centres, on the Internet or at kiosks. JourneyWeb’s main feature is then the capability to implement request/response of entire Journey plans.

There are currently several implementations in Europe using JourneyWeb, so it was adopted in the eMOTION framework. This consists of Journey Planning Package and Journey Request Package.

#### Journey Planning Package

There is a Journey Planning Package defined in the EMotionServices application schema which includes the definition of the service interface proper and of the main used types. Another Journey Planning package exists to specify all other data types used by the interface. This comprises the following sub-packages:
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- **Common**: Describes common types used by classes in different sub-packages
- **Discovery**: This sub-package defines Types, Classes and relations to define a distributed database for the localisation of Trunk Exchange Points, Adjacent Region Exchange Points and URLs of a Journey Planning Application associated to a specific Administrative Area.
- **ScopingParameters**: Contains types referred by Scoping Parameters which are the basic parameters that a user must specify to request a Journey. Scoping Parameters are: Origin, Destination, Range of the Request, Type Of the Request (Arrival or Depart)
- **AdditionalScopingParameters**: Contains types referred by Additional Scoping Parameters that can be used to request for a Journey. Additional Scoping Parameters includes: Via/Not Via Points, Operators, Services and Modes to explicitly exclude/include
- **ComputationalParameters**: Contains types referred by Computational Parameters that can be used to request a Journey. Computational Parameters includes: type of the Algorithm, Walking Speed, Limited accessibility specifications in terms of hazards to avoid, Maximum walk distance, and Interchange Speed.
- **LegDetailsParameter**: Includes types referred by those parameters of the interface used to specify types of leg details that has to be included in the response. For example IncludeIntermediateStop indicated what intermediate stop has to be included in the response leg.
- **Legs**: Contains type definitions related to Legs (structure and related timing information). A leg is a structure that is used to define each single Journey. A journey can be made of several legs.
- **ServiceGroups**: Includes types related to Services and Service Groups, referred by some parameters of the Journey Planning Service Interface and by some elements of the returned Journey.
- **TrackingAndMapping**: Contains data types suitable for Mapping and Tracking purposes
- **Points**: Contains types used by the 'Point request' part of the Journey Planning service
- **Service Interface. JourneyWeb** can handle different requests/responses. eMOTION Journey Planning Package includes the Journey and Points request/response definitions and all the necessary associated data types from JourneyWeb. All the information provided by the remaining JourneyWeb request/responses (which are not strictly related to journey planning) are accessible through the services defined in the eMOTION Public Transport package.
  - **Journey**: calculates the best journeys between combinations of stops
  - **Points**: return a list of remote stops for a locality or coordinate (e.g. retrieves all the stop points in a certain region)

Other requests/responses give additional information but are not strictly necessary for journey planning. This includes, for example:

- **Timetables**: returns a matrix of timetable data suitable for producing columnar timetables (e.g. retrieves data regarding schedules for a certain stop point)
- **Stop Events**: function can be used to obtain arrivals and departures at a stop or collection of stops, for example (e.g. retrieves departures in the next 5 minutes for a certain bus station, “departure monitor”)
- **Services**: returns a list of services for which the remote journey planner can return timetables. (e.g. retrieves Service in a certain region)
- **Operators**: can be used to request a list of all the operators supported by the journey planner (e.g. retrieves Operators in a certain region)
In eMOTION, the Journey Planning Package comprises all features needed for a distributed Journey Planning Service. The eMOTION Journey Planning Service, based on the JourneyWeb protocol has been further extended in order to have this part of the data model integrated with the application schema (for more detailed information see eMOTION D6 Appendix 1 pag 148-168; appendix 2, pag. 30-40).

**Journey Request**

JourneysRequest has a rich set of features. The parameters on the JourneysRequest can be divided into four groups:

- **Scoping parameters**: includes constraints on the journey such as origin, destination and time.
- **Additional scoping parameters**: Additional constraints, such as via points.
- **Computational parameters**: Indicates how the journey has to be computed
- **Leg detail parameters**: Indicates the level of detail of the returned legs.

Here’s the complete table of the Request parameters:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Use</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>origin</td>
<td>JP_OriginDestinationRequestType</td>
<td>mandatory</td>
<td>Origin for the requested Journey</td>
</tr>
<tr>
<td>destination</td>
<td>JP_OriginDestinationRequestType</td>
<td>mandatory</td>
<td>Destination for the requested Journey</td>
</tr>
<tr>
<td>Via</td>
<td>JP_Via_NotVia</td>
<td>Optional</td>
<td>Pass through / Exclude point</td>
</tr>
<tr>
<td>arrDep</td>
<td>JP_ArriveDepartType</td>
<td>Optional</td>
<td>Specifies if the request relates to an arrival or to a departure</td>
</tr>
<tr>
<td>algorithm</td>
<td>JP_AlgorithmType</td>
<td>Optional</td>
<td>Type of the algorithm used by the Journey Planning software</td>
</tr>
<tr>
<td>walkSpeed</td>
<td>JP_SpeedType</td>
<td>Optional</td>
<td>type of walk speed for the end user</td>
</tr>
<tr>
<td>maxWalkDistance</td>
<td>Integer</td>
<td>Optional</td>
<td>Maximum walking distance the end user is willing to cover (in metres)</td>
</tr>
<tr>
<td>InterchangeSpeed</td>
<td>JP_SpeedType</td>
<td>Optional</td>
<td>type of walk speed for the end user for interchanges</td>
</tr>
<tr>
<td>IncludeIntermediateStops</td>
<td>JP_IntermediateStepsRequestType</td>
<td>Optional</td>
<td>Type of intermediate stops to be included</td>
</tr>
<tr>
<td>realTime</td>
<td>Boolean</td>
<td>Optional</td>
<td>Include or not Real Time information if available</td>
</tr>
<tr>
<td>requestID</td>
<td>CharacterString</td>
<td>mandatory</td>
<td>ID of the Request</td>
</tr>
<tr>
<td>exclModes</td>
<td>JP_Modes</td>
<td>Optional</td>
<td>Modes To include/exclude</td>
</tr>
<tr>
<td>inRange</td>
<td>JP_Range</td>
<td>Optional</td>
<td>Range for the calculation of results</td>
</tr>
<tr>
<td>exclOperators</td>
<td>JP_Operators</td>
<td>Optional</td>
<td>Operators to be included/excluded</td>
</tr>
<tr>
<td>exclServices</td>
<td>JP_Services</td>
<td>Optional</td>
<td>Services to be included/excluded</td>
</tr>
<tr>
<td>accessibilityDetails</td>
<td>JP_LimitedAccessibility</td>
<td>Optional</td>
<td>Indicates whether to include Tracking information</td>
</tr>
<tr>
<td>includeTracks</td>
<td>Boolean</td>
<td>Optional</td>
<td>Indicates for what mode instructions have to be included</td>
</tr>
<tr>
<td>includeInstructions</td>
<td>JP_AllModes</td>
<td>Optional</td>
<td>Indicates whether to include</td>
</tr>
<tr>
<td>IncludeInterchanges</td>
<td>Boolean</td>
<td>Optional</td>
<td></td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>mappingSystem</th>
<th>JP_MapSystemReference</th>
<th>Interchanges information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Optional</td>
</tr>
</tbody>
</table>

**Figure 32: Request Parameters in Journey Request**

It’s interesting to note that the modes to be included/excluded can be either “Access” modes (like foot, bicycle, taxi etc.) and Vehicle modes with which a leg can be actually covered and this includes for example: railway, bus, metro, taxi, plane, private car and many other. (see

![Diagram of Request Parameters in Journey Request](image)

**Figure 33: Modes to be included/excluded in a Journey request**

Another interesting aspect is that in eMOTION JourneyPlanner Model, Origins and Destinations are mapped to a JP_OriginDestinationNode which includes a 0 to many Place instances. A Place is an abstract class which could be specialized as:

- **AddressedPlace**
- **PlaceOfInterest**
- **TopographicalPlace** (which can reference StopPlaces and StopPoint)
- **StopPlace**
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Every Place can have a pointProjection, zoneProjection, linkProjection which are location references which can carry different location referencing systems (AGORA-C, ALERT-C, TPEG-LOC, WGS-84, etc.).

The following figure shows the connections between the main topographical elements which can be related to JourneyPlanning Origin, Destination (and Via) points.

Figure 34: The concept of Place applied to Journey Planning Origin and Destination

The association between significant points of a Journey and the entity ‘Place’ allow a rich and extensible assignment of Origin, Destination and Via points to a variety of locations overcoming the need to enumerate or treating separately each type of location in a request or a response.

Other minor modifications are made to JourneyWeb types and enumeration in order to achieve the harmonization with the eMOTION Framework Data Model.
Journey Response

A Journey (described by the JP_Journey class) is made up of several different Legs (JP_Legs in eMOTION), which can be specialized in one of the different types supported by JourneyWeb:

**Timed Leg**: A leg that has specific timing points associated to a timetable

**Frequency Leg**: A Leg that runs at specified frequencies

**Continuous Leg**: A continuous leg doesn’t have a specific timing or frequency and is suitable for legs not covered by public transport, e.g. it can be used for car or walk legs

**Interchange Leg**: Interchange legs are typically used for walk journeys for interchange purposes. They have an origin and a destination and are described with a navigation path.

Timed leg, frequency leg and continuous leg have the same basic structure in common.

This includes:

- **Message**: error or information message.
- **ServiceOrigin**: Start point of the service. Optional.
- **IntermediateA**: Journey pattern between ServiceOrigin and LegBoard.
- **LegBoard**: Boarding point
- **IntermediateB**: Journey pattern between LegBoard and LegAlight.
- **LegAlight**: Alight Point
- **IntermediateC**: Journey pattern between LegAlight point and ServiceDestination.
- **ServiceDestination**: The ultimate end point of the service
- **LegTrack**: A map plot of the track

![Figure 35: Basic Structure of a Leg](image)

A major extension in the Journey Response is concerning the Returned Node structure included in the Leg class which has been substituted with a JP_ReturnedNode, including a Place class.
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Figure 36: Extension of Journey Returned Node

Taking up the previous considerations about the existence of an entity ‘Place’ which, in this case is associated to a returned node, a wide set of information can be carried out for the returned leg (as a set of nodes). In practice every information associated to a ‘Place’ can be returned. This may include, for example:

- The type of place (parking, POI etc.)
- The related infrastructure information (obstacles or accessibility facilities such as escalators, ramps etc.)
- The type of street (via the abstract network model)
- other

Another important aspect of a Journey Response is that each JP_Leg can include information on tracking&mapping (JP_LegTrack).

The complete specification of this part of the model can be found in:

- eMOTION UML Model, part of the eMOTION deliverable D6
- eMOTION Deliverable D6, Appendix 1, chapter 12

All documents are publicly available from the eMOTION project web site: www.emotion-project.eu
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The complete description of data types can be found in the eMOTION UML model.

Extensions

Duration of stay at the ‘Via’ location

In eMOTION it’s not possible to express a value to specify an optional duration of stay at the Via location. Just for example it could be possible to extend the eMOTION model in this way:

Adding a non-mandatory duration attribute to the JP_Via_Node class in the Enterprise Architect model and extend the xsd in order to reflect the change in the schema.

Other added attributes or classes

Like the previous extension and along the same lines, other attributes or classes can be added to the model to extend it in order to support further features. This may include the following elements to be specified in a Journey request:

- Possibility to specify the maximum number of changes within the journey
- Possibility to specify the exclusion of PT legs that has an increased ticket cost
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And the following information to be supported in a Journey Response:

- Events (for example Traffic Events) possibly related to every point composing a Journey. (In this case an association with the appropriate existing classes will enable the inclusion of such information in the XML response without the need to submit a separate query to get the information itself)

The eMotion xsd’s can be downloaded from the eMotion website under www.emotion-project.eu.

4.8 Static Public Transport Information Interface

4.8.1 Introduction

The test sites in VIAJEIO feature different availabilities concerning public transport data. On the one hand side, only “static” data such as time tables or stop positions are exchanged between system, in other cases also live data on public transport delays are available (see chapter 4.9 for details).

The European standard SIRI allows for a flexible and extensible approach, but is only suitable to model dynamic public transport data such as update time tables or delay data. However, nationally implemented standards basing on the same source, the European TRIDENT project, do feature those definitions (also the VDV standard). To define a common methodology for modelling the static public transport interface, the German VDV 452 “Network and Timetable” Version 1.4 standard was proposed, since it is a commonly agreed methodology and widely used.

The VDV 452 standard states in its introduction: “The ÖPNV Data Model as a Reference Point for Data Modelling in Public Transport. After the first publication of the VDV recommendation “ÖPNV Data Model”, also known as the “VDV Data Model” outside German territory in 1990, it has become the basis for data modelling in public transport. Perhaps it was due to the great success of the VDV Data Model that the VDV faced increasing demands to also develop practically orientated solutions, extending even beyond the capabilities of the VDV Data Model. Ideas included standard interfaces which, thanks to their plug-compatibility, are instantly usable, and which permit standard software modules to communicate with each other at a reasonable cost”…“This current edition of the VDV recommendation contains the ... interface definition ...[dealing] with the “Network and Timetable” area. The definition distinguishes itself from the ÖPNV Data Model insofar as it has the following characteristics:

- In conjunction with SQL access as required in earlier versions of the ÖPNV Data Model, an alternative file format is defined for offline data transfer (cf. VDV Schrift 451)
- The minimum scope of the Data Model is clearly outlined
- The range of values is more restrictively defined for the individual attributes of the user
- The individual attributes were described in more detail and therefore more precisely"

General Description

The aim of the “VDV Standard Interface Network/Timetable” is to transfer network definitions and timetables from a source system into a target system. As a general rule, the timetable data from a (vehicle

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and crew) scheduling program me is passed on to consumer systems for the purpose of transit operations’ supervision and control (AVMS), cost control and/or publication.

When transferring data from a planning system into an AVMS, the data in the AVMS can be supplemented by the user with AVMS-specific data. This will be referred to as “AVMS-specific data”.

Examples of data which are updated in the AVMS and which are not mapped in the VDV Standard Interface “Network / Timetable”:
- Traffic light influencing parameters
- Radio parameterising for the AVMS
- Data for dynamic passenger information

When transferring new data from the VDV Standard Interface “Network / Timetable”, the AVMS-specific data already present in the AVMS database must be taken into account.

**Scope of Data**

The VDV Standard Interface “Network / Timetable” comprises the following data:

- Calendar data (day types and their validity in the company calendar)
- Operational data (vehicle stock, vehicle types, announcement texts and destination texts)
- Location data (bus stops, stopping points, beacons, depots)
- Network data (route sections, distances, running time groups, running times, stopping times)
- Line data (lines and courses for different routes)
- Timetable data (runs and run-dependent stopping times, blocks)
- Connection information which facilitate the transfer of connection definitions together with their validity for example from a journey planning

### 4.8.2 Data to be transmitted

The main application of the interface is to transmit time tables and stop locations for a public transport network.

### 4.8.3 Technical Specification

The full technical specification in English can be found under [www.vdv.de/module/layout_upload/452_sdv14.pdf](http://www.vdv.de/module/layout_upload/452_sdv14.pdf) on the internet site of the VDV ([www.vdv.de](http://www.vdv.de)).

### 4.9 Dynamic Public Transport Information Interface

#### 4.9.1 Introduction

In order to propose to public transport consumer a well-adapted information for real-time, two different things are necessary:
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- Firstly, quick decision for preventing, anticipating or answering perturbation,
- and secondly a well-understandable information for real-time.

In the case of one public transport operator managing its own network, we can imagine that giving information about the services, events and perturbation (id est, a « modification of transport service », according the conceptual data model TRANSMODEL), could be easy.

Although, the most of the time, the traveller information system and the regulation system are separated: they don't use the same field equipments, the vocabulary used (for professional and for the user) is very often different, and the topics of the communication are not the same (a delay for one vehicle, is not necessary a delay for the public transport user; a lot of events have not to be known by the users). This situation can quickly become uncomfortable to manage when there is between the user and the transport operator, one public authority, who can demand to one operator to inform on a network he doesn't manage.

It is why the CEN (CEN/TC278/WG3/SG7) opened a work item called SIRI, for Service interfaces for Real-time Information. The scope of SIRI is the information exchanges inter-systems (in real-time). This technical specification defines a Service Interfaces for the information, and for its broadcasting. It allows to inform about all the modification of the transport offer due to a perturbation or not.

The specification for the base SIRI framework on which SIRI-SX is built is presented in five parts:

- **SIRI Part 1** (CEN/TS 00278181-1) « Context and framework », including background, scope and role, normative references, terms and definitions, symbols and abbreviations, business context and use cases.
- **SIRI Part2** (CEN/TS 00278181-2). « Communication Infrastructure », indicates the mechanisms to be adopted for data exchange communications links
- **SIRI Part 3** (CEN/TS 00278181-3) - « functional service interfaces – Data structures » which describes the Data structures (way for describing a data) for a series of individual application interface modules
  - Production Timetable (SIRI-PT).
  - Estimated Timetable (SIRI-ET).
  - Stop Timetable (SIRI-ST).
  - Stop Monitoring (SIRI-SM).
  - Vehicle Monitoring (SIRI-VM).
  - Connection Timetable (SIRI-CT).
  - Connection Monitoring (SIRI-CM).
  - General Message (SIRI-GM).

Additional documents are used for additional functional services, to date these are:

- **Part 4 – Functional Services Interfaces – Facility Management** (prCEN/TS 00278181-4) service is used to exchange information on the current status of facilities such as lifts, escalators or ticketing.
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machines. It provides a short description of the facility itself, expresses any change to its operational status and specifically the accessibility status for the disabled or those with special needs. It provides all the current relevant information relating to all facilities fulfilling a set of selection criteria.

- **Part 5 - Situation exchange** (prCEN/TS 00278181-5). The SIRI Situation & Incident Exchange service is used to exchange information messages between identified participants in a standardized structured format suitable for travel information services. It enables messages to be sent and to be revoked.

SIRI is now partially approved. The two last parts will be voted before the end of the year. The XML schema can be downloaded from www.siri.org.uk, along with available guidance on its use, example XML files, and case studies of national and local deployments. The SIRI-SX service is included in version 1.3 of the schema onwards.

The purpose of this report is not to present SIRI but to indicate how the model and services proposed in the Technical Specification could be locally implemented and the communication infrastructure used or improved for answering the requirements of the local stakeholders. SIRI is an open standard, which takes into account a lot of needs. It doesn’t impose an exhaustive implementation, but allows a progressive implementation. The counterpart is that we can easily implement non interoperable systems (in case they don't have the same functionalities). It is why the SIRI standard proposes to establish a local agreement, which will allow to impose restriction and constraint for exchanging data.

The first part of the chapter will indicate the data profile for different application case, and the second part concerning technical specification will give some recommendations depending on the existing infrastructure. It is possible that for existing systems the work to do for improving it costs more than the benefit expected by the local authorities. But it is necessary to keep in mind this proposition for further deployments of systems.

### 4.9.2 Data to be transmitted

The first approach is to define exactly the services targeted with the VIAJEKO platform experimentation. The following table indicates for each Demo site the kinds of services which will be implemented. SIRI allows to identify the data-model needed in the different cases indicated below.

Even if, each application case won’t be implemented in each demo site, it seems interesting to describe how SIRI gives way for describing this case. For more details, the website www.siri.org.uk.

Within the VIAJEKO demonstration the following data are potentially relevant for modelling within SIRI:

- Production Timetable (SIRI-PT).
- Estimated Timetable (SIRI-ET).
- Stop Timetable (SIRI-ST).
- Stop Monitoring (SIRI-SM).
- Vehicle Monitoring (SIRI-VM).
- Connection Timetable (SIRI-CT).
- Connection Monitoring (SIRI-CM).
General Message (SIRI-GM).

The so called “SIRI study model” was realized in 2006 in the Frame of a study asked by the CERTU to French experts contributing to the European working group. The model is presented with the UML formalism. It is built from the SIRI messages, and the order of the different attributes is linked with the message structure. The diagrams describing the applied model are contained in Annex B 3.3 on page 118.

4.9.3 Technical Specification

It is very important to define locally, together with the local stakeholders, the way they will define in details the different messages and the technical supports which will be used for exchanging information with the local open platform. It is why this aspect is not only technical but also organizational. The better way is to define local agreement. The documents which are produced below (see annex, with XSD files and data structures) come from the SIRI part 3 which produce a guide for Functional Services Interfaces and an application made in Île de France. In this case the “local agreement” is now an annex of the contract linking the transport operators and the Public authority.

4.10 Traffic Information over TPEG

4.10.1 Introduction and Reasoning

The Transport Protocol Experts Group (TPEG) was founded in 1997 by the European Broadcasting Union (EBU). It was a group of experts led by the EBU coming from all areas of the Traffic and Travel Information businesses, as well as broadcasting. The group developed the TPEG specifications for transmission of language independent multi-modal Traffic and Travel Information. Validation of the initial work was undertaken by the part-funded European Commission TPEG Project which had three year duration. The TPEG work was partly based on the work done with RDS-TMC, but TPEG data are human understandable as well as machine readable. In particular TPEG does not assume any large scale location or pre-coded phrase databases in any client receiving device. Its standards were then used as a starting point for the mobile.info project in Germany to develop an enhanced version of TPEG that is optimised for dynamic route guidance.

In 2008 the Traveller Information Services Association (TISA - http://www.tisa.org) was established as a not-for-profit company (ASBL under Belgian law) to ensure an international framework for market-driven, coordinated, proactive implementation of traffic and travel information services and products based on existing standards such as RDS-TMC and TPEG. It also works towards the development and deployment of future standards and services. TISA has taken over all the activities undertaken by the previous TMC Forum, TPEG Forum and the German Mobile.Info project. It also supports standards that provide elements or framework for services and products covering traffic and travel information, including roads, public transport and related information needs such as points of interest, weather and environmental information.

In the early days of the TPEG development applications were designed in two halves. On the one hand there were coding experts and on the other designers. At that time the primary focus was on a binary delivery using DAB. With the XML becoming more main stream it was very quickly adopted by the TPEG developers who unified the two separate approaches. At the same time it was clear that XML provided
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another channel to deliver Traffic and Travel Information. More recently TPEG developers have turned to UML to hold the conceptual content and to build new applications. Current work programmes include building UML extracts that will automatically generate the XML and binary specifications.

State of the Art

Figure shows the TPEG world as a whole. Currently the TPEG standards and specifications are classified respectively in TPEG-1 (the 18234 series) and TPEG-2 (the 21219 series). The dark green boxes refer to already standardized TPEG applications and services (RTM, PTI, SNI, LOC, LRC, SSF, INV), while the light green boxes are already specified and currently following the ISO’s approval procedure. For some of the standards an update (2nd version) is already under preparation. Besides the applications and services TISA has specified a set of profiles. Among the latter the TAP (TPEG Automotive Profile) is probably the most relevant. A profile defines specific selections out of possible application and parameter combinations within the TPEG base standards. TPEG Automotive Profile will define a distinct choice which applications and what transmission settings are to be used to provide a traffic information service to car navigation systems using DAB. Another interesting profile is the TPSMP (TPEG Public Service&Media Profile). The TPSMP will use TPEG-RTM for road traffic messages and TPEG-PTI for public transport information.

The development of TPEG has gained significant momentum over the last 12 months as commercial service providers in France, Germany, Italy and the UK begin to launch trials and plan next generation traffic services. The commercial traffic information sector in Europe is showing a clear commitment to launching TPEG services for the automotive industry. In addition to the commercial TPEG services there are also a
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number of public providers considering TPEG in Europe, particularly in Germany, Switzerland and the UK. These public services are unlikely to offer the same applications or use the same location referencing techniques as the automotive-focused commercial services. The next paragraphs provide an overview of commercial TPEG services available across Europe.

UK: TrafficMaster

TrafficMaster launched its Digital Traffic Broadcast service in partnership with Digital One, the world’s largest digital radio network operator. The combination of TrafficMaster’s world-leading traffic information and advanced DAB technology will enable navigation devices to receive more detailed and accurate traffic data. Traffic information is collated from TrafficMaster’s nationwide traffic monitoring network which covers 95% of the UK’s motorways and trunk roads. With the launch of TrafficMaster’s Digital Traffic Broadcast service, DAB compliant navigation systems will have access to better quality and more reliable traffic flow information, including emergency incidents and road works. This will allow drivers to receive enhanced routing instructions and more accurate delay times. The new digital service supports the full TPEG standard developed by TISA (The Traveller Information Services Association). It is commercially available to UK automotive manufacturers and portable navigation device providers. TrafficMaster’s Digital Traffic Broadcast is also championed by the Digital Radio Development Bureau (DRDB), a trade body that has been set up to encourage digital radio’s wide accessibility and swift adoption in the UK.

Germany: WDR

Westdeutscher Rundfunk Köln (WDR) is a Public Service Broadcaster in Germany. WDR started to broadcast TMC in 1997. In the meantime, WDR supported TPEG development and became a mobile.info project partner. Different TPEG variants have been broadcast in cooperation with many projects. Today, Traffic information is delivered by 4 FM radio channels, TMC, TPEG, DAB, via internet, teletext, on answering machines and (during rush hour) on AM.

4.10.2 Data to be transmitted

The data to be transmitted within the VIAJEO open platform demonstration are traffic messages and traffic flow information (level of service).

4.10.3 Technical Specification

TPEG has undergone a number of changes since it was conceived by the TPEG Forum. However, the fundamental construction of all TPEG messages is still made up of three building blocks that identify the message, describe the event and locate the incident, as shown in figure below.
Every TPEG message will include a Message Management Container (MMC) that provides information relating to its origins and features. The MMC is intended to allow devices to quickly determine the relevance and lifetime of the content without having to analyse the entire TPEG message. TPEG enables a range of applications to be delivered by using an Application Event Container (AEC). There are currently only three applications that have been standardized by ISO to date but there are already plans for another thirteen to be standardized in the future.

4.10.3.1 The need for TPEG RTM and TPEG TEC

Road Traffic Management (RTM) was the first application to be developed by the TPEG Forum but the automotive industry did not consider it to be suitable for route guidance purposes. A consortium of
German vehicle manufacturers and suppliers therefore developed the traffic Event Compact (TEC) application (through the mobile.info project) to address their navigation-specific needs. The TPEG TEC specification is currently at the last stage of the ISO proposal phase (10.99 new project approved).

4.10.3.2 The differences between TPEG RTM and TPEG TEC

RTM and TEC both use look-up tables to describe the parameters of road traffic incidents (see Figure below). This allows the message contents to remain language independent by having different look-up tables for each language.

Although RTM and TEC both use look-up tables to describe traffic incidents, the way in which the descriptions of the incident are structured varies significantly. These differences are summarised below.

The TPEG-RTM application is designed to deliver road information to any kind of end-user client (not just navigation systems). It is based on RDS-TMC event codes yet it provides considerably more detail and richness for a service provider to deploy. The information that RTM provides relates to event and status information on the road network and on associated infrastructure affecting a road journey. RTM does not, however, provide any specific structure to this content and there is no mandatory content. This situation could result in wide variations in the contents of messages created by different service providers across Europe. The TPEG-TEC application is designed to deliver road information specifically to navigation systems for dynamic route guidance purposes. Unlike RTM, TEC has a minimum level of mandatory information relating to the effect that an incident has on traffic flow. TEC also has a well-structured format for providing cause information using a linked set of encoding rules. This application is optimised for navigation systems because the content is delivered in a consistent and concise manner. The adoption of a single TPEG application for road traffic information across all services in Europe would be the best solution for vehicle manufacturers because it would provide a uniform structure for decoding messages. There are a number of barriers, however, that could prevent public service providers from adopting TPEG TEC. The most important obstacle is that public service providers need to cater to a much wider range of applications. While RTM is much broader and flexible this can be a drawback if applications need a concise information (that’s why it was necessary to design TEC for the routing related Use case of Navigation). As ITS applications most likely need a routable interpretation, TEC is a serious candidate for applications in a cooperative system environment.
Within VIAJEO the TPEG-RTM application will be used to deliver traffic events related information. The choice is based on the evidence that none of the services deployed during the VIAJEO project will target specific navigation devices for which the TEC application is more suitable. In any case, local service providers will be able to deploy customised TEC services starting from the RTM messages in a quite easy manner. In ANNEX a few samples of the TPEG RTM messages are given.

### 4.11 Interfaces not Considered within the Open Platform

#### 4.11.1 License Plate Recognition

A license plate recognition system is present in Beijing. As the licence plate data are solely used within a closed system and do not produce any information relevant for the applications in VIAJEO plus licence plate data imply very severe privacy issues, VIAJEO is neither foreseeing a standardized interface nor the use of those data in the open platform design. If required in future application scenarios, DATEX 2 should be flexible enough to have any relevant content modelled. As the location of the only system of this kind within VIAJEO is not located within the demonstration area the impact on the demonstration of VIAJEO is nil.
4.11.2 Road Map Data

Road Map data are provided mainly by the two major map providers Navteq and Teleatlas in standardized formats (.gdf und .psf).

As the VIAJEO platform is to be used ubiquitously anywhere in the world and the other map providers for might be more suitable in some areas, the standardization of this interface might pose an obstacle to the implementation of the VIAJEO platform. In reality, any entity requiring map data for its processes within a certain region will have an interface implemented in his system to import these data from the provider they choose. Hence, VIAJEO does not standardize this interface.
5 Design of the Functionalities of the Open Platform

The open platform designed in VIAJEO features two kinds of core functionalities depicted in the system boundary, a set of commonly defined interfaces and a well defined set of core processes building the road traffic data processing functionality. While the interfaces are specified in chapter 4, the functionalities of the core processes are depicted below.

This core processes offer the functionalities to receive specific data and information sets, to compute results on basis and to provide those results to subsequent processes.

The core process of the VIAJEO platform covers several principle functions, these are:

- Floating car data processing (see chapter 5.1 on page 71)
- Data fusion and validation (see chapter 5.2 on page 73)
- Traffic state calculation (see chapter 5.3 on page 76)
- Traffic forecast calculation (see chapter 5.4 on page 82)
- Traffic message generation (see chapter 5.4 on page 82)
- Database archiving (see chapter 5.7 on page 88)
- User Management (see chapter 5.8 on page 88)

The following figures illustrate these VIAJEO core processes in their context:
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The dark blue icons represent external data sources which feed data into the VIAJEO core processes. Interfaces on side of the core processes providing data to further external processes, such as e.g. a dynamic routing engine, would be applied to the database archiving process since all results are stored here until required.

Figure 44: Core Processes of the VIAJEO open platform
5.1 FCD Processing

Floating car data are one source of traffic data which are accepted by the traffic engine to deduce the current traffic status on the road network.

The FCD processing functionality calculates the current traffic situation based on the reported position for individual vehicles with data provided directly by the vehicles or in aggregated format (provided by a pre-processing centre). The messages are imported, matched to the road network and converted into speed and level-of-service information for the individual links of the network.

The FCD (Floating Car Data) processing step provides floating car data that can be used to calculate the current traffic situation, enrich model-based traffic data or enhance traffic messages.
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Each FCD record typically consists of numerous position block objects. A "position block" contains the FCD position messages delivered by a vehicle that is identified via a certain vehicle ID (which is however changed on a regular basis to ensure anonymity). An FCD position message contains a timestamp and the vehicle position. The vehicle speed and driving direction as an angle are optional information. In addition, further attributes can be transferred, e.g. pre-calculated LOS values. Applying a two-level procedure, consisting of NetMatching and subsequent traffic state estimation, this information can be evaluated to obtain significant traffic state data, improve the quality of the current traffic state calculation or enhance traffic messages.

5.1.1 MapMatching

As a first step of further FCD processing, the traces of the individual vehicles are referenced to the individual edges of the network using the MapMatching procedure. All information and input data are evaluated and synchronized with the geometry, topology and assigned attributes of the network.

5.1.2 Traffic State Estimator

After the FCD information has been referenced to the ITS network, the traffic state based on the speed of vehicles on individual network segments can be estimated. The traffic state estimation process does not only take the GPS position data of individual vehicles into account, but, by applying an interpolation method, can also account for the traffic state at all points of a vehicle's route. This information on the traffic state of a network can be used as a direct input parameter for current traffic conditions calculation or to validate traffic messages.

5.1.3 Process Abstract

The following figure shows an abstract process scheme for the FCD processing process:
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![Diagram](image)

Figure 46: Abstracted process chain for FCD processing

**Note:** This functionality is, depending on an existing architecture, be taken over by an core-process-external FCD centre which provides aggregated information via a DATEX 2 interface. Such a centre is represented as the blue figure reading “External FCD Data” in Figure 7 on page 13.

### 5.2 Data Fusion and Validation

The fusion process contains functions that allow data to be merged in different ways which is often required when dealing with complex traffic management tasks. Using data fusion processes, the validity of information sets and data can also be assessed by comparing different information sets from different sources. The following sections provide an overview of different functions which are normally part of a data fusion process.

#### 5.2.1 Net matching

With the aid of the net matching function, different road networks can be used as a basis for input or output data. Normally, a typical traffic state calculation will base its calculation on an internal map specifically tailored according to the internal needs and requirements.

On the side of external systems, there are often other network versions used in different subsystems.

External data referenced on these networks can be used as input data for the traffic state calculation if the given external network is first assigned to the internal network. This is can, for example, be realized using so-called network reference tables. The net matching function compares two digital road networks and identifies assignments according to the geometrical and topological correspondence of the data and their matching attributes. Even if the network structures and properties strongly differ from each other, the references found between the networks are normally of very high quality.

This network reference data is then imported into the system. It allows geocoded data from the core process network (typically traffic state, messages or traffic forecasts) to be assigned to another network.
This also works vice versa: Traffic data that has been referenced to another network than the one used by the core process can be imported via an interface and made compatible for the core process by applying a network reference table.

### 5.2.2 Traffic state combination

Depending on the system structure and input data used, the traffic state combination function might contain different traffic information data for the same link. With the traffic state combination function, these traffic states can be merged according to a set of rules specifying which of these traffic states shall actually be transferred to outside systems. The combination of traffic states allows a sequence of the traffic state calculation methods to be defined which are used to obtain a prioritization of data. For instance, the model-based Data Completion method is initially used to calculate the traffic state for the entire network. Then the traffic state for certain links is calculated using e.g. the ASDA/FOTO method that is based on detector data. This data will then overwrite the previously calculated model-based data for these links.

### 5.2.3 Traffic state harmonization

In addition to defining a sequence for the calculation methods applied to calculate the traffic state, more complex rules can also be defined, such as how the entire traffic state is compiled.

Various information sources can be combined (speed data, volume data, level-of-service values, etc.) to create one quality-assured, harmonized database. This value is calculated based on the reliability of the data source and the reliability of each of its values.

#### 5.2.3.1 Reliability of data sources

Each method used to calculate traffic state is assigned a value for reliability. For instance a higher value of reliability might be assigned to e.g. an ASDA/FOTO method than to floating car data (FCD).

#### 5.2.3.2 Reliability of individual values

Different values may feature different reliability levels. E.g. an ASDA/FOTO value can usually be considered more reliable the closer it is to the next detector. Its reliability thus decreases with increasing distance to the next detector. FCD, on the other hand, is more reliable, the more vehicles exist on the link to provide data. The reliability of individual values in connection with their calculation method can be calculated using a dedicated process. By combining both values of reliability, the total reliability for each individual value can be obtained.

Similar values for a link (independent of their data source) can then be used to define value groups. To do so, interval parameters are defined depending on the value types (e.g. speed, volume, LOS).

The values and total reliability of a group are then averaged to obtain a group value and a group reliability. These group reliabilities found for a link are compared in order to find the most reliable group. The corresponding group average value and its reliability value are finally the results that are used for further
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processing. The reliability values calculated in this way can be used to trigger the generation of a traffic message (e.g. in the event that they exceed a certain confidence threshold value).

5.2.4 Message fusion

Message fusion means that traffic messages from different sources can be combined to one message with a higher density and reliability of information. This function can e.g. be used to compare traffic messages generated by the traffic state calculation with externally obtained messages. From a procedural point of view, the messages are first spatially and temporally separated according to cause and effect. The data records are then analyzed. In a last step, matching message data is grouped. The following examples illustrate this feature:

Example 1: There is a message reporting a traffic jam due to road construction work on a link section. A traffic state calculation is performed for the same link section (e.g. using detector data or FCD) and finds that the traffic flow is hardly impeded. With message fusion only one message about a road construction work (without traffic jam) is transferred.

Example 2: There is a message reporting road construction work for a a certain stretch of road. The traffic state calculation results in a traffic jam for the same link section. The message fusion function recognizes the connection between these two incidents and generates a new message reporting a traffic jam due to road construction work.

5.2.5 Process Abstract

The following figure shows an abstract process scheme for the data fusion and validation process:

**Figure 47: Abstracted process chain for Data Fusion and Validation process**

In detail, the data validation process of roadside data is differing from the abstract sketch above. The data are also mapped onto the same network, but would be validated (e.g. by comparing neighbouring detector
values) and combined in the traffic state combination sub process where also the method for computation of the traffic state (e.g. ASDA/FOTO) is defined for each data set. The data are then forwarded to the data base archiving for retrieval by the traffic state calculation process. The traffic state harmonization is, acc. to the general function displayed above, not relevant for the validation.

The following figure shows the data fusion process for roadside data in principle:

![Data Fusion Process Diagram]

**Figure 48: Abstracted process chain for roadside data fusion and validation**

As described, traffic messages also go through a similar process chain involving the obligatory net matching and combination process.

### 5.3 Traffic State Calculation

The traffic state calculation is certainly the most decisive functionality of the VIAJEO open platform core process. It basically provides a traffic state for a given road network based on the actual conditions on the road. The traffic state calculation is comprising several core features which enable a close-to-reality result. These features are described below.

#### 5.3.1 Data Completion

As live data, be it from roadside traffic detectors or floating car data, will normally not be available for the whole network, data completion functionality is required to “fill the gaps”.
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Data Completion uses measured data at specific (point) locations to calculate the traffic state for an entire network. It is mainly deployed to estimate the traffic state on city roads and freeways. One of the strengths of the system is that data that is collected online can be linked to a validated traffic model. Compared to other methods, this allows a traffic state to be calculated based on only few well-positioned cross sections. The VIAJEO platform, using a traffic model, further provides added value through data analysis, in contrast to simple systems that merely display the traffic state in the network at the points of data collection. First of all, a traffic estimation system fulfils the task of data completion, i.e. it supplements traffic information for the parts of the road network for which there is no detector data. In the following, a typical situation is illustrated where there is no data available for a road section between two count sites and the traffic information is supplemented by the system:

During data completion there are situations in which unusual dynamics of the traffic flow can be expected. One of these situations is when a traffic detector detects a traffic jam. The data completion process is then used to model the spread of the traffic jam for the undetected part of the road network:

5.3.2 Sensitivity to measures in traffic state calculation

It is a real challenge for a system to take changes in transport supply and demand into account for traffic estimation. The capability of the system to take such additional information into account for traffic estimation is called "sensitivity to measures". Whether a road section has a reduced capacity due to an incident, construction work or traffic control is thereby irrelevant for model calculation. The following diagram schematically shows the response to traffic disruptions that is not detected by detectors: one lane of a road section between two detectors is closed due to construction work.

From a model that is "sensitive to measures" it can be expected that when a road section is congested, it will also model the traffic jam even if its effect has not spread to a detector yet.
There are generally two aspects of the effect of a traffic disruption: One aspect is that the disruption has a direct impact on the traffic flow stream, which typically leads to a tailback stream upwards and a decrease in the traffic volume stream downwards (due to the bottleneck). Another aspect is that a longer disruption causes road users to choose alternative links:

It is especially this "sensitivity to measures" that produces added value for the model based traffic estimation and forecast system, compared to information systems that are merely based on detector data. The number of detectors could be intensified to create a nearly perfect detection system for reporting a current situation, but this system could not provide a forecast of the effect of traffic control measures.

The basis of the message sensitivity is a consolidated message database. It covers a defined spatial and temporal area and contains defined effects on traffic in the form of changes to road capacity and speed. The impact of traffic incident messages are mapped to the road network before assignment is performed. During the assignment, both the decrease in road capacity and the free driving speed are taken into
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account, since both values are used by the road resistance function. Before the data propagation step, the
decrease in road capacity (described in the effects on traffic) is mapped to the links of the network model
that are listed in the geocoding data of the message. The changes in speed are also mapped to the links,
but are not relevant for data propagation. They are used later to interpret the data propagation results in
terms of traffic quality. The decrease in road capacity leads to an increase of the traffic volume on the links
affected and the data propagation might extrapolate a tailback.

5.3.3 Successive data propagation

This propagation method is based on the idea that the traffic volume detected at a cross section consists of
several traffic flow streams that branch into the network before and after the cross section. If the traffic
flow streams that the detector value is based on is known (i.e. the so-called route bundle is known),
individual streams can be distributed among the network routes. To illustrate this in an example, let us
assume that 100 vehicles were detected and it is known that 30% of them will turn right at the next
junction. This means it is known that 30 of the vehicles previously detected will take this link. For each
detector the traffic flow streams can be distributed downwards across the network. The propagated traffic
flow streams are then used to calculate a total value, the estimated traffic volume, for each link. Since this
way of tracing detector values becomes less and less reliable the more turns there are, a reliability value is
used for data propagation that decreases with increasing distance from the detector site.

Thus, to apply this method the routes that lead via a cross section must be known. This information is
provided through an automatic route estimate that is performed prior to data propagation. For data
propagation it is not relevant whether an assignment (e.g. equilibrium assignment) was used, the route
estimate is based on online data or was calculated using a certain method.

Modelling traffic jams with the aid of propagation follows a simple idea: The traffic volume can only be
continued to be propagated for a link as long as the result still meets the road capacity limits. If a lot of
traffic is propagated for a link, the difference is put in a queue. This queue is an attribute that is kept when
a switch is made from one time step to the next. If the queue reaches the storage capacity of the link, it is
propagated into preceding links. The queue is reduced when less traffic is propagated for a link than can
flow off the link according to its capacity. The traffic flow off the link is increased to link capacity as long as
there is still a queue.

5.3.4 Generation of the traffic situation on grade-separated links

For interurban areas, a method different from the one used for urban network sections is required to
provide the traffic status on the concerned road network. There are several methods of achieving this
result, among others there are:

- ASDA/FOTO (ASDA – Automatic Tracing of Moving Traffic Jams; FOTO – Forecasting of Traffic
  Objects)

ASDA/FOTO is a method used to calculate the traffic state on grade-separated links (freeways and
throughways). Thereby, the traffic state at the detected stationary cross sections is calculated every minute
and is used to identify so called "traffic objects". Traffic states are divided into three phases: free flowing
traffic ("normal"), synchronized flow and wide moving jams. These traffic objects move over the traffic
network with time, depending on current traffic messages. The ASDA/FOTO method can model this movement and thus also show the traffic state at non-detected cross sections. However, a sufficient density of cross sections is needed along the link.

**Figure 57**: Time-distance diagram of "Traffic Objects" calculated using the ASDA/FOTO method

Besides infrastructure characteristics, only the traffic volumes and speeds detected (separated by car and truck) are used to calculate the current traffic situation. This means neither traffic demand calculation nor calendars with time series for typical traffic volumes (weekdays, holidays, etc.) are used.

ASDA/FOTO requires the following input parameters:

**Static data**

- Definition of ASDA/FOTO link sections on the ITS map
- Geocoded detectors on the ITS map
- Dynamical data (online detector data)
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- Traffic volume $Q$ (vehicles per hour)
- Average speed $v$ (in kilometres per hour)

The method delivers the best results, if the dynamic data is provided per lane and every minute.

The results obtained from the ASDA/FOTO method are calculated "traffic objects" from which the following information can be deduced:

- Meter-exact position for the beginning and end of each object
- Total length
- Type (traffic jam, synchronized traffic, normal traffic)
- Speed within the traffic object
- Traffic flow $Q$ within the traffic object
- Truck Percentile of traffic flow

5.3.5 Process Abstract

The following figure shows an abstract process scheme for the traffic state calculation process:

![Abstracted process chain for Traffic State Calculation process]

**Figure 58: Abstracted process chain for Traffic State Calculation process**
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5.4 Traffic Forecast Calculation

The traffic state forecast process is used to create traffic state forecasts. This process is actually subdivided into several discrete sub-processes providing forecasts for different time horizons using different calculatory approaches. These are short-term forecasts, one-day forecasts, medium-term forecasts and long-term forecasts.

- The short-term forecast predicts the traffic states for a period of up to several hours. It is based on current data and the methods used within the traffic state calculation process (e.g. ASDA/FOTO).
- The End-of-day forecast extends the forecast period until the end of a day. It uses a model-based approach and a tailback estimator to analyze applicable traffic messages.
- The medium-term forecast sub-process is based on a traffic model and takes traffic messages valid for the time period in question into account. The time horizon encompasses one day to several months or even years.
- The long-term forecast also provides model-based results describing traffic situations in the future. In contrary to the medium term forecast it only takes traffic messages without displacement effects into account.

The quality or truthfulness (compared to reality) of a forecast naturally decreases with increasing length of the forecast period or, in other words, short term forecasts will be closer to reality than longer term forecasts.

5.4.1 Short Term Forecasts

Short term forecasts are used to predict the traffic status within a network for a time frame from minutes to several hours in the future. The following sections describe the processes used within this approach.

5.4.1.1 Short-term forecast in the data completion approach

The short-term forecast Data Completion is based on the Data Completion method for calculating the traffic state (see chapter 5.3.1). To forecast the traffic state for the entire road network, short-term forecasts use current detector data and historical data (showing typical time series, see 5.4.1.3), followed by applying the data propagation method (see 5.3.3) to extrapolate the data.

5.4.1.2 Calculating representative values for detectors

To calculate typical courses of traffic based on historical time series, the so-called clustering method can be used. The results of each detector are looked at individually with a high temporal resolution. The input parameters required for the clustering method are all day time series that are complete to a certain extent. They are differentiated by day category (e.g. "Tuesday to Thursday, during non-holiday periods") and place. Within these categories sub-groups, so-called clusters, are formed that include all day time series. Time series are similar when there is only little difference between their courses and distances. These sub-groups are used to create representatives through averaging that comprise all cluster criteria. Each category (place and day) can thus contain one or several clusters and thus representatives, depending
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on the variance of the day time series measured. The representatives of these categories are the results of the clustering method.

**Figure 59: Clusters and representatives of a place and day category**

### 5.4.1.3 Forecasts using representatives

During operation, the detector data collected is continuously compared with the cluster representatives to find the best representative for the detector. The best representative is then adjusted and used to forecast the following data for this cross section. The traffic volumes forecasted for the cross section are then propagated for the network via route selection (based on the demand valid for the forecast period) and the Data Completion method (see 5.3.1). If none of the representatives is similar enough to the present time series, or if a detector reports a traffic jam, then the current representative is discarded and a trend forecast is made instead.

The traffic jams that exist during the forecast period will then be included in the short-term forecast. The following figure illustrates the process.
A traffic state forecast with FOTO is based on the ASDA/FOTO method for traffic state calculation described in chapter 5.3.4. The underlying assumption here is that the time series of link volumes show similarities to previous ones, especially if there are disruptions. Therefore, a time series approach is followed that compares historical time series with the current time series. If a time series is found that is similar enough, it will be used to extrapolate the current detector data. The historical data used for comparison with the current data relates to a period of four weeks and is divided into two day categories (workday and weekend). The data is grouped to form 5-minute data of the directional cross section in order to reduce random fluctuation. This is done for both the current and historical time series. The comparison of day time series is based on quality-proven algorithms of the clustering method. If during this method a similar day time series is found in the pool of historical data, the raw data of this time series (per minute and lane) will serve as input parameters for a forecast of the traffic state.

This method allows the best possible forecast for each individual cross section. However, the time series of neighbouring cross sections often influence each other. To satisfyingly model such constellations, cross sections are combined into groups which influence each other into so-called count site groups. The time series of these groups are grouped and compared with the current time series. The day time series with the most similarities to the entire count site group is used to extrapolate the count data, although it might not be the one that best matches the individual count site. Count sites that do not significantly influence each other are not used to form count site groups.

5.4.2 End-of-day forecast

The so-called End-of-day forecast closes the temporal and content "gap" between the short-term forecast and the medium- and long-term forecasts, which generally provide forecasts that start the following day.
Similar to medium-term forecasts (see chapter 7.4), the short-term traffic state development is calculated with the help of a tailback estimator (see below in the example on BECKMANN/ZACKOR approach), based on model supported forecasted traffic states while considering valid traffic messages. Calculating a one-day forecast consists of the following steps that are based on each other:

- A medium-term forecast for the current day is used as a basis
- Current traffic disruptions are identified in incoming traffic messages and their impact on the reported location is pinpointed
- Based on the specified link and the corresponding time series of the medium-term forecast, the formation of a traffic jam is calculated

The traffic jam formation is estimated using a macroscopic model.

The following example illustrates a methodology based on the procedure according to BECKMANN and ZACKOR:

The method assumes that if an incoming traffic flow volume is larger than the capacity of a bottleneck, a tailback is formed that starts at the beginning of the bottleneck and grows towards the upstream traffic flow. Within the bottleneck the traffic flows with the maximum traffic volume (i.e. bottleneck capacity) and the maximum admissible speed. In the traffic jam section, the vehicles move at a selectable traffic jam speed (e.g. 20 km/h) and according to bottleneck capacity. If the traffic state in the section of the incoming, freely flowing traffic is known, the impulse wave traffic that develops between the incoming traffic and the congested traffic can be calculated. This allows the length of the tailback to be calculated for a certain time.

In general, this forecast type is used for forecasts of the current day (until midnight). For a forecast of the following day, medium-term forecasts mostly deliver similar results in terms of quality.

### 5.4.3 Medium-term forecast

The Medium-term forecast is not calculated based on the current traffic situation, but usually on basis of a traffic model. The medium term forecast also takes valid traffic messages, including model-based displacement effects, into account. The medium-term forecasts are normally calculated in advance, usually on the day before the forecast period, to avoid lengthy calculations upon actual requests. The length of the forecast period can be up to several months, depending on the network size and number of day categories available. To calculate medium-term forecasts for a project area, the traffic model uses the corresponding network supply and demand data for the respective network.

Demand data should be distinguished according to typical day schemes which may vary, depending on local traffic criteria and habits of the population (e.g. in Israel, Sunday would actually be on Friday). The following clusters are normally used as a default:

- Monday
- Tuesday to Thursday
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- Friday
- Saturday
- Sunday and holiday

The messages relevant for the forecast period are mapped to the corresponding links and change the network supply (e.g. reduced capacity due to closed lane). Depending on the network size, a day demand matrix and traffic messages are used to calculate the route selection in order to keep computing time down. This allows the medium-term forecast to be recalculated every hour. Assigning the travel demand to the network supply delivers traffic volume information for the individual link sections. Comparing this information with the capacity then allows the traffic quality to be estimated. The assignment procedure takes displacement effects due to traffic messages into account. Depending on the size of the project area, a pseudo-dynamic method is applied in addition to the assignment procedure. It accounts for the estimated travel time and if required, at the beginning of a new hour matrix, enters the previous hourly volume of a link as a basic load.

To achieve even more realistic results, additional demand data can be used alongside the static day categories to model further traffic demand situations. These additional different traffic demand situations could be:

- Holiday seasons
  - Individual weekdays before holidays
  - Individual weekdays during holidays
  - Public holidays during holidays
- Major events
  - Depending on the number of people attending/participating
- Extreme weather conditions
  - Predicted icy weather
- etc.

5.4.4 Long-term forecast

The Long-term forecast is not influenced by the current traffic situation, but is statically calculated based on a traffic model with hour-level detail. Traffic messages are also taken into account for this forecast, but without displacement effects. To calculate long-term forecasts for a network, this VIAJEKO core process uses the corresponding network supply and demand data provided by the underlying traffic model. In contrary to the short-term forecasts, traffic messages are not taken into account here and so the network supply data is not changed. Depending on the network size and the assumed travel times, traffic volumes are calculated based on a pseudo dynamic assignment procedure with day-level exact route selection.
5.5 Traffic Message Generation

Traffic messages are, on the one hand side, used for the core process internal traffic state calculations and forecasts and are, on the other hand side, also provided to external clients.

Traffic messages comprise information on traffic relevant incidents (e.g. road works) or traffic states (e.g. 2 km of traffic jam) at a certain location and a certain point of time. Some traffic messages can serve as an additional source of information on the road network, travel demand or traffic state when the traffic state is estimated.

The traffic message generation process describes the generation of traffic messages by the VIAJEO core process. The core process also accepts externally generated messages which are used in the data fusion and traffic state generation as well as traffic state prediction.

The sub processes are described in the following.

5.5.1 Message Generator

The Message Generator allows individual traffic messages to be generated based on traffic state calculation (see chapter 5.3). If, for example, detector data or FCD indicate a traffic jam on a network section, this information can be displayed as an encoded traffic message and made available for other systems via the defined interfaces.

5.5.2 Text Generator

Traffic messages are normally encoded to allow machine readability. The Text Generator can use this data to generate human-readable texts that can, for example, be displayed on a website as a traffic message list.

5.5.3 Speed Effect Generator for dynamic routing

This process computes the effects of traffic messages on basis of the current or forecast traffic state (depending on the required time horizon) and provides travel times (based on the dynamically computed traffic speeds on the network links) for an core process external dynamic routing process.

5.5.4 Consolidation of traffic messages

The information contained in traffic messages must be quantified or concretized to be included in the route estimate or propagation. Each message must include the following details:

- Location the traffic message referred to as number of links on the road network which are affected. Traffic messages that cannot be geocoded with this information cannot be included in traffic state estimates.
- Time period the traffic message is valid for
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- Effect of the message on traffic. To specify the latter, the traffic state/traffic forecast process uses the impact of the message to change basic parameters of its calculation, e.g. the road capacity and free flow speed on the affected links.

5.5.5 Provision of derived information for other processes

In a second step, the quantified effects on the network can be made available for further processes in the form of dynamic time series on the affected network segments. These time series that are updated at defined time intervals allow dynamic routing to be performed, i.e. routing that accounts for current traffic disruptions. (##Question: what is the difference to speed effect generation?)

5.5.6 Contour Generator

The contour generation process identifies the geometrical course of reported incidents. A traverse calculated in this way, for example for a traffic jam, can then be displayed on the map.

5.6 Travel Time Generation for Dynamic Routing

A common successor process for traffic state data are dynamic (in contrary to static routing engines which base their calculations on basic network features such as permitted speed) routing engines which respond to actual or forecast traffic conditions by generating dynamic routes. The VIAJEO platform is providing travel times on road links to those routers as basis for their calculations.

5.7 Database Archiving

The database services assure the short- and long term storage of all data relevant to or originating from the core process’s functions.

One main function of the database archiving is to ensure short access times for highly dynamic data, these data sets are normally stored only slightly longer than required their lifetime in the system. The other main functionality concerning the support of external services is to store the calculation results such as traffic states and messages so they can be provided upon request.

5.8 User management

All services of the VIAJEO open platform require that the calling client authenticates itself via a user name and password. In this context, it is normally not a person, but a connected computer or system. This permits the protection of the VIAJEO open platform against unauthorized access. Additionally, through authentication of the client with the access data, user-specific configurations for individual processes can be called. This allows the same process to be used but with different configurations by two separate clients.
5.9 Other Aspects

5.9.1 Georeferencing

Georeferencing is always a critical topic for operational services which rely on different map databases. As VIAJEO is designed as open platform it is very likely, that different map databases will be used by the processes connected via the platform, thus georeferencing is a core topic for the project.

Dedicated projects have born solutions to this problem, among others AGORA C and OPEN LR which are both still not fully finalized and/or very complex to implement. As VIAJEO is aiming on the establishment of openly described, standardized interfaces the very complex question of harmonised georeferencing is not focussed on in the project, but the interface definitions contain the option to include different georeferencing methodologies. In VIAJEO, the commonly used WGS84 standard will be foreseen as standard georeferencing system. In case a specific test site wishes to implement AGORA C or OPEN LR the architectural design of the platform will not prevent this, but the complex implementation may bear some risk concerning the time planning for the demonstrations.

5.9.2 Environmental Data

Environmental data are sometimes depicted in traffic information systems but are not used in the traffic models as yet, since first research projects are currently initiated. Here, data originating from environmental sensors at the road side are not directly fed into the traffic model but processed by an environmental centre first. This centre provides the data to a traffic model stating the impact on the traffic flow (e.g. reduced capacity of a road). Thus, a pre-processing of environmental data is necessary to generate those traffic related weather messages.

However, despite environmental data not being computed in the Core Process but have a standardized DATEX 2 interface defined (see chapter #) to allow easy future integration.

Alternatively, weather data is “only” provided as information to a given end user without considering it in the traffic model.
6 Recommendations towards Demonstration Sites

The technical implementation of the open platform is still to be discussed (e.g. realised using JavaOSGi) and each test site should decide for themselves by which means the open platform shall be realised. The important factor is the compliance to the open platform architecture.

- Stakeholders of each TS
- Definition of the required interfaces

In principle, WP3 will deliver the concept (this deliverable) and the test sites will implement the open platform within their dedicated work packages. In principle, interfaces between proprietary systems and the open platform should be considered to be implemented by the owner of the proprietary system as he would have the best knowledge on how to transform the data into a standardized format.

6.1 General Recommendations

This chapter holds general recommendations for all test sites, as the test sites can define the specific implementation aspects. Thus, a given test site may, for example, implement SIMONE on the OBUs of FCD vehicles for data transmission to a FCD centre or decide to maintain the proprietary interface. Also, the test site will decide upon the usage of DATEX 2 or SIMONE for the FCD centre interface delivering data to the traffic centre hosting the VIAJE0 core processes (Road Traffic Data Processing).

6.1.1 General Recommendations for DATEX 2 Interfaces

All interfaces specified according to the DATEX 2 interface should be modelled according to the DATEX 2 specification (RC1 2.0). Extensions should be applied as required, but the compatibility should be kept at level A, i.e. the original DATEX 2 model is followed. The demo sites have to clearly specify how the data to be exchanged shall be modelled within a clear DATEX 2 profile which has to be developed for each of the interfaces using the DATEX 2 standard.

The demo sites shall specify the data exchange methodology for each DATEX 2 interface implemented within their realm of responsibility within defined DATEX 2 profiles according to the requirements of the test site. DATEX 2 defines three principle methodologies, namely push periodic (describing that data are actively pushed by the server in periodic time intervals), push on occurrence (data are actively provided by the server if changes occur, e.g. if a new congestion message is appearing) and pull (meaning that the client sends a request to the server). [REFER TO USER GUIDE OF DATEX 2 FOR e.g. EACH SENTENCE].

6.1.2 Considerations concerning the Use of DATEX 2 for Road Side Data Transmission

6.1.2.1 Common Physical Architectures
DATEX 2, although versatile, can be a quite “heavy” solution – meaning that it requires considerable computing power to build the proper file formats at the host and considerable bandwidth on side of the transmission systems – as it is originally designed for centre to centre communication, where normally no limitations exist concerning those aspects.

Legacy road side units, however, can feature limited computing power and the data connection between roadside units and centre can be very limited as well, as it may consist of e.g. copper wiring with limited bandwidth. Also, the data sets provided by road side units might, depending on the existing architectures in a given site, be pre-processed or aggregated by sub-centres located in between the RSU and a traffic centre (the figure below illustrate the respective physical viewpoints).

**Figure 61: Physical Viewpoint of RSU and Sub centre Connection to Traffic Centres**

A sub centre would thus not provide classical “raw data” but elaborated or aggregated data sets.
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The test sites should consider their existing architectures and its ancillary conditions when defining the site specific DATEX 2 profiles, e.g. by using a “light” DATEX 2 profile for RSU use or by modelling the aggregated data sets provided by a sub centre instead of the raw data originating from a RSU.

6.1.2.2 Detector Identification and Location

The identification of a measurement site is provided by the called measurement site table publication. It contains information on the ID and the characteristics of the measurement site itself, its location (incl. lane ID) and, in case of a mobile platform, the vehicle.

The measurement site table in DATEX 2 can be found in the annex.

<table>
<thead>
<tr>
<th>Detector Value</th>
<th>Representation in Datex 2</th>
<th>Notes (to be partially erased for final version)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detector ID</td>
<td>MeasurementSiteIdentification</td>
<td></td>
</tr>
<tr>
<td>Timestamp</td>
<td>Time</td>
<td>Clarify: is that the data time stamp?</td>
</tr>
<tr>
<td>Lane Number</td>
<td>SpecificLane</td>
<td>In MeasurementSpecificCharacteristics</td>
</tr>
<tr>
<td>• Position of detector (Shanghai – is this the lane number or detector ID?)</td>
<td></td>
<td>Depends on what is meant by this data field</td>
</tr>
<tr>
<td>Driving direction which is covered by the detector</td>
<td>DrivingDirection</td>
<td>Extension by VIAJEO in MeasurementSpecificCharacteristics [0..1]</td>
</tr>
<tr>
<td>Detection Period (e.g. 30s)</td>
<td>Period</td>
<td>In MeasurementSpecificCharacteristics</td>
</tr>
</tbody>
</table>

Figure 62: Detector information and Location in Datex 2

The DATEX 2 model can also be extended. The following table present on hands of the data expected to be exchanged within the VIAJEO demonstration period which values are already defined and which values can to be defined as.
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Urban detectors for signal control:

<table>
<thead>
<tr>
<th>Detector Value</th>
<th>Representation in Datex 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timestamp</td>
<td>In header</td>
</tr>
<tr>
<td>Vehicle type</td>
<td>Vehicle Type</td>
</tr>
<tr>
<td>Speed</td>
<td>AverageVehicleSpeed</td>
</tr>
<tr>
<td>Occupancy</td>
<td>Extension: Occupancy</td>
</tr>
</tbody>
</table>

*Figure 63: Urban Detector information in Datex 2*

Interurban detectors:

<table>
<thead>
<tr>
<th>Detector Value</th>
<th>Representation in Datex 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle type</td>
<td>VehicleType</td>
</tr>
<tr>
<td>Speed</td>
<td>AverageVehicleSpeed</td>
</tr>
<tr>
<td>Occupancy</td>
<td>Extension: Occupancy</td>
</tr>
<tr>
<td>Traffic volume</td>
<td>PCUFlow</td>
</tr>
<tr>
<td>Long vehicle number</td>
<td>PercentageLongVehicles</td>
</tr>
</tbody>
</table>

*Figure 64: Interurban Detector information in Datex 2*

6.1.2.3 Transmission methodology

DATEX 2 foresees three different kinds of transmission methods:

- Pull periodic – meaning, that the client is periodically “pulling” the data from a server
- Push periodic – the server actively “pushes” data to the client according to a preset period
- Push on occurrence – the server actively “pushes” data once the data set has changed, e.g. if a new traffic message is generated

In case of the detectors, the server mentioned above would be the road side unit (RSU) or sub centre (SC) and the client would be the traffic centre. As new data are generated and aggregated according to preset periods the reasonable option for the communication is push or pull periodic, meaning that the RSU or SC periodically transmits the collected data to the connected centre.

The test sites will define the specific methodology within WP4 according to their ancillary conditions (see chapter 6 for details).
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6.1.3 General Recommendations concerning the information provision to services and service providers

For a widespread use of the information provided by the processes in the VIAJEO open platform it is essential, that the data and information sets can be easily accessed and retrieved by services and service providers. Web feature services (WFS) are today commonly used as communication method for requesting and delivering data sets via the applicable interfaces (TPEG RTM, IN TIME interface for routes) as this method is commonly applied in today’s data exchange networks and preferred by service providers (see chapter 6.2 for relevant interfaces).

Web map services (WMS) are similarly widespread and can be used for providing services and service providers with graphic data, e.g. map pictures featuring a route.

Note: WFS and WMS are not applicable to DATEX 2 interfaces since DATEX 2 specifies delivery mechanisms already.

6.1.4 Considerations for the FCD Interface in the Test Sites

As already mentioned in chapter 5.1, the situation concerning FCD can differ from test site to test site. Mainly this relates to the existence of a FCD centre which already provides some functionality, ranging from mapping the positions to a road network to the elaboration of traffic states on basis of the FCD.

The following figure shall illustrate the different physical architectures.

![Physical Viewpoint of RSU and Sub centre Connection to Traffic Centres](image)

The test sites should consider which physical architecture is present in their legacy environment. If the FCD are directly transmitted to the traffic centre (hosting the VIAJEO core process), SIMONE is the protocol of choice. If an FCD centre exists it is likely, that the OBUs providing the FCD will not be modified to use SIMONE but will maintain the use of the existing propriety protocols. The communication between the FCD centre and the traffic centre, on the other hand, should either be realized using SIMONE or DATEX 2, depending on the processes and resulting data sets from the FCD centre. Each test site should decide how they would like to make use of the defined interfaces within their existing ancillary conditions but should be
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aware, that the VIAJEO core process should accept FCD (or pre-processed FCD) either via a SIMONE or DATEX 2 interface.

6.1.5 Considerations concerning the Use of VDV 452 for Static Public Transport Information

Only two test sites feature any sources for static public transport information focusing on time tables and the position of public transport stops. It should be noted, that the data may only be available on paper format and thus the test sites should decide, if the specified interfaces shall be implemented in their test site since the set up of a database to feed this interface might be resource demanding.

6.1.6 Notes concerning the Use of VDV 452 for Static Public Transport Information

The enterprise architect files used to generate the figures in chapter 0 can be requested from Yannick Denis of CERTU for the test site specific modelling.

6.1.7 Considerations concerning the Use of TPEG RTM and DATEX 2 as alternative

As seen in chapter 6.2, TPEG RTM can be used instead of DATEX 2 for the supply of information and data sets at the “end of the process chain” meaning when providing data to service providers and services such as web sites. Apart from the project’s demonstration sites, this might also include radio stations as a good example. Radio stations might prefer the use of the TPEG RTM interface because the modelling of TPEG TEC or TMC formats will be less complex and costly based on this technology. The test sites should strongly consider the use of TPEG RTM in parallel or instead of DATEX 2 if they can assume the information transmitted via these interfaces will be valuable for service provider providing end user services.

6.1.8 Recommendations concerning road network data

In principle, high quality road network information is required for all calculation processes in the VIAJEO open platform as this is the very basis governing high quality results. Two major providers are currently available for providing those kinds of information, namely TeleAtlas and NavTeq. Those well renowned companies can supply map data for almost any region of the world. However, also here (especially for China) the available quality needs to be checked in detail and, if not sufficient, other sources for map data (e.g. governmental organizations responsible for mapping in a given region) have to be checked. “Off the shelf” map data featuring sufficient quality should be available for Athens and Sao Paolo, the quality of available information from the mentioned providers should be double checked with focus on the specific test areas in Shanghai and Beijing (e.g. Google maps does not base on NavTeq/TeleAtlas data).

As the topic of georeferencing is not considered in VIAJEO, the easiest way to avoid any trouble (e.g. a traffic message is applied to a different and thus “wrong” network link by the recipient than intended by the provider of the message) when exchanging georeferenced data between different systems is to use the same map provider and the same map version. Also, as the test site areas are economically highly dynamic, the road network layout may change rapidly so the map version match should not be underestimated. Also, if an “aged” version is used, the results may look somewhat awkward (e.g. a route might not be leading
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over a new bridge since the map database would not – yet – contain information on this infrastructure). However, since VIAJEO is a research project, the quality of results is not of as high importance as with a system designed to be operated over long periods of time. Regarding the latter aspect, map updates should not be foreseen in the test sites as they usually are quite time-consuming, especially if many different systems / processes are involved. As described in chapter 5.2.1, at least the netmatching references have to be adapted each time any map data base in any process is updated.

As an alternative to professional maps (which are also expensive), open source maps can be used for visual representation. This limitation exists, because they are normally updated by a group of interested entities but are prone to the risk, that not all (important) network links are contained and are also usually not fit to be used in automated processes such as routing (e.g. as the network links are not connected at intersections and important information is missing for the network links). Within a visual representation, it might be that a route may be drawn over a non-existing road section (as it may not be contained in the map data) but this is rather a visual issue concerning the presentation. Again, this will impact the perceived quality of the demonstration service but, as VIAJEO is a research project, it might be considered a secondary issue.

6.2 Test Site Specific Recommendations

This chapter holds the recommendations for each test site, where the interfaces defined in VIAJEO could be implemented in the data flows present in each site. For DATEX 2 based interfaces, the representations distinguish between the interfaces for roadside data provision (DATEX 2 LOOP, see chapter 4.4), environmental data provision (DATEX 2 Environmental, see chapter 4.5) and inter-centre communication (DATEX 2 Centre, see chapter 4.6).

In the figures for each test site, the methods web feature services (WFS) and Web Map Services (WMS) are also mentioned, but only apply to the interfaces TPEG RTM (see chapter 4.10) and IN TIME (exchange of routing information between centres, see chapter 4.7) and not to DATEX 2 interfaces, as DATEX 2 defines methods for data exchange already. In some cases, several interfaces are applicable in parallel and thus, if WMS and WFS are mentioned, these are not applicable to DATEX 2 interfaces.

Also, for integrated systems present in a test site which are described by separated functions in the data flow diagrams, the VIAJEO interfaces should not be implemented between the integrated processes as, in reality, those systems would not be torn apart just to implement standardized interfaces in between them.
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Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation/Acronym</th>
<th>Full Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCD</td>
<td>Floating Car Data</td>
</tr>
<tr>
<td>DATEX II</td>
<td>(version 2 of European standard for traffic and travel) data exchange (between traffic control and information centres as well as other actors of the traffic and travel information sector)</td>
</tr>
<tr>
<td>UTMC</td>
<td>Urban Traffic Management and Control</td>
</tr>
<tr>
<td>UN</td>
<td>User Needs</td>
</tr>
<tr>
<td>RSU</td>
<td>Road Side Unit</td>
</tr>
<tr>
<td>OBU</td>
<td>On Board Unit</td>
</tr>
<tr>
<td>RD</td>
<td>Raw Data</td>
</tr>
<tr>
<td>MRD</td>
<td>Map matched Raw Data</td>
</tr>
<tr>
<td>TT</td>
<td>Travel Time</td>
</tr>
<tr>
<td>OD</td>
<td>Origin Destination Matrix</td>
</tr>
<tr>
<td>TE</td>
<td>Traffic Event</td>
</tr>
<tr>
<td>LTZ</td>
<td>Limited Traffic Zone</td>
</tr>
<tr>
<td>PVT</td>
<td>Position, velocity, time</td>
</tr>
<tr>
<td>POI</td>
<td>Point of Interest</td>
</tr>
<tr>
<td>TMC</td>
<td>Traffic Message Channel</td>
</tr>
<tr>
<td>TPEC</td>
<td>Transport Protocol Experts Group</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modeling Language</td>
</tr>
<tr>
<td>WP</td>
<td>Work Package</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardisation</td>
</tr>
<tr>
<td>XML</td>
<td>Extensible Markup Language</td>
</tr>
<tr>
<td>XSD</td>
<td>XML Schema Definition</td>
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References

[4] SIRI – Available at www.siri.org.uk

The following figures were taken from existing material:

<table>
<thead>
<tr>
<th>Figure</th>
<th>Source</th>
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</thead>
</table>
| Figure 20 | Progetto S.I.MO.N.E.  
Definizione del protocollo di comunicazione  
Attività 2 e 3 – Deliverable 2.1 |
| Figure 21 | Progetto S.I.MO.N.E.  
Definizione del protocollo di comunicazione  
Attività 2 e 3 – Deliverable 2.1 |
| Figure 22 | ITIS Web site |
| Figure 23 | TomTom Web site |
| Figure 24 | Mediamobile web site |
| Figure 25 | CVIS Project |
| Figure 26 | TC 204 WG Web Site |
| Figure 27 | TC 204 WG Web Site |
| Figure 38 | TISA Public presentation |
| Figures 48-56 and 58-59 | PTV AG, Traffic Platform Description |
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### Appendix A – User Needs in Viajeo

<table>
<thead>
<tr>
<th>Number</th>
<th>Category</th>
<th>Short definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Public transport and car drivers</td>
<td>More complete information</td>
</tr>
<tr>
<td>2</td>
<td>Public transport and car drivers</td>
<td>More correct information</td>
</tr>
<tr>
<td>3</td>
<td>Public transport and car drivers</td>
<td>More timely information</td>
</tr>
<tr>
<td>4</td>
<td>Public transport and car drivers</td>
<td>Information on SMS to mobile phone</td>
</tr>
<tr>
<td>5</td>
<td>Public transport and car drivers</td>
<td>Information through the radio</td>
</tr>
<tr>
<td>6</td>
<td>Public transport and car drivers</td>
<td>Information via Email to personal mobile with access to the web</td>
</tr>
<tr>
<td>7</td>
<td>Public transport and car drivers</td>
<td>Information via internet</td>
</tr>
<tr>
<td>8</td>
<td>Public transport and car drivers</td>
<td>Information from restricted geographically areas</td>
</tr>
<tr>
<td>9</td>
<td>Public transport and car drivers</td>
<td>Information via enquiry hotlines</td>
</tr>
<tr>
<td>10</td>
<td>Public transport and car drivers</td>
<td>Personalised information, possibility to select which information to receive</td>
</tr>
<tr>
<td>12</td>
<td>Public transport</td>
<td>Estimated travel times of public transport</td>
</tr>
<tr>
<td>13</td>
<td>Public transport</td>
<td>Public transport timetables</td>
</tr>
<tr>
<td>14</td>
<td>Public transport</td>
<td>Accurate public transportation arriving time</td>
</tr>
<tr>
<td>15</td>
<td>Public transport</td>
<td>Information about occurred incidents affecting public transport (accidents, etc for buses, closed stations for trains, etc)</td>
</tr>
<tr>
<td>16</td>
<td>Public transport</td>
<td>Information on displays in stations and bus stops</td>
</tr>
<tr>
<td>17</td>
<td>Public transport</td>
<td>Information in the bus on arrival time at next stop</td>
</tr>
<tr>
<td>18</td>
<td>Public transport</td>
<td>Better visibility of bus stops</td>
</tr>
<tr>
<td>19</td>
<td>Car drivers</td>
<td>Estimated travel times for car drivers</td>
</tr>
<tr>
<td>20</td>
<td>Car drivers</td>
<td>Real time information regarding incidents such as accidents, strikes, closed roads due to public works, etc.</td>
</tr>
<tr>
<td>21</td>
<td>Car drivers</td>
<td>Park &amp; Ride information</td>
</tr>
<tr>
<td>22</td>
<td>Car drivers</td>
<td>Information via VMS and DMS systems</td>
</tr>
<tr>
<td>23</td>
<td>Car drivers</td>
<td>Information through personal navigation system</td>
</tr>
<tr>
<td>24</td>
<td>Cross modal</td>
<td>Best travel route based on real time traffic information</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th></th>
<th>Cross modal</th>
<th>Information on most environmental route</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Cross modal</td>
<td>Information on most environmental friendly transport mode</td>
</tr>
<tr>
<td>27</td>
<td>Visitors</td>
<td>Information in other languages than the official language</td>
</tr>
<tr>
<td>28</td>
<td>Road transport planner</td>
<td>Multi system cooperation between providers of traffic information</td>
</tr>
<tr>
<td>29</td>
<td>Road transport planner</td>
<td>Road traffic congestion information</td>
</tr>
<tr>
<td>30</td>
<td>Road transport planner</td>
<td>Traffic congestion causes</td>
</tr>
<tr>
<td>31</td>
<td>Road transport planner</td>
<td>Countermeasures analyses</td>
</tr>
<tr>
<td>32</td>
<td>Road transport planner</td>
<td>Real-time road traffic condition</td>
</tr>
<tr>
<td>33</td>
<td>Road transport planner</td>
<td>Vehicle fleet and type</td>
</tr>
<tr>
<td>34</td>
<td>Road transport planner</td>
<td>Information on traffic flows</td>
</tr>
<tr>
<td>35</td>
<td>Road transport planner</td>
<td>Tools to conduct speed measurements and occupation of lanes</td>
</tr>
<tr>
<td>36</td>
<td>Public transport planner</td>
<td>Information on freight transport in the city centre</td>
</tr>
<tr>
<td>37</td>
<td>Public transport planner</td>
<td>Multi system cooperation between providers of traffic information</td>
</tr>
</tbody>
</table>
Appendix B – UML

B.1 UML Model on IN TIME Interface for multimodal routes

From the High Level Description, two different UML models are derived. One for the request and another for the response.
Figure 66: Minimum sets of Feature Types and DataTypes in IN TIME Route Interface
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Figure 67: InterfaceResponseClass in IN TIME Route Interface
B.2 UML Model for the Roadside Environmental Interface

The following figures are taken from the DATEX 2 documentation and can act as guideline for the test sites on how to model the environmental data according to the DATEX 2 model.

![UML Diagram](image)

*Figure 68: Payload Publication of DATEX 2 to Model Environmental Data*
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Figure 69: Measured Data Class of DATEX 2 to Model Environmental Data
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Figure 70: Basic Data Value Class of DATEX 2 to Model Environmental Data
Figure 71: Weather Value Class of DATEX 2 to Model Environmental Data
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The view on the element by xml-spy is provided below:

Figure 72: Weather Value Class of DATEX 2 in xmlspy view
B.3 UML Model for the DATEX 2 Based Roadside Traffic Count Interface

The following figures are taken from the DATEX 2 documentation and can act as guideline for the test sites on how to model the roadside traffic count data according to the DATEX 2 model.

B.3.1 Detector Identification and Location

The following figure shows the measurement site table publication.

Figure 73: Measurement Site Table Publication of DATEX 2 to Model Detector Location
B.3.2 Roadside Traffic Data

The following figure shows the traffic value class of the Datex 2 basic data value class.

Figure 74: Traffic Value Class of DATEX 2 to Model Roadside Count Data
The related logical model is provided in the following figure:

Figure 75: View of Logical Model of DATEX 2 to Model Roadside Count Data
Figure 76: Detailed View of Logical Model of DATEX 2 Measurement Site Table
Figure 77: Detailed View of Logical Model of DATEX 2 Measurement Site Record
Figure 78: Detailed View of Logical Model of DATEX 2 Measurement Specific Characteristics and D2LogicalModelLocation
B.3.3 Dynamic Public Transport Data – The SIRI Study Model

This model provides a global view of the “SIRI data”. We can see a lot of imbrications and redundancies. In order to facilitate the reading of the scheme, the color meaning is this one:

- “salmon” and white rectangle: respectively, elements of the SIRI transport layer (F.ex. ServiceDelivery), and of the SIRI service layer (p.ex. StopModelDelivery);
- “yellow lemon” rectangle: concrete elements of a message,
- “straw yellow” rectangle: components of a message.

The six first diagrams show the SIRI messages and the seventh the general structure of the messages. The two last diagrams show the types respectively simple and complex of data which are not necessary called in the first diagrams.
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![Diagram](image)

Figure 80: SIRI Estimated(Time)TableDelivery
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Figure 81: SIRI StopTimetableDelivery
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Figure 82: SIRI MonitoringVehicleJourney
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Figure 83: SIRI StopMonitoringDelivery
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Figure 84: SIRI GeneralMessageDelivery
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Figure 85: SIRI ConnectionTimetableDelivery

---

[Diagram of SIRI ConnectionTimetableDelivery]
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<table>
<thead>
<tr>
<th>DistributorDepartureCancellation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason[0..1] : nString</td>
</tr>
<tr>
<td>Extensions[0..1] : any</td>
</tr>
</tbody>
</table>

Figure 86: SIRI DistributorDepartureCancellation
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Figure 87: SIRI Simple DataTypes
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Figure 78: SIRI ComplexDataTypes

Figure 88: SIRI SimpleDataTypes
Appendix C – XSD Schemas

C.1 XSD of the Datex 2 Detector Identification and Location for Road Side Traffic Data Provision

The .xsd for the site measurement looks like:

```xml
<xs:complexType name="SiteMeasurements">
  <xs:sequence>
    <xs:element name="measurementSiteReference" type="D2LogicalModel:Reference"/>
    <xs:element name="measurementTimeDefault" type="D2LogicalModel:DateTime"/>
    <xs:element name="measuredValue" maxOccurs="unbounded">
      <xs:complexType>
        <xs:complexContent>
          <xs:extension base="D2LogicalModel:MeasuredValue">
            <xs:attribute name="index" type="xs:int" use="required"/>
          </xs:extension>
        </xs:complexContent>
      </xs:complexType>
    </xs:element>
    <xs:element name="siteMeasurementsExtension" type="D2LogicalModel:ExtensionType" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
```
C.2 XSD of the Datex 2 Weather Value Class

The related XSD looks like the following [to be placed in the annex later]:

```xml
<xs:complexType name="PollutionMeasurement">
  <xs:documentation>Details of atmospheric pollution.</xs:documentation>
  <xs:sequence>
    <xs:element name="pollutantConcentration" type="D2LogicalModel:ConcentrationMicrogramsPerCubicMetre">
      <xs:annotation>
        <xs:documentation>The average concentration of the pollutant in the air.</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="pollutantType" type="D2LogicalModel:PollutantTypeEnum">
      <xs:annotation>
        <xs:documentation>The type of pollutant in the air.</xs:documentation>
      </xs:annotation>
    </xs:element>
    <xs:element name="pollutionMeasurementExtension" type="D2LogicalModel:ExtensionType" minOccurs="0"/>
  </xs:sequence>
</xs:complexType>
```

C.3 XSD for the IN TIME Interface for Dynamic Multimodel Journey Planning

```xml
<xs:schema targetNamespace="http://namespace.emotion-project.eu/version/Final2.1.0/jp" elementFormDefault="qualified" version="Final2.1.0">
  <annotation>
    <documentation>This package contains everything needed for inter-modal journey planning.</documentation>
  </annotation>
  <import namespace="http://namespace.emotion-project.eu/version/Final2.1.0/ctypes" schemaLocation="eMotionVersionFinal2.1.0-CommonTypes.xsd"/>
  <import namespace="http://namespace.emotion-project.eu/version/Final2.1.0/pubtrans" schemaLocation="eMotionVersionFinal2.1.0-PublicTransport.xsd"/>
  <import namespace="http://namespace.emotion-project.eu/version/Final2.1.0/fixinf" schemaLocation="eMotionVersionFinal2.1.0-FixedInfrastructure.xsd"/>
  <import namespace="http://namespace.emotion-project.eu/version/Final2.1.0/locref" schemaLocation="eMotionVersionFinal2.1.0-LocationReference.xsd"/>
  <import namespace="http://www.opengis.net/gml" schemaLocation="./ISO19139-GML311/gml/3.1.1/base/gml.xsd"/>
  <element name="JP_Journeys" type="ejp:JP_JourneysType" substitutionGroup="gml:Feature"/>
</xs:schema>
```
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```xml
<complexType name="JP_JourneysType">
  <complexContent>
    <extension base="gml:AbstractFeatureType">
      <sequence>
        <element name="madeUpOf" type="ejp:JP_JourneyPropertyType" maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<complexType name="JP_JourneysPropertyType">
  <sequence minOccurs="0">
    <element ref="ejp:JP_Journeys"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
</complexType>

<element name="JP_Journey" type="ejp:JP_JourneyType" substitutionGroup="ect:EMotionFeature"/>

<complexType name="JP_JourneyType">
  <complexContent>
    <extension base="ect:EMotionFeatureType">
      <sequence>
        <element name="madeUpOf" type="ejp:JP_LegPropertyType" maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<complexType name="JP_JourneyPropertyType">
  <sequence minOccurs="0">
    <element ref="ejp:JP_Journey"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
</complexType>

<element name="JP_AllModesEnum" type="ejp:JP_AllModesEnumType" substitutionGroup="gml:_Object"/>

<complexType name="JP_AllModesEnumType">
  <choice>
    <element name="accessModesIncluded" type="ept:AccessModesEnumType" minOccurs="0" maxOccurs="unbounded"/>
    <element name="vehicleModesIncluded" type="ept:VehicleModePropertyType" minOccurs="0" maxOccurs="unbounded"/>
  </choice>
</complexType>

<complexType name="JP_AllModesEnumPropertyType">
  <sequence>
    <element ref="ejp:JP_AllModesEnum"/>
  </sequence>
</complexType>

<element name="JP_Map" type="ejp:JP_MapType" substitutionGroup="gml:_Object"/>

<complexType name="JP_MapType">
  <sequence>
    <element name="renderedMapURL" type="string" minOccurs="0"/>
  </sequence>
</complexType>
```
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- <element name="mapping" minOccurs="2" maxOccurs="unbounded">
  - <complexType>
    - <choice minOccurs="0">
      <element ref="elr:PointGeometry"/>
      <element ref="elr:PointLocationReferenceCollection"/>
      <element ref="elr:OpenLRPoint"/>
    </choice>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </complexType>
</element>

- <complexType name="JP_MapPropertyType">
  - <sequence>
    <element ref="ejp:JP_Map"/>
  </sequence>
</complexType>

- <complexType name="LimitedInterval" type="ejp:LimitedIntervalType" substitutionGroup="gml:_Object">
  - <complexType name="LimitedIntervalType">
    - <sequence>
      <element name="max" type="integer"/>
      <element name="interval" type="dateTime"/>
      <element name="min" type="integer" minOccurs="0"/>
      <element name="maxInterval" type="dateTime" minOccurs="0"/>
    </sequence>
  </complexType>
</complexType>

- <complexType name="LimitedIntervalPropertyType">
  - <sequence minOccurs="0">
    <element ref="ejp:LimitedInterval"/>
  </sequence>
</complexType>

- <complexType name="JP_OriginDestinationNodeType">
  - <complexContent>
    - <extension base="gml:AbstractFeatureType">
      - <sequence>
        <element name="journeyTime" type="dateTime" minOccurs="0"/>
        <element name="place" type="ept:PlacePropertyType" minOccurs="0" maxOccurs="unbounded"/>
        <element name="uses" type="ejp:JP_SeedPropertyType" minOccurs="0"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

- <complexType name="JP_OriginDestinationNodePropertyType">
  - <sequence minOccurs="0">
    <element ref="ejp:JP_OriginDestinationNode"/>
  </sequence>
</complexType>

- <complexType name="JP_OriginDestinationNode" substitutionGroup="gml:_Feature">
  - <complexContent>
    - <extension base="gml:AbstractFeatureType">
      - <sequence>
        <element name="journeyTime" type="dateTime" minOccurs="0" maxOccurs="unbounded"/>
        <element name="place" type="ept:PlacePropertyType" minOccurs="0" maxOccurs="unbounded"/>
        <element name="uses" type="ejp:JP_SeedPropertyType" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>
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<element name="JP_Range" type="ejp:JP_RangeType" substitutionGroup="ejp:JP_RangeType"/>

<complexType name="JP_RangeType">
  -
  <complexContent>
    <extension base="ejp:JP_RangeTypeType">
      <sequence>
        <element name="eachOrigin" type="boolean"/>
        <element name="eachDestination" type="boolean"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<complexType name="JP_RangePropertyType">
  -
  <sequence>
    <element ref="ejp:JP_Range"/>
  </sequence>
</complexType>

<element name="JP_FreightVehicle" type="ejp:JP_FreightVehicleType" substitutionGroup="gml:_Object"/>

<complexType name="JP_FreightVehicleType">
  -
  <sequence>
    <element name="averageConsumption" type="double" minOccurs="0"/>
    <element name="COS2emission" type="double" minOccurs="0"/>
    <element name="height" type="double" minOccurs="0"/>
    <element name="weight" type="double" minOccurs="0"/>
    <element name="width" type="double" minOccurs="0"/>
  </sequence>
</complexType>

<complexType name="JP_FreightVehiclePropertyType">
  -
  <sequence>
    <element ref="ejp:JP_FreightVehicle"/>
  </sequence>
</complexType>

<element name="JP_Seed" type="ejp:JP_SeedType" substitutionGroup="gml:_Feature"/>

<complexType name="JP_SeedType">
  -
  <complexContent>
    <extension base="gml:AbstractFeatureType">
      <sequence>
        <element name="startTime" type="dateTime" minOccurs="0"/>
        <element name="numChanges" type="integer" minOccurs="0"/>
        <element name="walkDistance" type="integer" minOccurs="0"/>
        <element name="service" type="ept:ServicePropertyType"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<complexType name="JP_SeedPropertyType">
  -
  <sequence minOccurs="0">
    <element ref="ejp:JP_Seed"/>
  </sequence>
</complexType>
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<attributeGroup ref="gml:AssociationAttributeGroup"/>
</complexType>
<element name="JP_LimitedInterval" type="ejp:JP_LimitedIntervalType" substitutionGroup="gml:_Object"/>
−
<complexType name="JP_LimitedIntervalType">
−
<sequence>
<element name="max" type="integer"/>
<element name="interval" type="dateTime"/>
<element name="min" type="integer" minOccurs="0"/>
<element name="maxInterval" type="dateTime" minOccurs="0"/>
</sequence>
</complexType>
−
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<sequence>
<element ref="ejp:JP_LimitedInterval"/>
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</complexType>
<element name="JP_RangeType" type="ejp:JP_RangeTypeType" substitutionGroup="gml:_Object"/>
−
<complexType name="JP_RangeTypeType">
−
<sequence>
<element name="interval" type="dateTime" minOccurs="0"/>
<element name="sequence" type="integer" minOccurs="0"/>
<element name="limInterval" type="ejp:LimitedIntervalPropertyType" minOccurs="0"/>
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</complexType>
−
<complexType name="JP_RangeTypePropertyType">
−
<sequence>
<element ref="ejp:JP_RangeType"/>
</sequence>
</complexType>
<element name="JP_OriginDestinationRequestType" type="ejp:JP_OriginDestinationRequestTypeType" substitutionGroup="gml:_Object"/>
−
<complexType name="JP_OriginDestinationRequestTypeType">
−
<sequence>
<element name="givenName" type="string" minOccurs="0"/>
<element name="madeUpOf" type="ejp:JP_OriginDestinationNodePropertyType" maxOccurs="unbounded"/>
</sequence>
</complexType>
−
<complexType name="JP_OriginDestinationRequestTypePropertyType">
−
<sequence>
<element ref="ejp:JP_OriginDestinationRequestType"/>
</sequence>
</complexType>
−
<simpleType name="JP_ArriveDepartTypeType">
−
<restriction base="string">  
<enumeration value="arrive"/>  
<enumeration value="depart"/>  
</restriction>
</simpleType>
<element name="JP_Points" type="ejp:JP_PointsType" substitutionGroup="gml:_Feature"/>
−
<complexType name="JP_PointsType"/>
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```xml
<complexContent>
  <extension base="gml:AbstractFeatureType">
    <sequence>
      <element name="madeUpOf" type="ept:StopPointPropertyType" maxOccurs="unbounded"/>
    </sequence>
  </extension>
</complexContent>

<complexType name="JP_PointsPropertyType">
  <sequence minOccurs="0">
    <element ref="ejp:JP_Points"/>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </sequence>
</complexType>

<complexType name="JP_ContinuousLegType">
  <annotation>
    <documentation>
      A Continuous Leg is a leg that is not associated to any type of schedule. For example it can be a walk, car or taxi leg
    </documentation>
  </annotation>
  <complexContent>
    <extension base="ejp:JP_LegType">
      <sequence>
        <element name="continuousLegInformation" type="ejp:JP_ContinuousLegTypePropertyType" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>

<complexType name="JP_ContinuousLegPropertyType">
  <sequence>
    <element ref="ejp:JP_ContinuousLeg"/>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </sequence>
</complexType>

<complexType name="JP_FrequencyGroupType">
  <sequence>
    <element name="definedAsFrequency" type="ejp:JP_FrequencyPropertyType" minOccurs="0" maxOccurs="unbounded"/>
  </sequence>
</complexType>

<complexType name="JP_FrequencyGroupPropertyType">
  <sequence>
    <element ref="ejp:JP_FrequencyGroup"/>
    <attributeGroup ref="gml:AssociationAttributeGroup"/>
  </sequence>
</complexType>

<element name="JP_ReturnedNode" type="ejp:JP_ReturnedNodeType" substitutionGroup="gml:_Object"/>
```
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<xsd:complexType name="JP_ReturnedNodeType">
  <xsd:sequence>
    <xsd:element name="timingInformationPoint" type="boolean"/>
    <xsd:element name="ETA" type="dateTime" minOccurs="0"/>
    <xsd:element name="returnedPlace" type="ept:PlacePropertyType" minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="JP_ReturnedNodePropertyType">
  <xsd:sequence>
    <xsd:element ref="ejp:JP_ReturnedNode"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="JP_Frequency" type="ejp:JP_FrequencyType" substitutionGroup="gml:_Object"/>

<xsd:complexType name="JP_FrequencyType">
  <xsd:sequence>
    <xsd:element name="max" type="duration"/>
    <xsd:element name="min" type="duration"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="JP_FrequencyPropertyType">
  <xsd:sequence>
    <xsd:element ref="ejp:JP_Frequency"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="JP_InterchangeLegType" type="ejp:JP_InterchangeLegTypeType" substitutionGroup="ect:EMotionFeature"/>

<xsd:complexType name="JP_InterchangeLegTypeType">
  <xsd:complexContent>
    <xsd:extension base="ect:EMotionFeatureType">
      <xsd:sequence>
        <xsd:element name="notes" type="string"/>
        <xsd:element name="interchangeLegOrigin" type="ejp:JP_ReturnedNodePropertyType"/>
        <xsd:element name="interchangeLegDestination" type="ejp:JP_ReturnedNodePropertyType"/>
        <xsd:element name="map" type="ejp:JP_MapPropertyType" minOccurs="0"/>
        <xsd:element name="interchangeSchematics" type="string" minOccurs="0"/>
        <xsd:element name="describedAs" type="ejp:JP_InterchangePathPropertyType" minOccurs="0" maxOccurs="unbounded"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:complexType name="JP_InterchangeLegTypePropertyType">
  <xsd:sequence>
    <xsd:element ref="ejp:JP_InterchangeLegType"/>
  </xsd:sequence>
  <xsd:attributeGroup ref="gml:AssociationAttributeGroup"/>
</xsd:complexType>

<xsd:element name="JP_Leg" type="ejp:JP_LegType" substitutionGroup="gml:_Feature"/>

<xsd:complexType name="JP_LegType">
  <xsd:complexContent>
  "i"
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```xml
<extension base="gml:AbstractFeatureType">
  <sequence>
    <element name="requestId" type="string"/>
    <element name="legCost" type="double"/>
  </sequence>
</extension>
</complexContent>
<complexType name="JP_LegPropertyType">
  <sequence minOccurs="0">
    <element ref="ejp:JP_Leg"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
</complexType>
<element name="JP_InterchangePath" type="ejp:JP_InterchangePathType" substitutionGroup="gml:_Object"/>
<complexType name="JP_InterchangePathType">
  <sequence>
    <element ref="ejp:JP_InterchangePath"/>
  </sequence>
</complexType>
<complexType name="JP_InterchangePathPropertyType">
  <sequence minOccurs="0">
    <element ref="ejp:JP_InterchangePath"/>
  </sequence>
</complexType>
<element name="JP_ContinuousLegType" type="ejp:JP_ContinuousLegTypeType" substitutionGroup="ect:EMotionFeature"/>
<complexType name="JP_ContinuousLegTypeType">
  <complexContent>
    <extension base="ect:EMotionFeatureType">
      <sequence>
        <element name="notes" type="string" minOccurs="0" maxOccurs="unbounded"/>
        <element name="mode" type="ept:AccessModesEnumType"/>
        <element name="CO2emission" type="double" minOccurs="0" maxOccurs="unbounded"/>
        <element name="fuelConsumption" type="double" minOccurs="0" maxOccurs="unbounded"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>
<complexType name="JP_ContinuousLegTypePropertyType">
  <sequence minOccurs="0">
    <element ref="ejp:JP_ContinuousLegType"/>
  </sequence>
</complexType>
</complexType>
```

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<complexContent>
  <extension base="ejp:JP_LegType">
    <sequence>
      <element name="interchangeLegInformation" type="ejp:JP_InterchangeLegTypePropertyType" minOccurs="0" maxOccurs="unbounded"/>
    </sequence>
  </extension>
</complexContent>
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<restriction base="string">
<enumeration value="default"/>
<enumeration value="fastest"/>
<enumeration value="noChanges"/>
<enumeration value="max1Change"/>
<enumeration value="max2Changes"/>
<enumeration value="leastWalking"/>
<enumeration value="leastConst"/>
</restriction>
</simpleType>

<simpleType name="JP_HazardsType">
<restriction base="string">
<enumeration value="escalator"/>
<enumeration value="stairs"/>
<enumeration value="lift"/>
<enumeration value="ramp"/>
<enumeration value="difficultSurface"/>
<enumeration value="notIlluminated"/>
<enumeration value="other"/>
</restriction>
</simpleType>

<complexType name="JP_ServicesPropertyType">
<sequence>
<element ref="ejp:JP_Services"/>
</sequence>
</complexType>

<complexType name="JP_Via_NodeType">
<complexContent>
<extension base="gml:AbstractFeatureType">
<sequence>
<element name="duration" type="time" minOccurs="0"/>
<element name="exclModes" type="ejp:JP_ModesPropertyType" minOccurs="0"/>
</sequence>
</extension>
</complexContent>
</complexType>

<element name="JP_Via_Node" type="ejp:JP_Via_NodeType" substitutionGroup="gml:_Feature"/>

<complexType name="JP_ServicesPropertyType">
<sequence>
<element name="exclude" type="boolean"/>
<element name="madeUpOf" minOccurs="0" maxOccurs="unbounded" type="ept:ServicePropertyType"/>
</sequence>
</complexType>

<complexType name="JP_ServicesType">
<sequence>
</sequence>
</complexType>

<element name="JP_Services" type="ejp:JP_ServicesType" substitutionGroup="gml:_Object"/>

<complexType name="JP_ServicesType">
<sequence>
</sequence>
</complexType>

<element name="JP_IntermediateStopsRequestTypeType">
<restriction base="string">
<enumeration value="all"/>
<enumeration value="before"/>
<enumeration value="beforeAndLeg"/>
<enumeration value="leg"/>
<enumeration value="legAndAfter"/>
<enumeration value="after"/>
<enumeration value="none"/>
</restriction>
</simpleType>

<element name="JP_IntermediateStopsRequestType" type="ejp:JP_IntermediateStopsRequestTypeType" substitutionGroup="gml:_Object"/>

<complexType name="JP_ModesPropertyType">
<sequence>
</sequence>
</complexType>

<complexType name="JP_ModesType">
<sequence>
<element ref="ejp:JP_Modes"/>
</sequence>
</complexType>

<element name="JP_Modes" type="ejp:JP_ModesType" substitutionGroup="gml:_Object"/>

<complexType name="JP_ServicesType">
<sequence>
</sequence>
</complexType>

<element name="JP_Services" type="ejp:JP_ServicesType" substitutionGroup="gml:_Object"/>

<complexType name="JP_HazardsType">
<restriction base="string">
<enumeration value="escalator"/>
<enumeration value="stairs"/>
<enumeration value="lift"/>
<enumeration value="ramp"/>
<enumeration value="difficultSurface"/>
<enumeration value="notIlluminated"/>
<enumeration value="other"/>
</restriction>
</simpleType>
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<element name="inclModes" type="ejp:JP_ModesPropertyType" minOccurs="0"/>
<element name="viaPlace" type="ept:PlacePropertyType" minOccurs="0" maxOccurs="unbounded"/>
</sequence>
</extension>
</complexContent>
</complexType>
−
<complexType name="JP_Via_NodePropertyType">
−
<sequence minOccurs="0">
−
<element ref="ejp:JP_Via_Node"/>
</sequence>
<attributeGroup ref="gml:AssociationAttributeGroup"/>
</complexType>
<element name="JP_NotVia" type="ejp:JP_NotViaType" substitutionGroup="gml:_Object"/>
−
<complexType name="JP_NotViaPropertyType">
−
<sequence>
−
<element ref="ejp:JP_NotVia"/>
</sequence>
</complexType>
<element name="JP_Modes" type="ejp:JP_ModesType" substitutionGroup="gml:_Object"/>
−
<complexType name="JP_ModesPropertyType">
−
<sequence>
−
<element ref="ejp:JP_Modes"/>
</sequence>
</complexType>
<element name="JP_NotVia_Node" type="ejp:JP_NotVia_NodeType" substitutionGroup="gml:_Feature"/>
<complexContent>
<extension base="gml:AbstractFeatureType">
  <sequence>
    <element name="notViaPlace" type="ept:PlacePropertyType" minOccurs="0" maxOccurs="unbounded"/>
  </sequence>
</extension>
</complexContent>

<complexType name="JP_NotVia_NodePropertyType">
  <sequence minOccurs="0">
    <element ref="ejp:JP_NotVia_Node"/>
  </sequence>
  <attributeGroup ref="gml:AssociationAttributeGroup"/>
</complexType>

<element name="JP_Via_NotVia" type="ejp:JP_Via_NotViaType" substitutionGroup="gml:_Object"/>

<complexType name="JP_Via_NotViaType">
  <choice>
    <element name="includesNotVia" type="ejp:JP_NotViaPropertyType" minOccurs="0" maxOccurs="unbounded"/>
    <element name="includesVia" type="ejp:JP_ViaPropertyType" minOccurs="0"/>
  </choice>
</complexType>

<complexType name="JP_Via_NotViaPropertyType">
  <sequence>
    <element ref="ejp:JP_Via_NotVia"/>
  </sequence>
</complexType>

<element name="JP_Via" type="ejp:JP_ViaType" substitutionGroup="gml:_Object"/>

<complexType name="JP_ViaType">
  <sequence>
    <element name="givenName" type="string" minOccurs="0"/>
    <element name="viaMadeUpOf" type="ejp:JP_Via_NodePropertyType" maxOccurs="unbounded"/>
  </sequence>
</complexType>

<complexType name="JP_ViaPropertyType">
  <sequence>
    <element ref="ejp:JP_Via"/>
  </sequence>
</complexType>
</schema>