**D3.1 Data models, object models and ontology definition**

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</tr>
<tr>
<td>Author(s) :</td>
<td>Sergio Campos, Iraide Unanue, Begoña Molinete</td>
</tr>
<tr>
<td>Partner(s) contributing :</td>
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**Abstract:** This document describes the current outcome of Task 3.1, which addresses the definition of MoveUs data and objects model. At this stage, the focus is put on the main functional modules supporting the provision of multimodal, personalized and eco-efficient mobility services.
### Data models, object models and ontology definition

#### HISTORY

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## Contents

HISTORY ......................................................................................................................... 2
Contents ......................................................................................................................... 3
List of Figures ................................................................................................................ 5
List of Tables ................................................................................................................... 6
List of Abbreviations ..................................................................................................... 7
Executive Summary ....................................................................................................... 9
1 MoveUs Overview .................................................................................................... 10
2 Methodology ............................................................................................................. 11
3 MoveUs data model .................................................................................................. 15
    3.1 Functional block User Management ................................................................... 15
    3.1.1 Existing specifications .................................................................................... 15
    3.1.2 Extensions ..................................................................................................... 16
    3.2 Functional block Traffic Management ............................................................... 23
    3.2.1 Existing specifications .................................................................................... 24
    3.2.2 Extensions ..................................................................................................... 36
    3.3 Public Transport Operation Management ......................................................... 48
    3.3.1 Existing specifications .................................................................................... 48
    3.3.2 Extensions ..................................................................................................... 50
    3.4 Functional Traveller Journey Assistance ............................................................ 52
    3.4.1 Existing specifications .................................................................................... 53
    3.4.2 Extensions ..................................................................................................... 56
    3.5 Functional block Incentive Management ............................................................ 57
    3.5.1 Existing specifications .................................................................................... 59
    3.5.2 Extensions ..................................................................................................... 59
    3.6 Functional block CF/EC Estimation .................................................................... 64
    3.6.1 Existing specifications .................................................................................... 65
    3.6.2 Extensions ..................................................................................................... 65
    3.7 Functional block Feedback ................................................................................ 66
    3.7.1 Existing specifications .................................................................................... 66
    3.7.2 Extensions ..................................................................................................... 67
    3.8 Functional Block Registry .................................................................................. 67
    3.8.1 Existing specifications .................................................................................... 67
    3.8.2 Extensions ..................................................................................................... 67
List of Figures

Figure 1 MoveUs data model definition process ................................................. 12
Figure 2 eMotion status & scope ........................................................................ 12
Figure 3 In-Time status & scope ......................................................................... 13
Figure 4 Co-Cities status & scope ...................................................................... 14
Figure 5 User management extensions (Taxonomy) ............................................. 17
Figure 6 User management extensions (Information) .......................................... 22
Figure 7 User management extensions (Organizations) ...................................... 23
Figure 8 Road Data Model .................................................................................. 26
Figure 9 Traffic Related Data ............................................................................. 27
Figure 10 Measured data publication .................................................................. 28
Figure 11 Data values .......................................................................................... 30
Figure 12 Elaborated data publication ................................................................. 31
Figure 13 Incidence Related Data ...................................................................... 33
Figure 14 Incidence Related Data. Non road Event ........................................... 33
Figure 15 Dynamic Weather Model .................................................................. 34
Figure 16 Dynamic Traffic Event Information ..................................................... 35
Figure 17 Dynamic Parking Model .................................................................... 36
Figure 18 Intersection information static model (partial view) ......................... 39
Figure 19 Intersection data frame ...................................................................... 40
Figure 20 Approach Object data frame ............................................................... 40
Figure 21 Intersection static info global data model .......................................... 42
Figure 22 Intersection static info global data model. Lane information .............. 43
Figure 23 BT readers (BTFix receptors) static model ........................................ 43
Figure 24 BT readers (BTFix receptors) dynamic model ................................... 44
Figure 25 SPAT data model ............................................................................... 45
Figure 26 SRM data model ................................................................................. 46
Figure 27 SSM data model ................................................................................ 47
Figure 28 Dynamic Bike sharing Model .............................................................. 48
Figure 29 Public Transport (PT) Service Model ............................................... 49
Figure 30 Carpooling Service Model ................................................................ 50
Figure 31 PT Line Management Model ............................................................. 51
Figure 32 PT Line Management Model (detail) .................................................. 52
Figure 33 Journey Planning services ................................................................. 54
Figure 34 Journey Planning services (II) ............................................................ 54
Figure 35 Journey Planning services ................................................................. 55
Figure 36 Link between Journeys and Incentives .............................................. 56
Figure 37 Journey with additional information .................................................. 56
Figure 38 Trace Spatio-temporal information ..................................................... 56
Figure 39 Incentive Management Functional View .......................................... 57
Figure 40 Incentive Currencies ......................................................................... 60
Figure 41 Incentive Transactions ...................................................................... 61
Figure 42 Incentive & Rules .............................................................................. 62
Figure 43 Coupons & Awards ............................................................................ 64
Figure 44 Feedback Model ................................................................................. 67
Figure 45 Registry Model .................................................................................. 69
Data models, object models and ontology definition

List of Tables

Table 1 MoveUs users ........................................................................................................18
Table 2 MoveUs equipment and systems .........................................................................18
Table 3 Incentive data blocks ..........................................................................................58
Table 4 Measure/Currency Units ......................................................................................59
Table 5 Energy Efficiency concepts ..................................................................................65
### List of Abbreviations

<table>
<thead>
<tr>
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</tr>
<tr>
<td>ATOS</td>
<td>ATOS SPAIN</td>
</tr>
<tr>
<td>BSM</td>
<td>Basic Safety Message</td>
</tr>
<tr>
<td>BT</td>
<td>Bluetooth</td>
</tr>
<tr>
<td>BTFix</td>
<td>Fix Bluetooth Reader</td>
</tr>
<tr>
<td>CF</td>
<td>Carbon Footprint</td>
</tr>
<tr>
<td>D</td>
<td>Deliverable</td>
</tr>
<tr>
<td>DATEX2</td>
<td>Standard for ITS on European Roads</td>
</tr>
<tr>
<td>EC</td>
<td>Energy Consumption</td>
</tr>
<tr>
<td>EMT</td>
<td>Empresa Municipal de Transportes de Madrid</td>
</tr>
<tr>
<td>FCD</td>
<td>Floating Car Data</td>
</tr>
<tr>
<td>ID</td>
<td>Identification</td>
</tr>
<tr>
<td>IFOPT</td>
<td>Identification of Fixed Objects in Public Transport</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transport System</td>
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<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
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<td>MAP</td>
<td>Map Data</td>
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<tr>
<td>MSG</td>
<td>Message</td>
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<td>POI</td>
<td>Point of Interest</td>
</tr>
<tr>
<td>PT</td>
<td>Public Transport</td>
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<tr>
<td>RHW</td>
<td>Road Hazard Warning</td>
</tr>
<tr>
<td>RSU</td>
<td>Road Side Unit</td>
</tr>
<tr>
<td>RT</td>
<td>Real Time</td>
</tr>
<tr>
<td>SAE</td>
<td>SAE international (Society of Automotive Engineers)</td>
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<td>SICE</td>
<td>Sociedad Ibérica de Construcciones Eléctricas, S.A.</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
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<tr>
<td>SIRI</td>
<td>Service Interface for Real Time Information</td>
</tr>
<tr>
<td>SOF</td>
<td>Softeco Sismat Srl</td>
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<tr>
<td>SPAT</td>
<td>Signal Phase And Timing Message</td>
</tr>
<tr>
<td>SRM</td>
<td>Signal Request Message</td>
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<tr>
<td>SSM</td>
<td>Signal Status Message</td>
</tr>
<tr>
<td>TECNALIA</td>
<td>Tecnalia Research and Innovation</td>
</tr>
<tr>
<td>TPEG</td>
<td>Transport Protocol Experts Group</td>
</tr>
<tr>
<td>TRE</td>
<td>Tampereen Kaupunki</td>
</tr>
<tr>
<td>TUT</td>
<td>Tampere University of Technology</td>
</tr>
<tr>
<td>UC</td>
<td>Use-case</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modelling Language</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform resource locator (internet)</td>
</tr>
<tr>
<td>V2I</td>
<td>Vehicle to Infrastructure</td>
</tr>
<tr>
<td>V2V</td>
<td>Vehicle to Vehicle</td>
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<tr>
<td>VIM</td>
<td>Vehicle Interface Module</td>
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<td>WG</td>
<td>Working group</td>
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Executive Summary

WP3 as a whole is concerned with the MoveUs Architecture design and the platform component specification, to be implemented and deployed in the different city pilots. Specifically, this deliverable addresses the underlying data and object models, able to support the information needs of the different processes and interfaces, with existing data sources, field devices and involved actors.

The methodology to implement this data model, starts eliciting the information needs by analysing the different use-cases, continues with the validation of these data requirements, checks their coverage by previous reference data models (from eMotion, In-time and Co-Cities projects) and finally, fills existing gaps.

The conceptual MoveUs Data Model has been set up in Unified Modelling Language (UML), by using the Enterprise Architect CASE Tool. This ensures standard compliance and service generation support.

The main conclusion remarks that existing models cover a significant portion of the concepts needed for the storage of information and provision of MoveUs services. Nevertheless, the most innovative project goals: incentive management, energy efficiency, services customization and specific intelligent traffic management have not been previously addressed, so appropriate extensions have been provided.

Furthermore, the work package scheduling determines an iterative approach, constituting this document (v1.1) a final version, updated after the original delivery date (M10) to perfectly match the platform and services specification and design, which have just been completed at the end of the 1st project year (M12).
This Deliverable D3.1 is the first deliverable expected for **WP3 – Analysis, Specification and Design of the MoveUs Architecture and City Services**.

The **objectives** of WP3 are:

- To define the data models relevant for MoveUs operation.
- To define the high-level architecture for the MoveUs Cloud-based platform and its functional specifications in detail.
- To provide detailed specifications and design for the set of services to be provided in MoveUs pilots.
- To identify the data security and privacy issues to be taken into account in the MoveUs architecture and include them in the definition of the platform and services.
- Develop innovative business models determining the users’ willingness to pay for the uptake of MoveUs services.

Specifically, Task 3.1 is aimed at collecting and identifying major data protocols and data and object models relevant for MoveUs. After this analysis versus previously elicited use-cases, and aligned with architectural and service design, a common data model is defined.
2 Methodology

The initial step of Task 3.1, was to identify, analyze and evaluate reference ontologies in the context of MoveUs and evaluate their implementation. To this day we can find different references for ontologies in the field of Smart Cities and traffic, namely, being the most remarkable: Ontology of Traffic Networks (OTN) [1], which extends GDF formalizing in OWL, Ontology of Urban Planning Process (OUPP) [2] based on the CityGML model on survey data, LinkedGeoData (OSM) [3] and the Townontology COST initiative [4] among others.

Although some successful results [5][6], after a deeper analysis, we can conclude that these solutions are not compatible with each other, and cover partially the needs elicited in MoveUs project, so an important effort should be necessary to extend and harmonize these initiatives.

On the other hand, the potential of ontologies and semantics, in general, is maximized in scenarios with unstructured, textual and multimedia data. Although, MoveUs manages heterogeneous information, this is basically structured. Besides, is not intended to address issues as dynamic service composition and semantic reasoning, so prioritizing the efficiency of information capture and access processes, our approach is to maintain a single relational data model as data structure for MoveUs project and implement specific adaptors when needed.

Once set our scope, the data and objects models definition included in this document has been developed following the next key concepts and methodology:

It is important to remark that one of the main objectives of the MoveUs project is to develop a data model following the more relevant related standards and previous European projects. In this way, the data model will not start from the scratch, reusing previous development and aligning itself with other European initiatives and standardization activities, and consequently, making the whole project more interoperable. Another point to stand out is that the model is formally defined in UML (Unified Modelling Language) by using the EA (Enterprise Architect) tool.

The methodology followed to implement this data model encompasses the following steps. First of all, an initial identification of MoveUs use cases requirements has been done in order to detect the information needed in the project. After this analysis, a complete resource evaluation from previous projects has been done identifying 3 European projects: eMotion[7], In-Time [8][8] and Co-Cities [9]. The next step of this methodology is to clearly identify data requirements for each pilot according to the use cases, the validation of these data requirements with each pilot and, finally, to check whether these data requirements are covered by eMotion, In-Time or Co-Cities data models by filling, eventually, the possible gaps. The result of this process is the MoveUs data model.
Before going deeply into MoveUs data model, a concise description of the identified European projects is presented in this document:

**eMOTION** was an initiative co-funded by the European Commission under the thematic area Sustainable Development, Global Change and Ecosystems of the 6th Framework Programme for Research and Development, May 2006-July 2008. In relation to the work presented herein, its main contribution was to develop a data model (available at[7]) harmonising several international and European standards along the lines of the ISO 19100 series of Geographic Information standards:

- **DATEX 2**: individual traffic and a general situation message.
- **Transmodel**: public transport base information.
- **SIRI**: public transport schedule information.
- **IFOPT**: fixed transport infrastructures resources and objects.
- **TPEG**: location referencing, road traffic messages, public transport information messages and parking facilities.

**In-Time** project was co-funded by the European Competitiveness and Innovation Programme, PSP-ICT for adaptive urban transport management infrastructure and
Data models, object models and ontology definition

services, starting 1st of April 2009 with duration of 3 years. Based on eMotion, In-Time data model is already available at [8] covering the following concepts:

- Static road traffic
- Dynamic road traffic & weather
- Points of interest + static and dynamic parking
- Static and dynamic public transport
- Dynamic traffic event
- Static and dynamic flight
- Dynamic multimodal journey planning

Co-Cities was a European pilot project aiming to extend and validate existing mobility services to improve current traffic information management in cities and urban areas. The novelty about the Co-Cities services was their cooperative feature permitting the end users to report their feedback to the traffic management centres. This point is the main contribution to the data model, as it is also based on In-Time and eMotion projects. While Co-Cities data model is not yet publicly available at the time of writing the present document, formal contact has been established between project coordinators in order to facilitate the re-use and adaptation of this model to MoveUs needs, thanks to the mediation of SOF and ATOS as partners involved in both projects. Further detail on this collaborative activity can be found in deliverable D8.5.1[13], released also in M12.
Data models, object models and ontology definition

Figure 4 Co-Cities status & scope
3 MoveUs data model

Although performed in parallel with task T3.2, the data model is aligned with the different functional blocks so far identified on the functional architecture. Moreover, the fact of relying on the FRAME methodology [10] helps to identify high-level information needs by means of the DFD’s data stores, conceptual repositories of information supporting selected functionalities.

At this stage of the project, the following functional blocks can be identified:

- User Management
- Traffic Management
- Public Transport Operation Management
- Incentive Management
- CF/EC Estimation
- Feedback
- Register

3.1 Functional block User Management

The requirements in terms of User Management, identity provision and access rights emerging from the Use Case definition suggest that in principle a basic level of service could be provided for anonymous users. A user profile, instead, is required for:

- Personalized access to the mobility services
- Management of the incentives-related operations
- Management of the energy efficiency operations

The level of complexity of the user profile, associated to the two previous aspects can vary from a simple pair: userID - password to a complete personal profile made of a rich set of datatypes for the storage of preferences, habits, personal settings etc.

3.1.1 Existing specifications

For the present and future needs in MoveUs, the definition a complete user profile, based on the possibilities identified in the Use Cases is foreseen. This includes also personal information that is non-mandatory\(^1\) in the data model.

\(^1\) The feature types introduced in the data model can have attributes with different multiplicity, identified with square brackets and two identifiers: one for the lower limit and one for the upper limit of possible instances of the attribute. A multiplicity of \([0..1]\) for instance indicates that the attribute is not mandatory (zero or one instances are allowed) like in the case of personal data that are introduced and
Considering the general requirements and especially those specifically related to the incentive management, the analysis of the existing Co-Cities model led to the decision that a completely new, dedicated package was appropriate.

### 3.1.2 Extensions

A basic user profile is defined as a super class of the more specific user types.

The basic user profile is defined with attributes necessary for granting secure access and basic access management operations:

- Activation status
- Logging
- UserID and password recovery
- Role management

Roles can be created to grant different access levels to the city services in addition to the mechanisms already foreseen for the activation/deactivation of certain functions.

The main characterization in terms of user types comes from the FRAME-based methodology adopted for the design of the MoveUs architecture.

Specifically, considering the actors according to the FRAME definitions and the above mentioned requirements on user management, the following user types and related features have been identified as the most significant ones:

- Incentive-related User Types \((MV\_UserType\_I)\)
- Drivers \((MV\_UserType\_D)\)
- Travellers \((MV\_UserType\_T)\)
- Equipment/Sensors \((MV\_UserType\_E)\)
- Energy-efficiency related User Types \((MV\_UserType\_EE)\)
- Administrators \((MV\_UserType\_A)\)
- Transport Operators \((MV\_UserType\_TO)\) (not developed here)
- Vehicles \((MV\_UserType\_V)\) (not developed here)

An additional User Type is defined for convenience as \(MV\_UserType\_MV\). This is the generic MoveUs User type that can be assigned to both anonymous and registered users whenever necessary.

The classes for other FRAME user types are defined as placeholders for future use.

All user types and the sub-types defined as enumerations are used as part of the City Services access profile (see also section 3.8 on the Registry).

---

defined in the current data model definition but may be not used in the city services.
Figure 5 User management extensions (Taxonomy)
The sub-types attribute for each user type defines the specific actor (user) within a main user category.

**Table 1 MoveUs users**

<table>
<thead>
<tr>
<th>Code</th>
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<tr>
<td>d.e</td>
<td>Emergency Vehicle Driver</td>
</tr>
<tr>
<td>d.fvd</td>
<td>Freight Vehicle Driver</td>
</tr>
<tr>
<td>d.hgvd</td>
<td>Hazardous Goods Vehicle Driver</td>
</tr>
<tr>
<td>d.odsd</td>
<td>On-Demand Service Driver</td>
</tr>
<tr>
<td>d.pr</td>
<td>Private Driver</td>
</tr>
<tr>
<td>d.prd</td>
<td>Public Transport Driver</td>
</tr>
<tr>
<td>d.tpd</td>
<td>Trip Planning Driver</td>
</tr>
<tr>
<td>t.c</td>
<td>Cyclist</td>
</tr>
<tr>
<td>t.cp</td>
<td>Car-Pooler</td>
</tr>
<tr>
<td>t.odsp</td>
<td>On-Demand Service Passenger</td>
</tr>
<tr>
<td>t.pd</td>
<td>Pedestrian</td>
</tr>
<tr>
<td>t.ptd</td>
<td>Public Transport Passenger</td>
</tr>
<tr>
<td>t.ptt</td>
<td>Pre-Trip Traveller</td>
</tr>
<tr>
<td>t.sd</td>
<td>Static Traveller</td>
</tr>
<tr>
<td>t.vd</td>
<td>Vehicle Driver</td>
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Analogously, the sub-types attributes for different equipment and systems within the equipment category are the following:

**Table 2 MoveUs equipment and systems**

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<tr>
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<tr>
<td>bti.bs</td>
<td>Bridge Structures</td>
</tr>
<tr>
<td>bti.tms</td>
<td>Tunnel Management System</td>
</tr>
<tr>
<td>mms.mmc</td>
<td>Multi-Modal Crossing</td>
</tr>
<tr>
<td>mms.mmmms</td>
<td>Multi-Modal Management System</td>
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<tr>
<td>mms.omfs</td>
<td>Other Mode Freight System</td>
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<tr>
<td>ors.EMS</td>
<td>Emergency Management System</td>
</tr>
<tr>
<td>ors.etms</td>
<td>Environmental Traffic Management System</td>
</tr>
<tr>
<td>ors.hgvm</td>
<td>Hazardous Goods Vehicle Route Monitoring</td>
</tr>
<tr>
<td>ors.itms</td>
<td>Incident Traffic Management System</td>
</tr>
<tr>
<td>ors.iutms</td>
<td>Inter-urban Traffic Management System</td>
</tr>
<tr>
<td>ors.ond</td>
<td>Other Navigation Device (e.g. OBU)</td>
</tr>
<tr>
<td>ors.ptms</td>
<td>Public Transport Management System</td>
</tr>
<tr>
<td>ors.pts</td>
<td>Public Transport Stop</td>
</tr>
<tr>
<td>ors.tsc</td>
<td>Traffic Signal Controller</td>
</tr>
<tr>
<td>ors.tss</td>
<td>Traffic Simulation System</td>
</tr>
<tr>
<td>ors.utms</td>
<td>Urban Traffic Management System</td>
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<td>Multi-modal Planner</td>
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<td>ors.cpos</td>
<td>Car pooling Operator System</td>
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<td>Bike Hiring Operator System</td>
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<td>ors.btn</td>
<td>Bluetooth Network</td>
</tr>
<tr>
<td>ors.itc</td>
<td>Local Traffic Controller</td>
</tr>
<tr>
<td>ors.eps</td>
<td>External Payment System</td>
</tr>
<tr>
<td>ors.egeo</td>
<td>External Geocode</td>
</tr>
</tbody>
</table>
Data models, object models and ontology definition

In blue, those specifically defined for MoveUs requirements.

The characterization of MV_UserType_I comes from the definitions given for the Incentives-related operations:

- **Electronic Wallet Registry**: set of payments systems;
- **Coupon**: a digital code that allow you to get discounts;
- **Voucher**: a digital code that corresponds to a prepaid purchase;
- **Advertisement**: a set of information and data that can be used to publish or link an advertisement;
- **Incentives**: set of material and virtual objects that help modifying the mobility behaviour to obtain a reduction of driving and/or a use of alternative modes (i.e. from private vehicle to public transportation, or to a higher Euro class). Incentives can be also defined as the generic ‘money’ that can be spent to get benefits (awards).

The user types defined for these objects are:

- **Type 1**: Entity defining RULES
- **Type 2**: Entity providing INCENTIVES
- **Type 3**: Entity where INCENTIVES can be spent, entity providing awards (benefits that can be obtained with a certain amount of incentives)
- **Type 4**: Final users (these are defined in the model as User Types “D” and “T”)
- **Type 5**: Entity providing COUPONS. It can be:
  - UT5_MOVEUS: MoveUs Internal module usable by other entities to provide COUPONS.
  - UT5_EXT: External entities providing directly COUPONS via a MoveUs interface available for this purpose.
- **Type 6**: Entity providing ADVERTISEMENTS
  - UT6_MOVEUS: MoveUs Internal module usable by other entities to provide ADVERTISEMENT
  - UT6_EXT: External entities providing directly ADVERTISEMENT via a MoveUs interface available for this purpose.

For the other MoveUs services, the following types (MV_UserType_E, MV_UserType_A) are defined:

- **Type 7 (UT7)**: Transport/Mobility Service Operator
  - UT7_CarPollingOp: Car Pooling Service Operator
  - UT7_PTBusOp: Bus Public Transport Operator
  - UT7_PTRailOp: Railway Public Transport Operator
  - UT7_PTSubwayOp: Subway Public Transport Operator
  - UT7_PTTranOp: Tran Public Transport Operator
  - UT7_PTOtherOp: Other Public Transport Operator
  - UT7_BikeHiringOp: Bike hiring Service Operator
  - UT7_TrafficControlOp: Centralized Traffic Control Operator
- **Type 8 (UT8)**: Field Devices and systems

---

2 Refer to Deliverable D2.2 [12] for more information on the Incentives model
3 The Advertisements are not functionally related to the incentives. Together with the coupons, these are introduced as a possibility for future financial sustainability of MoveUs.
Data models, object models and ontology definition

- **UT8_MMPPlanner**: Multi-modal Planner
- **UT8_IncManSys**: Incentive management system
- **UT8_CarPoolingSys**: Car Pooling Operator System
- **UT8_BikeHiringSys**: Bike Hiring Operator System
- **UT8_BTNetwork**: Bluetooth Network
- **UT8_TLC**: Traffic Light Controller
- **UT8_LTC**: Local Traffic Controller
- **UT8_EXTGC**: External Geocode
- **UT8_BusOBU**: On-board Unit (bus)

  o **Type 10 (UT10)**: MoveUs Platform Administrator
    - **UT10_AdminCity**: MoveUs City Administrator
    - **UT10_AdminPlatform**: MoveUs Platform Administrator

Final User (UT4) can log with a personal identification or in a totally anonymous mode.

- **Final UT4_Anonymous**: User that wants to keep their identity anonymous (for a basic service set e.g. excluding car pooling and incentives)
- **UT4_Identified**: Users that provide their information to the MoveUs platform

Although energy consumption issues are currently under definition in WP4 and set later, two additional users are expected:

- **Type 9 (UT9)**: MoveUs Energy-efficiency module users
  - **UT9_IncEqDef**: Entity that receives the incentives equivalences – green points values per journey
  - **UT9_IncCharge**: Entity in charge of updating the equivalences of energy efficiency and carbon footprint to incentives (credits/green points) based on the characteristics of different cities

From this definition, the different types of users involved in the incentive model can be clustered into two main categories:

- Final users (private or professional users): users of Type 4
- Organizations: all other types of users (except those associated to field devices and systems (Type 8)).

Two main sets of attributes can then be defined and associated to the above categories. These attributes are identified considering that the “Organization” object is mainly defined for the purposes of incentives assignment, definition and operational information provision, while type 4 users are those who typically access the MoveUs mobility City Services and can do this in a personalized way thanks to the mobility profile they have defined and that is constantly updated and refined within the normal service usage. The assumption, given these considerations is that the users of type 4 are exactly the **Drivers** and the **Travellers**, each with a specific characterization:

- **Drivers**: generally professional drivers that can use a specific profile of MoveUs services
- **Travellers**: end users that can use the common MoveUs services and in a few cases specific parts of them (e.g. the carpooling)
3.1.2.1 User Type 4

The User type 4 is described by a personal profile where all strictly personal information is non-mandatory.

Each main Class (MV_UserType_D and MV_UserType_T) has specific feature types associated to it that form an extended profile used for the operations in MoveUs.

The Traveller profile comprises:

- Interest
- Mobility-related preferences, needs and parameters
- Settings on the possibility of receiving notifications or get tracked.
- Incentives-related settings
- Energy-efficiency measurements
- The Carpooling-related profile with the preferences and parameters necessary for the carpooling service according to the definition given in the Use Case definition (D2.2)[12]. This data type support the definition and storage of the carpooler’s profile and can be used eventually at applicative level to find and match the different trip offerings:
  - Indicators about habits of the carpooler (smoker, has animals etc.)
  - Temporal thresholds allowed for departure and arrival time
  - Spatial thresholds for departure and arrival position
  - Size of an ideal corridor around the journey path where possible pick-ups are allowed
  - Preferences about other carpoolers

The Vehicle profile and the Preferences are, instead associated to the personal profile because these are in common to both Drivers and Travellers.

MV_PersonalProfile is also associated with the feature type MV_SpatialExtent to allow defining a default city for the user according to the criteria of selection of the active City, described in the trip planning city service (Deliverable D3.3)[14].
Figure 6 User management extensions (Information)
3.1.2.2 Organizations

The Organization feature type describes the User types that can be classified as organizations or companies. These are especially user types “I” but can be also other FRAME actors.

A personal profile is present as an attribute (Contact Person) and is described by the same feature type that describes the user type 4.

![Figure 7 User management extensions (Organizations)](image)

3.2 Functional block Traffic Management

This functional block encompasses the different functionalities to be included to monitor in real-time the state of roads and public spaces, to detect and manage the impact of incidents and provide road transport operation improvements in terms of energy-efficiency and final user safety and satisfaction.

It also establishes appropriate connections with external service and information providers, both to receive information and request/execute commands.

Several data stores or information repositories have been identified as relevant. The first distinction can be established between static and dynamic (real-time) information; also the nature of information and further treatment determines the different data stores.
Data models, object models and ontology definition

Urban Road Static Data. This static data covers the actual layout, topology and configuration of the urban road network, being used as reference by a variety of functions to monitor, regulate and predict road traffic. It could be also used by Public Transport Operation System (buses, tram) to define services, routes and schedules, overlapping both networks and other systems.

Inter-urban Road Static Data. It shall contain the static data for the inter-urban traffic road network managed by the system, being its meaning analogous to the urban one. In the scope of MoveUs, only segments coming to urban city have significance (as traffic source or sink).

Urban Traffic Data. It contains traffic flow and other traffic related data for the urban road network. The data in the store shall be divided into two parts comprising historic and current data.

Inter-Urban Traffic Data. Analogous semantics as previous one, only segments coming to urban city are relevant.

Incident Data. Collected data about mobility incidences (e.g. traffic, maintenance, events, environmental). Commonly, the information is captured and refreshed iteratively, evolving In-Time aspects.

Urban Car Park Data. Static and dynamic data related to the car parks available in the urban zone: location, availability and occupancy level.

Road Traffic Prediction Data. In MoveUs, these data will be produced from previously collected data (e.g. historical register), by application of prediction rules involving relevant parameters (e.g. day of year/week, hour, incidences). Detailed information needs will be elicited based on WP5 algorithms.

Aggregated Road Data. Reference representation of the monitored road network (Urban Road Static) to which additional layers are added. On the various links between nodes, information from vehicles crossing at each instant of time (stored position and velocity) and measurements from stations/ fixed sensors (e.g. Bluetooth sensor network) will be managed.

Aggregated Road Historic Data. Historical repository of Aggregated Road Information, which stores data belonging to a predefined time interval.

Environmental Data. It integrates data about the environmental conditions within the geographic area managed by the System.

3.2.1 Existing specifications

Urban Road & Inter-urban Road Static Data

In-Time project already defines a network data model including a location reference and road network specification, being both specifications general enough to be applicable to different domains (Figure 8).

Starting with the location reference specification, it can be used to give points (PointLocationReference), lines (LinearLocationReference) or areas.
Data models, object models and ontology definition

(AreaLocationReference) addressing different geometry types (Figure 8). It is important to remark that different locations can be grouped by using LocationReferenceCollection class. For extended details see[8].

In-Time network model defines 2 abstract feature types to represent network points (nodes, NetNode) and linear areas (links, NetLink). Both features are NetElements although they differ in their attributes: NetNode has a mandatory point attribute (GM_Point) representing a point geometry and NetLink are edges in a network graph with curve attribute (GM_Curve).

Going deeply into the road networks, it is important to point out that In-Time specification uses concepts from EuroRoads project and defines GML as encoding for data exchange, based on the ISO TC211 framework of “geo-standards”. This model is even simpler than EuroRoads model as it is limited to just nodes (RoadNetNode) and links (RoadNetLink) maintaining its attributes e.g. formOfNode for RoadNetNode describing the network node type, such as junction, roundabout, etc. For ferry (FerryLink) and road (RoadNetLink) links, the class RoadNetLink is defined. For extended details see[8].
Data models, object models and ontology definition

Urban Traffic Data && Inter-urban Traffic Data && Environmental Data && Road Traffic Prediction Data

Regarding dynamic traffic information, the In-Time data model provides a specific package TrafficRelatedInformation, mainly based on DATEX II, that differences between TrafficRelatedData and TrafficRelatedSituation (that will be analysed later, in incident data section). TrafficRelatedData manages both sensed data, comprising measured: volume, density, velocity/speed, individual travel times and delay time and also derived (processed) data like segment level of service. Any of these values could represent a real or forecasted measure.
Data models, object models and ontology definition

Figure 9 Traffic Related Data

Measured data are captured, usually periodically, by direct sensors or equipment (e.g. loops, cameras, weather stations) as traffic values (flow, speed, traffic density and individual vehicle data (FCD)), environmental/weather values (pollution, temperature, wind and precipitations), travel times and traffic status.

A measurement data set is represented by the SiteMeasurements class, associated locally to a site or location (measurementSiteReference) and temporal period (measurementTimeDefault).
Figure 10 Measured data publication
This class constitutes the basis for the specific types of measures (TrafficStatusValue, TravelTimeValue, TrafficValue, WeatherValue and supplementaryPositionalDescription). The image bellow shows the most relevant types of measures managed.
Figure 11 Data values
On the other hand, ElaboratedData provides a representation for the main aggregated measures per road segment and temporal interval (this time at Traffic Centre level, that is integrating measures from the different deployed equipment): TravelTimes (elaborated time, free flow time, normally expected time), Traffic status that identifies five different values (free flow, heavy, congested, impossible, unknown) and Traffic values: flow, speed, headway, concentration.

To specify the aggregation criteria, ElaboratedData, defines specific classes: BasicDataValue (describing accuracy, applied method, standard deviation and temporal/geographical, data quality), Validity (defining a time period intervals (Period, TimePeriodOfDay, DayweekMonth) by means of interval data definition, intersection and union operations) and SourceInformation (identification, location and mainly reliability). All these characteristics are relevant for the data fusion algorithm.

Figure 12 Elaborated data publication

The Aggregated Road Historic Data is a historical repository of sequential snapshots of the road map state.

Incident Data

Based on identified data requirements, the incident data model already included in In-Time already covers MoveUs data necessities.

Since eMotion/In-Time information model has been developed following the encoding rules defined in the ISO 19100 series of international standards, some changes had been applied to the original DATEX 2 model, mainly of formal nature. As defined in eMotion and In-Time documentation, the changes refer especially to:

- Stereotypes of the classes,
- Data types of the attributes,
- Addition of role names,
- Addition of a few attributes,
Data models, object models and ontology definition

- Variation of the Location Reference and
- Adaptation of enumerations.

The incidents are *TrafficRelatedSituation* objects having 4 main categories:

- *TrafficElement* (road or traffic related event).
- An *OperatorAction*.
- A *NonRoadEventInformation*.
- Weather and environmental events affecting road users.

This is, *TrafficRelatedSituation* refers to incidents and accidents, congestions, weather and environmental events, road works and road closures for specific points on the road, routes or administrative areas and can contain and be described by several concepts as shown in the next plots. Each incident or message represents a *SituationRecord*. A *SituationRecord* is one element of a *Situation* and is characterised by values at a given time, defining one version of this element. It is important to remark that a *TrafficRelatedSituation* is associated with a *LocationReference* and it should then be always possible to identify the traffic disturbance on the network.

On the one hand, and as shown in the next plot, activities, accidents, abnormal traffic states and obstructions (general obstructions, environmental obstructions and vehicle obstructions) are already covered as different *TrafficElements* to be recorded (*TrafficRelatedSituationRecorded*). On the other hand, the actions or activities undertaken by the operator (*OperatorAction*) are also included distinguishing between maintenance (*MaintenanceWorks*) and construction activities (*ConstructionWorks*). Generally speaking, they are actions implemented to prevent or help correct dangerous or poor driving conditions, including maintenance of the road infra-structure.
Data models, object models and ontology definition

Figure 13 Incidence Related Data

Figure 14 Incidence Related Data. Non road Event
On the other hand, In-Time simplified data model also covers weather and environmental events affecting road users (RoadWeatherAndEnvironmentEvent). Concretely, it defines road weather events according to a selection of the TMC Event Code List (next plot).

Finally, In-Time data model has a special service so as to included incidences having no relation with road events (NonRoadEventInformation in next plot) but which may affect drivers behaviour and therefore the traffic flow: service disruptions relevant to road users (e.g. petrol shortage or rest area closed), availability of transit services and information relating to their departures, limiting to transit services which are of direct relevance to road users (e.g. connecting rail or ferry service) and car parks.
Data models, object models and ontology definition

Urban Car Park / Bike Sharing Data

In-Time simplified data model defines data structures for static and dynamic information related with car parking (next plot). The ParkingPoints are identified as PointOfInterest places specifying the location and the category among others concepts. Each parking has static information as tariffs and a complete description of its facilities (e.g. toilets for the disabled available, total capacity, user types, etc.) whereas dynamic information is related to the real time occupancy (e.g. fill rate, queue time, etc.). It is important to remark, that the CarparkDynamic information is also linked to the NonRoadEventInformation in the incidents (as seen in previous section).
3.2.2 Extensions

Urban Road Static Data & Road Static Data

An extension of In-Time data model is needed in order to cover all information requirements for Madrid use-cases. This extension is mainly related to the necessity of a deep description of each intersection (number and type of lines, possible...
Data models, object models and ontology definition

movements, etc.) and the equipment installed around them, concretely Bluetooth readers.

ETSI TS 102 637 is a technical specification that specifies the vehicular communication standard produced by ETSI Technical Committee Intelligent Transport System (ITS).

The second part (part 2) of the document includes the specification of cooperative awareness basic service, while the third part (part 3) includes the specification of decentralized environmental notification basic service.

Cooperative Awareness data is sent to neighbouring nodes through the Cooperative Awareness Messages (CAM) as defined in part 2 of the ETSI TS 102 637 document. The CAM messages are distributed within the V2X communication network and provide information of presence, positions as well as basic status of communicating ITS stations to neighbouring ITS stations that are located within a single hop distance.

In the case of urban traffic controllers involved in the use cases of Madrid, those cooperative awareness data do not comply with the status data related to the traffic controllers, that include signal phasing and timing, and are very limited with respect to the geometrical localization of the traffic lights.

Therefore, the CAM messages do not provide complete information about the status of the urban traffic lights, and are therefore disregarded in comparison with SPAT and MAP messages as they are being nowadays specified in CEN ISO TS 19091 and as already described in SAE J2735.

The European Commission Directorate General for Communication Networks, Content and Technology and the United States Department of Transportation Intelligent Transportation System (ITS) Joint Program Office have been working together so as to internationally harmonize cooperative ITS standards to support cooperative ITS.

Since December 2012 strong support from CEN/TC278/WG16 & ISO/TC204/WG18 working groups to modify SAE J2735 “Dedicated short Range Communications Message Set Dictionary” standard [11] to meet apparent needs for immediate deployment in Europe based of trials conducted to date and to harmonize the message sets, and to create the CEN ISO TS 19091 standard.

At the time this document is created, the CEN ISO TS 19091 document structure is still at current thinking and a draft version is available only for internal evaluation at WG level, and a technical review of it is planned by the third quarter of the year 2014.


Therefore, the SAE J2735 has been identified as starting point for the static and dynamic information related with intersections, and has been selected for the
Data models, object models and ontology definition

development of the use cases in Madrid in MoveUs project, in the absence of an European standard document published and available for use by the consortium at the current moment.

The aim of this standard is to specify all messages, data frames and data elements used for both Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) exchanges.

Based on this standard and taking into account the requirements identified for Madrid use-cases, a selection of the messages and data frames has been done in order to cover both, static and dynamic information related with intersections. There are 4 messages defined in this standard, which are been also specified in CEN ISO TS 19091, to support intersection mapping, signal phase and timing and priority and pre-emption data:

- **Signal Phase and Timing Message (SPAT)**: Relates the current intersection signal light phases[11].
- **Map Data (MAP)**: Relates the Physical Geometry of the intersection [11].
- **Signal Request Message (SRM)**: Requests preemption or priority services[11].
- **Signal Status Messages (SSM)**: As a reply to the priority request (SRM)[11].

*Map Data message* has been selected to include the static information related with intersections while the other 3 messages are going to be used for dynamic information (next subsection).

The following plot (Figure 18) shows the IntersectionInfo class where a *Map Data message* and geographical information (*Circle* and *ValidRegion*) are combined in order to cover Madrid uses cases requirements.
Data models, object models and ontology definition

**Figure 18 Intersection information static model (partial view)**

- **Circle**: to define a circle centered at a given point and extended to the given radius. It is typically used to describe the location of signs so that the receiving vehicle can determine if the sign applies to them and their current path.[11]

- **ValidRegion** is used to describe one or more geographic locations to which a message (typically road signs or advisories of some sort) is applied or considered valid [11].

Going deeply into the **Map Data message**, it contains all unchanging information of one or more intersections in the **intersection** data frame. This message, not only describes the lane geometry paths and the allowed movements in each lane but also additional information related with barriers, pedestrian walks, etc. is provided.
A Map Data message can contain a sequence of intersections (intersections attribute of Intersection type). In this standard, an intersection is a collection of approaches while an approach (Figure 19) is a collection of related lanes. The ApproachObject structure (Figure 20) allows arbitrary groupings of lanes being these lanes both driven vehicle use type lanes as well as other lane types defined by the standard: “pedestrian” lanes (cross walks) and “special” lanes for shared lanes, rail track and other multi-modal uses, and “barriers” for various dividers. Approach lanes are also divided into approach (ingress, incoming) and egress (outgoing) lanes.
Data models, object models and ontology definition

As additional attributes in Intersection (Figure 19) the preemptionZones and priorityZones are defined in order to provide support for priority and preemption requests at the intersection. These two concepts are used to determine which specific request to make, allowing the mapping of the intersection geometry into specific request zones and values (0~7).

The global model of the static information related with intersections is shown in Figure 21 and Figure 22. For further details see[11].
Figure 21 Intersection static info global data model
As explained at the beginning of this section, an extension is needed in order to incorporate the Bluetooth equipment installed in each intersection. The new `BTReader` class collects the identifier, the Bluetooth address and the information needed to determine its position in the intersection.

**Figure 22 Intersection static info global data model. Lane information**

**Figure 23 BT readers (BTFix receptors) static model**
Urban Traffic Data && Inter-urban Traffic Data && Environmental Data && Road Traffic Prediction Data

Analogously to the previous subsection, an extension is needed in order to cover the information sent by each Bluetooth reader. This information is recorded as an event (BTDetectionEvent) linking the detected device with the Bluetooth device of the road infrastructure that is responsible of generating that event (i.e. the Bluetooth reader).

![BTDetectionEvent]

**Figure 24 BT readers (BTFix receptors) dynamic model**

As explained in previous subsection, the SAE J2735 has been used as starting point in order to define the dynamic information related with intersections, in absence of a published version of the European standard CEN ISO TS 19091 that could be available for use for the MoveUs consortium at present. Concretely, these 3 messages have been identified:

- **Signal Phase and Timing Message (SPAT)**: Relates the current intersection signal light phases[11].
- **Signal Request Message (SRM)**: Requests preemption or priority services[11].
- **Signal Status Messages (SSM)**: As a reply on previous request message (SRM)[11].

Starting with the message selected for the smart crossing use case from Madrid, the **Signal Phase and Timing Message (SPAT)** data model is shown in Figure 25.
Figure 25 SPAT data model

SPAT is used to convey the current status of a signalized intersection. Along with the Map Data message (which conveys a full geometric layout of the intersection in question) the receiver of this message can determine the state of the signal phasing and when the expected next phase will occur. The SPAT message sends the current movement state of each active phase in the system as needed (values of what lights are active and values of for what durations the light is expected to continue). The state of inactive movements (typically all red) is not normally transmitted. Movements are mapped to specific lanes and approaches by use of the lane numbers present in the message. These lane numbers correspond to the specific lanes described in the MAP message for that intersection. The current signal pre-emption and priority status values (when present or active) are also sent. [11]

It is important to remark that this message has a sequence of the following relevant data: intersection identifier (IntersectionID), status of the controller (IntersectionStatusObject), additionally the number of states to follow (lanesCnt), each active Movement/lane is given in turn and contains its state, seconds to the next event, etc. (MovementsStates) and optionally active priority (SignalState) and preemption (SignalState) state data.

The main part of this data structure consists of a sequence of MovementsStates for each lane in the intersection. This data frame is used to combine different information about current signal state of one or more lanes of a common type (motorized vehicle, pedestrian, train and transit lanes).

For further details see[11].

For the smart prioritization of vehicles used case in Madrid other 2 messages have been identified: Signal Request Message (SRM) to send the priority request while the bus is in the control zone and Signal Status Messages (SSM) to reply to the priority request.
**Data models, object models and ontology definition**

*Signal Request Message (SRM)* is a message sent by a vehicle to the RSU in a signalized intersection. It is used for either a priority signal request or a pre-emption signal request depending the way the message flag is set. In either case, it identifies itself (using its VIN or another method supported by the VehicleIdent data frame), its current speed, heading and location (using the Blob of the BSM), and makes a specific request for service (Vehicle Request) as well as an anticipated time of service (a start time and end time in seconds from the present). The specific request for service is typically based on previously decoding and examining the list of supported zones for that intersection (sent in the *map data messages*). The outcome of the all pending requests to a signal can be found in the *Signal Status Message*, and may be reflected in the SPAT message contents if successful[11].

![Figure 26 SRM data model](image)

As shown in Figure 26, the *Signal Request Message* is a sequence of requests to the intersection (*SignalRequest*) mainly containing the intersection identifier, a cancel flag, the requested action and optional lanes data such as, the time in the near future when service is requested to start (*timeOfService*), end of service (*endOfService*), additional information of transit events (*transitStatus*), vehicle identifier (*vehicleVIN*) and its current position (*vehicleData*) and status (*status*).

For further details see[11].

*Signal Status Messages (SSM)* is a message sent by an RSU in a signalized intersection. It is used to relate the current status of the signal and any collection of pending or active pre-emption or priority events acknowledged by the controller. When there have been no recently received requests for service messages, this message may not be sent. The outcome of the all pending requests to a signal can be found in the Signal Status Message, and the current event may also be reflected in the SPAT message contents if successful[11].
Data models, object models and ontology definition

The SSM mainly includes the information related with general status of each signal controller (status), an optional attribute covering active priority (priority of SignalState) and preemption (preempt of SignalState) state data, optional also the identification of the vehicle asking for priority (priorityCause) or preemption (preemptCause) and, finally, additional information pertaining to transit evens (transitStatus).

For further details see [11].

Incident Data

No extension is necessary as In-Time simplified data model already covers all data requirements. Part 3 of the ETSI TS 102 637 document will be taken as basis in the case Road Hazard Warning (RHW) use cases would be considered in MoveUs Project.

Urban Car Park Data

No extension is necessary as In-Time simplified data model already covers all data requirements for static and dynamic information related with car parking. However, to cover other public transport as bike sharing, car hiring or electric vehicle hiring and charging, an analogue model is proposed. In the case of bikes, the information related to bike sharing is kept in an analogous structure, with the following adaptations: BikeSharingPoints are included as possible PointOfInterest; additional datatypes BikeUsingTariffs, BikeSharingDynamic and BikeBasicData are included. For those elements being outdoors, specific attributes of parking places are removed (e.g. queue estimation, entrances/exit location, type, disabled capability).
3.3 Public Transport Operation Management

The main objective of this section is to model all the information needed in order to fulfill MoveUs pilot and use cases requirements in terms of public transport operation and management. This information covers a wide range of different concepts such as the definition and planning of different lines or routes or journey tracking (vehicle of each trip, departure and arrival times, etc.).

### 3.3.1 Existing specifications

The existing In-Time simplified model (package Dynamic Public transport Information) covers the main part of MoveUs requirements as it includes the data models for journeys, service description and information related with stop points.

Each trip or journey is tracked by recording the TargetVehicleJourney, the information related to that vehicle (TargetVehicleJourneyInfo) and concepts related with the service and operator. It is important to remark that each trip is also linked with the Line description (specifying the direction, the line and the name) and the stop point elements. The stop point description is related to the timetabledStopVisit; more timetabledStopVisit form the Timetable. The
Data models, object models and ontology definition

TargetedVehicleJourney is also associated to a TargetedCall with arrival and departure info and with an association to the stop point sequence description.

Figure 29 Public Transport (PT) Service Model
Data models, object models and ontology definition

3.3.2 Extensions

An extension of the data model is operated for Car Pooling Management according to the requirements emerging from the Use Case definition and the City Service specification.

The trips stored as carpooling offerings are defined by the MV_CarPoolingTrips feature types. Here the same feature types used for Journey Origin and Destinations are used to identify the origin and destination of the carpooling trip (JP:OriginDestinationRequestType).

Additionally this feature type includes the attributes that define the additional details of the trip offering, typical of the car-pooling:

- Calendar: set the days of the week and time when the offering is available
- Role: driver, passenger or unspecified
- Visibility: set if the offering is visible or not
- Roundtrip: to specify whether it is a round trip
- Validity: to specify until when the offering is valid

In order to achieve the integration of functionalities from external (federated) Car-Pooling systems, according to the working principles of the Car Pooling Service, described in the Deliverable D3.3[14], an association is established from MV_CarPoolingTrips to the feature type of the Registry package that defines the external local services (in this case used for the external local car pooling system). This allow each single trips to be associated with the metadata (including the URL) of the external system thus enabling the foreseen behaviour.

![Figure 30 Carpooling Service Model](image-url)
Data models, object models and ontology definition

Other extension needed is related to specific management carried out in the scope of Madrid use-case (UC1):

On the other hand, a more precise information of each bus line or route is included by (1) adding headerA and headerB attributes in Line class in order to specify the starting and ending places, (2) summarizing the temporal information of the scheduling in the LineTimingDescription class (i.e. maximum and minimum frequency, temporal information of the first and last service and which days the service is available) and, finally, (3) defining the geographical stop place sequence for each line (LineStopSequence and StopPlace).

Figure 31 PT Line Management Model

On the other hand, for the correct development of Madrid use-case (UC1) it is necessary to incorporate more detailed information of each trip (Figure 32). With that objective, the following attributes have been incorporate to the already defined VehicleJourneyInfo class: dayType, expedition (theoretical or real vehicle number), directionRef (journey direction), trip (theoretical or real journey number), originDepartureTime and destinationArrivalTime.
Data models, object models and ontology definition

3.4 Functional Traveller Journey Assistance

This functional area enables multi-modal information provision, journey planning, and on-trip trace and support.

The relevant data blocks are the following:

**Trip Plan Data.** The result of the trip planning process is used along the on-trip phase, as a reference to identify perturbations affecting estimation times and travel viability.

**Aggregated Road Traffic Data.** It contains information about the road network and the traffic conditions within for use in planning trips. It shall be possible to integrate current and predicted data for different date/time combinations. It is mainly used for planning.

**PT Route Dynamic Data.** Analogous to Road Trip Planning Data, it integrates the information about the services provided by the Public Transport operator plus the fares that will be charged; and it shall be for use in planning trips.

**Travel Information Data.** Real-time updated network information.

**General Trip Preferences (GTP) Data.** Contains the personalised data needed to support the Traveller during all his/her trips, from the trip planning, trip execution and finally, being updated once finalized.

**Personal Mobility Data.** Repository of historical information, which hosts all the information sent by the application track capture module. This information is used in the queries associated with mobility analysis.

---

**Figure 32 PT Line Management Model (detail)**

```plaintext
class Simplified Dynamic Public Transport Model
«DataType»
Journeys::VehicleJourneyInfo
+ destinationAimedArrivalTime :DateTime [0..1]
+ destinationName :PT_FreeText [0..1]
+ destinationRef :JourneyPlaceCode [0..1]
+ destinationShortName :PT_FreeText [0..1]
+ headwayService :Boolean [0..1] = false
+ journeyNote :PT_FreeText [0..1]
+ originAimedDepartureTime :DateTime [0..1]
+ originName :PT_FreeText [0..1]
+ originRef :JourneyPlaceCode [0..1]
+ originShortName :PT_FreeText [0..1]
+ vehicleJourneyName :PT_FreeText [0..1]
- dayType :PTI34ServiceDayTypeEnum
- expedition :string
- trip :string
- destinationArrivalTime :DateTime
- originDepartureTime :DateTime
- directionRef :DirectionCode
```
3.4.1 Existing specifications

**Trip Planning Data (Personal/Road and Public Transport).** The next plot is extracted from eMotion data model and represents a complete single-multimodal journey planning. This single-multimodal journey planning covers the following options:

- Dynamic Road Traffic Routing Information.
- Dynamic Public Transport Journey Routing.
- Dynamic Walking Planning.
- Dynamic Cycling Planning.
- Comparative Dynamic Multi Modal Journey Planning.

`JP_Journey` class describes a journey and it is made up by several `JP_Legs` (a leg is a structure that is used to define each single journey. A journey can be made of several legs). There are 4 leg types:

- **Timed Leg**: a leg that has specific timing points associated to a timetable e.g. Public Transport.
- **Frequency Leg**: a leg that runs at specified frequencies.
- **Continuous Leg**: a continuous leg does not 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 walking trips for interchange purposes. They have an origin and a destination and are described with a navigation path.

Another important concept to point out from this data model is that each `JP_Leg` can include information on Tracking&mapping (`JP_LegTrack`).
Data models, object models and ontology definition

Figure 33 Journey Planning services

Figure 34 Journey Planning services (II)
Data models, object models and ontology definition

For deeper detail of classes and attributes needed for each leg see In-Time data model, which includes information regarding messages, service origin, etc.

Personal Mobility Data

As mentioned in the previous section, each JP_Leg can include information on Tracking & mapping (JP_LegTrack). The TrackingAndMapping contains data types suitable for Mapping and Tracking purposes. Objects of type JP_Map and may include instructions. The next plot is extracted from eMotion data model.

Figure 35 Journey Planning services
Data models, object models and ontology definition

3.4.2 Extensions

An additional extension will be considered for MoveUs, associating an incentive (MV_incentive, see section 3.5) and recording the incentive associated with each journey. The incentive calculation is based on a set of rules, applicable for a specific temporal period and location, with user behaviour as parameter. Here, a journey plan (JP_Journey), is defined as a sequence of transport modes in a time slot.

![Figure 36 Link between Journeys and Incentives](image)

Additionally, a link is defined for each journey and leg, with the collected feedbacks and energy measures.

![Figure 37 Journey with additional information](image)

Personal Mobility Data

An additional attribute timestamp will be added to keep the specific timing points associated to the different JP_LegTracks that compose the trip and allowing spatio-temporal analysis of the mobility patterns.

![Figure 38 Trace Spatio-temporal information](image)
3.5 Functional block Incentive Management

The component diagram depicting the organization and functional view on the Incentives Management is included as a reference.

A complete description of the Incentives model can be found in Deliverable D2.2[12].

In chapter 3.1 of the present Deliverable, the Data model supporting the User Management according to the requirements of the Incentives model is described.

In order to define the Data Model supporting the data storages involved in the Incentives management, according to the model definition and as depicted in the previous diagram, the following high-level view is provided:
### Table 3 Incentive data blocks

<table>
<thead>
<tr>
<th><strong>Users:</strong></th>
<th>Registry of users described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• ID</td>
</tr>
<tr>
<td></td>
<td>• User Type</td>
</tr>
<tr>
<td></td>
<td>• Name</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
<tr>
<td></td>
<td>Plus User-specific attributes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Electronic Wallet</strong></th>
<th>Information and URL of available payment services the user can be redirected to. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• URL</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Advertisement</strong></th>
<th>Data on Advertisement. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• URL of the advertisement</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Coupons</strong></th>
<th>Data on Coupons. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• Validity (Geographical, Dates)</td>
</tr>
<tr>
<td></td>
<td>• Cost</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Incentives</strong></th>
<th>Data on incentives. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• Type</td>
</tr>
<tr>
<td></td>
<td>• Unit of measure</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>User Balance</strong></th>
<th>Amount of incentives units (credits and coins) gained by the users. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Incentive type</td>
</tr>
<tr>
<td></td>
<td>• Total</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Awards Catalogue</strong></th>
<th>Benefits, awards, rewards that can be obtained by giving a certain amount of credits or coins. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• Cost</td>
</tr>
<tr>
<td></td>
<td>• Validity</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Rules</strong></th>
<th>Data that define the measure/rule for each incentive. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• Validity (Dates, Geographic area etc.)</td>
</tr>
<tr>
<td></td>
<td>• Beneficiaries (Type 4 users)</td>
</tr>
</tbody>
</table>
Data models, object models and ontology definition

| Vouchers | Contains the historical data on Issued Vouchers. |

The incentives-related data model is described by focusing on three aspects that together form the overall Incentives-related package:

- Introduction of incentive currencies
- Assignment of incentives to the user
- Definition of incentives and rules
- Awards, coupons, advertisement

3.5.1 Existing specifications

The incentive schema defined within MoveUs is supported by a specific and dedicated Data Model which needs to be defined completely. No existing parts of the In-Time/Co-Cities Data Model are then re-used.

3.5.2 Extensions

3.5.2.1 Incentive currencies

The basic types of incentives can be identified with three base units of measure or currencies:

<table>
<thead>
<tr>
<th>Table 4 Measure/Currency Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit of measure / Currency</td>
</tr>
<tr>
<td>CREDIT</td>
</tr>
<tr>
<td>M_COIN (MoveUs Coins)</td>
</tr>
<tr>
<td>B_COIN (Bonded Coin)</td>
</tr>
</tbody>
</table>

In order to allow a higher flexibility, an additional MV_IncentiveCurrency extends the base currency by adding the same features to it:

- A name
- A monetary value
- A temporal and spatial validity
Data models, object models and ontology definition

The extension allows the management of different types of incentives (e.g. incentives provided by different organizations) either within one single City or from one City to another.

*MV_IncentiveCurrency* becomes the unit of measure for:

- Incentives storage in the user balance,
- Award assignment,
- Coupon issuing.

![Figure 40 Incentive Currencies](image)

### 3.5.2.2 Assignment of incentives

The feature type *MV_IncentiveBalance* is defined to store the amount of incentives. The assumption is that only the user type T (Traveller) can own zero or more incentives balances. Each balance features a specific incentive currency.

The Total amount of incentives is an attribute of the *MV_IncentiveBalance* class while the single transactions are described with the *MV_IncentiveTransactions* feature type.
### 3.5.2.3 Incentives and rules

An incentive is defined with a specific Incentive Currency and follows one or more rules that define how the incentives can be gained by the user.

The rule is composed by a super class with a base profile including a temporal and spatial validity. The sub-classes define the sub-rules, namely the set of attributes necessary to define how many incentives are rewarded for a specific situation or behaviour (whose relevant attributes are present in the sub-class to support the related city service functionalities). Two sub-rules are defined at the present stage:

- **Smart mobility rule**: defines how many incentives can be gained by covering a distance with certain modes of transport and in specific timeslots.
- **Feedback rule**: defines how many incentives can be gained by providing a number of feedbacks of a certain type.
Data models, object models and ontology definition

Figure 42 Incentive & Rules
The coupons are described by a complex feature (MV_coupons) that can be used to describe most aspects of the object associated to the coupon. An URL of a detail page is present to link the coupon to the organization that provides it.

The **MV_Award** describe the single entry of a catalogue of awards. A single award applies to one or more incentives.

Awards can be obtained and paid by means of an *Incentive Payment Type*. The feature type **MV_IncentivePaymentType** extends the concept of Incentive Currency previously introduced by adding a monetary tradeoff. This tradeoff expresses the percentage that could be applied to pay an award partially in incentives and partially in real money.

**Example:**

An instance of *IncentiveCurrency* named “CustomCoin” is of type “B_COIN”, and each coin has a value of 1 euro.

An instance of *IncentivePaymentType* has the value of CustomCoin and additionally has a monetary tradeoff of the 50%.

An award of value = 100Euro can be then obtained with 100 CustomCoin or with 50 CustomCoin + 50 Euros.

**MV_Advertisement** is a basic feature type supporting the Advertisement object.

**MV_Vouchers** is used to store the information of the Vouchers that have been issued and can be used for historical purposes or for retrieving the details of the Voucher (for example at the moment of use of the voucher).

The Electronic Payment Service Registry (**MV_EPS_Registry**) is defined for the Electronic Wallet Service according to the definition of this service in the Use Case description. Having the characteristics of the Registry entity defined in 3.8. The **MV_EPS_Registry** is defined as a super class of it. See 3.8 for more details on the registry features.
Data models, object models and ontology definition

![Data Models Diagram](image)

**Figure 43** Coupons & Awards

### 3.5.2.5 Coordination with User Management functional block

As described in section 3.1 the definitions of the Incentives-related Data Model are fully harmonized with those of the User Management and therefore the feature types defined in the present functional module have to be understood and completed with those of Functional block 1.

### 3.6 Functional block CF/EC Estimation

Energy Consumption and Carbon Footprint issues will be supported by an specific algorithm to be used by a computational engine in order to output ‘global’ Energy/CO2 computed values (per user, per routing, per means of transportation etc.), based on input information concerning the Energy/CO2 label set and
Data models, object models and ontology definition

information related to mobility options chosen by users in real time. The assessment methodology, methods and underlying data needs are currently under definition in WP4.

3.6.1 Existing specifications

No existing parts of the In-Time/Co-Cities Data Model are then re-used. The energy efficiency schema defined in WP4 will be supported by a specific and dedicated Data Model which needs to be defined from scratch.

3.6.2 Extensions

Expected extensions of the common MoveUs data model are expected according to the WP4 working progress. The CEN ISO TS 19324 standard will be considered in the context of WP4, being updated this part of the data model accordantly if applies.

In advance, some of the key concepts to be managed are outlined at the table below.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Set of Key Performance Indicators related with energy efficiency and carbon footprint in the transportation domain.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Described by:</td>
</tr>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• Calculation</td>
</tr>
<tr>
<td></td>
<td>• Relation to transportation modality</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy labels</th>
<th>Set of translations of energy efficiency values for users. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• Equivalence to user meaningful values, e.g. cost,</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy affecting parameters</th>
<th>Set of parameters that are affected by KPIs in the different living labs. Described by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Description</td>
</tr>
<tr>
<td></td>
<td>• KPIs related to this parameter</td>
</tr>
<tr>
<td></td>
<td>• Positive or negative effect for energy consumption and carbon footprint</td>
</tr>
<tr>
<td></td>
<td>• Etc.</td>
</tr>
</tbody>
</table>
3.7 Functional block Feedback

MoveUs proposes a co-operative mobility concept, seen as the interconnection of users, vehicles and infrastructure that enables a full sharing of information between the different actors. Here, is a key issue the final user involvement. Specifically, the feedback provided by users enables cities and transportation operators to adapt their plans and offer in a more efficient way.

This feedback can be achieved in two different ways: passive, as automated application process, or active, answering the own user questions related to the quality of the own MoveUs Application information or the public transport environment (e.g. feedback traffic and transportation related events and metrics).

3.7.1 Existing specifications

The existing Co-Cities Data model defines a package of feedback-related feature types that are used in MoveUs.

Among the set of feedback services specified in Co-Cities, two domains are specifically considered for MoveUs:

1. Journey Planning-related feedbacks
2. Traffic-related feedbacks

The super-class Feedback features the base feedback attributes. This includes a Trust Level that can be used to differentiate (namely, assign different reliability levels) the subject who formulated the feedback.

The sub-classes of Feedback define the specific data types of the feedback information:

- Traffic feedback (new data about a traffic event): this is a class with an attribute of type TrafficElement (see section 3.2).
- Traffic quality feedback (quality of information of a given traffic event): a set of boolean values indicating if the specific information given about a traffic event is correct or not.
- Journey Planning quality feedback (quality of information of a given journey): a set of Boolean values indicating if the specific information given for each leg of a journey is correct or not.
3.7.2 Extensions

No extension is foreseen at the moment for the MoveUs Feedback functional block compared to the Data features defined by the Co-Cities model.

3.8 Functional Block Registry

The registry of Metadata in MoveUs is used to direct the dynamic functionalities of the City Services.

3.8.1 Existing specifications

The existing eMotion specifications are used in part for the service (API) description.

3.8.2 Extensions

A simplified description profile for MoveUs is introduced.

An optional eMOTIONServiceDesc association links the registry to a more complete WSDL-based service description.
Data models, object models and ontology definition

MV_Registry is a superclass of local registry entities (MV_LocalRegistry) that have a spatial extent (mandatory) and a temporal extent (non-mandatory). For example there may be an instance of MV_LocalRegistry for Madrid, one for Genoa and one for Tampere.

The service descriptions MoveUs-specific (URIs) or eMotion-based (WSDL:Service) are associated to MV_LocalRegistry.

MV_LocalRegistry has also an association with the feature type ExternalLocalServices containing the metadata that describes the external services or systems used by MoveUs for the Electronic Wallet and Car Pooling services. The access criteria, necessary for differentiating the functionalities in the city services are defined by considering the user type, defined as the union of the different (sub-)user types and also the additional role ID (see 3.1.2 for more details on these data types). With the implementation of the services a differentiation can then be operated by considering generic (MV_UserType_MV) or specific (types “I”, “T” or “D”) user profiles and by combining these with the additional User role if necessary. The possibilities can be:

- Anonymous access (generic MoveUs user type and commonly agreed user role)
- Access regulated by User Type only (using a common or known user role)
- Access regulated by User Role only (using the generic MoveUs user type)
- Combination of the previous two options

For each instance of access criteria a set of pair key-values is defined as a generic method for activating, de-activating or differencing the functionalities and features of the city services.

More information on the dynamic behaviour of the City Services can be found in Deliverable D3.3[14].
Additionally, in order to ensure the application tailoring and customization according to each city peculiarities (e.g. premium services as green route access available for profiles tagged as “eco-friendly”), official languages and identity (e.g. logo, app style). These characteristics will be coded by means of different key-values.

**Figure 45 Registry Model**
4 Conclusions

The outcomes of Task 3.1 remark the existing work in the field of mobility services and in particular the availability of information models, which cover quite of the static and dynamic elements identified as relevant. A significant portion of the concepts needed for the storage of information and provision of services in MoveUs project have been previously considered in the projects taken as reference.

However, a deep analysis of the use cases has determined necessary to define adaptations and specific packages for the most innovative project goals, i.e.: incentives management, energy efficiency, services customization and of course, those aspects related to intelligent traffic management.

Furthermore, the parallel execution of the definition activities for the information model (T3.1), system architecture (T3.2), service specifications (T3.3) and the underlying algorithms (e.g. calculation of energy efficiency and trip planner) have motivated an iterative working approach during this phase of the project.

While the document delivered in M10 (v1.0) constituted a mature version of the MoveUs data model integrating most of the specific and complex aspects before mentioned, this update (v1.1) was deemed necessary at the end of the 1st project year (M12) to make sure that the final T3.1 result is fully aligned with the final outcome of the two parallel tasks mentioned (T3.2 and T3.3), now already available.
5 References

http://rewerse.net/deliverables/m18/a1-d4.pdf

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in Urban Civil Engineering Projects (2008)


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February 2012 (2012)


29)(2008)

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common specifications for the pilots

[13] MoveUs deliverable D8.5.1 - First report on cooperation with other projects

[14] MoveUs deliverable D3.3 - MOVEUS city services: specification and design