MOBIDATALAB

Labs for prototyping future mobility data sharing solutions in the cloud

D2.9 Use cases definition (V1)

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Author(s): Johannes LAUER, Thierry CHEVALLIER, Didier DE RYCK, Chiara RENSO, Sebastian VAN DE HOEF

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Summary sheet

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Responsible Author(s)	Johannes LAUER (HERE)
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Abstract	This deliverable is a report to provide an overview of the Task 2.6, which consists of the use case description for the first version of use cases. This version one provides the initial input from project stakeholders including the relevant standards, the data and the potential tooling to realise the implementation of the use cases. This initial set is used to cover a broad set of mobility data sharing use cases and initiates with this the input for the following living labs. Within the project time, this set will be reviewed, and learnings will flow into the living labs and the second version of use cases, which will be part of D2.10 at the last third of the project time.

Legal Disclaimer

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Project partners

Organisation	Country	Abbreviation
AKKA I&S	France	AKKA
CONSORZIO INTERUNIVERSITARIO PER L'OTTIMIZZAZIONE E LA RICERCA OPERATIVA	Italy	ICOOR
AETHON SYMVOULI MICHANIKI MONOPROSOPI IKE	Greece	AETHON
CONSIGLIO NAZIONALE DELLE RICERCHE	Italy	CNR
HOVE	France	HOVE
HERE GLOBAL B.V.	Netherlands	HERE
KATHOLIEKE UNIVERSITEIT LEUVEN	Belgium	KUL
UNIVERSITAT ROVIRA I VIRGILI	Spain	URV
POLIS - PROMOTION OF OPERATIONAL LINKS WITH INTEGRATED SERVICES	Belgium	POLIS
F6S NETWORK IRELAND LIMITED	Ireland	F6S

Document history

Version	Date	Organisation	Main area of changes	Comments
0.5	16/06/2021	HERE	First integrated draft including corrections and completion	
0.8	19/06/2021	HERE	Included internal review comments and HOVE use case content	
0.9	20/06/2021	HERE	Added references integrated HOVE changes	
0.10	20/07/2021	HERE	Review integration	HOVE comments
0.11	20/07/2021	HERE	Review integration	POLIS comments
0.12	25/07/2021	HERE	Review integration and document refinement	
1.0	30/07/2021	AKKA	Quality check	Final version
1.1	12/10/2021	HERE	Integration of further tables (requirements, use-cases)	
2.0	13/10/2021	AKKA	Quality check	Final version

Executive Summary

The deliverable 2.6 is a report providing an overview on the version 1 of the use cases. The listed use cases are a representation of the project stakeholder capabilities. Therefore, they mainly focus on established tools and existing datasets. The use cases version 1 will be used to seed the living labs as well as for getting into data and standards discussions.

Given the heterogeneity of data, tools and interfaces, as well as potential use cases and users, this first set of use cases only claims a subset of potential use cases that will be possible within the context of MobiDataLab.

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Abbreviations and acronyms

Abbreviation	Meaning
API	Application Programming Interface
B+R	Bike and Ride
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CH	Could Have
D	Deliverable
ETA	Estimated Time of Arrival
GBFS	General Bikeshare Feed Specification
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GTFS	General Transit Feed Specification

GTFS-RT	General Transit Feed Specification – Real Time
GPS	Global Positioning System
KPI	Key Performance Indicator
LOD	Linked Open Data
LDM	Linked Data Mashups
MaaS	Mobility as a Service
MH	Must Have
NeTEx	Network Exchange
OGC	Open Geospatial Consortium
OJP	Open Journey Planning
OSM	OpenStreetMap
P+R	Park and Ride
PU	Public
Req Number	Requirement Number
SH	Should Have
SIRI	Service Interface for Realtime Information
UML	Unified Modelling Language
V	Version
WH	Would Like
WP	Work Package

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1. Introduction

1.1. Project overview

There has been an explosion of mobility services and data sharing in recent years. Building on this, the EU-funded MobiDataLab project works to foster the sharing of data amongst transport authorities, operators and other mobility stakeholders in Europe. MobiDataLab develops knowledge as well as a cloud solution aimed at easing the sharing of data. Specifically, the project is based on a continuous co-development of knowledge and technical solutions. It collects and analyses the advice and recommendations of experts and supporting cities, regions, clusters and associations. These actions are assisted by the incremental construction of a cross-thematic knowledge base and a cloud-based service platform, which will improve access and usage of data sharing resources.

1.2. Purpose of the deliverable

This “Use Cases V1” document aims to provide **Demonstration Cases** for the MobiDataLab Transport Cloud functionalities (WP4). This version 1 will be followed by a “Use Cases V2” (D2.10) based on concrete mobility challenges faced by the MobiDataLab reference group of stakeholders (municipalities and regions).

1.3. Intended Audience & Review process

The dissemination level of the D2.9 deliverable is ‘public’ (PU). HERE as Task 2.6 leader is responsible for it with the contribution of CNR, AKKA and HOVE. An external review is conducted by members of the Advisory Board.

It should be noted that the content of this WP2 deliverable will be the initial set of use cases for the living labs within the context of MobiDataLab. The version one use cases will be followed by a second version (D 2.10), which integrates the learnings from version one use cases, the living labs and the evolution made within the project lifetime.

1.4. Structure of the deliverable and its relation with other work packages/deliverables

Dependencies to other deliverables, work packages (WP) or tasks’ contributions.

- WP2 – Open Knowledge Base: Relevant standards relate to the Standard Requirements (Task 2.3) and possible technologies relate to the Frameworks Report (Task 2.4).

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- WP3 - New data sharing services and business models: Actors' needs and market Analysis provide the requirements and gives the justification for the usefulness of the designed use cases.
- WP4 – Transport Cloud Prototype: This WP provides the basics to run the use cases (reference data, data access, data processors) and the analyses to fulfil requirements, such as anonymisation. A relationship exists especially on the used datasets, which are also in the Reference Data Catalogue (Task 4.2).
- WP5 – Living and Virtual Labs: The use cases are core part of the input for the Living Labs and seed further ideas that should grow within the living labs.

The methodology for defining V2 use cases involve the MobiDataLab reference group of stakeholders (municipalities, regions and others), which is the topic of task 6.4 (multi-stakeholder group creation and coordination).

1.5. Use Case Key Performance Indicator (KPI)

1.5.1. All use cases formalised according to Unified Modeling Language (UML) model (use case diagrams)

All the MobiDataLab use cases (100%) are formalised according to the standardised UML model and use case diagrams in particular. A use case diagram is a graphical depiction of a user's possible interactions with a system. Use case diagrams can be broken down into four different elements: system, actors, use cases and relationships.

- **System**: a system could be a website, a software component, a business process, an app or anything that can be developed. A system is represented with a rectangle and with the name of the system at the top. In these demonstration cases, the system is most of the time the MobiDataLab transport cloud.
- **Actor**: who or what is going to use the System, knowing that a **primary actor** initiates the use of the system while a secondary actor is more reactionary. The actor could be a person, an organisation, another system or an external device. An actor depicted by a stick figure is someone or something that uses the system to achieve a goal.
- **Use case**: a use case is depicted with an oval shape and it represents an action that accomplishes a task within the system. Each use case starts with a verb and is sufficiently descriptive and it is a good practice to put the use cases in a logical order when possible.
- **Relationships**: by definition, an actor is using the system to achieve a goal, so each actor must interact with at least one of the use cases within the system. We call these interactions relationships. The main relationship between an actor and a use case is called an **association**, represented by a solid line. In addition to association there are **include**, **extend** and **generalisation**.

The structure of the descriptive tables for the use case diagrams consists of two columns: “Category” and “Description”. Each use case has a descriptive name. The “Category” contains one or more “Preconditions”. The “Preconditions” need to be fulfilled to run the use case. These are followed by 1.n “Steps”. Those describe the user actions. The use case closes with one or more “Postconditions”. These are reflecting the state of the system, when the use case is done.

For each use case, a table with the requirements is given. This table consists of:

- **Req Number:** The requirement number/ID with the use case and a sequential and hierarchical numbering for each requirement (example: UC3-R02.1).
- **Description:** The verbal description of the requirement.
- **Priority:** Defines a priority in four grades (from high importance to low importance):
  - Must have [MH]: the project will be seriously impacted if this requirement is not met in time/at the delivery.
  - Should have [SH]: a requirement that, if it is not met, seriously impacts the project, but it can be delivered on a different timescale than the must-haves.
  - Could have [CH]: optional requirements which can improve the project outcome and the value of its results but are not essential to the main delivery (not too many Could-have requirements should be dropped in the design).
  - Would like [WL]: truly optional features which can be delivered if there is sufficient effort available within a task, or if they can be found elsewhere and integrated easily.

1.5.2. Linking use case with an established organisation that already provides a data governance scheme

With the linkage of use cases with existing projects/organisations with a governance schema, we can build on top of a working process. Within a three-year project, the risk is too high for building an own community within this short amount of time. Furthermore, MobiDataLab can be linked as a catalyst to connect communities and increase their number of (active) members. An example for an established community/project is OpenStreetMap (OSM). OSM is a community-based mapping project, with the intention to map the globe in a style which has been described in (Goodchild, 2007) as in a volunteered geographic information. The use case “*OpenStreetMap for inclusive transport*” offers the possibility for the MobiDataLab community to interact with the OSM community within a well-established governance framework.

1.5.3. Use cases that are provided by the MobiDataLab reference group of mobility stakeholders

As stated in the introduction, the use cases presented in this deliverable are data-driven and standard-driven use cases demonstrating the functionalities of the MobiDataLab transport cloud. They were defined by the consortium members during the writing of the project proposal, based on their respective expertise and background in mobility data related projects.

At that stage of the project, the reference group of municipalities and regions interested in participating in the MobiDataLab innovation sessions (or labs) was not yet defined, although some public authorities agreed to a letter of support. The consolidation of the reference group is the subject of task T6.4 which, at this stage of the project, is already well advanced. This will evolve within the use cases version 2, which is represented in D2.10 to ensure that the use cases are relevant to the needs expressed by the stakeholders. The following v1 use cases will then be amended or complemented by additional use cases corresponding to the concrete mobility challenges faced by our referring municipalities.

1.6. Use Case Partners

Table 1: Partners who provided a Letter of Intent

Company/Institution	Contact
CER (European railways)	Dr Libor LOCHMAN (Executive Director)
IRF Global	Brendan HALLEMAN (VP)
UITP	Umberto GUIDA (Sr Director Knowledge & Innovation)
CARA (European Cluster for mobility solutions)	Gilles Le CARRE (President)
La Fabrique de Mobilités	Bertil de FOS, Sarah CORNUZ de ROBERT
STIB Brussels	Rob ROEMERS (Manager BI Solutions)
Agenzia Mobilita Ambiente Territorio	Glois ZOROTTO (CEO)
Ayuntamiento de Màlaga	Francisco SALAS MARQUEZ (Managing Director of Promálaga)
E-trikala	Odysseas RAPTIS (CEO)
Municipality of Eindhoven	Niels WIERSMA (Mobility data & platform consultant)
Municipality Roma	Gabriela SARACINO
Politecnico di Bari	Prof. Maria Pia FANTI
Le Village by CA	Sarah CORNUZ de ROBERT

As per the current state of Task T6.4 (“Multi-stakeholder group creation and coordination”) further use-case partners are listed in Table 2.

Table 2: *Further use-case partners*

Company/Institution	Description
HERE Technologies	Location Company - Platform & Services & Content (project partner)
HOVE	Mobility Company (project partner)
AKKA	System integrator (project partner)
CNR	Research Institute (project partner)
Benelux/NRW living lab for MaaS	International collaboration including all of the above
Cubic Transportation Systems	Transportation Technology Provider
City Hall of Timisoara	Local Authority
Municipality of Eindhoven	Local Authority
Leuven	Local Authority
Rome Mobility Agency	Local Authority
TIER Mobility	Micro-mobility operator
Nahverkehrsgesellschaft Baden-Württemberg mbH (- Mobility agency for the state of Baden-Württemberg)	Mobility Agency
New York State Department of Transportation	Transport Authority
Hamburger Hochbahn AG	Public Transportation Company

2. Use Case Definitions: Use Cases for Operations

2.1. Optimisation of Transport flow and ETA

In this use case, influencing data for computing Estimated Time of Arrival (ETA) is analysed. ETA is highly relevant in optimising, monitoring, and managing transport flow. Arrival time is dependent on huge number of parameters.

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It is particularly challenging to estimate in road transport and inter-modal transport due to the decentralised nature of the transport infrastructure. Estimating the arrival time requires combining a large number of static and dynamic data sources using state of the art data processing techniques.

In this use case, we focus on a commercial transport setting. The user is a dispatcher, who plans routes and schedules for several vehicles. Planning tours is supported by dispatcher software, which applies advanced routing and stop sequence optimisation algorithm. Vehicles in turn have telematics devices that can give feedback on their location and progress in their tour, i.e., information about which customers have been served. This data is continuously compared with the original tour plan and the arrival time at upcoming stops is estimated. Based on that comparison, several sub use cases are enabled:

- Alerts for delayed stops to the dispatcher / driver
- (Semi-)automatic update of the tour plan to meeting delivery time windows
- Sharing the arrival time with customers (planning dock availability etc.)
- Rest time planning of the driver
- Post trip reporting and analysis (what causes missed delivery time windows, how narrow can delivery time windows be set, etc.).

The use case is dependent on two types of data. The first kind of data is mostly user-independent data about the transport system at large that feeds into the ETA estimation. It is provided through data sharing platform from a variety of sources. The second kind of data concerns the transport operations of the user. It is provided by the user or through access-controlled data-sharing platforms. Both types of data are combined to individual ETA estimations for the user.

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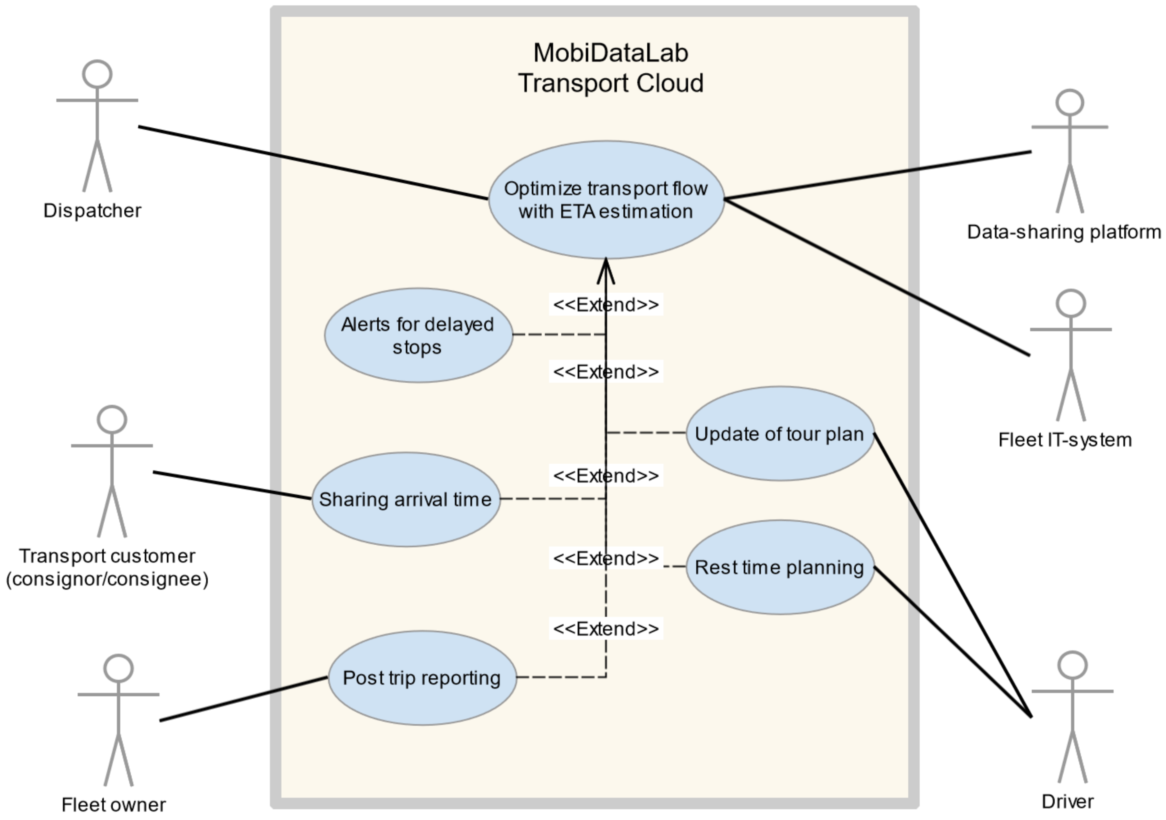

Figure 1: *Use case diagram for Optimisation of Transport flow and ETA (a connection to the base use case is to be interpreted as an involvement to all use cases)*

- System: the MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
  - Primary: the primary actors are the Dispatcher, the Transport customer, and the fleet owner.
  - Secondary: the data sharing platform and fleet IT system
- Use cases:
  - Optimise transport flow with ETA estimation
  - Alerts for delayed stops
  - Sharing arrival time
  - Post trip reporting
  - Update tour plan
  - Rest time planning

Table 3: Use case description for Optimisation of Transport flow and ETA

Category	Description
Case "alerts for delayed stops"	
Pre-condition 1	Tour is in progress
Pre-condition 2	Tour has been planned with estimated arrival times
Step 1	Likely delay for arrival at one or more stops is being identified
Step 2	Driver, Dispatcher, Transport customer and Dispatcher are automatically alerted of the delay
Post-condition 1	Concerned parties have been alerted of the potential delay
Case "sharing arrival time"	
Pre-condition 1	Tour is in progress
Pre-condition 2	Tour has been planned with estimated arrival times
Step 1	Transport customer retrieves (repeatedly) the estimated arrival time
Post-condition 1	Transport customer gets increasingly accurate estimation of the arrival time
Case "post trip reporting"	
Pre-condition 1	Some tours have been completed
Pre-condition 2	These tours have been monitored and arrival times have been computed
Step 1	Fleet owner requests report for those tours
Step 2	Report data is generated
Step 3	Report is returned to the fleet owner in a useful format
Post-condition 1	Fleet owner has report comparing planned and actual arrival times
Post-condition 2	Fleet owner can identify problems leading to missed arrival times
Case "update tour plan"	
Pre-condition 1	Tour is in progress
Pre-condition 2	Tour has been planned with estimated arrival times
Pre-condition 3	Estimated arrival time deviates from planned arrival time on one or more stops
Step 1	Tour is updated to reflect the updated arrival times
Step 2	Driver receives updated tour plan
Post-condition 1	Driver has updated tour plan reflecting the updated estimated arrival times
Case "rest time planning"	
Pre-condition 1	Stops on tour have been defined
Step 1	Rest times are planned taking into account arrival times at parking lots and stops on the tour
Post-condition 1	Driver has a plan when and where on the tour to rest following rest and break time regulations

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2.1.1. Used Data

- Data for ETA computation
    - Traffic (real-time and historic)
    - Static map data
    - Weather
    - Rest time regulations
    - Planned events (road closures etc.).
- Operational data
    - Telematics data of vehicles
    - Location of vehicles
    - Completed stops
    - Tour plans
    - Driver shift time (to figure out when the driver needs to take a rest).

2.1.2. Relevant Standards

- Open Trip Model
    - Data model standard for modelling trips, locations, vehicles etc.
    - https://www.opentripmodel.org/ (OpenTripModel, no date)
- FMS
    - Remote fleet management interface for getting vehicle tracking data.
    - http://www.fms-standard.com/Truck/index.htm (FMS-Standard, no date)
- Rest time regulations of the European Union
    - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02006R0561-20200820 (EUR-Lex - 02006R0561-20200820 - EN - EUR-Lex, no date)
- DATEX II (Homepage | DATEX II, no date) for traffic related real time data
- TN-ITS for static map data

2.1.3. Possible technical solutions

For possible solutions, we will consider (not exclusively, but as a possible input and solution) the combination and extension of HERE services available as APIs via the HERE Platform:

- HERE Tour planning API
- HERE arrival-time estimation (fleet telematics)
- HERE router

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2.1.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

Table 4: Requirements table - Optimisation of transport flow and ETA

Id	Description	Priority
UC1-R01	The user registers a tour in transport cloud for ETA estimation	MH
UC1-R02	A fleet IT system can provide real-time updates to the transport cloud for ETA estimation	MH
UC1-R03	A data sharing platform can provide real-time data for ETA estimation (for instance, traffic, weather, etc.)	MH
UC1-R04	A data sharing platform can provide static data for ETA estimation (for instance, road network structure)	MH
UC1-R05	The estimated time of arrival at stops of a tour can be estimated by the transport cloud using static and real-time data (refer to UC1-Req2-4)	MH
UC1-R06	The user can retrieve real-time deviations between planned an estimated arrival time	MH
UC1-R07	A tour can be updated using estimated arrival times	MH
UC1-R08	Rest times can be planned according to official regulations considering estimated arrival times	MH
UC1-R09	The user can retrieve a report of the difference between planned, initially estimated and actual arrival times of tours	MH
UC1-R10	Estimated arrival time at selected stops can be shared with transport customers	MH

2.2. Emission Reporting

Reducing environmental impact is highly relevant for any form of mobility and transport. Working towards environmentally friendly and sustainable mobility is highly dependent on traceable and reproducible measures. Concrete action for reducing the environmental footprint can only be taken in a systematically if the impact can be reported in a clear and transparent manner. Emissions' reporting is both used to understand where there is greatest potential for reducing emissions as well as during the planning for comparing different planning choices. Furthermore, reporting emission makes stakeholders accountable for their emissions and serves that way as incentive for reducing them.

Emission reporting is a two-fold process. The first part deals with estimating the emissions of a particular transport asset, such as a truck, a ship, an airplane etc. They in turn are comprised of direct and indirect emissions. Direct ones are those that are directly linked to the operation of the vehicle, such as tail pipe emissions. Indirect emissions are caused by the production of assets needed for the transportation, such as manufacturing the vehicle.

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The second part deals with attributing the emissions to transported goods or people. Most trips, especially for goods, happen via several journey legs sharing transport assets. Attributing the share of emissions caused by one item/person is non-trivial, in particular, considering empty miles, detours etc. Attributed emissions can be, for instance, much lower when a trip had would have been performed empty if the item/person had not been transported on the same route.

Emissions' reporting is a very complex endeavour. Emissions, in particular indirect emissions, are influenced by a huge number of parameters, many of which are not readily available. Therefore, it is useful to draw on established models and feed them with the required data for estimating emissions of individual operations. The focus in the scope of this project will be on providing established emission models with the correct data set through data sharing platforms.

Emissions reporting can be integrated into services used during the transport planning, such as routing, tour planning, tracking, arrival time estimation etc. In addition to computing the plan, the services also compute estimated emission. This can be predicted emissions (e.g. routing) or emission that have already taken place (e.g. tracking, route matching).

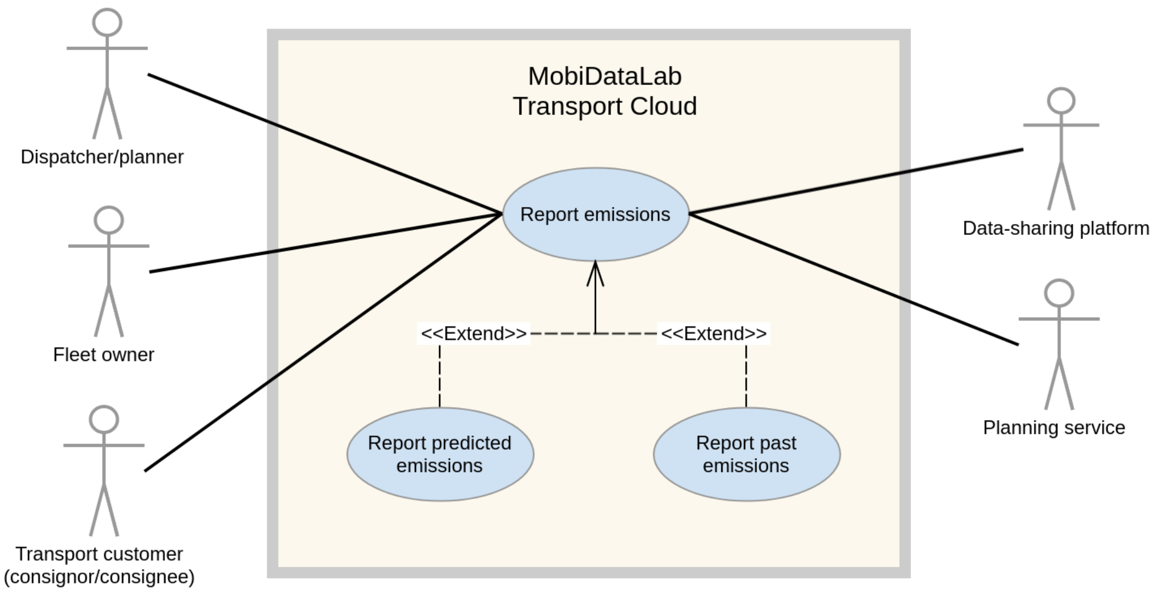

Figure 2: Use case diagram for Emission Reporting

- System: the MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
  - Primary: the primary actors are the Dispatcher, the Transport customer, and the fleet owner.
  - Secondary: the data sharing platform and the Planning service
- Use cases:
  - Report emissions
  - Report predicted emissions
  - Report past emissions

Table 5: Use case description for Emission Reporting

Category	Description
Case "report predicted emissions"	
Pre-condition 1	Tour plan has been created by planning service
Step 1	Predict emissions caused by execution of the tour plan
Step 2	Return predicted emissions in suitable format to dispatcher, fleet owner and transport customer
Post-condition 1	Dispatcher, fleet owner and transport customer are informed about the emissions of the planned tours
Case "report past emissions"	
Pre-condition 1	Tours have been executed
Pre-condition 2	Telematics data on those tours has been collected
Step 1	Select tours for which emissions should be reported
Step 2	Compute estimated emissions caused by those tours
Step 3	Return estimated emissions in suitable format to dispatcher, fleet owner and transport customer
Post-condition 1	Dispatcher, fleet owner and transport customer are informed about the emissions of the completed tours

2.2.1. Used Data

- Emission models
- Tour plans, routes
- Telematics data (GPS traces etc.)
- Weather
- Traffic
- Vehicle data, fuel type
- Vehicle load

2.2.2. Relevant Standards

- ESG (Environmental, Social, Governance) standards
- Emission standards for vehicles
  - https://ec.europa.eu/growth/sectors/automotive/environment-protection/emissions_en (Emissions in the automotive sector | Internal Market, Industry, Entrepreneurship and SMEs, no date).

2.2.3. Possible technical solutions

- Database, catalogues, dataset for emissions models
- Microservice for computing emissions from emission models
- Integration into relevant planning services such as routing, tour planning etc.

2.2.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

Table 6: Requirements table - Emission reporting

Id	Description	Priority
UC2-R01	The planning service can provide tour plans the transport cloud	MH
UC2-R02	Emissions for a tour plan can be predicted taking into account relevant data sources	MH
UC2-R03	Dispatcher, fleet owner and transport customer can retrieve predicted emissions for a tour	MH
UC2-R04	The data sharing platform can provide relevant data for emission estimation	MH
UC2-R05	The data sharing platform can provide telematics data for tour for which emissions should be reported	MH
UC2-R06	Dispatcher, fleet owner and transport customer can retrieve estimated emissions for tours based considering telematics data and other relevant data sources in suitable format	MH

2.3. Analytics & Learning

The use case "analytics and learning" is a generic use case in which tools are developed, extended and reused to analyse existing and newly integrated data.

The focus of this use case is related to:

- Data access
- Data analysis
- Learning from data

This use case is providing a horizontal connection to all use cases, since analysis and learning methods can contribute to most of the presented use cases.

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From the tooling perspective, the focus relies on established (open source) tools, such as the popular GIS tool QGIS, which brings already many interoperable interfaces to interact with a large set of data sources. Further tools will enrich the "toolbox", such as libraries and SDKs, that already interacts with mobility data interfaces, or that can be extended to make use of their analytics and learning capabilities.

Figure 3 shows the use case diagram for the analytics and learning use case. Four key actors: Researcher, Data Scientist, Domain Expert (data clients) will load data and produce results out of it for the fourth stake holder, the decision maker.

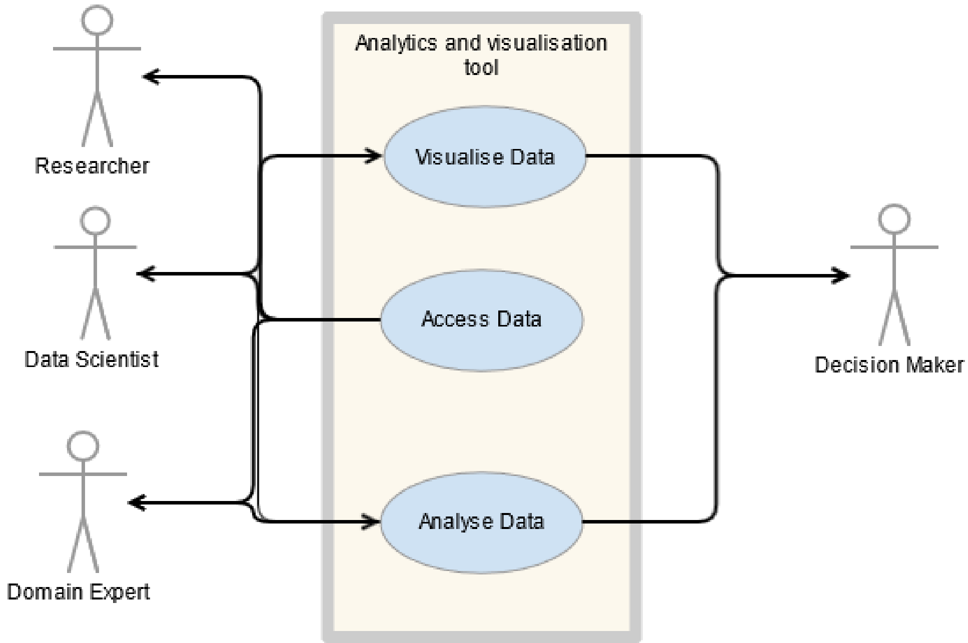

Figure 3: Use case diagram for Analytics & Learning

- System: the analytics and visualisation tool connected to the MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
  - Primary: the primary actors are the Researcher, the Data Scientist and the Domain expert
  - Secondary: the Decision Maker
- Use cases:
  - Visualise data
  - Access data
  - Analyse data

Table 7: *Use case description for Analytics & Learning*

Category	Description
Case "Visualise Data"	
Pre-condition 1	Data is available in the Transport Cloud
Pre-condition 2	Data visualisation client is installed and ready to connect
Pre-condition 3	Client can connect to the Transport Cloud and can load data
Step 1	Data visualisation client is connecting to the Transport Cloud and loads data
Step 2	Data client is visualising the data
Post-condition 1	Actor (Data Scientist, Domain Expert, Researcher) are able to visualise and visually inspect the data
Case "Access Data"	
Pre-condition 1	Data is available in the Transport Cloud
Pre-condition 2	Data client is installed and ready to connect
Pre-condition 3	Client can connect to the Transport Cloud and can access data
Step 1	Data client is connecting to the data service
Step 2	Data client is loading data from the mobility data cloud
Post-condition 1	Data is available at the data client for further processing
Case "Analyse Data"	
Pre-condition 1	Data is available in the Transport Cloud
Pre-condition 2	Data client is installed and ready to connect
Pre-condition 3	Client can connect to the Transport Cloud and can load data
Step 1	Data client is connecting to the data service and loads data
Step 2	Data client is performing data analysis algorithms on the data
Post-condition 1	Actor (Data Scientist, Domain Expert, Researcher, Decision Maker) is able to use the analysed data

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Figure 4 shows the QGIS tool with manifold options for data analytics and connections to many standardised interfaces for loading, visualising and analysing spatial data.

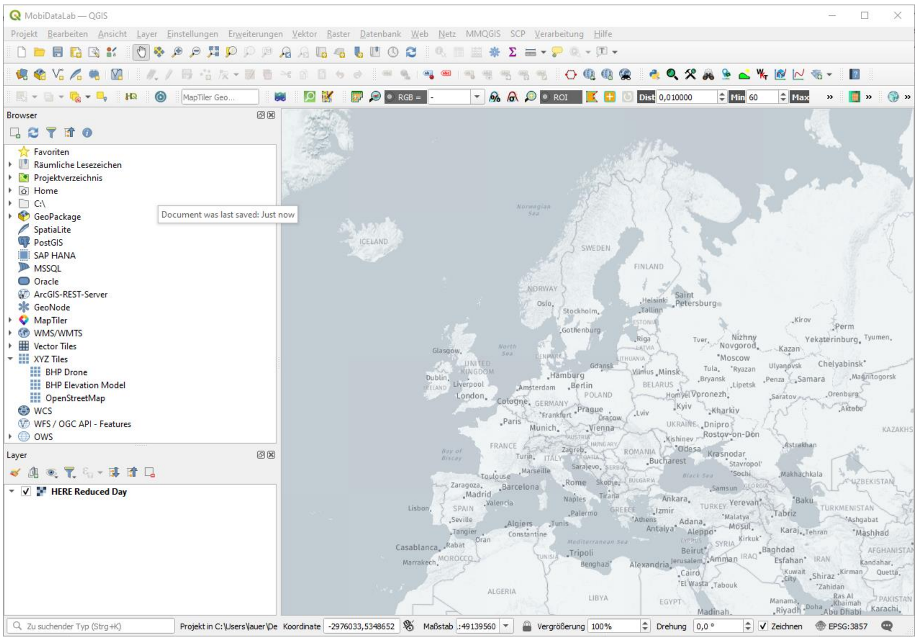

Figure 4: QGIS as tool for analytics and learning

2.3.1. Used Data

The Analytics & Learning use case should be generic in the way, that it is independent from the data sources (as long as the source is available in a standardised format). However, the practical usage will be demoed via access and analysis of existing data sets.

A list of potential data sources and providers is given below:

- OpenStreetMap as data provider for community generated map data
- Mobilitäts Daten Marktplatz (https://www.mdm-portal.de/) (Mobilitäts Daten Marktplatz MDM - MDM Portal, no date)
- WikiData (www.wikidata.org) (Wikidata, no date)
- Further data available from project stakeholders, associates and other platforms.

2.3.2. Relevant Standards

Since the variety and heterogeneity of the used data is high, because of the different domains (many data suppliers) and the broad usage (many different use cases), the relevant standards to access the data will be as heterogeneous as the data and domains.

- From the domain of geographic data sets, standards provided by the Open Geospatial Consortium (OGC) are covering a large part. Especially interface, such as WMS (WebMapService) (Web Map Service | OGC, no date), WFS (WebFeatureService) (Web Feature Service | OGC, no date) or GML (Geographic Markup Language) (Geography Markup Language | OGC, no date) are only some of the relevant standards.
- Especially for data visualisations, map vector tiles are state of the art for vectorised base maps GeoJSON (rfc7946, no date) as a format for more granular and flexible data semantic.
- Standards for further mobility data / traffic data or ticketing data will also have a relevant role for this use case.
- Almost every standard in which data and services are provided. The focus lies here on the most common standards and will be aligned with the other use cases. Besides the listed standards within this use case, every data standard from this project is a candidate for this use case to analyse its data.

Decisions on standards being used in this use case will be made during the implementation phase of the use case and the first prototypes and will be adjusted during the project time.

2.3.3. Possible technical solutions

- QGIS as data analysis tool.
- Python libraries/frameworks (libraries and APIs to access, analyse and visualise data, e.g. Jupyter notebooks and state-of-the-art analytics frameworks).

2.3.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

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Table 8: Requirements table - Analytics & Learning

Req.No.	Description	Priority
UC3-R01	Connect to the Transport Cloud	MH
UC3-R02	Loading data from the Transport Cloud	MH
UC3-R02.1	Loading spatial data	MH
UC3-R02.2	Loading non-spatial (e.g. tabular data)	CH
UC3-R03	Visualise data loaded from the Transport Cloud	MH
UC3-R03.1	Filtering data for visualisation	CH
UC3-R03.2	Styling data	CH
UC3-R03.3	Labelling data	CH
UC3-R04	Analyse data from the transport cloud	SH
UC3-R04.1	Spatial data analysis	CH
UC3-R04.2	Density analysis (e.g. Heat maps)	CH
UC3-R04.3	Loading non-spatial data	CH

2.4. Re-use of transport data for journey planners / digital services

Many digital service providers would like to be able to add journey planning capabilities to their services, using different modes of transports. Such services obviously include transport applications (multi-modal transport), but also other type of services, for example: city applications (points of interest), retail applications (how to get to a physical store with public transport), real estate (public transport travel time, optimisation of commute time from home to office), employment (list of job offers with travel optimisation), ride sharing (help commuters to connect for sharing the same vehicle) and many more.

It would be too complicated for these digital service providers to deal with raw transport data sets, especially for multi-modal journey planning as it would require them to combine different kind of data sets (public transports, free floating, cartography, points of interest …), especially considering each of these raw data sets may use different format (proprietary or standard).

A common solution for journey planning would therefore foster the use of transport data, through a service layer (unified API, common user experience) that simplifies the usage and allows the use also for non-domain experts.

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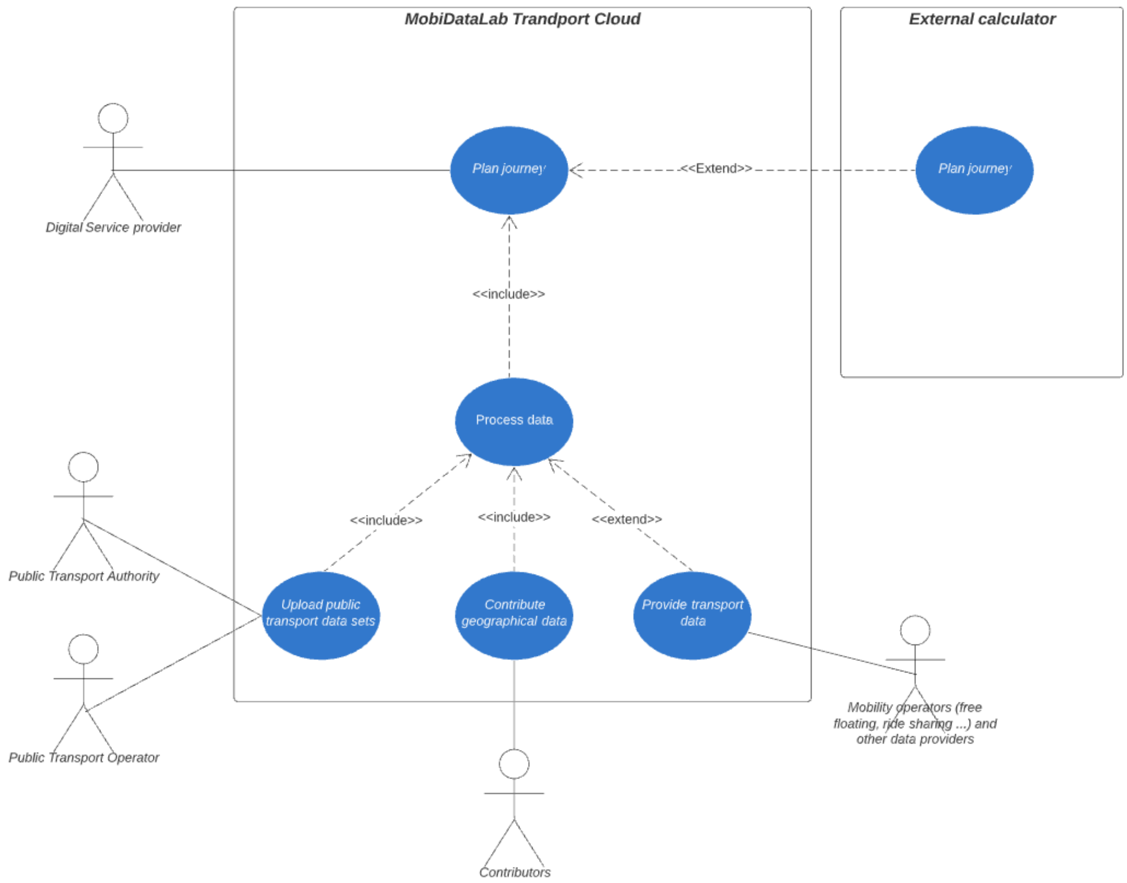

Figure 5: *Use case diagram for Journey planning*

- System: the MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
    - Primary: the primary actors are the Digital Service Provider, the Public Transport Authority, the Public Transport Operator, the contributors and the mobility operators
    - Secondary: the External calculator
- Use cases:
    - Process data
    - Plan journey

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Table 9: Use case description for Journey planning

Category	Description
Case "Process data"	
Pre-condition 1	PTA and PTO operators make public transport data sets available to the Transport Cloud
Pre-condition 2	OSM contributors or other geographical data contributors make geographical data available to the Transport Cloud
Pre-condition 3	Other mobility operators share their data sets with the Transport Cloud
Step 1	Quality check
Step 2	Enrichment (data combination)
Step 3	Conversion to a common data format
Post-condition 1	All transport data sets had been processed
Case "Plan journey"	
Pre-condition 1	Processed data set are available within the Transport Cloud for each transport mode
Pre-condition 2	External calculators available for transport modes that would not be available within the Transport Cloud (optional)
Pre-condition 3	Public API available and exposed to users of the Transport Cloud
Step 1	User sends a request using the API: start point, end point, requested transport modes and other search criteria
Step 2	Journey planner system process the request
Post-condition 1	User gets a response with all possible journeys, using a standardised format (e.g. JSON)

2.4.1. Used Data

- Public transport data
    - Static data
    - Transportation Lines
    - Schedules
    - Stop points
    - Stop areas
    - Real-time / dynamic data
    - Disruptions, traffic alerts
    - Next arrivals and departures
    - Vehicle information (occupancy, location)

- Geographical data
    - Cartography
    - Addresses
    - Points of interests

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- Other transport data
  - Free floating
  - Ride sharing
  - Road traffic

For journey planning in France for example, one will typically use the following datasets:

- Open public transports data sets available from https://transport.data.gouv.fr (Le Point d'Accès National aux données ouvertes de transport, no date) or from https://www.navitia.io (navitia.io | The open API for building cool stuff using transport data, no date)
- BANO (Base d'Adresses Nationale Ouverte) for postal addresses
- OpenStreetMap (e.g., extracted points of interest).

Some journey planning systems (e.g. Navitia) may also integrate with other service providers (e.g. HERE) to propose multi-modal journeys combining the capabilities of each system.

2.4.2. Relevant Standards

- Public transport data
  - GTFS (General Transit Feed Specification) and GTFS-RT (GTFS Real time): a standard initially developed by Google but now under governance of a non-profit organisation (https://mobilitydata.org/) (MobilityData | The one-stop organisation for mobility data standards, no date);
  - NeTEx (Network Exchange – static data) and SIRI (Service Interface for Realtime Information - real time data): European norms (http://www.transmodel-cen.eu/) (Transmodel – CEN Reference Data Model for Public Transport, no date).

- New mobility
  - GBFS (General Bikeshare Feed Specification), initially developed by the North American Bikeshare Association (NABSA), now under governance of the same non-profit organisation as GTFS (https://mobilitydata.org/);
  - TOMP-API (TOMP-WG – TOMP working group, no date).

- Geographical data
  - OpenStreetMap (OSM) provides cartography and points of interests (https://www.openstreetmap.org/) (OpenStreetMap, no date).

- Journey planning
  - Transmodel is a European norm that provides an abstract model of common public transport concepts and data structures, most of them being relevant for journey planning (http://www.transmodel-cen.eu/) (Transmodel – CEN Reference Data Model for Public Transport, no date);
  - OJP (Open Journey Planning) is part of the Transmodel specifications. It defines a way to interconnect journey planning systems (http://www.transmodel-cen.eu/standards/ojp/) (OJP standard – Transmodel, no date).

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2.4.3. Possible technical solutions

A common set of APIs could be defined, based on Transmodel concepts and data structures, to allow digital service providers to access journey planning features in a standardised way, without having to deal with raw datasets.

Navitia (https://www.navitia.io/) is an open source trip planner that proposes an open API already based on Transmodel concepts, and therefore could be a good starting point for defining such a standard API that could then be implemented by any journey planner system.

Open Trip Planner (OTP, https://www.opentripplanner.org/) is another open source trip planner, that proposes an open API.

To compute long journeys between different countries for example, it will be necessary to interconnect different trip planners. Open Journey Planning (OJP) could be used as a starting point to implement such interconnection.

2.4.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

Table 10: Requirements table - Journey planning

Req.No.	Description	Priority
UC4-R01	Integrate public transport data sets	MH
UC4-R02	Integrate other transport modes	SH
UC4-R03	Integrate points of interests	SH
UC4-R04	Process and enrich data sets	SH
UC4-R05	Plan journeys using integrated data sets	MH
UC4-R06	Plan journeys using results from external calculators	CH
UC4-R07	Get journeys using a standardised API	SH
UC4-R08	Get journey planner statistics	SH

2.5. Mobility as a Service (MaaS)

The Mobility as a Service (MaaS) use case covers the requirements for **Transport data sharing across other modes (micro-mobility)** mentioned in the grant proposal. Mobility as a Service provides a larger context and allows more freedom to evolve the V1 use cases. Especially for the virtual labs and x-athons, a flexible guideline needs to be given to show on the one hand specific realisations, but providing on the other hand options for evolutions, extensions and new thoughts. The two sets of use cases (v1 and v2), allow adjusting the use cases with the support of additional stakeholders of the reference group and the feedback out of the virtual- and living labs.

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Mobility takes new forms, with new behaviours and new services – especially in urban areas. Mobility becomes a mixture of different modes of transport, both individual transport solutions (either cars, bicycles, e-scooters, etc.) and new forms of public transport like ride pooling and ridesharing.

In order to motivate users to use and mix these different modes of transport, it is important to offer them a complete end to end solution that will not only allow them to plan their journey, but also to book and pay their ticket for the complete journey. These features, when combined (plan, book, and pay for multiple types of mobility services using a single channel) constitute the core principles of the Mobility as a Service (MaaS) use case.

The MobiDataLab project may benefit MaaS projects in two different ways:

1. MobiDataLab Transport Cloud could be used by MaaS operators to retrieve raw transport data sets.

2. MobiDataLab Transport Cloud journey planning, can be used by MaaS operators to plan journeys, rather than dealing with raw transport data.

The use case presented below describes the second option (use of MobiDataLab journey planning system). Note that in this case, the MaaS operator plays the role of the Digital Service Provider in the journey planning use case described §2.4.

In addition, the use case presented below is two folded: MaaS operators may use MobiDataLab journey planning capabilities, but MobiDataLab Transport Cloud may also retrieve, process and share data from the MaaS operator. Information about MaaS users and journeys may be very useful to analyse, for example: What are the most commonly planned journeys? Using which transport modes? How many planned journeys are actually purchased? If the MaaS operator does not want or cannot process these data, then this task could be offloaded to MobiDataLab transport cloud.

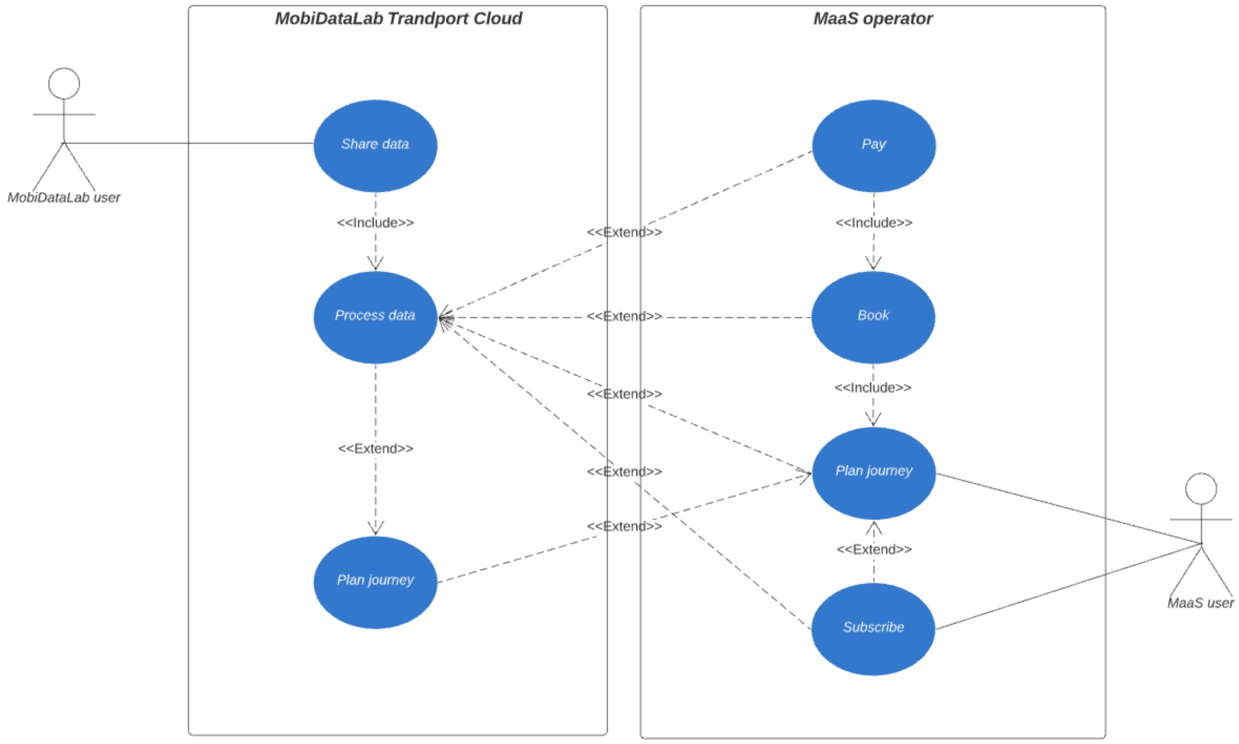

Figure 6: Use case diagram for Mobility as a Service

- System: the MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
    - Primary: the MobiDataLab user
    - Secondary: the MaaS user through the MaaS operator
- Use cases:
    - Share data
    - Process data
    - Plan journey

Table 11: Use case description for Mobility as a Service

Category	Description
Case “Share Data”	
Pre-condition 1	Transport Data sets available outside the Transport Cloud
Step 1	User uploads transport data sets
Post-condition 1	Transport Data sets have been uploaded
Case “Process data”	
Pre-condition 1	Transport data sets available
Pre-condition 2	Maas Data sets available (booking data, payment data, subscription data)
Step 1	Analyse data
Step 2	Combine data
Post-condition 1	Statistical analysis, prediction models about multi modal journeys
Case “Plan journey”	
Pre-condition 1	Processed data set are available within the Transport Cloud for each transport mode
Pre-condition 2	External calculators available for transport modes that would not be available within the Transport Cloud (optional)
Pre-condition 3	Public API available and exposed to MaaS operators
Step 1	MaaS operator sends a request using the API: start point, end point, requested transport modes and other search criteria
Step 2	Journey planner system process the request
Post-condition 1	Maas operator gets a response with all possible journeys, using a standardised format (e.g. JSON)

2.5.1. Used Data

Journey planning is a core component of MaaS, therefore the same data inputs will be required: transport data and geographical data.

In addition, MaaS services will require data related to ticketing (for booking and payment). This will typically be provided through partner APIs (Application Programming Interfaces) that will have to be called for each transport mode that is part of the complete journey.

2.5.2. Relevant Standards

The relevant standards for the journey planning part of the MaaS use case are described in the journey planning section.

Regarding ticketing, there exist two main standards:

- Calypso: under governance of CNA (Calypso Network Association) (Calypso Networks Association - Calypso Networks Association, no date).
- CIPURSE: under governance of OSPT Alliance (Open Standard for Public Transportation Alliance) (CIPURSE Specifications | OSPT Alliance, no date).

2.5.3. Possible technical solutions

Mobility-as-a-Service use case is very broad, and several initiatives already exist to implement this use case. We can mention in particular the MaaS4EU project, which is part of the European Union's Horizon 2020 Research and Innovation Program, started in June 2017 and ended in October 2020.

Only a subset of MaaS use case could be handled by MobiDataLab Transport Cloud, namely: journey planning and data processing. Booking and ticketing, on the contrary, are not in MobiDataLab Transport Cloud scope, at least at the moment (except for eventual data processing and sharing).

For journey planning, a possible technical solution has already been outlined in §2.4.3.

For data processing, possible solutions are outlined in §2.3.3. It should also be checked with MaaS actors and operators which kind of data could be retrieved by MobiDataLab Transport Cloud and how. Then we could decide if these data flows are of the same nature than other data flows already handled by MobiDataLab Transport Cloud or if we should implement specific data formats, connectors and/or processing tools.

2.5.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

Table 12: *Requirements table - Mobility as a Service*

Req.No.	Description	Priority
UC5-R01	Export journey planning data	MH
UC5-R02	Export raw transport data sets	MH
UC5-R03	Integrate MaaS booking data	SH
UC5-R04	Integrate MaaS payment data	SH
UC5-R05	Integrate MaaS journey data	CH
UC5-R06	Export MaaS data sets	MH

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3. Use Case Definitions: Use Cases for Research

Sharing data within each sector is essential, but so is sharing data between sectors. The aim of these use cases is to show how it will be possible for participants in the innovation sessions (Living Labs and Virtual Labs) to enrich mobility data with data from other sectors, using the transport cloud. These use cases are motivated by the observation that mobility data would gain value by being combined with other datasets to obtain additional results. To do this, the data need to be interoperable and standardised.

Mobility data enrichment methods:

In the framework of the MobiDataLab project, we propose mainly two methods to perform this enrichment, which will be part of the MobiDataLab toolbox implemented in WP4:

- Geospatial enrichment, which is based on a common geometry between data from different sources;
- Semantic enrichment, which is based on a common vocabulary or a mapping between the vocabularies used to describe the different datasets.

3.1. Geodata sharing applied to Transport: OpenStreetMap for inclusive transport

The challenge: The lack of information about accessibility makes it hard for people who use a wheelchair or move around with strollers to take part in the daily life. Regulations in EU member states declare that local public transport must be usable for people with limited mobility possibilities (e.g. the German law for Barrier-free Travel Chain). In this context, public transport authorities are requested to examine all train stations and bus stops with respect to accessibility to disabled persons, providing detailed mapping of train stations and bus stops including infrastructure, P+R, B+R, vehicle sharing, etc. These kinds of projects, organisations and initiatives aim to improve significantly the daily life of citizens with limited mobility.

On the other hand, several associations are mapping accessibility data worldwide to build a repository of places with accessibility attributes – an information which is often hard to find. Most of these associations reuse OpenStreetMap data and contribute themselves to the project. One of the main contributors to OpenStreetMap accessibility data is the SozialHelden association and the wheelmap thematic OSM map showing which places are wheelchair accessible and which places are not (www.wheelmap.org) (Wheelmap – Finde rollstuhlgerechte Orte., no date). Other associations work in the same objective with their own communities (e.g. Jaccede in France, AXS maps, IwheelShare, etc.). All these associations having different strategies to collect and crowdsource data, they decided to collaborate with each other and grow faster and help their user community for broader acceptance and common solutions on a larger scale.

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This resulted in the “Accessibility.cloud”, a data exchange service allowing all those data sources to interact with each other. Following the FAIR principle of Findable, Accessible, Interoperable and Reusable (cf.: Wilkinson et al., 2016).

Figure 7 shows how MobiDataLab can accelerate the exchange of accessibility data and build innovative solutions on it, providing an access channel to the accessibility cloud and the OpenStreetMap data.

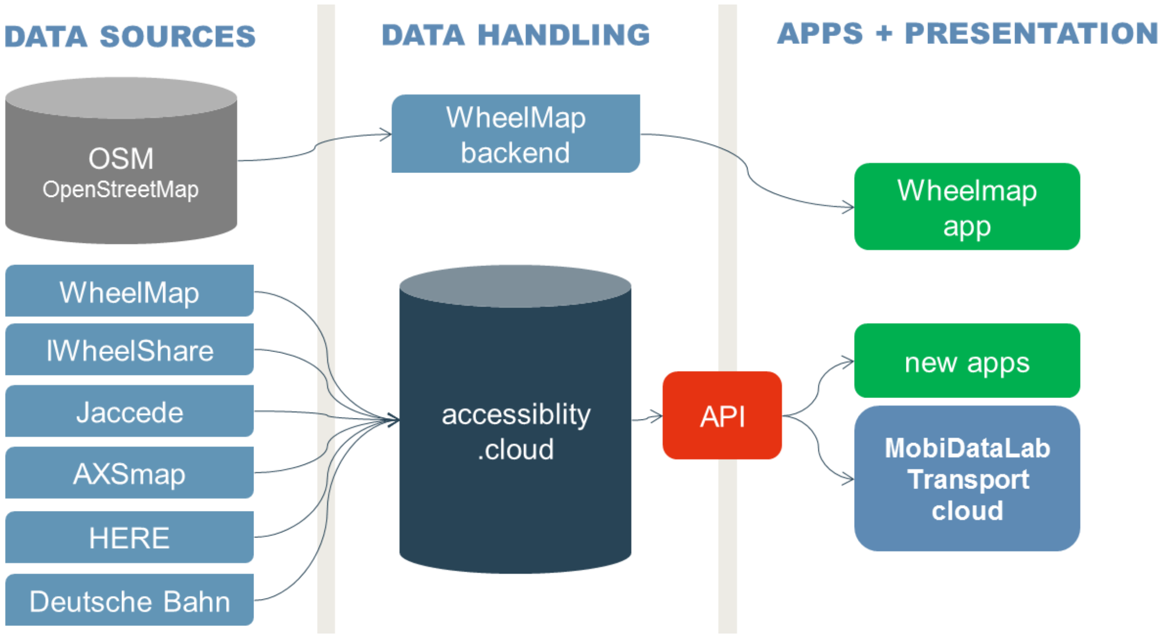

Figure 7: *The accessibility cloud (credit: wheelmap.org)*

Not only associations and communities are contributing to OpenStreetMap, but also some transport authorities (e.g. Baden Wurttemberg), making OpenStreetMap the de facto common basis for the exchange of geo-referenced accessibility data.

In a nutshell, this use case aims to evaluate in partnership with one or several local authorities from the MobiDataLab reference group, if the local public transport is usable for persons with reduced mobility. All train stations and bus stops will be evaluated with respect to their accessibility to disabled persons, combining OpenStreetMap data with many open datasets available in the local context (from public authorities to private and associative accessibility cloud data providers).

This use case will result in a detailed mapping of trains stations and bus stops in the Virtual Lab interface, including P+R, B+R and the infrastructure, hence a contribution of MobiDataLab to the OpenStreetMap project.

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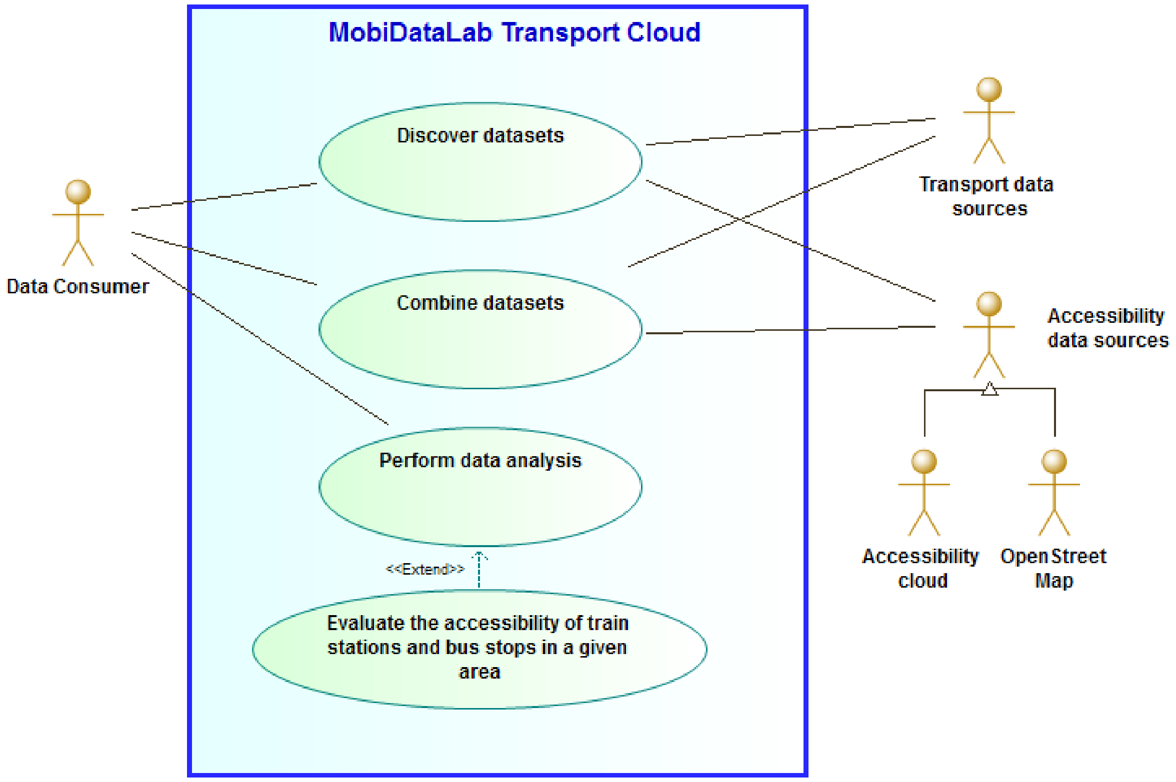

Figure 8: *Use case diagram - OpenStreetMap for inclusive transport*

- System: the MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
  - Primary: the primary actor is the MobiDataLab Data Consumer. Data consumers use the MobiDataLab transport cloud to discover and access mobility data.
  - Secondary: the transport data sources and accessibility data sources, who only respond upon a query from the data consumer (see the section datasets used below for more details).
- Use cases:
  - Discover datasets: The data consumer wants to browse and explore datasets on the MobiDataLab Transport Cloud data catalogue
  - Combine datasets: The data consumer wants to combine the transport and accessibility datasets
  - Perform data analysis
  - Evaluate the accessibility of train stations and bus stops in a given area: this is actually the main use case described above. It extends the base use cases “perform data analysis” because the Data Consumer has the option to perform this specific analysis with the datasets retrieved.

Table 13: *Use case description for OpenStreetMap for inclusive transport*

Category	Description

Case “discover datasets”	
Pre-condition 1	The data consumer has not selected any dataset to work on
Pre-condition 2	The data consumer has identified search criteria
Step 1	The data consumer search for transport and accessibility datasets on the MobiDataLab Transport Cloud data catalogue based on predefined search criteria
Step 2	The Transport Data Cloud connects to the corresponding Transport Data sources and accessibility data sources (Accessibility cloud and OpenStreetMap)
Step 3	Transport and Accessibility data sources are displayed to the data consumer
Post-condition 1	The data consumer has selected one or several datasets corresponding to transport and accessibility search criteria
Case “combine datasets”	
Pre-condition 1	The data consumer has selected transport and accessibility datasets corresponding to her criteria
Step 1	The data consumer displays the datasets on the user interface and is proposed several data processors to enrich and combine the data
Step 2	The Transport Data Cloud joins the Transport and Accessibility datasets based on a common geometry
Step 3	The result an enriched and consolidated dataset, containing different information from different data sources
Post-condition 1	The data consumer benefits from an enriched and consolidated dataset, containing different information from different data sources (Transport open data, Accessibility cloud, OpenStreetMap)
Case “perform data analysis”	
Pre-condition 1	The data consumer has retrieved a consolidated dataset, containing different information from different transport and accessibility data sources (Transport open data, Accessibility cloud, OpenStreetMap)
Step 1	The data consumer downloads and/or connects to the consolidated dataset
Step 2	Using her preferred analysis tool, the data consumer performs an analysis to evaluate the accessibility of train stations and bus stops in a given area
Post-condition 1	The data consumer has performed a data analysis based on a combination of transport and accessibility datasets

3.1.1. Datasets used

- [National Access Points for Public Transport data]
- Mobilitäts Daten Marktplatz (www.mdm-portal.de)
- Wheelmap (www.wheelmap.org)
- AXSmap (www.axsmap.com) (Venues | AXS Map, no date)
- Jaccede (www.jaccede.com) (Jaccede.com, no date)
- OpenStreetMap data (www.openstreetmap.org) (tags wheelchair, sidewalk, etc).

Data sharing is at the heart of the OpenStreetMap ecosystem, with a common exchange format based among others on the concept of "tags". For accessibility mapping several tags are available. The tag wheelchair is used to indicate if some places or means of transportation are physically accessible with wheelchairs or similar disabilities. OSM also provides tags for mapping accessibility to blind and deaf persons, like *tactile_paving* for public transportation stops with platforms, *traffic_signals: sound* and *traffic_signals: vibration* for mapping pedestrian crossings with and without acoustic guidance, POIs that offer special service for the blind, etc.

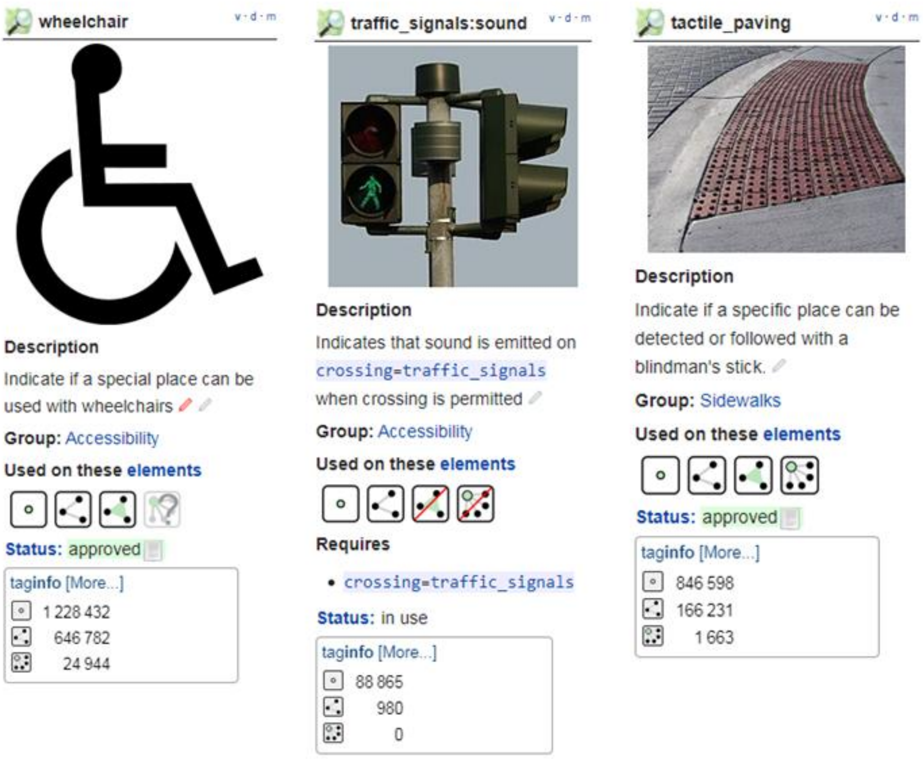

Figure 9: *OSM accessibility tags and corresponding dataset figures*

3.1.2. Standards

- Public Transport GTFS, NeTEx, etc
- OpenStreetMap data format
- Geographical Information Systems exchange service (WFS, WMS, etc).

3.1.3. Possible technical solutions

- OpenStreetMap Overpass API
- Accessibility cloud.

3.1.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

Table 14: Requirements table - OpenStreetMap for inclusive transport

Req.No.	Description	Priority
UC6-R01	The data consumer can select a specific transport and/or accessibility data source in the data catalogue	MH
UC6-R02	The data consumer can connect to a specific transport and/or accessibility data source in the data catalogue	MH
UC6-R03	The data consumer can select one or several data processors to enrich the data	MH
UC6-R04	The data consumer can join transport and accessibility datasets based on a common geometry	MH
UC6-R05	The data consumer can download the enriched dataset	MH
UC6-R06	The data consumer can perform spatial data analysis on joined datasets, e.g. evaluating the accessibility of train stations and bus stops in a given area	SH

3.2. Geodata sharing applied to Transport: Environmental data for sustainable transport

The challenge: The European Commission wants the EU transport system to achieve a green and digital transformation and targets a 90% cut in emissions by 2050. An intermediary step is that by 2030 around 100 European cities will become climate neutral. Digital technologies can help reaching this ambitious sustainable goal, boosting innovation and the use of data and Artificial Intelligence.

In this respect it is crucial to be able to exchange data from the transport and environmental sectors, as this combination will provide key information on the environmental impact of Green Deal policies.

This use case aims at exposing a combination of data provided by the public (transport) authorities of the Reference Group with local environmental data (air quality, atmospheric conditions, weather, etc.) following the Geographical Information Systems formats and exchange standards (OGC, INSPIRE (Eu, 2007), GeoJSON (rfc7946, no date), open APIs, etc.). These data can be static (e.g. low emission zones), real-time (e.g. road traffic and and/or historical. The result of this analysis could be e.g. a geographical representation of the environmental impact of road traffic in a given territorial context.

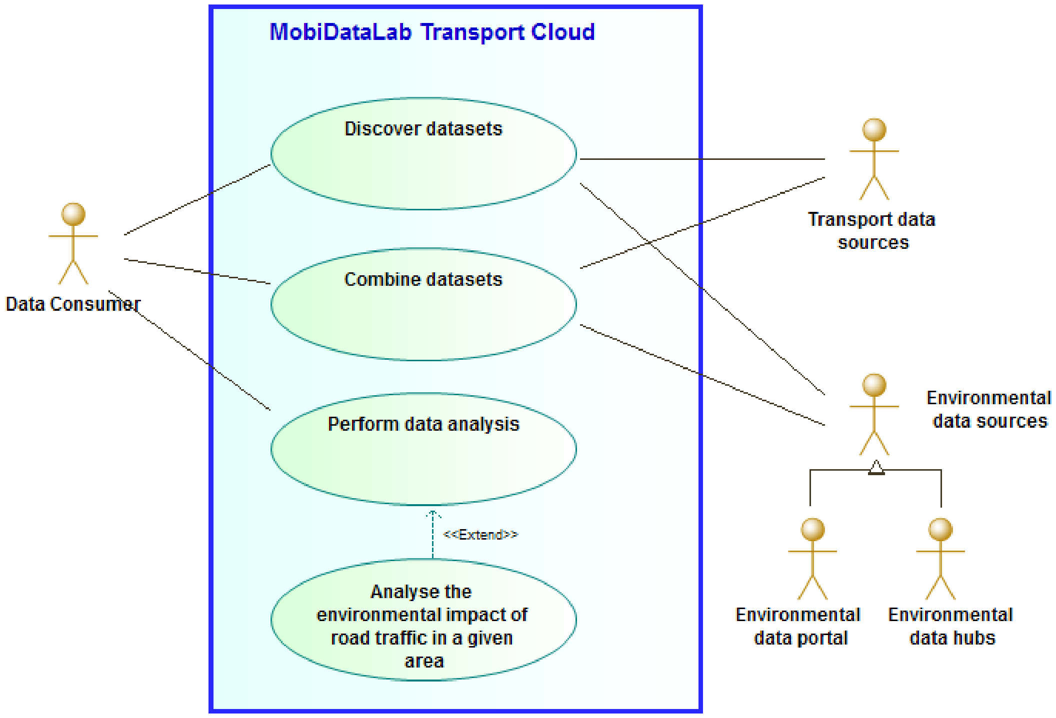

Figure 10: Use case diagram - Environmental data for sustainable transport

- System: The MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
  - Primary: The most obvious actor is the MobiDataLab Data Consumer. Data consumers use the MobiDataLab transport cloud to discover and access mobility data.
  - Secondary: the transport data sources and environmental data sources, who only respond upon a query from the data consumer (see the section datasets used below for more details).
- Use cases:
  - Discover datasets: The data consumer wants to browse and explore datasets on the MobiDataLab Transport Cloud data catalogue
  - Combine datasets: The data consumer wants to combine the transport and environmental datasets
  - Perform data analysis
  - Analyse the environmental impact of road traffic in a given area: this is actually the main use case described above. It extends the base use cases "perform data analysis" because the Data Consumer has the option to perform this specific analysis with the datasets retrieved.

Table 15: *Use case description for Environmental data for sustainable transport*

Category	Description
Case "discover datasets"	
Pre-condition 1	The data consumer has not selected any dataset to work on
Pre-condition 2	The data consumer has search criteria
Step 1	The data consumer searches for transport and environmental datasets on the MobiDataLab Transport Cloud data catalogue based on predefined search criteria
Step 2	The Transport Data Cloud connects to the corresponding Transport Data sources and environmental data sources (e.g. environmental data portals and/or data hubs)
Step 3	Transport and Environmental data sources are displayed to the data consumer
Post-condition 1	The data consumer has selected one or several datasets corresponding to transport and environmental search criteria
Case "combine datasets"	
Pre-condition 1	The data consumer has selected transport and environmental datasets corresponding to her criteria
Step 1	The data consumer displays the datasets on the user interface and is proposed several data processors to enrich and combine the data
Step 2	The Transport Data Cloud joins the Transport and Environmental datasets based on a common geometry
Step 3	The result an enriched and consolidated dataset, containing different information from different data sources
Post-condition 1	The data consumer benefits from an enriched and consolidated dataset, containing different information from different data sources (Transport open data, environmental open data)
Case "perform data analysis"	
Pre-condition 1	The data consumer has retrieved a consolidated dataset, containing different information from different transport and environmental data sources (Transport open data, environmental open data)
Step 1	The data consumer downloads and/or connects to the consolidated dataset
Step 2	Using her preferred analysis tool, the data consumer performs an analysis to analyse the environmental impact of road traffic in a given area
Post-condition 1	The data consumer has performed a data analysis based on a combination of transport and environmental datasets.

3.2.1. Datasets used

- National Access Points
- HERE Traffic API (Guide - HERE Traffic API - HERE Developer, no date)
- Environmental data portal (INSPIRE geoportal) (INSPIRE Geoportal, no date)

- Environmental data hubs and APIs
- OpenAQ API (OpenAQ, no date)
- OpenWeatherMap API (Weather API - OpenWeatherMap, no date).

3.2.2. Standards

- OGC standards
- INSPIRE data models
- Data on the Web Best practices (Open APIs)
- Spatial data on the Web Best practices (GeoJSON APIs)
- DATEX II (Homepage | DATEX II, no date).

3.2.3. Possible technical solutions

- Geospatial enrichment processor (use case specific within MobiDataLab)
- GeoServer (GeoServer, no date) for providing geospatial data sets via OGC standardised interfaces.

3.2.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

Table 16: Requirements table - Environmental data for sustainable transport

Req.No.	Description	Priority
UC7-R01	The data consumer can select a specific transport and/or environmental data source in the data catalogue	MH
UC7-R02	The data consumer can connect to a specific transport and/or environmental data source in the data catalogue	MH
UC7-R03	The data consumer can select one or several data processors to enrich the data	MH
UC7-R04	The data consumer can join transport and environmental datasets based on a common geometry	MH
UC7-R05	The data consumer can download the enriched dataset	MH
UC7-R06	The data consumer can perform spatial data analysis on joined datasets, e.g. analysing the environmental impact of road traffic in a given area	SH

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3.3. Transport data sharing within the Linked Open Data vision

Digital technologies in general, and data sharing in particular, have an important role to play in improving tourist mobility. Especially when planning their trip and during their travels on site, visitors need good travel information, for which it is crucial to be able to combine transport and tourism related information. Local authorities that organise tourism in their area (e.g. tourist offices) would gain a lot from integrating all available mobility services, if possible in real time, with their data - especially to improve the tourist information they provide (e.g. with car parks, public transport services, tourist buses, and even data from bike sharing companies). On the other hand, mobility organising authorities could be more efficient if they could integrate tourist information into their passenger information systems - for cities and regions that are tourist destinations in particular.

For the latter case, considering tourists as a specific category of transport users is a necessity, as - contrary to residents - they are not familiar with the area and the available transport services (and do not even know how they work), they follow different travel patterns, do not need to travel at peak times, and they often do not speak the language.

In this case study we assume to exploit the services offered by the Transport Cloud to enrich mobility data with semantic information provided by Linked Open Data and use the resulting enriched datasets to perform analyses that can be then exploited by the Tourist Service provider to issue recommendations.

We assume that mobility data that need to be enriched can fall within two categories, i.e., (1) tracks generated by the use of position-enabled devices which collect the movements of tourists visiting a city, or (2) segments (i.e., sequence of geo-located points satisfying some criteria) suggested by some journey planner service.

The goal to be achieved in this use case is to allow a tourist service, via the services offered by Transport Cloud, to offer personalised services that enrich and improve the tourists' visiting experience by leveraging the mobility data that is being tracked and collected. Clearly, the tracking and collection of position data of individuals is subjected to GDPR and related privacy regulations.

Use Case Scenario recommendation example:

Let us consider a scenario where some tourist plans to arrive at the airport, reach the hotel, then combine sightseeing to the main attractions' points using different transportation means, then stop to lunch, and finally go back to the hotel. Let us further suppose that said tourist wants to receive suggestions on which transportation means are preferable, depending on weather and traffic conditions.

Furthermore, the tourist would like to receive recommendations concerning attractions they may want to visit, with said attractions being related to a specific historical period and that can be easily reached by walking.

Finally, the tourist would like to receive recommendations concerning vegetarian restaurants that are not too expensive and that can be reached from their hotel by the metro. The question then becomes: how a tourist service provider can satisfactorily answer the tourist's queries? It is clear, that we need to combine semantic contextual knowledge deriving from different data sources, both in tourism domain and in transportation domain.

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In the context of MobiDataLab, this knowledge will be available and linked though the Transport Cloud, while the actual semantic enrichment will be executed by the data processors.

The Linked Open Data (LOD) is an interesting technology for semantic enrichment. LOD principles promote the creation and publication of previously isolated databases as interlinked, reusable data graphs by means of known Web standards (for instance, HTTP, RDF, URIs, JSON-LD (JSON-LD 1.1, no date), and so on). Representing mobility data (e.g., trajectories) according to these principles offers a strategy to seamlessly incorporate mobility data into a global data space, i.e., the Web of Data, in a way that it can be easily shared, (re)used, and analysed. Even more interestingly, the very same Web of Data can be used as the main source of contextual information to enrich mobility data. One then can see how the transport cloud vision promoted by MobiDataLab can be framed in the context of the LOD principles (c.f. (Luebke et al., 2002)), and the case study that is introduced next attempts to offer a concrete example.

In (Ruback et al., 2016) the authors have shown how repositories of semantic trajectories can be built, and subsequently used to answer mobility queries, in line with the Linked Data principles.

To this end the authors provide a framework that operates as follows:

1. First, a given set of raw trajectories are segmented, i.e., the framework transforms each raw trajectory into a sequence of segments, where each segment is in turn a sequence of points satisfying some criteria. Criteria are provided by a so-called *Segmented Trajectory Ontology* (for brevity, STO). The STO used in (Ruback et al., 2016), and that is relevant for the purposes of this use case, is the stop-and-move ontology. The ontology defines four types of segments: *begin* (the object associated with the trajectory begins its trip), *move* (the object initiates or resumes some movement), *stop* (the object stops its current movement), and *end* (the object terminates its trip). Note that the segmentation process is agnostic to STOs, thus different ontologies may be used for different scenarios.

2. Segmented trajectories then go through a process called *semantic enrichment*. In this step each segment is matched to the most appropriate semantic entities. Semantic entities represent information that can be attached to segments to give them further meaning relevant to the considered scenario – for instance, to indicate which transport method was used by a person while crossing a segment, the points of interest that were visited during a stop, and so on.

Semantic entities are made available via the creation or selection of Linked Data Mashups (LDM), i.e., data sources that are obtained by combining, aggregating, and transforming data from heterogeneous data sources like, for example, the MobiDataLab transport cloud with its federated data sources.

By creating views on the LDMs of choice, one can then proceed to match segments to semantic entities.

The final result is a *repository of enriched trajectories*, where movement data and the associated semantic follow a unified formalism. Once the repository of semantic trajectories is in place, one can then proceed to query it – to this end, in (Ruback et al., 2016) the authors employ the SPARQL language.

In line with the approach presented in (Ruback et al., 2016), this use case study wants to describe a semantic enrichment process performed by the Transport Cloud, where data made available by tourism operators, transport data providers, and Linked Open Data providers, is exploited for this purpose. Also, Linked Open Data is employed to enrich mobility data thanks to the use of data processors (more specifically, semantic enrichment and geographic enrichment).

The use case diagram is illustrated in Figure 11, while Table 17 presents the preconditions, steps, and postconditions associated with the main case. The Figure shows different actors on the right (data provisioning) side: *transport data providers* (e.g. transportation agencies), *tourism data providers* (e.g tourism agencies) and *linked open data providers*. These actors interact with the transport cloud by discovering, providing, and combining data. On the other hand, the actor on the left (service consumption) side, i.e., the *tourist service provider*, sends requests to the transport cloud to perform some data analyses on enriched datasets. The tourist service provider can then build on the results provided by the transport cloud to offer services to their users - for instance, recommendation, journey planning, and historical mobility data analysis.

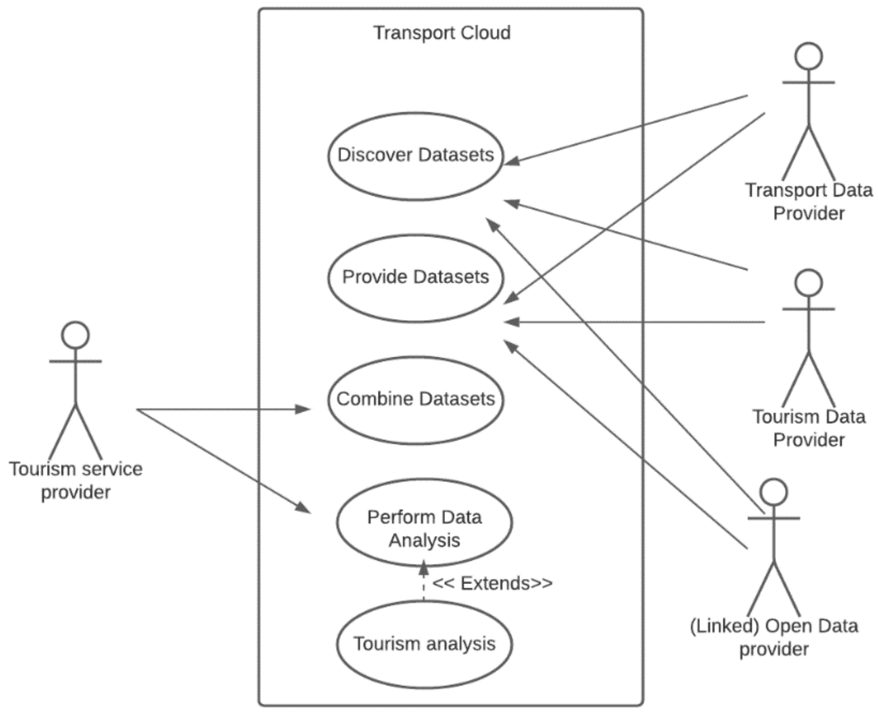

Figure 11: *Use case diagram - Transport data sharing within the Linked Open Data vision*

- System: the MobiDataLab Transport Cloud
- Actors (who or what is going to be using the MobiDataLab Transport Cloud in this context):
  - Primary: The Tourism service provider
  - Secondary: The Transport Data provider, the Tourism Data provider and the (Linked) Open data provider.
- Use cases:
  - Discover Datasets
  - Combine Datasets
  - Perform Tourism Analytics

Table 17: Use case description for Transport data sharing within the Linked Open Data vision

Category	Description
Case “tourism analytics”	
Pre-condition 1	The Tourism Service provider has access to the Transport Cloud to request its services.
Pre-condition 2	Data source providers have access to the Transport cloud to share their data
Pre-condition 3	The Transport Cloud provides suitable mechanisms that allow the actors to find out the data sources and processors they need to complete their tasks.
Pre-condition 4	The Semantic Enrichment Processor is active and available within the Transport Cloud
Pre-condition 5	Other processors (e.g. geographic enrichment) which may be needed to satisfy the Tourism Service Provider’s requests are active and available within the Transport Cloud
Step 1	The Tourism Service provider access the data sources and the processors needed to perform tourism analysis on enriched data from the Transport Cloud.
Step 2	The Transport Cloud activates the enrichment processors (semantic and geographic) to enrich datasets.
Step 3	The Transport Cloud activates the analysis processor on the enriched data to perform specific task (e.g., to perform tourism analyses, recommendations, and so on)
Step 4	The Transport cloud sends the final results to the Tourism Service provider
Post-condition 1	The Tourism service provider owns the results provided by the Transport Cloud to be exploited inside its services (e.g. recommendation)

3.3.1. Datasets used

We observe that nowadays the smartphone is becoming the multi-modal travel assistant which is being used by tourists and commuters. However, availability of applications e.g. (Home - Skipit, no date) is not yet common. And a combination of both – a real "tourism + transport" oriented app is quite rare, i.e. there can be a tourism app on one side and a transport app on the other, but applications integrating both information remain rare. Nevertheless, some transport operators are beginning to offer them, and quite unsurprisingly this has started in the capital cities and major tourist cities. For instance, the RATP public transport operator in Paris proposes NEXT STOP PARIS (https://www.ratp.fr/en/apps/next-stop-paris), and Transport for London (https://tfl.gov.uk/) proposes content dedicated to visitors on their website. But when asking ourselves why there are yet so few hybrid tourism + transport applications, we realise that proposing quality content is difficult, as mixing tourism and transport data implies using different access channels (APIs, etc.) following different standards, and adding/creating content which transport actors are not familiar with.

However, technology, data and content are now openly available and combining transport open data, tourism open data and content is now becoming possible - at least in certain member states, notably in France. Indeed, besides the French National Access Points for mobility data (transport.data.gouv.fr), the French government launched in 2017 the DataTourisme platform (https://www.datatourisme.gouv.fr/) (DATAtourisme > La plateforme nationale OpenData du tourisme en France, no date). DataTourisme aims at collecting, processing and disseminating tourist information in Open Data. These Open Data are aggregated daily from local tourist information systems in the country, maintained by local authorities, regional committees, departmental agencies and tourist offices. These heterogeneous data are gathered in a semantic database following a common formalism, the DataTourisme ontology, and they can be consulted and queried via a web interface and SPARQL queries. These data are also under Open Licence (OL).

Quality open content is now also available at an international level from crowdsourced projects like the Wikimedia projects (Wikipedia, Wikimedia Commons, etc.) and all this content is now both usable by humans and machines thanks to the Wikidata project. Like DataTourisme, Wikidata is a semantic database, a structured information graph composed of "triplets": subject, predicate, object where everything is described according to this formalism. Data can be queried via the Mediawiki APIs and/or SPARQL queries (https://query.wikidata.org/) (Wikidata Query Service, no date).

We propose to explore Semantic interoperability with transport open data thanks to corresponding vocabularies (cf. the Shift2Rail project (Home - Shift2Rail, no date) and the Semantic Interoperability Framework[1]).

3.3.2. Standards

- Ontology Web Language (OWL)
- Resource Description Framework (RDF)
- SPARQL Protocol and RDF Query Language (SPARQL).

3.3.3. Possible technical solutions

[1] https://www.youtube.com/watch?v=xMV-GxWEYy4

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Possible solutions can be realised by using wiki data APIs and state-of-the-art tools for (Geo) SPARQL.

3.3.4. Requirements table

Based on the use case description, the following use case requirements can be defined:

Table 18: Requirements table - Transport data sharing within the Linked Open Data vision

Req.No.	Description	Priority
UC8-R01	The Tourist Service provider issues a request for enriched trajectories analysis service to the Transport Cloud.	MH
UC8-R02	The Transport data provider and tourism data provider provide to the Transport Cloud either (1) one or more datasets(s), (2) an endpoint SPARQL or (3) API access to their data.	MH
UC8-R03	The Linked Open data provider exposes and communicates an interface (e.g., end point SPARQL or API) that allows the Transport Cloud to access its data.	MH

4. Learnings for V2 Use Cases

As we have seen, the V1 Use Cases are demonstration cases aiming at showcasing the functionalities of the MobiDataLab transport cloud in the context of the Living and Virtual Labs. These use cases, data-driven and standard-driven, were defined based on the expertise and background of the consortium members in data-related projects.

As for the V2 Use Cases, it will be the result of the consortium's exchanges with the referring municipalities and regions which will assist the consortium (our so-called “challenge providers”).

These use cases will show how data can solve concrete problems that these local authorities are facing in their local context, e.g. related to parking, public transport, road traffic.

A briefing for these municipalities has been prepared, aiming to organise regular workshops from the autumn of 2021 (more details in WP6 / Task 6.4). The challenges co-defined during these workshops will then be proposed to a community of innovators and data users, engaged through the F6S platform and involved in dedicated hackathons / datathons.

The V2 Use Cases design will be later in the project. Therefore, the learnings from the V1 Use Cases will influence the V2 Use Cases. The increased experience within domains, the realisations within the consortium, the external partners and further stakeholder groups and the continuous technical evolution will influence the V2 Use Cases.

4.1. Generic use case for v2

Although it is a bit premature to define what the v2 use cases will look like, it is however possible to envision a generic use case taking into account the system and the different actors involved - in particular the municipalities and public transport authorities of the reference group that can be identified as a “challenge providers”. The Figure 12 below shows this generic use case diagram for V2 use cases with the different actors and their actions.

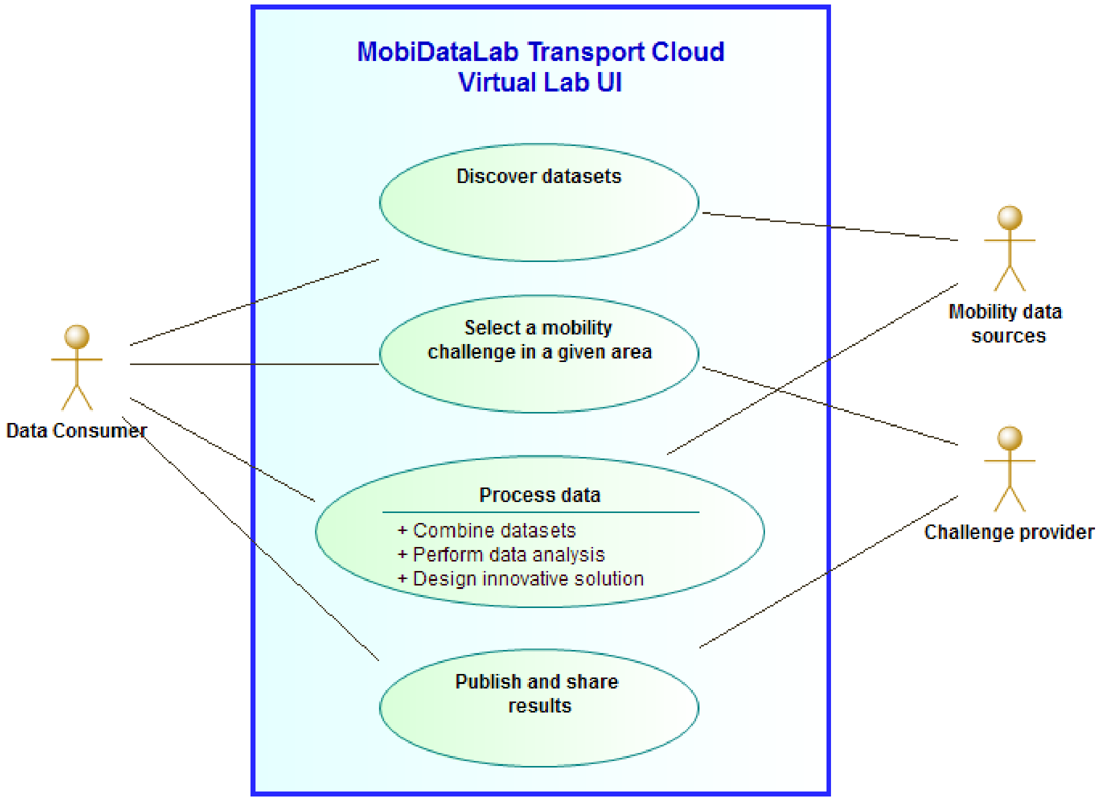

Figure 12: *Generic Use case diagram for V2 use cases*

- System: here the system is the Virtual Lab User Interface (UI), an extension of the MobiDataLab Transport Cloud allowing accessing the challenges proposed by the MobiDataLab stakeholders.
- Actors (who or what is going to be using the MobiDataLab Virtual Lab UI in this context):
  - Primary: the MobiDataLab Data Consumer or participant to Virtual Lab sessions;
  - Secondary:
    - the mobility data sources made available through the data catalogue
    - the challenge provider: member of the MobiDataLab Reference Group of stakeholders, providing challenges corresponding to concrete problems they face organising mobility in their territorial context (for cities or regions) or in their transport sector (associations).
- Use cases:

- Discover datasets;
- **Select a mobility challenge in a given area**: the data consumer participating to MobiDataLab living and virtual labs can explore the challenges proposed by the referring municipalities and select one to take up during the hackathon/datathon: this is the main use case to be detailed
- Process data
- Combine datasets using the data access channels and data processors
- Perform data analysis during the hackathons
- Design innovative solution to the selected challenge.

4.2. Example: Transport data sharing between administrations for efficient decision-making

A typical example of a V2 use case involving MobiDataLab so-called challenge providers (i.e. municipalities and transport organising authorities which assist the consortium) is the "**Transport data sharing between administrations for efficient decision-making (parking, traffic management, network planning)"** use case mentioned in the grant proposal.

This use case will be contextualised during the workshops organised in the context of the ongoing Task 6.4 (Multi-stakeholder group creation and coordination) involving different stakeholders – mainly public authorities – in order to gather input on use cases, needs, problems, opportunities and other issues related to data sharing. These challenges will be proposed to the innovators and data users engaged through the F6S platform and involved in the WP5 x-athons.

As a recall, the potential challenges could relate to the following concrete mobility issues:

- accessibility to large events (sport, concert, etc.) or touristic areas;
- accessibility to critical infrastructures (hospitals) and priority given to ambulances
- daily commuting congestion and low emission zones management
- etc.

5. Conclusions

The "Use Cases Definition V1" describes a first set of use cases with the intention to cover a broad variance of interfaces, data and user requirements in the context of mobility data sharing.

The use cases definition is divided into two parts: version 1 and version 2. In this deliverable, version 1 is described. This first version of use cases starts with examples from project stakeholders. The use case "Transport data sharing between administrations for efficient decision-making", which has been mentioned in the grant proposal, depends strongly on input from the reference group. Therefore, it will be part of the V2 use cases. The presented use cases can be realised with the expertise and the knowledge of the project group. This facilitates the project team to start the project in an agile project setup and get early results. Since further work packages are depending on an early available set of use cases and their results, it is intended to get this via the first version. This set of use cases will be also the seeding for the first living labs.

The use cases in version 1 are classified into “Use Case Definitions: Use Cases for Operations” and “Use Case Definitions: Use Cases for Research”. This distinction is motivated by having operational use cases with a clear mission and direct connections and research focused use cases with a focus on exploration separated. The operational use cases can be further distinguished into passenger/consumer related use cases and planner/operations related use cases. However, at the beginning of the project, we decided to have enough freedom to explore the manifold use cases, not limited by categories. Within the version 2 later in the project, the classification will be further influenced by the experience made within the use case implementation, the living labs, the feedbacks of the reference groups and (potential) users. We assume, that the classification will then become more granular and specific.

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MobiDataLab consortium

The consortium of MobiDataLab consists of 10 partners with multidisciplinary and complementary competencies. This includes leading universities, networks and industry sector specialists.

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