MOBIDATALAB

Labs for prototyping future mobility data sharing solutions in the cloud

D4.5 Data Access Services (V1)

Pilot set of data provided via services and initial interfaces

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Abstract	The deliverable is a text document that describes the demonstrator for D4.5 Data Access services v1 – Pilot set of data provided via services and initial interfaces. The prototype is constituting the practical integration of available data access services and data channels. The task is also related to task 4.2 Reference Data Catalogue.

Legal Disclaimer

Project partners

Organisation	Country	Abbreviation
AKKA I&S	France	AKKA
AETHON SYMVOULI MICHANIKI MONOPROSOPI IKE	Greece	AETHON
CONSIGLIO NAZIONALE DELLE RICERCHE	Italy	CNR
HOVE	France	HOVE
HERE GLOBAL B.V.	Netherlands	HERE
F6S NETWORK IRELAND LIMITED	Ireland	F6S
POLIS - PROMOTION OF OPERATIONAL LINKS WITH INTEGRATED SERVICES, ASSOCIATION INTERNATIONALE	Belgium	POLIS

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Executive Summary

This task aims for the practical integration of available data access services and data channels into the transport cloud and beyond, their usage in the presented use cases, the labs and further aplications. Availability, documentation and usability will be key assets of this part. Aligned with the work done in the other Transport Cloud work packages, within this task, available data sets and services from project partners and their platforms will be connected.

The activities are connected to parallel tasks in this context (e.g. T4.2 Reference Data Catalogue) and will generate a positive impact.

Furthermore, this task will be a key item for the Living Labs where data access is one of the main drivers. Within ongoing standardisation activities, participants of Task 4.3 will actively contribute to standard discussions and implementations.

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Abbreviations and acronyms

Abbreviation	Meaning
GTFS	General Transit Feed Specification
OGC	Open Geospatial Consortium
CSV	Character Separated Values
WMS	Web Map Service
WFS	Web Feature Service
SOS	Sensor Observation Service

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1. Introduction

Data access and services is a very broad field. Especially, when it handles cross-domain activities, where data and functions from one domain are being used in another domain.

This is quite typical for the mobility domain, where data from many connected domains is needed to handle the requirements of the use cases. (Masó, 2022) explains the field from a geospatial perspective and classified the services into “visualization services”, “data exchange services”, “processing services” and “discovery services”.

This classification also fits with the available services in MobiDataLab. “Discovery services” are mainly handled in Task 4.2 - “Reference data catalogue”, Task 4.4 - “Data processors” and Task 4.5 - “Anonymisation” refers to the “processing services category” and “data exchange services”, “visualisation services” will be covered mainly in Task 4.3 – “Data access services”.

The purpose of this deliverable, the demonstrator, is the analysis of the available data sets on their accessibility and interoperability. Exploration of the used formats for data and APIs and exploring a solution to make them available in an easy way to make them accessible for users.

Further, the discussion on potential standards and alignment of service interfaces and data within the heterogeneous stakeholder groups of owners and users will be triggered by this task.

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2. Standards

For the standards section, we differentiate between data access, as described in chapter 2.1 and services described in chapter 2.2, which are providing functionality, e.g. routing or journey planning.

There is obviously a grey zone, where services are providing data (e.g. in situ weather data or traffic conditions) or a visualisation service is generating in situ maps (e.g. land use maps as rendered image tiles).

2.1. Data Access

Access to mobility data is as heterogeneous as the data itself. Since mobility-relevant data is provided from different domains (e.g. traffic, physical geography, meteorology, road navigation, transportation, …) these datasets depend on different standardization communities.

Initiatives in the geospatial domain, like the Open Geospatial Consortium[1], have been pushing geospatial standards for years to support the FAIR principle (Wilkinson *et al.*, 2016) and to make it easy for data users to find and access data in an interoperable way. Conversely, proprietary started standards like GTFS (GTFS.org, no date) have been published by companies, evolved and maintained by an interest group.

Other interfaces are designed to be fully proprietary and support only a low level of interoperability. These are mainly used in closed eco-systems or homegrown solutions by very exclusive data providers, where the data is special and no standard currently exists or existing standards are not fulfilling the requirements of the proprietary ecosystem. Examples in the domain of geospatial data are ESRI ArcGIS Feature server or ESRI REST services. In (Masó, 2022), 16.4, an example for the end-to-end integration from data sources to solutions running on the client is given. This is realized by standardised open interfaces like WMS, WFS and SOS.

2.2. Services

Services that are providing functionalities, e.g. route planners, are usually offered by service providers. There exist many specialized use cases, where such services justify a proprietary API, e.g. where a connection to another proprietary API is mandatory.

However, there are also common use cases, where an alignment of service interfaces, through standard, would be useful.

For the route planning use-case, this has been done in (*Routing Pilot | OGC*, no date), where a set of route planning APIs has been analysed on their request/response structure.

[1] https://www.ogc.org/

In MobiDataLab, the set of services is spanning a large ecosystem, from location-based services, such as routing, via environmental services (e.g. the latest weather, flood data, …), to ticketing and public transport schedules services.

One can think about every service that provides mobility-relevant data. This shows the enormous heterogeneity in the mobility services ecosystem.

The analysis of the services and their APIs and the availability of metadata (e.g. OpenAPI/Swagger[2] standardized service documentation) to enable the FAIR principle for services is part of this task.

[2] https://swagger.io/specification/

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3. Data Access Demonstrator

3.1. Reference Group Data Sets

In V1 of this deliverable, the main focus is on the data sets provided by the reference group. Available data sets are checked on their access in terms of data service interfaces and data formats.

The data sets provided by the project reference group in WP4 are documented in an Excel sheet with links and resources, that are relevant for use cases in Europe as well as internationally. The table consists of 439 data sets in total.

After importing the reference data sets into GeoNetwork (described in D4.3), the meta-data becomes searchable and can be further investigated. The data user/consumer can get a better overview of the available data sets, namely their data types, their geographical extent and the relevant use case within the scope of MobiDataLab.

During an initial investigation of the available data sets, we made the following observations:

- Access:
  - 57 data sets require payment
  - 19 data sets are only accessible to registered users
  - the remaining majority is available via open access
- The data sets span 8 countries:
  Belgium, France, Germany, Netherlands, Greece, USA, Spain, Romania
- Most data sources support at least one standardised format, namely:
  - GTFS, Shapefile, GeoJSON, WMS, WFS.
- Linked resources point to the publisher's online catalogue, and not the data itself. Further additional steps on the publisher's website are required to obtain the data.
- A large number of the data sets are sourced for use case 2.4, re-use of transport data for journey planners and digital service, and can be categorized into 3 main groups:
  - Public transport data:
    Transportation lines, schedules, traffic alerts, next arrivals and departure
  - Geographical data:
    Cartography, Addresses, Point of interests
  - Other transport:
    Free-floating, ride-sharing, road traffic
- Some issues with data access are identified:
  - Links to the data sets are outdated
  - Data sets are no longer “open”
- The size of some datasets is voluminous, which can surpass the processing or the storage system capacities of some users
- Some datasets require additional analysis to check their validity and compliance with their standardized format (for example: in the case of the public transportation schedules data).

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- Some datasets can be divided and scattered into multiple parts or sources.
- Some data from rural regions or small municipalities is not always available or updated on a regular basis

We also set up a monthly harvest of seven municipalities' public transport schedules datasets from the reference group into the HOVE OpenDataSoft's private instance[3]. The standard format of these datasets is GTFS. They are accessible using a URL provided by their respective city open data portals. To add these datasets to the OpenDataSoft catalogue, a user with permissions to *create new datasets*, *manage own datasets' security,* and *publish own datasets* must log in, browse to catalogue/datasets or catalogue/harvesters in order to configure their retrieval.

In OpenDataSoft, an administrator can either render a dataset private or open. In this context, all the datasets are directly accessible in the portal without the need for a token or an authentication.
Each record has 3 default tabs (this aspect of OpenDataSoft can be customized to include visualizations, a map etc.):

- Information: a generic description form of the dataset filled by the administrator. If activated, this section will also display interoperability metadata. There are three kinds of interoperability metadata available (DCAT, DCAT-AP for Switzerland and INSPIRE).

- Table: It visualizes the data in a table format. In this case, it features the metadata since the datasets were further enriched by HOVE, so they were redistributed and stored in the instance and can be downloaded by clicking on the file name in the Download field. Here, we have 2 formats: GTFS and NTFS. They're accessible because the harvester used establishes a connection with an FTP server.

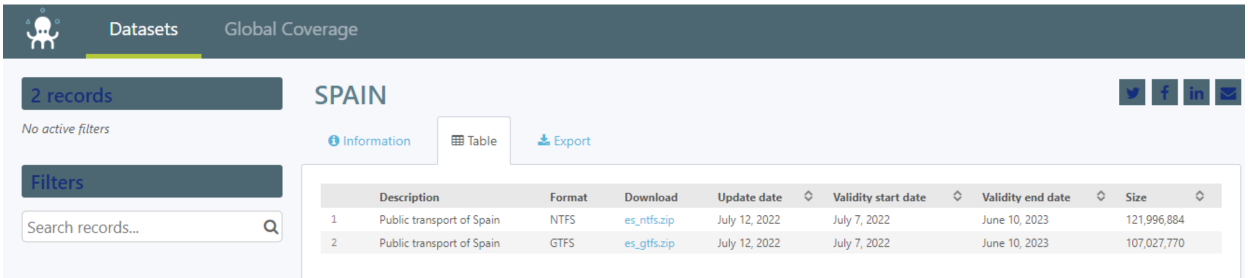

Figure 1 Table tab for the Spain dataset record in the HOVE ODS instance

- Export: to download the dataset (the metadata in our case). The default flat formats are CSV, Excel, and JSON. More specific formats can be available for export: like geographical file formats if needed: GPX, GeoJSON, KML and Shapefile. As well as CIFS and DCAT-AP. There is an *Alternative exports area* to upload any file of any format.

We also need to mention, that as these datasets are also used by the journey planner Navitia.io, they are aggregated to a global dataset by merging them with other cities' GTFS from the same country. However, OpenDataSoft can publish each dataset separately.

[3] https://navitia.opendatasoft.com/explore/?sort=modified

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Table 1 Source and access links of the reference group datasets in ODS

City/ Municipality	License	Source URL	ODS link
Rome	CC BY 3.0 IT	Dati del Trasporto Pubblico (GTFS) del Comune di Roma - GTFS Statico - CKAN	ODS Italie
Milan	CC BY 4.0	https://www.amat-mi.it/downloads/gtfs/gtfs.zip	
Leuven	ODbL	sncb-opendata hafas	ODS Belgium
Hamburg	dl-de/by-2-0	daten transparenz hamburg	ODS Germany
Eindhoven	ODbL	http://gtfs.ovapi.nl/new/gtfs-nl.zip	ODS Netherlands
New York	ODbL	https://data-usdot.opendata.arcgis.com/search?tags=Transit	ODS USA-New York
Malaga	CC BY 4.0	datosabiertos malaga	ODS Spain

3.2. External Data Sets

The reference group data sets analysed in chapter 3.1 reflect a basic set of data, which is being used in the project use-cases V1 (WP2, T2.6). Besides this data, there is much more available data, that brings further complexity due to heterogeneous access and formats. A first set of examples, e.g. external data sources in the surrounding regions will be given in this sub-chapter.

Table 2 External Catalogue Sources

External Catalogue Sources	Country	Number of data sets
www.metaver.de - CSW-Schnittstelle (MetaVer)	Germany	22,222
geodati.gov.it - RNDT - Servizio di ricerca	Italy	21,762
catalogue.geonormandie.fr - Service de découverte (CSW) de GéoNormandie	France	11,085
metadane.podgik.pl - Katalog metadanych Geo-System - Usługa wyszukiwania metadanych (CSW)	Poland	7,810
csw.cartografia.agenziaentrate.gov.it - Servizio di ricerca (CSW) sui metadati del Catasto Italiano	Ireland	7,720
geodaten.freiburg.de - Catalogue Service of the GDI Freiburg (CSW)	Germany	2,810
geobretagne.fr - Service de découverte (CSW) GeoBretagne	France	2,684
sitmun.diba.cat - Discovery Web Service CSW of the Spatial Data Infrastructure of the Barcelona Provincial Council (IDEBarcelona)	Catalonia	2,413
apps.geoportal.nrw.de - CSW GEO catalog.NRW	Germany	2,370
catalogue.sigena.fr - Service de découverte (CSW) Sigena	France	2,029

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Others		21,604
Grand Total		104,509

There are several initiatives, that are providing data access. Their main purpose is to make data available/accessible.

- MobilityData.org
  The initiative mobilitydata.org[4] provides data via a simplified spreadsheet[5]. This is a very basic searchable structure. Focused on availability, but less on searchability of the provided datasets.
- National Access Points – Delegated Acts of the ITS Directive (2010/40/EU)
  With the directive, the EU member states are required to provide access points for their mobility data. A document with links to the National Access points is available via the pages of the EU[6].
  For our project partners, the access points are:
  - Belgium: https://www.transportdata.be/en/
  - France: https://transport.data.gouv.fr/
  - Germany: https://service.mdm-portal.de
  - Greece: http://www.nap.gov.gr/
  - Ireland: https://data.gov.ie/
  - Italy: https://www.cciss.it/web/cciss/
  - Netherlands: https://nt.ndw.nu/#/home
- Private companies' open data catalogues:
  - OpenDataSoft Data Hub: https://data.opendatasoft.com/pages/home/ is an open data catalogue of OpenDataSoft. It hosts 27,303 datasets including 2,129 mobility and transport datasets.
- HOVE: https://navitia.opendatasoft.com/explore/?sort=modified. To redistribute reused and modified open data per license, this company provides open access to public transport schedules' datasets from 37 countries (23 European countries). They can be downloaded directly from the export tab of each country's record in GTFS and NTFS formats. These datasets are also used by Navitia.io API for multimodal journey planning.

Such initiatives demonstrate an overall motivation to make data accessible. However, there is still a way to go to be aligned with the FAIR principle.

[4] https://mobilitydata.org/
[5] https://database.mobilitydata.org/
[6] https://transport.ec.europa.eu/document/download/963c997d-efd9-40ae-a38b-5d4b935bdfcf_en?filename=its-national-access-points_0.pdf

4. Service Access Demonstrator

Mobility services can be divided into two broad categories. The first category includes the services that interact with mobility datasets. The most common use case of these kinds of services is to access/ retrieve (read-only) mobility data through standard or proprietary API interfaces. These kinds of services are referred to as *mobility data services* hereafter. The second category, hereafter referred to as *mobility analysis services* comprises services that perform different types of analysis on the mobility data sets and returns analysis results based on user inputs. Routing service is one of the examples of such kind where spatial analysis on transport network dataset is carried out to return typically the best routes between two given locations. Other services in this category include but are not limited to geocoding, geofencing, conflation, map matching, journey planning, etc.

Mobility data services, repository and their access are described in section 3 in more detail. This section focuses on mobility analysis services.

4.1. Mobility analysis services metadata repository V1

The main goal here is to create a metadata repository containing the mobility analysis services provided by the MobiDataLab consortium partners and extend it further with the external service providers. We can think of such a repository as a one-stop service point to explore the mobility analysis services available within the consortium and beyond.

As an initial version 1 effort, an excel sheet is created and populated with the metadata of the mobility analysis services from the consortium partners and beyond. A glimpse of this list is provided below in Figure 2. This list is not complete and perhaps will never be. Rather this list is a living list and will be continuously updated moving forward. Currently, the repository contains 78 mobility analysis services metadata from the consortium partners and beyond.

A description of the structure (columns) of the excel file is provided below

- **Service Provider:** company or organization that owns and provides the service
- **Service Name:** the official name of the service
- **Service Description:** a short description of the service containing what purpose it serves
- **Service API:** the root API endpoint link
- **Service Type:** Indicates the type of service. For example, is the service REST-based or SOAP-based or any other.
- **Documentation:** link for detailed documentation of the service
- **Standards:** Indicates if the service is built upon any standard. A service can comply with standards in two areas. These are standards in API definition and standards in response format.
- **Usage:** specifies whether the service is free or paid

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	Serice Provider	Service Name	Service Description	Service API	Service Type	Documentation	Standards	Usage
2	HERE	Fleet Telematics	A diverse and rich set of location features designed to support some of the most complex use cases related to routing, search and map data retrieval	https://fleet.ls.hereapi.com/2	REST	https://developer.here.com/documentation/fleet-telematics/dev_guide/index.html	proprietary	Paid
3	HERE	Fuel prices	Fuel prices resources are responsible for serving fuel stations for given geo spatial area inclucing dynamic information about fuel types avaliable on station and real-time fuel prices.	https://fuel.hereapi.com/v3/	REST	https://registry.services.api.platform.here.com/v1/services/hrn%3Ahere%3Aservice%3A%3Aolp-here%3Afuel-prices-3/openApi	proprietary	Paid
4	HERE	HERE Destination Weather	Give insights into real-time weather forecasts and weather alerts	https://weather.hereapi.com/v3/	REST	https://registry.services.api.platform.here.com/v1/services/hrn%3Ahere%3Aservice%3A%3Aolp-here%3Adestination-weather-3/openApi	proprietary	Paid
5	HERE	HERE GNSS	Provides HD GNSS and A GNSS services.	https://gnss.hereapi.com/websocket/v1	REST	https://developer.here.com/documentation/gnss-positioning/	proprietary	Paid
6	HERE	HERE Geofencing	Geofence asset position against HERE Map objects or custom fence objects.	https://geofencing.hereapi.com/v8/	REST	https://developer.here.com/documentation/geofencing-api/dev_guide	proprietary	Paid
7	HERE	HERE Isoline Routing	The Isoline service generates polygons which represent the area of reach from a given point based on time, distance or available energy.	https://isoline.router.hereapi.com/v8	REST	https://developer.here.com/documentation/isoline-routing-api/dev_guide/index.html	proprietary	Paid
8	HERE	HERE Map Attributes	Simple and fast access to the rich HERE Map Content, seamlessly extensible by your own map data.	https://smap.hereapi.com/v8/	REST	https://developer.here.com/documentation/advanced-datasets-api/dev_guide	proprietary	Paid
9	HERE	HERE Map Image	Get access to pre-rendered map images already optimized for desktop and mobile devices including the ability to overlay content like markers, routes etc.	https://image.maps.ls.hereapi.com/mia/1.6	REST	https://developer.here.com/documentation/map-image/dev_guide/topics/quick-start-show-default-location.html	proprietary	
10	HERE	HERE Map Matching	This simple, fast, and efficient REST API microservice matches your GPS probe data to any HERE Map Content version, including the latest, and thus allows for building block-style recomposability and flexibility in your application.	https://mapmatcher.hereapi.com/v1	REST	https://mapmatcher.hereapi.com/swagger/views/swagger-ui/index.html	proprietary	
11	HERE	HERE Map Tile - Aerial	The aerial tile resources are responsible for delivering satellite, terrain and hybrid tile images. In this context, hybrid refers to an image that contains satellite imagery along with labels and such.	https://[1-4].aerial.maps.ls.hereapi.com/maptile/2.1	REST	https://developer.here.com/documentation/map-tile/dev_guide/topics/resource-aerial-tile-intro.html	proprietary	
12	HERE	HERE Map Tile - Base	Show fresh day-time map tiles in multiple styles (e.g. base, aerial) including rendered live-traffic tiles for flow overlay.	https://[1-4].base.maps.ls.hereapi.com/maptile/2.1	REST	https://developer.here.com/documentation/map-tile/dev_guide/topics/resource-base-tile-intro.html	proprietary	
13	HERE	HERE Map Tile - Traffic	Display map tiles with real-time traffic flow information overlays reflected as colored lines drawn on affected streets and roads.	https://[1-4].traffic.maps.ls.hereapi.com/maptile/2.1	REST	https://developer.here.com/documentation/map-tile/dev_guide/topics/resource-traffic-traffictile.html	proprietary	

Figure 2 An initial version of the mobility analysis service metadata repository in excel file.

4.2. Mobility analysis services metadata repository V2 - next steps

An excel-based listing of mobility analysis services metadata is a quick and efficient starting point for creating the repository as a version 1 (V1) solution. But this is a living list which is expected to grow significantly moving forward. Therefore, the excel-based solution will not be sufficient since the list will scale up. It will require human and machine access both internally and externally and will require more interactivity in terms of search and edit. Moreover, it needs to be integrated with the Mobility Transport Cloud.

Therefore, as version 2 (V2) of the repository, a REST-based application is intended to be developed where the excel based V1 repository will be imported to a backend database and the interaction with the repository will be provided through REST APIs. V1 repository will thus provide a solid base for the V2.

A very high-level architecture of the V2 REST application is provided in Figure 3. Since the V2 will be developed in the next months, detailed technical granularities cannot be provided at this stage. However, the description of some of the API endpoints in Figure 3Figure 2 follows. The payloads either in the body or response for the API invocations will be based on JSON.

- **Insert new service metadata:** an HTTP POST request to inset new mobility analysis service metadata with a predefined JSON payload
- **Get service metadata by ID:** every mobility analysis service metadata will be assigned a unique ID. The user can retrieve a particular mobility analysis service metadata by ID through this HTTP GET request.

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- **Get service metadata by type:** an HTTP GET request to retrieve all the mobility analysis service metadata of the same type. For example, a user/application may look for all routing services.
- **Get service metadata by vendor:** an HTTP GET request to retrieve all the mobility analysis service metadata of a particular vendor. For example, a user/application may look for all the mobility analysis services from HERE Technologies.
- **Modify service metadata:** an HTTP PUT request to modify or update a particular mobility analysis service metadata.
- **Delete service metadata:** an HTTP DELETE request to delete a mobility analysis service metadata.

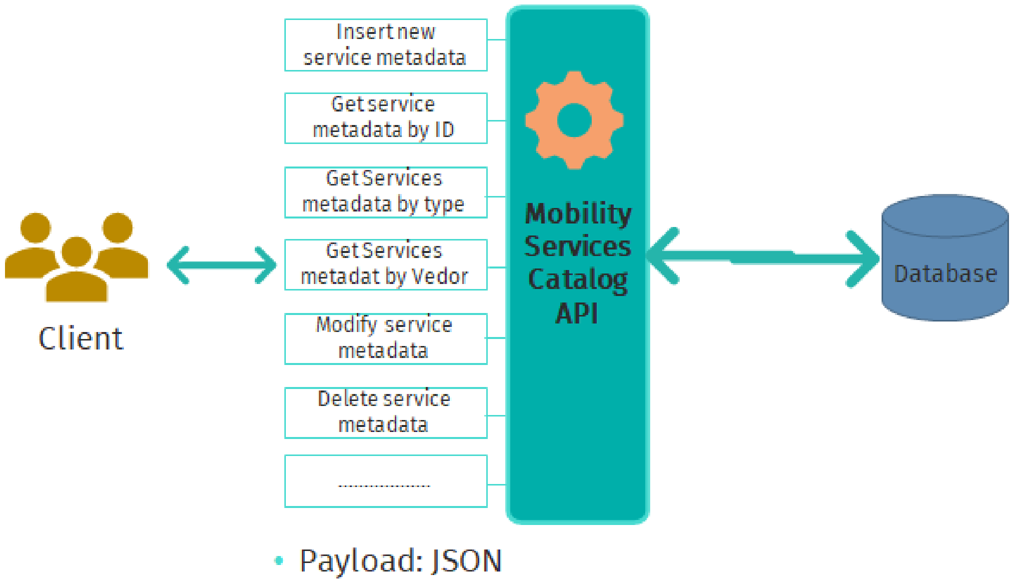

Figure 3 A high-level architecture of the V2 REST application.

4.3. Challenges with standards in mobility analysis

There are several de facto and de jure standards already in the realm of *mobility data services* that play a substantial role to ensure interoperability among the services.

For example, in the domain of geographic information, the international Web Feature Service (WFS) standard created by the Open Geospatial Consortium (OGC) specifies the way geographic information could be created, modified, and exchanged on the web. The General Transit Feed Specification (GTFS) specifies a standard format for public transportation schedules and associated geographic information.

4.3.1. Example: Route planner interfaces

The situation of standards and interoperability is quite the contrary in the domain of *mobility analysis services* compared to the mobility data services. Since the well-known and widely used service in the realm of mobility analysis service is the routing service which in its simplest form returns the best routes between two given locations, three routing services have been compared in terms of their API definition and the response format to find out if there are any standards involved and to assess their interoperability. These routing services are: Here routing[7], OpenRouteService[8] and Graphhopper[9] (Figure 4).

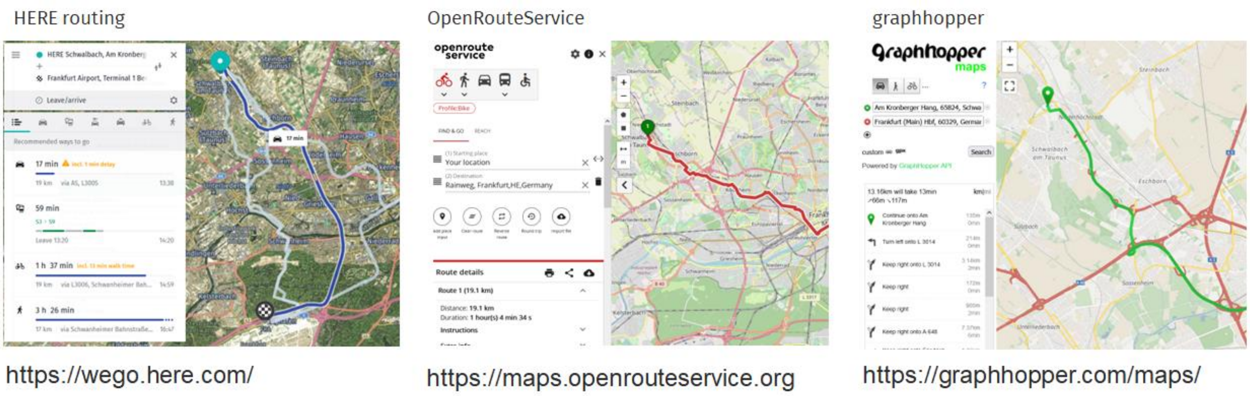

Figure 4 Routing in the web applications of three routing services

The web user interface of all these three services can take at least two locations as input and can highlight a car-based route between them in the map (cf. Figure 4). But this does not reveal any standard involved, nor does it confirm the interoperability. Therefore, in the second attempt, the same route requests were sent not through the web application, but via the underlying REST APIs of those three routing services. The exact HTTP GET request URLs with the query parameters for the three route service APIs are provided in Figure 5.

HERE routing

https://router.hereapi.com/v8/routes?transportMode=car&origin=54.32556,14.65314&destination=54.65422,14.66636

openroute service

https://api.openrouteservice.org/v2/directions/driving-car?start=8.681495,49.41461&end=8.687872,49.420318

graphhopper maps

https://graphhopper.com/api/1/route?point=51.131,12.414&point=48.224,3.867&profile=car

Figure 5 HTTP GET requests to invoke the car-based routing

[7] https://wego.here.com
[8] https://maps.openrouteservice.org
[9] https://graphhopper.com/maps/

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The dark blue parts of the URLs are the respective API endpoints which must be different for different service providers. Let us focus on the query parameters parts of the URLs. The car-based route is parameterized differently in these three services. HERE delineates it by transportMode=car, OpenRouteService even embeds it within the API endpoint URL and Graphhopper delineates it by profile=car. The two locations between which the route is calculated are also parameterized very differently. For HERE it is origin and destination, for OpenRouteService it is start and end and for Graphhopper is it just two points.

Although the simplest form of route calculation requires three inputs: two locations (start and destination) and a driving mode, these three routing services came up with different naming conventions and approaches to parameterize these.

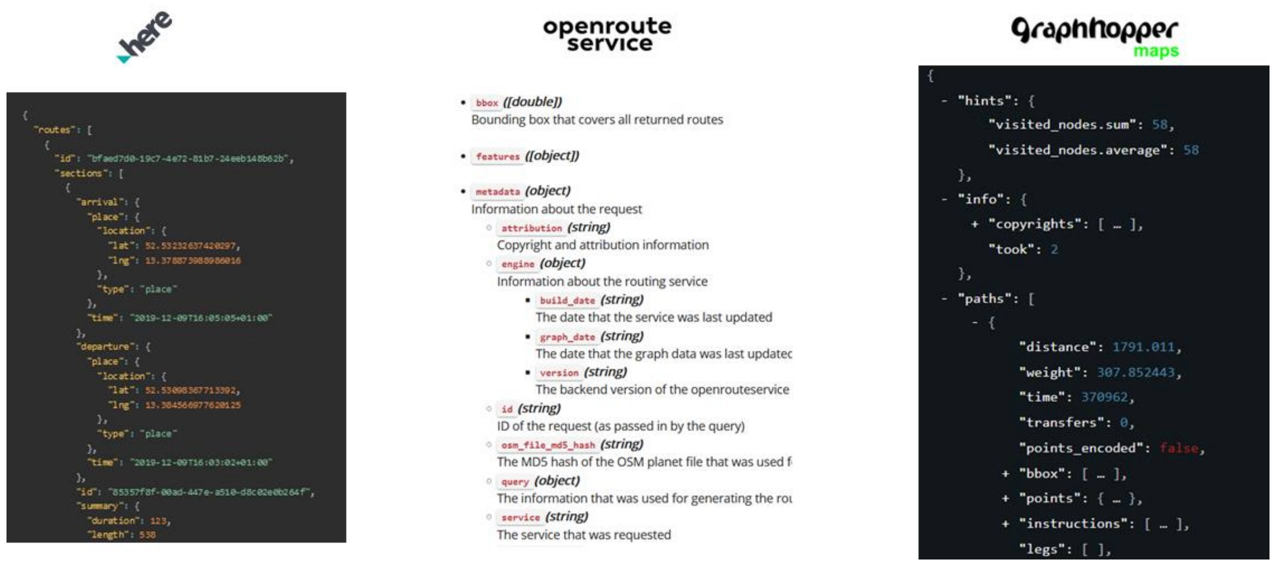

Figure 6 Response payloads from the services

Figure 6 depicts the respective response payloads for each of the requests in Figure 5. The only thing which is common among these payloads is the file format which is JSON. But the structures of these files are completely different and therefore would require three different parsers to perse these at application level.

A deeper look at the API definitions and the response formats of these three different routing services clearly reveals the lack of standardization and interoperability. The same type of service (routing) from different proprietors comes here with numerous heterogeneities. This is therefore certainly a gap which renders the services not interoperable.

Unlike the availability of standards in the domain of mobility data service, no standard exists in the domain of mobility analysis services. This section has revealed the lack of standards regarding the routing service only. But the same applies to any other mobility analysis services like geocoding, search, journey planner, etc.

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4.3.2. Example: Journey planner interfaces

A journey planner is a software service allowing end users to plan a journey between two given locations (departure and arrival). It is also sometimes called a trip planner or a route planner. However, route planning is usually associated with private transportation modes, for example driving (e.g. Here routing: https://wego.here.com) or cycling (e.g. Géovélo: https://geovelo.fr/en). On the contrary, trip planning or journey planning is usually associated with at least one public transport mode, e.g. bus, train or plane, eventually combined with other transportation modes.

When a journey planner can combine different transportation modes, whether public or private, it is considered a multi-modal journey planner. Which transport modes are available and how they are combined to propose an optimized journey depends on the data sets that are made available to the journey planner engine and the algorithmic performance of this engine.

There are many different journey planner systems, that are mono-modal or multi-modal. Examples of the more generic route planners (journey planners focusing on private transport modes) are given in 4.3 (Here, Openrouteservice, Graphhopper). The most well-known and probably most commonly used journey planners today are the ones provided by Google through Google Maps and Apple with their product Apple Maps. However, there is also a number of smaller companies that rely on different journey planner engines, whether they are proprietary and closed source (e.g. RATP, Citymapper) or open source (e.g. Valhalla, Open Trip Planner).

At this stage, it is important to distinguish between the journey planner engine, which handles all the computing, and the front end, usually a web or mobile application, whose role is to display the computing results. These two components are usually completely separated, the front end using a specific interface (API for Application Programming Interface) exposed by the journey planner engine to send requests and display the proposed journeys to the end user.

Some proprietary journey planner engines do not expose any public API (e.g. RATP). Others, such as Google, Apple and Citymapper propose a public API, despite their engine being closed source:

- Google Maps Directions API:
  https://developers.google.com/maps/documentation/directions/overview
- Apple MapKit MKDirections API:
  https://developer.apple.com/documentation/mapkit/mkdirections
- Citymapper SDK:
  https://docs.external.citymapper.com/index.html

Open source journey planners obviously also expose a public API:

- Navitia: https://doc.navitia.io/#journey_planning
- Open Trip Planner: http://docs.opentripplanner.org/en/latest/
- Valhalla: https://github.com/valhalla/valhalla

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However, these APIs do not follow any common standard, which results in a lack of interoperability. It is not feasible for a client to switch between different journey planners, without adapting to each API individually, e.g. the Client for Apple Maps cannot just replace the Apple journey planner with another journey planner engine (e.g. the one proposed by Navitia). All API calls and a large part of the application code would have to be rewritten. Not to speak about the semantic gaps regarding different interpretations of data and travel attributes.

There is an initiative from the Transmodel EU standardization group to promote such a standardised interface: Open Journey Planning (OJP: https://www.transmodel-cen.eu/ojp-standard/). This interface, as other Transmodel concepts and standards, is specifically conceived for public transport, but could probably have been extended to private transport modes as well. Contrary to other Transmodel standards such as SIRI and NeteX, it has not really gained traction, and to the best of our knowledge, no journey planner engine has implemented the OJP API so far (for more details about Transmodel and OJP, see D2.4 "State of the art on mobility data sharing standards", chapter 2.1.4.1).

Transmodel itself needs to be seen as a first step to unify journey planner interfaces since it provides a common framework including transport concepts and data structures. It triggers the alignment process by using the same conceptual model and the same terminology as a first step towards interoperability.

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5. End-to-End example of data and service usage

5.1. End-to-End use case for data search, loading and visualisation

This section demonstrates an end-to-end workflow from data discovery to data visualization, using QGIS and GeoNetwork catalogue.

QGIS [10]is a free and open-source geographic information system. Available for many platforms, with many extensions/plugins to connect to data stores (local and cloud-based), execute external/cloud-based processing (e.g. routing), and algorithms for many spatial analysis challenges.

GeoNetwork[11] is an open-source reference tool to manage geo data catalogues. Besides the support of catalogue service for the web (CSW), which is a common standard in the spatial metadata ecosystem, the software also supports further catalogue formats and has import capabilities for self-defined metadata structures. With its harvester capabilities, it can also load larger sources automatically and scheduled over the web. Further information on the catalogue tool is given in the deliverable D4.3, which is part of Task 4.2.

Since both open source tools are widely used in the spatial communities and due to their interoperability, they have been good fitting candidates for this example.

Data discovery was done with QGIS built-in MetaSearch tool, which allows users to query for data sets from an OGC CSW server. In this example, the CSW API of the GeoNetwork catalogue is used.

[10] https://qgis.org
[11] https://geonetwork-opensource.org

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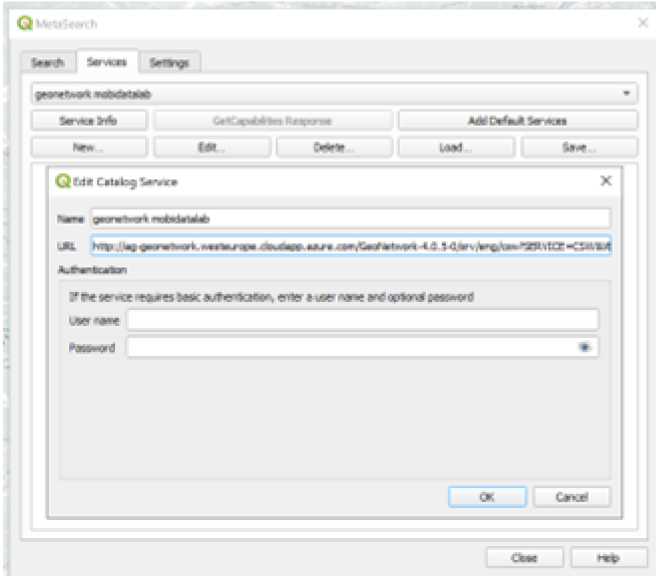

Figure 7 Setup CSW catalogue source in QGIS MetaSearch

After setting up the CSW connection (Figure 7), the user can proceed to query the data of interest via keywords or spatial extent. The screenshot (Figure 8) shows some results from the reference data sets, denoted with the keyword "mobidatalab".

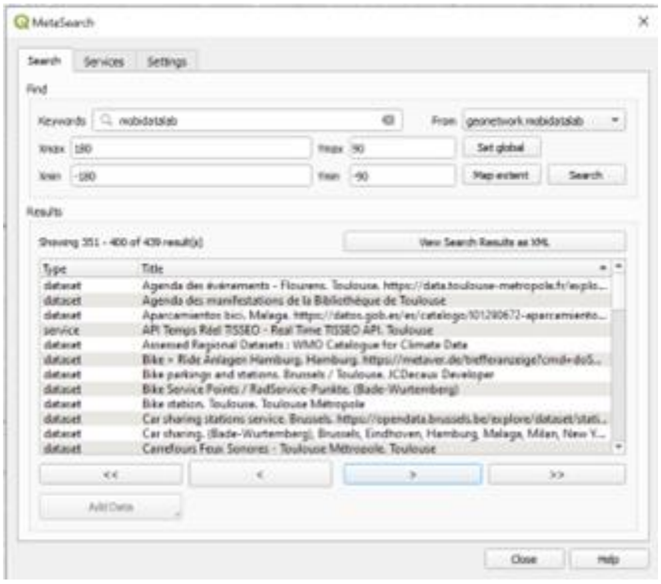

Figure 8 Query for keywords in CSW catalogue in QGIS MetaSearch

Figure 9 shows more details of the selected data set. In the links section, the user can navigate through the resources to obtain the published data. For supported resources like WMS or WFS data sources, they can be loaded directly in QGIS without intermediate steps.

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In this example, however, the link to the publisher's website is listed (Figure 10), so the user needs to view and download the data in the web browser and then load it into QGIS. The data in Figure 11 refers to the Cambio stops in Brussels and can be found in the MobiDataLab GeoNetwork catalogue (link).

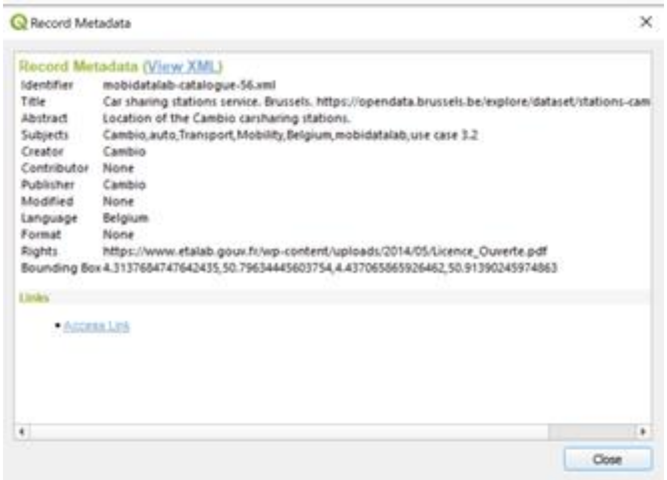

Figure 9 Detail of a metadata CSW record in QGIS MetaSearch

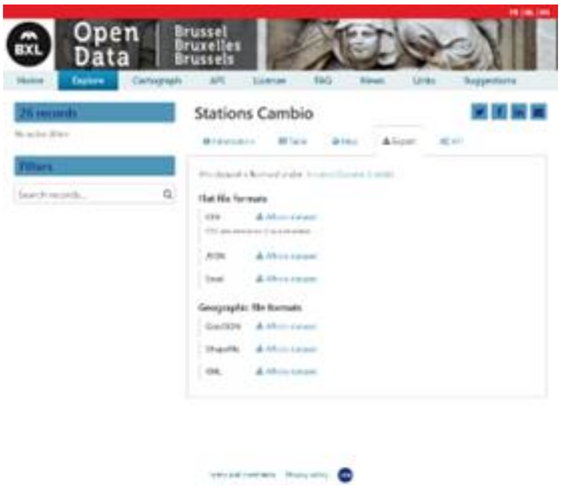

Figure 10 Detail of a metadata CSW record in the linked resource in the web browser

Figure 11 Shapefile of Cambio stations in Brussels loaded in QGIS

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Another example entails loading GTFS data from the reference data sets into QGIS with the plugin "GTFS Go"[12]. The data in the screenshot (Figure 12) refers to the transport lines in Toulouse and can be found in the catalogue (link).

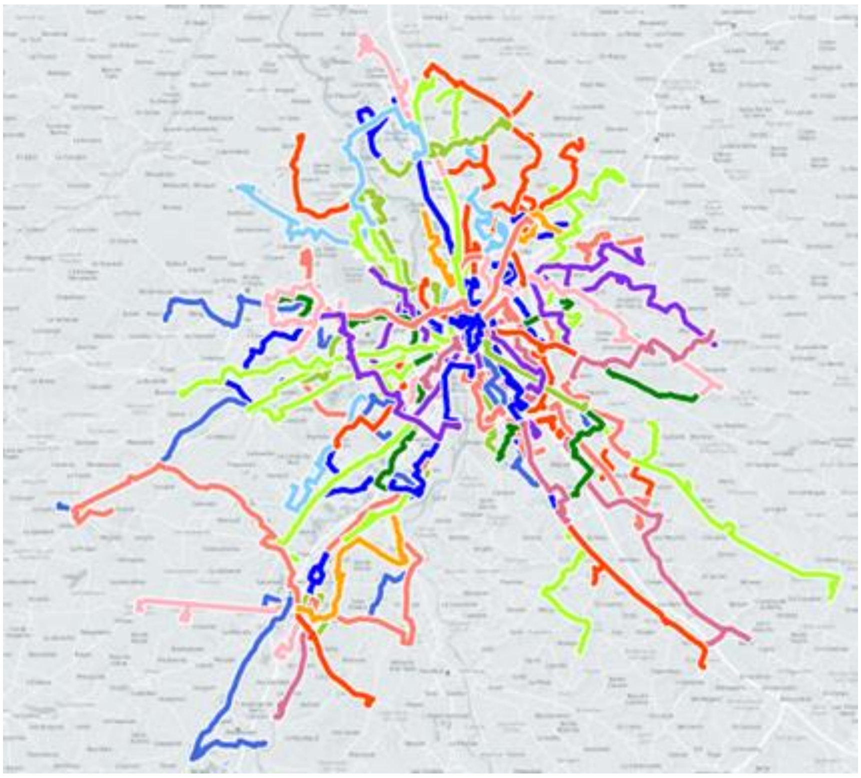

Figure 12 GTFS of transportation lines in Toulouse loaded in QGIS

This end-to-end example demonstrates a typical data acquisition, loading and analysis workflow which is part of many challenges about mobility data. On the one hand, it shows, that a tool like QGIS, with its many plugins, can build an interoperability level on tool-site, that allows users to harmonize data and combine external datasets to fulfil the analytics and visualization use case.
However, this is only enabled in the single client tool, given the fact, that the specialized plugins are integrated and are fitting to the available data(formats).

To avoid this, and achieve better interoperability, it is proposed to use open standards for tool independent interoperability. Bringing that many data providers together, to solve the challenges within the mobility domain, is one of the main goals of MobiDataLab.

[12] https://plugins.qgis.org/plugins/GTFS-GO-master/

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5.2. End-to-End use case for journey planners

Another example is the journey planner API of Navitia. The API can be seen as a normalising layer to simplify the access to different route planners for users.

Navitia API is based on Transmodel, which should make answers provided by Navitia journey planner a little bit easier to interpret when familiar with Transmodel concepts. An example of a potential journey is given in Figure 13.

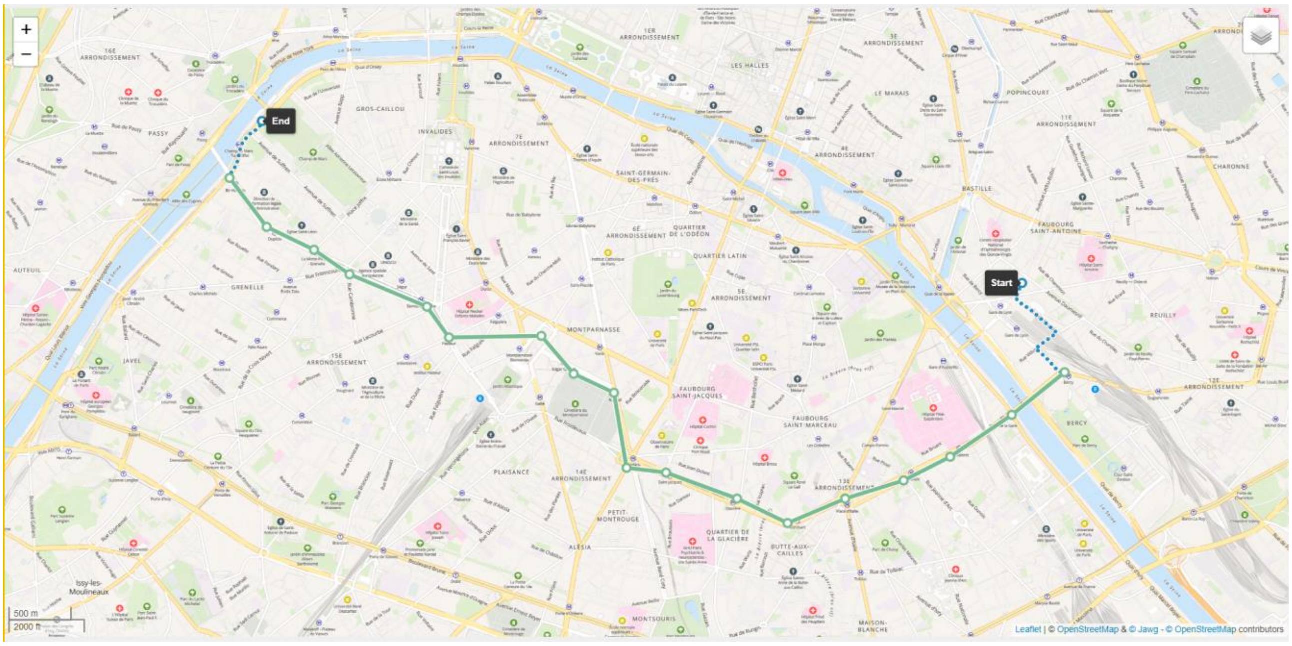

Figure 13 Intermodal route in Paris from "Gare de Lyon" to "Tour Eiffel" by Navitia

The request for the journey is described by a start (from) and a destination (to) coordinate:

```
#request
$ curl 'https://api.navitia.io/v1/coverage/sandbox/journeys?from=2.3749036;48.8467927&to=2.292292
6;48.8583736' -H 'Authorization: 3b036afe-0110-4202-b9ed-99718476c2e0'
```

Figure 14 REST request for a journey start to destination

The response from the Navitia API consists of a detailed multimodal journey. This includes timetables of the public transport systems and further information on location, transportation mode, etc.:

```
#response
HTTP/1.1 200 OK

{
```


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```
    "tickets": [],
    "links": [...],
    "journeys": [
    {
        "fare": {...},
        "status": "",
        "tags": [],
        "type": "comfort",
        "nb_transfers": 0,
        "duration": 2671,
        "requested_date_time": "20160613T133748",
        "departure_date_time": "20160613T133830",
        "arrival_date_time": "20160613T142301",
        "calendars": [...],
        "co2_emission": {"unit": "gEC", "value": 24.642},
        "sections": [
        {
            "from": {... , "name": "Rue Abel"},
            "to": {... , "name": "Bercy (Paris)"},
            "arrival_date_time": "20160613T135400",
            "departure_date_time": "20160613T133830",
            "duration": 930,
            "type": "street_network",
            "mode": "walking",
            "geojson": {...},
            "path": [...],
            "links": []
        },{
            "from": {... , "name": "Bercy (Paris)"},
            "to": {... , "name": "Bir-Hakeim Tour Eiffel (Paris)"},
            "type": "public_transport",
            "display_informations": {
                "direction": "Charles de Gaulle — Étoile (Paris)",
                "code": "6",
                "color": "79BB92",
                "physical_mode": "M?tro",
                "headsign": "Charles de Gaulle Etoile",
                "commercial_mode": "Metro",
                "label": "6",
                "text_color": "000000",
                "network": "RATP"},
            "departure_date_time": "20160613T135400",
            "arrival_date_time": "20160613T141500",
            "base_arrival_date_time": "20160613T141500",
            "base_departure_date_time": "20160613T135400",
            "duration": 1260,
            "additional_informations": ["regular"],
            "co2_emission": {"unit": "gEC", "value": 24.642},
            "geojson": {...},
            "stop_date_times": [
            {
                "stop_point": {... , "label": "Bercy (Paris)"},
                "arrival_date_time": "20160613T135400",
                "departure_date_time": "20160613T135400",
                "base_arrival_date_time": "20160613T135400",
                "base_departure_date_time": "20160613T135400"
            },
            {...}
            ]
        },
        {
```


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```
            "from": {... , "name": "Bir-Hakeim Tour Eiffel (Paris)" },
            "to": {... , "name": "Allée des Refuzniks"},
            "arrival_date_time": "20160613T142301",
            "departure_date_time": "20160613T141500",
            "duration": 481,
            "type": "street_network",
            "mode": "walking",
            "geojson": {...},
            "path": [...],
        }]
    },
    {...},
    {...}],
    "disruptions": [],
    "notes": [],
    "feed_publishers": [
    {
        "url": "",
        "id": "sandbox",
        "license": "",
        "name": ""
    }],
    "exceptions": []
}
```


Figure 15 Server response in JSON on the journey request of the figure above

Another point regarding Navitia is that it can use different journey planner or route planner engines, even external ones so that it can use the best engine depending on the transport mode or other criteria (e.g. Here for car, Géovélo or Valhalla for bike, Handimap for accessibility …).

This way, frontend developers get unified access to different journey planner APIs. However, the capabilities of the underlying journey planner engines may not all be exposed through Navitia API.

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6. Future Plans

Task 4.3 consists of two parts. The first part (V1) is represented in D4.5 with the exploration of the datasets and services provided by the project partners and the reference group.

The datasets and services have been mainly chosen based on the use-cases V1 from D2.9. The second part of T4.3 will be built on top of the findings within V1 and will extend the demonstrator. Within the course of the project, new services will appear, standards will evolve and new data will become available.

Therefore, a V2 of the T4.3 will include the findings and the evolution made from month 18 to month 32, with the reference group feedback, updated data, an improved service catalogue and early learnings from the labs in WP5.

Findings will be also communicated and discussed within standardisation groups to raise awareness and improve interoperability – aligned with the FAIR principle.

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7. Conclusions

D4.5 with the V1 of task 4.3 provides insights into the very heterogeneous ecosystem of data access and services. Within MobiDataLab, data and the services that are building on top of the data, play a central role. Therefore, the principle of FAIR is highly important to make it easy to access and consume data.

An overview of available data sets, based on the used standards for accessing the data and using the data is provided. The awareness and the availability of standardised interfaces for data provisioning are higher than for services (e.g., due to achievements of standardization organizations, e.g. OGC for spatial data) or due to individual initiatives (e.g. the GTFS format). However, mobility-relevant data is coming from a very broad and heterogeneous ecosystem, where multiple domains are providing their data. Many of them in their domain-specific standards, some of them in proprietary formats and services and others via highly standardized interfaces in interoperable data formats.

A requirement for the data sharing use-case of many data contributors is a common language and a common way of providing their data. In some cases, that might be a common denominator, which decreases the technical capabilities of individuals to a common level. However, this enables straightforward access and usage by a growing group of consumers. The awareness of existing standards for data access and service interfaces, which we want to raise with this project, will help to further enable the data sharing of mobility data.

Besides data access and data formats, location-based services and their interfaces play an important role to enable consumers to use mobility data for their individual use-cases. Services and their interfaces have an even larger lack of interoperability. Initiatives, such as the OGC Routing Pilot have shown options for common standards. However, services are usually later in the chain and do have in many cases a direct interface to the end-user. This “single vendor architecture” might be a reason, why the state of standards, accessibility and interoperability did not play the most important role for current service implementations. Within the mobility domain, many services are contributing to one use case. These use cases can raise the requirement of replaceable individual services to run the use case with a service that is providing another region/spatial extend, with higher performance, lower costs etc. Multiple vendors will then be requested to serve parts of this architecture and value chain. Interoperable interfaces will then enable this requirement and simplify the scalability and reusability of individual components.

Last, but not least, service consumers need to be aware of the services. They need to be findable and the consumers need to be able to make the best decision for the relevant use case. This requires further standardization of service interfaces and meta-data to catalogize the services and make it easy for human users and automated tools to search them and make a choice based on their requirements and the available services.

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8. References

GTFS.org (no date) *General Transit Feed Specification*. Available at: https://gtfs.org/ (Accessed: 5 May 2022).

Masó, J. (2022) 'Geospatial Web Services', pp. 493–530. doi: 10.1007/978-3-030-53125-6_16.

Routing Pilot | OGC (no date). Available at: https://www.ogc.org/projects/initiatives/routingpilot (Accessed: 8 May 2022).

Wilkinson, M. D. *et al.* (2016) 'The FAIR Guiding Principles for scientific data management and stewardship', *Scientific Data 2016 3:1*, 3(1), pp. 1–9. doi: 10.1038/sdata.2016.18.

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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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