Deliverable D 2.1
Technology Survey, C-REL

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Table of Contents

List of Figures

List of Tables

1. Executive Summary

This document constitutes deliverable D2.1 "Technology Survey, C-REL" of the IP4MaaS project. The main goal of the document is to collect the available information about the services provided by IP4MaaS TSPs that can be integrated in the Shift2Rail IP4 ecosystem.
The deliverable provides:

- a list of the relevant functions available in the Shift2Rail ecosystem, as communicated by Call For Member project partners;
- an analysis of the web services available in each of the six demo sites of the IPMaaS project (Barcelona, Padua, Athens, Osijek, Liberec and Warsaw) that can be integrated in the functions of the S2R ecosystem;
- a description of the information stored for each of the surveyed services in the Shift2Rail Asset Manager (part of the Shift2Rail Interoperability Framework).

The list of available services for each demo site has been created by first distributing a questionnaire among IP4MaaS TSPs, to collect some initial information about the services; then, this information has been integrated through ad hoc communications with each demo site, to complete the picture of available services.
The following table gives a quick overview of the services that the TSPs involved in the various demo sites offer, grouped by the relevant function of the Shift2Rail ecosystem.

Demo site service providers						
	Barcelona	Padua	Athens	Osijek	Liberec	Warsaw
Journey Planning	TMB	Trenitalia BusItalia	Miraklio OASA BrainBox TaxiWay	GPP	[CRWS] [AMS]	[Jakdojade]
Network data	TMB BusUp	Trenitalia BusItalia	Miraklio	GPP	[CRWS] [AMS]	[Jakdojade] ZTM
Booking	BusUp (incomplete)	Trenitalia BusItalia	BrainBox TaxiWay		[CRWS]	
Ticketing and validation		Trenitalia BusItalia	OASA BrainBox TaxiWay		[CRWS]	
Trip tracking	TMB BusUp	Trenitalia BusItalia	TaxiWay		[CRWS]	ZTM

The survey of services provided by this deliverable will be the basis for the design of the demonstrations, which will be carried out in WP4.

2. Abbreviations and acronyms

Abbreviation / Acronym	Description
AVL	Automatic Vehicle Location
CFM	Calls for Members
DL	Dissemination and exploitation leader
DoA	Description of the Action
EL	Ethical leader
EU	European Union
FS	Financial Statement
GA	Grant Agreement
H2020	Horizon 2020
IP4	Innovation Programme 4
OC	Open Call
PC	Project coordinator
PM	Project manager
PMO	Project Management Office
PMT	Project Management Team
PO	Project Officer
QAC	Quality Assurance Committee
S2R JU	Shift2Rail Joint Undertaking
TC	Travel Companion
TL	Technical leader
TRL	Technology Readiness Level
TSP	Travel service provider
WP	Work Package
WPL	Work package leader

3. Background

The main goal of the IP4MaaS project is to support the demonstration activities of the technologies developed in the Shift2Rail (S2R) Innovation Programme 4 (IP4). These demonstrations will require the integration of services provided by IP4MaaS Transport Service Providers (TSP) into the S2R IP4 ecosystem. Hence, to design and plan the demonstrations, a careful analysis of the services that are available from IP4MaaS TSPs that are suitable to be integrated in the S2R ecosystem is necessary. This document provides a survey of such services.

The present document constitutes the Deliverable D2.1 “Technology Survey, C-REL” in the framework of the WP2, Task 2.1 of the IP4MaaS project (S2R-OC-IP4-01-2020, GA 101015492). It contributes as well to WP3 and WP4 of the IP4MaaS project, which will rely on the information regarding the services actually available from TSPs to design the demonstrations.

Notice that, in the rest of this document, the term “service” (without further qualification) will refer to a software mechanism (e.g., a web service) that can be used (e.g., through the invocation of suitable software primitives) by software clients (in the broad sense of the term) to achieve some result. We will use the expression “transport service” to refer to the physical transportation service.

4. Objective/Aim

This document has been prepared to provide an overview of the services available to use for the demonstration sites in the IP4MaaS project. Each demo site has a dedicated chapter, in which the services that are available in that demo site are described.
The goal of this survey is to provide the basic technical details that are necessary to (i) decide which services will be integrated in the S2R ecosystem for each demonstration, and (ii) identify the technical steps that are necessary to set up the demonstrations. In particular, the information contained in this deliverable should be used by partners of Call For Member (CFM) projects (and especially partners of the COHESIVE and ExtenSive S2R IP4 projects, with whom the IP4MaaS partners are constantly in contact), who are in charge of actually integrating services in the S2R ecosystem.

It is not the goal of this deliverable to actually evaluate the services to be integrated, or the Shift2Rail ecosystem itself. This evaluation will be done through the demonstrators, and in particular through the User Satisfaction Index survey that will be defined within Workpackage WP3, in Deliverable D3.2 “List of operational KPIs, analysis of the users’ satisfaction and methodology as a whole, F-REL”. The results of the survey, and the potential for transferability of the technologies to other European locations will instead be analysed in Deliverable D3.3 “Final version of the methodological framework for future projects”.

5. Methodology and Overview of the results

The collection of the information regarding the services available in the various IP4MaaS demo sites has been carried out according to the following three mains steps:

1. A list of functions available in the S2R ecosystem was collected from CFM project members; from this list, the types of services that can be integrated in the S2R ecosystem have been inferred.
2. A questionnaire was distributed among IP4MaaS partners, and in particular TSPs, to collect a preliminary list of services available in each demo site.
3. The results of the questionnaire were analysed, and follow up actions with each demo site were carried out to integrate and complete the list of available services.

In the rest of this section, we first outline the main functions available in the S2R ecosystem, which have been identified using the information provided by CFM project partners. Then, we briefly introduce the questionnaire that was distributed among IP4MaaS TSPs. Finally, we provide an overview of the current picture of services available in IP4MaaS demo sites.

5.1. Functions of the S2R ecosystem

As emerged during collaboration meetings carried out with CFM project partners, to carry out meaningful demonstrations of technologies available in the S2R IP4 ecosystem, IP4MaaS TSPs should provide a suitable set of services that can be accessed by the S2R Travel Companion (TC) application.

The categories of services that are supported by the S2R IP4 ecosystems, and which are of potential interest for IP4MaaS TSPs, are the following:

- Journey Planning: in a nutshell, this type of service should provide primitives that allow clients to retrieve a (possibly multimodal) trip plan from given an origin and a destination. The services could also include offer price calculation. To be able to integrate a journey planner in the S2R ecosystem, network data (i.e., information about lines and stops) in GTFS[1] format should be available. In addition, it is useful to be able to retrieve information about fares, for example through a separate service.
- Booking: for TSPs that allow the booking of trips, there should be a service allowing the TC to gather information regarding reservations, their creation and cancellation. However, many TSPs (e.g., those focusing on local public transport) by design do not offer booking facilities.
- Issuing: where applicable, each TSP should provide a service that allows the TC to collect the tokens to be validated by passengers using the TSP infrastructure.

[1] https://developers.google.com/transit/gtfs

- Validation and inspection: each TSP should provide a service that allows the TC application to verify the user's entitlement to travel on a leg handled by the TSP.
- Ancillary services: TSPs offering additional facilities onboard their vehicles (e.g., wifi, meals, bar) should provide services through which information about available facilities can be retrieved.
- Trip tracking and real time information: to allow the TC to notify travellers of disruptions (e.g., delays) and other details regarding a particular travel service, and to let the user monitor their trip in real time, TSPs should provide mechanisms to retrieve real time information about the transport service.
- After-sales services: in case such services comply with the business model of a TSP, TSPs interacting with the IP4 ecosystem should provide services for the cancellation or trips, or for the re-accommodation of the traveller.

Of potential interest for the IP4MaaS project is also the possibility offered by the S2R IP4 ecosystem to create so-called "mobility packages", which combine several trips to provide travellers with better (e.g., more convenient) offers.

In the course of the interactions with CFM project members, a few limitations concerning the TC emerged, that should be taken into account when organizing the IP4MaaS demonstrations. In particular, the TC application is only available in English. Future plans could include language packages updates local to the application deployment, but it is not expected to happen in time for the demonstration phases.
Secondly, the TC application is not yet available in the Google Play Store for Android devices, which is the only OS the app is going to be developed in, for now.

5.2. Overview of the questionnaire

The questionnaire distributed among IP4MaaS TSPs to collect information about provided services was created taking into account the list of functions presented in Section 5.1. In particular, the questionnaire asked, for each type of function listed in Section 5.1, what services are currently available, and some initial details about them, such as their Technology Readiness Level (TRL) and what data formats they use. Annex 1 shows the questionnaire that was distributed.

The outcome of the questionnaire was the starting point of the survey presented in this document. However, additional dedicated, specific actions were carried out with each demo site to provide a fuller picture of the actual available services. The results of these actions are described in the next chapters and are overviewed in Section 5.3.

5.3. Overview of services available in IP4MaaS demo sites

Table 1 matches each relevant S2R IP4 function with the IP4MaaS TSPs providing services, related to that function, that could be integrated in the S2R ecosystem. In some cases (in particular for the Liberec and Warsaw demo sites) the services are offered through third-party systems that cover one or more TSPs. In these cases, the name of the third-party is listed between square brackets, instead of the name of the TSP.

Demo site service providers						
	Barcelona	Padua	Athens	Osijek	Liberec	Warsaw
Journey Planning	TMB	Trenitalia BusItalia	Miraklio OASA BrainBox TaxiWay	GPP*[2]	[CRWS] [AMS]	[Jakdojade]
Network data	TMB BusUp	Trenitalia BusItalia	Miraklio	GPP	[CRWS] [AMS]	[Jakdojade] ZTM
Booking	BusUp (incomplete)	Trenitalia BusItalia	BrainBox TaxiWay		[CRWS]	
Ticketing and validation		Trenitalia BusItalia	OASA BrainBox TaxiWay		[CRWS]	
Trip tracking	TMB BusUp	Trenitalia BusItalia	TaxiWay		[CRWS]	ZTM

Table 1 – Overview of the services available in IP4MaaS demo sites

No TSPs offer services that provide information about ancillary services, or that handle after-sales, thus these functions are not listed in Table 1.

Each of the next chapters details the services that are available in each demo site. The structure of the chapters follows the list of functions. In addition, Annex 2 provides the details of the offered services in a spreadsheet format that was defined by CFM project members to facilitate the collection of information on their side.

[2] GPP Journey planning: it is said to be available, but the documentation currently does not provide an API endpoint that could be used.

6. Barcelona Demo Site

Table 2 lists the APIs that are available in the Barcelona demo site.

TSP APIs	
BUSUP	
Documentation	https://documenter.getpostman.com/view/4899302/TzY4gFBM
API entrypoint	https://api.sandbox.busup.com/beta/
Data format	REST/JSON
TMB	
Documentation	https://developer.tmb.cat/api-docs/v1
API entrypoint	https://api.tmb.cat/v1/
Data format	REST/JSON

Table 2 – APIs available in the Barcelona demo site

The initial investigation on the situation shows promise for this demo site as involved TSPs provide a lot of useful services that cover most of the requirements.
The following sections present some of those that are deemed critical for the demonstration. Notice that some services (e.g., those provided by BusUp) are not publicly available as APIs, yet (booking, tracking, etc.). These services were not included in this deliverable.

SocialCar is excluded from the following analysis as no information or documentation was provided regarding their services. As a consequence, services from SocialCar are not being considered for the C-REL version of the demonstrations. SocialCar services are still being investigated; once the related information is available, it will will be integrated into the ongoing survey, and the services will be considered for the F-REL version of the demonstrations.

6.1. Journey Planning

TMB		
API Endpoint	https://api.tmb.cat/v1/planner/plan	
Parameters and Resources	fromPlace toPlace date time arriveBy::boolean mode **Optional** maxWalkDistance showIntermediateStops	Plan resource containing date from itineraries to

Notes	Coordinates for longitude and latitude comma-separated: 41.3755204,2.1498870. The *time* parameter specifies departure or arrival time based on the *arriveBy* Boolean Modes include TRANSIT,WALK

Table 3 – Details of the TMB journey planner

Journey planning in Barcelona demo site is available only via the TMB TSP: their API provides an endpoint through which the system allows clients to create a PlanResource given starting and destination location and time. Further parsing is required as this data is in a custom format and needs to be transformed into GTFS format if needed.
Additionally, TMB allows clients to set a parameter for the desired maximum walk distance to include in the creation of the journey.
On the other hand, BusUp provides an endpoint to retrieve available routes, but the user cannot select a custom pair for their trip as creating one is a lengthy and manual process not available on demand.

6.2. Network data

BusUp		
Information about all available routes		
API Endpoint	https://api.sandbox.busup.com/beta/routes?include=routeRates.periodRate	
Parameters and Resources	Page: integer, pagination page to retrieve (query stringparameter)	RouteResource: title, code, track[] (Array of track segments compressed using Google's polyline algorithm)
Notes	Returns a detailed and paginated list of Routes available to the user	
Stops for a specific route		
API Endpoint	https://api.sandbox.busup.com/beta/routes/:routes_id	
Parameters and Resources	RouteID	RouteStopsResource: tilte, address, lat, long
Notes	Returns the detailed information of a specific route	
Availability of a specific route		
API Endpoint	https://api.sandbox.busup.com/beta/routes/:routes_id/availability	
Parameters and Resources	Page: pagination parameter	RouteAvailability: Date, capacity_left (amount of available seats left on that day. Null when not applicable)

Notes	Returns the days a route is expected to operate, and the amount of seats left if applicable. By default the response is sorted from earliest to latest

Table 4 – Details of the BusUp service providing network data

TMB		
Static GTFS data		
API Endpoint	https://api.tmb.cat/v1/static/datasets/gtfs.zip	
Parameters and Resources	None defined	GTFS zip file
Notes	Dataset containing all static information about the network	
Bus lines		
API Endpoint	https://api.tmb.cat/v1/transit/linies/bus	
Parameters and Resources	None defined	Example of returned resource in JSON format available from https://developer.tmb.cat/api-docs/v1/transit#operation/linies_bus
Notes		
Metro lines		
API Endpoint	https://api.tmb.cat/v1/transit/linies/metro	
Parameters and Resources	None defined	Example of returned resource in JSON format available from https://developer.tmb.cat/api-docs/v1/transit#operation/linies_metro
Notes		
Information on a line (bus or metro)		
API Endpoint	https://api.tmb.cat/v1/transit/linies/{trasport_type}/{codi_linia}/recs	
Parameters and Resources	Transport type parameter refers either to bus or metro line, while codi_linia is the code/id representing the route	Example of returned resource in JSON format available from https://developer.tmb.cat/api-docs/v1/transit#operation/recs
Notes		

Table 5 – Details of the TMB service providing network data

Network information for Barcelona is quite complete: all TSPs provide services to retrieve data concerning stops, navigation lines, schedules and timetables. TMB also provides different endpoints per service type (bus, metro).
However, some of this data needs further conversion into GTFS format before being used in the project ecosystem as their initial representation follows a custom format.

6.3. Booking

BusUp		
Reservations		
API Endpoint	https://api.sandbox.busup.com/beta/reservations/:reservations_id	
Parameters and Resources	None defined	
Notes	Get information on the reservations made	
Reservations of a specific user		
API Endpoint	https://api.sandbox.busup.com/beta/users/:users_id/reservations	
Parameters and Resources	Filter[status]: Optional: By default, the user's active bookings will be returned. If other statuses are to be returned, the statuses must be separated by commas. 10 => Active status 20 => Expired status -10 => Status cancelled Example: -10,20,10	
Notes		
Cancel Reservation		
API Endpoint	https://api.sandbox.busup.com/beta/reservations/cancel	
Parameters and Resources		Data object containing list of objects defined by “reservation” type and id
Notes		
Avalability of a specific route		
API Endpoint	https://api.sandbox.busup.com/beta/routes/:routes_id/availability	
Parameters and Resources	Page: pagination parameter	RouteAvailability: Date, capacity_left (amount of available seats left on that day. Null when not applicable)
Notes	Returns the days a route is expected to operate, and the amount of seats left if applicable. By default the response is sorted from earliest to latest	

Table 6 – Details of the BusUp service providing booking-related information

Given the nature of the transport service they provide (i.e., local public transport including metro and bus services), TMB does not have a booking service.
BusUp, on the other, hand provides Reservation endpoints in their API to check a reservation for

a registered user or cancel one that has already been created. However, no endpoints are available to make a new reservation as a user of the API.
Additionally, a user can also check the seat availability for a particular route they are interested in: this service displays the capacity offered for a route and the number of seats left to book.

6.4. Token generation and validation

For this demo site no provided service deals with token generation and validation. TMB has mentioned plans to introduce digital tickets, but the service is not implemented, yet, leaving only paper-based tickets that must be printed beforehand and are delivered to the user via email as there is no service available to download them from.
The same issue concerns ticket validation for TMB: there is no publicly available service that can be used to verify the validity of a ticket.
Contrarily, BusUp, which provides booking as a service, does not expose any endpoint for ticket validation or generation.

6.5. Vehicle information and tracking

BusUp		
Tracking service		
API Endpoint	https://api.sandbox.busup.com/beta/services/:services_id/tracking	
Parameters and Resources	Tracking collection with latitude longitude timestamp	
Notes	Latitude and longitude are geolocations, timestamp is in ISO-8601 format (zulu time)	
Ticket consumption during service		
API Endpoint	https://api.sandbox.busup.com/beta/services/:services_id/check-ins	
Parameters and Resources	TicketConsumption with timestamp	
Notes	Sorted list of events from earliest to latest in ISO-8601 format (zulu time)	

Table 7 – Details of the BusUp service providing real-time transport service information

TMB	
Tracking service for buses	
API Endpoint	https://api.tmb.cat/v1/ibus/stops/{codi_parada}

Parameters and Resources	Collection of forecasts for a stop	
Notes		

Table 8 – Details of the TMB service providing real-time transport service information

Tracking is available only partially for Barcelona: involved TSPs provide some services to allow tracking, but those cover only some of the information required for an accurate tracking system.
BusUp provides a notification-based GPS tracking service for their fleet which allows the user to retrieve information on the position with a timestamp, but any further calculation based on this data ought to be done separately, for instance delays.
Moreover, service disruptions and other problems are not tracked by the system or are not available to clients.
TMB provides tracking only for a subset of their services (buses) and the information is not precise as it is but a forecast of the next stop on a specific line of service.
Delays, disruptions and other additional information are not available to clients.

7. Padua Demo Site

Table 9 lists the APIs that are available in the Padua demo site.

TSP APIs	
Trenitalia & Busitalia	
Documentation	Resources available on demand
API entrypoint	https://api.lefrecce.it/pico/olta
Data format	SOAP

Table 9 – APIs available in the Padua demo site

Both TSPs (Trenitalia and Busitalia) in this demo site provide services integrated in the same SOAP API.
As a side note, a request must be made to access resource definitions presented in the following tables. Moreover, no endpoint is available to collect a GTFS dataset for the entire network in which these TPSs operate, though it is possible to reconstruct this dataset, whenever needed, by performing multiple calls to endpoints provided in the following sections. However, for what concerns Busitalia specifically, FST made available a GTFS dataset for the related service that is updated twice a year. Such dataset can be made available for use within the project.

Trenitalia provides information about the real-time status of vehicles (in particular, delays and expected time of arrival) through the ViaggiaTreno website.[3] However, there are currently no APIs that are available to gather that information in a machine-readable way.

7.1. Journey Planning

Trenitalia - Busitalia		
Search travel solutions		
API Endpoint	https://api.lefrecce.it/pico/olta/Sale.SolutionEngine.SOAP/TravelSolutionService	
Parameters and Resources	TravelSearchCriteria	SearchResponse
Notes	<denomination> attribute is not a necessary attribute for the channel, but is an attribute relative to solution engine business logic. If you need to get transport classification you will have to call the searchTransportClassification service.	

[3] http://www.viaggiatreno.it

Table 10 – Details of the journey planner available in the Padua demo site

Journey planning services provide multimodal travel options when selecting the trip as results may include both TSPs at once.

7.2. Network data

Trenitalia - Busitalia		
Stops of a particular line		
API Endpoint	https://api.lefrecce.it/pico/Sale.ProductProvider.SOAP/TravelSolutionService	
Parameters and Resources	getTransportStops	getTransportStops
Notes	Returns a collection of stops for the requested line in XML format	

Table 11 – Details of the service providing network data in the Padua demo site

Network data retrieved from the Trenitalia API is not in GTFS format. This will require subsequent transformation and parsing steps. Busitalia, on the other hand, can only export GTFS data from its internal management system.

7.3. Booking

Trenitalia - Busitalia		
Search for available tickets		
API Endpoint	https://api.lefrecce.it/pico/Sale.SaleProcess.SOAP/SalesCoordinatorService	
Parameters and Resources		One or more TravelSolution returned from search service A list of Travellers related to the travel solutions
Notes	This service generates the prices of travel solutions	
Verify the eligibility of offered services selected		
API Endpoint	https://api.lefrecce.it/pico/Sale.SaleProcess.SOAP/SalesCoordinatorService	
Parameters and Resources	CustomerKey IssueDate oldTravelSolutions postSaleDetails travelSolutions travellers	TravelSolutions travellers validSelection

Notes	Only if you are purchasing a ticket for a specific company, you have to set in this request the attribute customerKey with the attribute returned by filterAdmissibleOffers service	
Create Reservation		
API Endpoint	https://api.lefrecce.it/pico/Sale.SolutionEngine.SOAP/CatalogReservationService	
Parameters and Resources	Travel	RefreshInterval Travel
Notes	It does a pre-reservation for services associated with a TravelSolution, providing a unique ID with a time expiration that allows not to be available the corresponding services for the assigned time interval. The returned Travel object will be the container for the completed Sales transaction and all its elements	

Table 12 – Details of the service providing booking-related information in the Padua demo site

7.4. Token generation and validation

Trenitalia - Busitalia		
Prepare Order		
API Endpoint	https://api.lefrecce.it/pico/Sale.SaleProcess.SOAP/OrderProcessService	
Parameters and Resources	AccountingShiftId additionalCharges channelId channelUrl customerKey idRda invoiceRequested ipAddress orderParameters paymentRecords postSaleRecord requestor reusedPaymentRecords reversedPaymentRecords travel userName	Order travel
Notes	It is one of the operations that control the process of creating and completing a customer Order only if you are purchasing a ticket for a specific company, you must set in this request the attribute customerKey with the attribute returned	

	by filterAdmissibleOffers service.	
Validate Interaction		
API Endpoint	https://api.lefrecce.it/pico/Sale.PaymentGateway.SOAP/PaymentService	
Parameters and Resources	InteractionData paymentRecord	paymentRecord
Notes	After authorization is validated, channel must invoke completeOrder operation	
Complete order		
API Endpoint	https://api.lefrecce.it/pico/Sale.SaleProcess.SOAP/OrderProcessService	
Parameters and Resources	Order travel	travel
Notes	After the successful execution of the financial transaction, the updated Order is persisted (completeOrder) and Payment confirmed asynchronously	
Print tickets		
API Endpoint	https://api.lefrecce.it/pico/Sale.SaleProcess.SOAP/TicketsAndReceiptsService	
Parameters and Resources	Order ticketDocumentFilter travel	pdfDocuments
Notes	The service producePdfTicketDocuments provides the ticket in PDF format, this service it is always called at the end of the service completeOrder. The services needs the field <currentEntitlements>, if the field is not present, it will not produce any .PDF files	

Table 13 – Details of the service for token issuing in the Padua demo site

8. Athens Demo Site

Table 14 lists the APIs that are available in the Athens demo site.

TSP APIs	
OASA	
Documentation	Under development
API entrypoint	http://otp.imet.gr
Data format	
Taxiway	
Documentation	Under development
API entrypoint	Under adaptation for Athens
Data format	
BrainBox	
Documentation	Under development
API entrypoint	Under development
Data format	
Miraklio	
Documentation	Under development
API entrypoint	https://transitool.com/
Data format	JSON

Table 14 – APIs available in the Athens demo site

While various APIs are available in the Athens demo site, some of them are still under development, or need adaptation for the IP4MaaS project. In particular, the APIs for Journey Planning will be developed for OASA and MIRAKLIO in the context of the IP4MaaS project based on available solutions (more precisely, the OpenStreetMap planner by CERTH for OASA, and TransiTool tool by Aethon for MIRAKLIO).
Moreover, the exploitation of existing APIs for OASA ticket issuing on an NFC contactless card is under discussion.

8.1. Journey planning

The relevant web services for TAXIWAY exist, but need adaptation for usage in the Athens pilot. The relevant web services for BRAINBOX are under development; the functionality exists but it is not yet available through an API. Table 15-Table 18 present the information currently available for the various journey planners.

MIRAKLIO

Plan journey		
API Endpoint	https://transitool.com/<TBD: Journey Planning>	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to plan a multimodal journey, based on the GTFS data that is stored within TransiTool (in that particular case, the GTFS of MIRAKLIO). It provides trip itineraries and journey planning directions to the client in JSON format.	

Table 15 – Details of the MIRAKLIO journey planner

OASA		
Plan journey		
API Endpoint	http://otp.imet.gr	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to plan a multimodal journey with the Open Trip Planner tool, based on the GTFS OASA data. It provides trip itineraries and journey planning directions to the client in JSON format.	

Table 16 – Details of the OASA journey planner

BRAINBOX		
Bike availability, battery level and location		
API Endpoint	Under development	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to retrieve real time information of bike's location, battery level and availability	

Table 17 – Available information regarding the Brainbox journey planner

TAXIWAY
Estimated fares

API Endpoint	Under adaptation for Athens	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to retrieve estimation of taxi fares for specific routes	

Table 18 – Available information regarding the Taxiway journey planner

8.2. Network data

MIRAKLIO		
Stops		
API Endpoint	https://transitool.com/<TBD: Get stops>	
Parameters and Resources	Documentation under development	
Notes	used to retrieve stops in the vicinity of a location defined by a latitude/longitude pair based on the GTFS data stored in TransiTool for the TSP-user. It can also optionally return the TSP's routes that service each stop. Accepts HTTP or JSON (preferred) payload.	
Schedule		
API Endpoint	https://transitool.com/<TBD: Get Timeschedule>	
Parameters and Resources	Documentation under development	
Notes	retrieves the timeschedule for a stop, route or trip per the TSP's GTFS. If a stop is given, then the timeschedule for all routes using the stop (arrival and departure times) are returned. If a route is given, then the arrival and departure times for all stops and trips in the route are returned. If a trip is given, then the arrival and departure time for the specific trip for all stops is returned	
Next scheduled arrival		
API Endpoint	https://transitool.com/<TBD: Get Next Scheduled Arrivals>	
Parameters and Resources	Documentation under development	
Notes	retrieves the next scheduled arrivals for a single stop per the TSP's GTFS	
Routes		
API Endpoint	https://transitool.com/<TBD: Get Routes>	

Parameters and Resources	Documentation under development
Notes	retrieves the routes of the TSP's GTFS data given a name (or part of a name), route id or a start and end position (latitude/longitude pairs)

Table 19 – Details of the MIRAKLIO service providing network data

Table 19 shows the available details regarding the service providing network data for the MIRAKLIO TSP in GTFS format. The OASA network data, instead, are not provided through a web service, but they can still be made available in GTFS file format.

8.3. Booking

OASA and MIRAKLIO do not provide booking services, since they are local transport operators. Booking is only available for the bikes and cars of BRAINBOX and for the taxis of TAXIWAY. The relevant web services for TAXIWAY exist, but need adaptation for usage in the Athens pilot. The relevant web services for BRAINBOX are under development; the functionality exists, but it is not available yet through APIs.

BRAINBOX		
User registration		
API Endpoint	Under development	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to allow user registration at the bike sharing backend	
User log in		
API Endpoint	Under development	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to allow user log in at the bike sharing backend	
Bike booking		
API Endpoint	Under development	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to allow bike booking 1 hour prior to use	

Table 20 – Available information regarding the Brainbox service providing booking-related information

TAXIWAY		
Taxi booking		
API Endpoint	Under adaptation for Athens	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to allow taxi booking	

Table 21 – Available information regarding the Taxiway service providing booking-related information

8.4. Token generation and validation

The ticket issuing for OASA will be following the existing procedure with the Athena card and the Athena card application. The relevant web services for TAXIWAY exist, but they need adaptation for usage in the Athens pilot. The relevant web services for BRAINBOX are under development; the functionality exists, but it is not yet available through APIs.

OASA		
Purchase and download OASA tickets		
API Endpoint	Under development	
Parameters and Resources	Documentation under development	Documentation under development
Notes	Integration with Athena app to purchase and download tickets to Athena card through NFC-enabled mobile phones	

Table 22 – Available information regarding the OASA token issuing and validation mechanisms

BRAINBOX	
Bike use entitlement	
API Endpoint	Under development

Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to generate bike sharing entitlement at the system's back end	
Bike unlock		
API Endpoint	Under development	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to allow unlocking of the bike by registered/logged in user	

Table 23 – Available information regarding the Brainbox token issuing and validation mechanisms

TAXIWAY		
Reserved taxi travel entitlement		
API Endpoint	Under development	
Parameters and Resources	Documentation under development	Documentation under development
Notes	The API is used to issue travel entitlement for taxi	

Table 24 – Available information regarding the Taxiway token issuing and validation mechanisms

8.5. Vehicle information and trip tracking

The relevant web services for TAXIWAY exist, but they need adaptation for usage in the Athens pilot. MIRAKLIO is working on developing an Automatic Vehicle Location (AVL) system and at the time of the creation of the present document the timeline for the completion of the service is unknown, it should therefore be considered as currently not available.

TAXIWAY		
Taxi location		
API Endpoint	Under adaptation for Athens	
Parameters	Documentation under development	Documentation under development

and Resources		
Notes	The API is used to retrieve real time information of taxi's location	

Table 25 – Available information regarding the Taxiway service concerning real time information

9. Osijek Demo Site

Table 26 lists the APIs that are available in the Osijek demo site.

TSP APIs	
GPP	
Documentation	Provided on demand
API entrypoint	Under development
Data format	JSON

Table 26 – APIs available in the Osijek demo site

There are currently still some uncertainties regarding the situation in the Osijek demo site. A few mechanisms rely not on web services, but on using an FTP server to download a notification file that is being updated each time an event occurs. This can make it difficult to integrate these mechanisms in the S2R IP4 ecosystem.

9.1. Journey planning

No journey planning service is directly available. The main journey planning mechanism in Osijek is Google Transit, where Google retrieves GTFS data by accessing a "feed" zip file stored on GPP FTP servers. However, during discussions on the topic, it was mentioned that the Digitransit platform[4] could be used for this purpose.

9.2. Network data

Table 27 shows a list of primitives that are used to retrieve static data, in GTFS format, concerning network data for the Osijek demo site. The exact details of the endpoint have not yet been made available, but they can be provided on demand.

GPP		
Stops		
API Endpoint	GetStops	
Parameters and Resources		
Notes	Primitive to retrieve list of stops in GTFS format	

[4] http://85.114.46.238/

Routes		
API Endpoint	GetRoutes	
Parameters and Resources		
Notes	Primitive to retrieve list of routes in GTFS format	
Trips		
API Endpoint	GetTrips	
Parameters and Resources		
Notes	Primitive to retrieve list of trips in GTFS format	

Table 27 – List of names of primitives for retrieving network data in Osijek demo site

10. Liberec Demo Site

Table 28 lists the APIs that are available in the Liberec demo site.

TSP APIs	
Service provider	
CHAPS (CRWS, AMS)	
Docementation	Provided on demand
API entrypoint	Not available publicly
Data format	JSON/SOAP

Table 28 – APIs available in the Liberec demo site

Information for this demo site is available through several SOAP services provided by third parties, which cover the TSPs of the region: CRWS, IDOLKA and AMS Bus. CRWS and AMS services have been already integrated in previous S2R projects (Shift2MaaS in particular), which should facilitate their use also in the IP4MaaS project.
The AMS Bus service provides methods to handle booking, ticketing and cancellation. Tickets are available for download in a pdf document the user can use for validation later. As for journey planning, AMS retrieves an array of long-distance bus connections given the starting and destination positions and dates. The GTFS data is not available automatically, only on request.
On the other hand, CRWS is a SOAP web service that covers all the information required for static and network data, such as stops, stations, municipalities for all the TSPs in Czech Republic including vehicle information and real-time data (e.g., delays). These are available through endpoints in a custom format which would possibly require additional parsing or transformation.

10.1. Journey Planning

AMS		
Search for a connection		
API Endpoint	v1/Connection/{guid}?from={from}&to={to}&dateTime={dateTime}&searchFlags={searchFlags}	
Parameters and Resources	{guid} string ID partner (static, received from the service admin) {from} string name or mask of object FROM (starting point of connection) {to} string name of mask of object TO (finishing point of connection) {dateTime} DateTime date and time of ride (if it's not entered, actual date is used)	ConnectionArray

	{searchFlags} int signs for searching according enum SEARCHFLAGS (if it's not entered, nothing)	
Notes	As connections here, are considered only direct connections; connections with stopovers can't be searched. Function returns maximally 10 connections. Basic details (connection handle, connection index, from, to, dates and times, standard price, line number and operator, number of free seats) are returned to each connection	
Retrieve information about a single connection		
API Endpoint	v1/ConnectionBack/{guid}/{handleThere}/{idxThere}?from={from}&to={to}& dateTime={dateTime}&searchFlags={searchFlags}	
Parameters and Resources	{guid} string ID partner {handleThere} int handle connection there {idxThere} int index connection there {from} string name or mask of object FROM (starting point of connection) {to} string name of mask of object TO (finishing point of connection) {dateTime} DateTime date and time of ride (if it's not entered, actual date is used) {searchFlags} int signs for searching according enum SEARCHFLAGS (if it's not entered, nothing)	ConnectionArray
Notes	The function returns detail information about one concrete connection, means list of tariffs, prices and operators on that connection including seat map of bus, else information that reservation is not working with particular seats.	

Table 29 – Details of the AMS journey planner

CRWS		
Search for a connection		
API Endpoint	SearchConnectionInfo	
Parameters and Resources	SUserID: user ID SUserDesc: identification of a user for logging purposes	connection search data

	SCombID: TT combination ID AoFrom: objects From AoTo: objects To AoVia: objects Via (optional, must be passed through in the entered order) AoChange: objects Change (optional, a change can only take place here, order irrelevant) DtDateTime: reference time and date of the travel (if none is entered, the current time is used) BIsDep: search only for departures after entered time, or arrivals until entered time OConnParms: search parameters (if missing, default are used) IRemMask: mask of required remarks on a service as per REMMASK enumeration ISearchMode: mode of searching aoFrom/aoTo/aoVia/aoChange as per SEARCHMODE enumeration IMaxObjectsCount: highest number of alternative offers for objects IMaxCount: highest number of requested connections, see below IRegMode: level of returning of regions in names as per REG enumeration ITTInfoDetails: level of returning of object details as per TTINFODETAILS enumeration ICoor: coordinates system as per COOR enumeration SSubstID: substitution ID LTTDetails: level of returning of details as per TTDETAILS enumeration ILang: language IConnHandle: handle of a connection list (0=not set)	
Notes	The function attempts to resolve the entered object masks and if that turns out well, it searches for the requested connections. The service searches for objects according to the mask using a search mode as per the iSearchMode parameter	

Table 30 – Details of the CRWS journey planner

AMS provides only long-distance buses and has a simple journey planning service ready to use as it is necessary before any booking and ticketing services. Whereas CRWS is the basic journey planner already integrated in other Shift2Rails projects and provides a solution for the entire demo site. This journey planner refers to a public nation-wide journey planner that covers all timetables for public transportation, including long-distance buses and trains.

10.2. Network data

CRWS		
GetCombinationInfo		
API Endpoint	GetCombinationInfo	
Parameters and Resources	string sUserID string sUserDesc: identification of a user for logging purposes string[] asCombID: absolute ID of combinations of TTs for which information is required ref DateTime dtLastChange: reference date acquired at the last call int iLang: language	CombinationInfo[] date and time of the last data change
Notes	By this function the client gets information about all timetable combinations applicable for the client (asCombID = null) or only about selected combinations. The asCombID value, if entered, has no influence on the order of returned data as it is always ordered according to the server configuration. The dtLastChange parameter's purpose is partial optimisation of communication. The state from the last loading of timetable data is returned here at the first call. If the client then enters it on their next data request, it returns null, unless the data has changed since then. Language is entered only for the possible text of an exception and has no influence on returned data.	

Table 31 – Details of the CRWS service providing network data

10.3. Booking

AMS

SeatBlock		
API Endpoint	v1/SeatBlock/{guid}/{handle}/{idx}	
Parameters and Resources	ID partner (static, received from the service admin) {handleThere} int handle connection there {idx} int index connection there request body SeatRequest: required tariff (rate) and seats	BlockInfo: information about booked seats and prices, contains handle of assigned seats (seat numbers there and back, price, list of required additional user information – i.e. name, ID/passport number, phone)
Notes	Function executes blocking seats and determines prices, which is the first step towards purchasing the tickets. If {handle} connection BACK, then both ways ticket is booked. Blocking of seats is valid for 15 minutes; if in this time the booking is not finished by user (by operation POST Ticket), blocking is over/fails.	
DELETE SeatBlock		
API Endpoint	v1/SeatBlock/{guid}/{ticketHandle}	
Parameters and Resources	{guid} string: ID partner {ticketHandle} string: handle assigned seats (from result of operation POST SeatBlock)	BlockInfo: information about booked seats and prices
Notes	Function releases seats blocked operation POST SeatBlock. Client should use this function in case he reserves seats and then decides not to finish the booking.	
Complete ticket purchase		
API Endpoint	v1/Ticket/{guid}/{ticketHandle}	
Parameters and Resources	{guid} string: ID partner {ticketHandle} string: handle assigned seats	Ticket: information about created tickets
Notes	Finishing of ticket purchase and entering additional user details. If connection handle BACK was entered in BlockSeat function, purchase of both ways ticket is finished. Only the additional details which were requested for that particular connection, must be entered. Information about created tickets (as result of function) contains mainly URL, where PDF ticket can be downloaded. Furthermore transaction code and price of course too	
DELETE Ticket		
API Endpoint	v1/Ticket/{guid}/{ticketHandle}	
Parameters and Resources	{guid} string: ID partner {ticketHandle} string: handle assigned seats	Ticket information about deletedtickets
Notes	Function allows cancelling purchase (means successful operation POST Ticket) without cancellation fee. It is determined for solution of technical problems (i.e. in case the ticket wasn't able to get downloaded or printed)	

	and its usage can be done within 15 minutes after purchase only. In case operation POST Ticket wasn't finished (or 15 minutes after execution was expired) function returns HTTP status 404 – NotFound.

Table 32 – Details of the AMS service providing booking-related information

10.4. Token generation and validation

A solution called **MOS** (multichannel check-in system) operated by another third party called **Operator ICT** has been integrated. It supports both QR codes and NFC check-in.
Validation is performed by the equipment installed in vehicles, for inspection a special device is used by inspectors.

10.5. Vehicle info and trip tracking

There are departure tables and position of vehicles displayed on the map, both are parts of one solution called **MPVnet**, developed and operated by CHAPS, but the availability of their APIs is still not totally clear.

CRWS		
Delay query		
API Endpoint	DelayQuery	
Parameters and Resources	sUserID user ID sUserDesc identification of a user for logging purposes sCombID TT combination ID sDelayQuery query for a location of a service iLang language	service location data
Notes	The function queries an external system in the background and returns information about the location of a service. The client gets sDelayQuery value from a connection search (ConnectionTrainInfo.sDelayQuery) and from arrivals/departures (ArrDepTrainInfo.sDelayQuery).	
Search train positions in an area of the map		
API Endpoint	SearchTrainPositionsInRect	
Parameters and Resources	sUserID user ID sUserDesc identification of a user for logging purposes SCombID: TT combination ID dMinX, dMaxX, dMinY, dMaxY:	list of current locations of services in a map area

	dimensions of the rectangle iMaxCount highest number of returned connections sOwnerMask optional mask of allowed/forbidden carriers aiTrTypeD optional limitation on a transport mode DDeltaMoveM optional location offset in case of an overlap, in metres iLang language	
Notes	This function finds locations of services in an area of a map. If the iMaxCount parameter is not entered, 1000 is used. Carrier limitation is set in the same manner as in the ConnectionParmsInfo class in connection search, i.e. a set of masks of carrier names is entered (separated by comma, semicolon, tab) and if the first character is a minus, then it excludes services of those carriers.	

Table 33 – Details of the CRWS service providing real-time transport service information

11. Warsaw Demo Site

Table 34 lists the APIs that are available in the Warsaw demo site.

TSP APIs	
ZTM	
Documentation	https://api.um.warszawa.pl
API entrypoint	
Data format	JSON
Service providers	
Jakdojade	
Documentation	Available on demand
API entrypoint	http://jakdojade.pl/api
Data format	JSON

Table 34 – APIs available in the Warsaw demo site

Many relevant APIs, and in particular those regarding the journey planner, are provided by a third party company (jakdojade[5]) and require additional coordination to access.
However, some TSPs provide services that are publicly available as APIs, in particular ZTM. The documentation of the APIs (both those provided by jakdojade and those of ZTM) is in Polish, but, given their technical nature, Google Translate does a good job of automatically providing a clear translation in English.

11.1. Journey Planning

Jakdojade		
Journey planning		
API Endpoint	http://jakdojade.pl/api/rest/v2/routes	
Parameters and Resources	Added after "?", Separated by "&" the full list is available at the documentation link	The answer is returned in XML format. The answer is a list of connections, made up of a list of lines made up of lists of stops. For the sake of consistency, the pedestrian sections of the route are also covered by a communication line, but of the pedestrian line type.
Notes	https://jakdojade.pl/public/pages/api/routes.html	

[5] https://jakdojade.pl

Table 35 – Details of the jakdojade journey planner

The journey planner available in Warsaw is provided by the jakdojade external company, which has strong links to the Warsaw municipality. In particular, their journey planner is based on data provided by ZTM.

11.2. Network data

Network data is available through web services offered by both ZTM and jakdojade (which relies on information coming from ZTM). None of the services natively returns GTFS data.

Jakdojade		
List of cities served by the application		
API Endpoint	http://jakdojade.pl/api/rest/v1/cities	
Parameters and Resources	None	The response is returned in XML format
Notes	https://jakdojade.pl/public/pages/api/cities.html	
Retrieving location and basic data of a place		
API Endpoint	http://jakdojade.pl/api/rest/v1/locationmatcher	
Parameters and Resources	Added after "?", Separated by "&" Agglomeration text	Location match result in a custom XML format
Notes	https://jakdojade.pl/public/pages/api/locations.html	
Schedules		
API Endpoint	http://jakdojade.pl/api/rest/v1/schedule/table	
Parameters and Resources	Added after "?", Separated by "&" Operator Line symbol Stop code	The answer is a set of departure times for selected lines with explanations of specific routes from the selected stop. The specified stop has its own metadata, i.e. the name, bar code, type of the stop, which lines use this stop, its coordinates and the zone in which it is located.
Notes	https://jakdojade.pl/public/pages/api/tables.html	

Table 36 – Details of the jakdojade service providing network data

ZTM

List of stops		
API Endpoint	https://api.um.warszawa.pl/api/action/dbtimetable_get	
Parameters and Resources	Id of the Resources to be queried or name busstopId busstopNr Line	The response is returned in JSON format as a list of values based on invocation parameters
Notes	Polish characters, e.g. in the names of stops, require codingURLencoding (UTF-8) eg: name=Marsza%C5%82kowska	

Table 37 – Details of the ZTM service providing network data

11.3. Vehicle information and trip tracking

Real-time information in Warsaw is available only for what concerns the position of the vehicles (buses and trams).

ZTM		
On-line localization of public transport vehicles		
API Endpoint	https://api.um.warszawa.pl/api/action/busestrams_get/	
Parameters and Resources	Id of the resource to be queried Brigade Line apikey type (1 bus, 2 tram)	The response is returned in JSON format
Notes	Information on the location of public transport vehicles is updated with frequency of 10 seconds.	

Table 38 – Details of the ZTM service providing real time information on vehicle localisation

12. Catalogue of assets

Information about the services that are available in the various IP4MaaS demo sites has been collected in the Asset Manager (AM), a tool that is part of the S2R Interoperability Framework (IF) that has been created for the purpose of making service definitions and descriptions easily available in one place whenever is needed [1].
For the purposes of the IP4MaaS project we used the version of the AM developed within the SPRINT project,[6] which is still in its prototype phase, but allowed us to store the information regarding services offered by IP4MaaS TSPs.

In order to have a service added to the AM it has to be documented and a way to access it must be provided. These services are divided by categories describing the areas they are used in (e.g., booking, issuing, planning).
Information required to document a service on the asset manager include, but are not limited to:

- the company in charge of developing and maintaining the service;
- contact information of such company and how to reach it;
- a description for the provided asset;
- information regarding a way to use said service (endpoints, resources, resource types).

The following screenshots present the user interface of the tool in which the main aspects are shown: the collection of service categories and an example of an added service with the information needed to include one into the Asset Manager.
More precisely, Figure 1 shows the dashboard of the AM – that is, the entry point to the AM. As the picture shows, assets are organized by type (e.g., booking).

[6] http://sprint-transport.eu

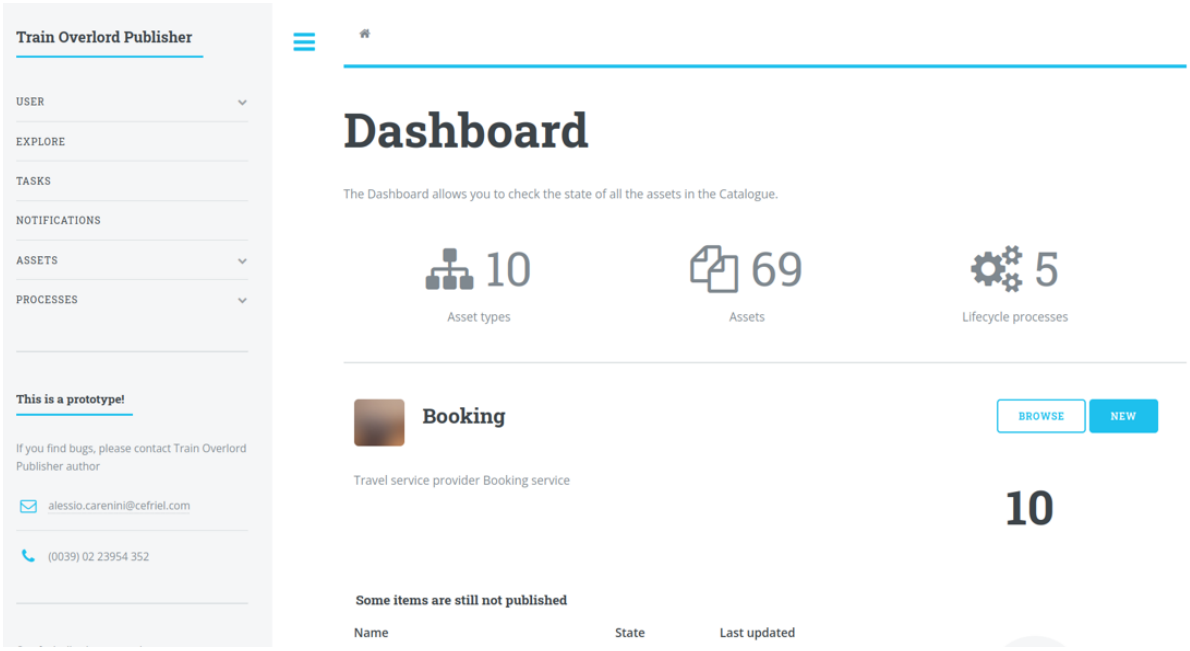

Figure 1 – Screenshot of AM showing the dashboard highlighting booking services

Figure 2, instead, shows a list of assets that belong to the category "journey planning", for example those related to BusUp (see Chapter 7).

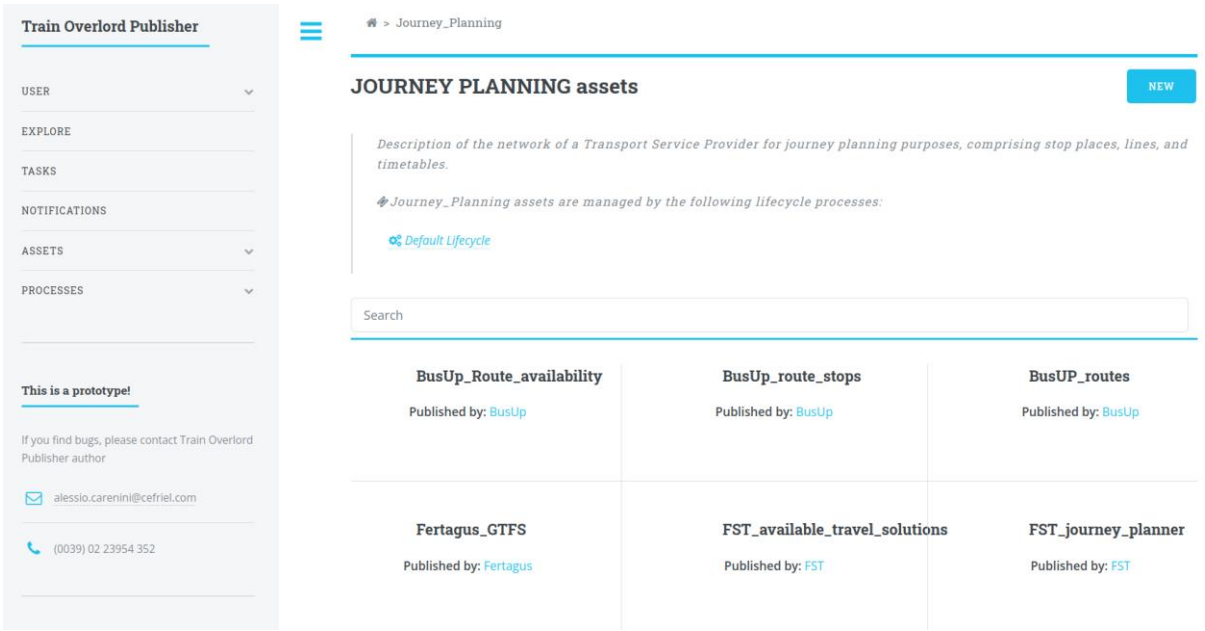

Figure 2 – Screenshot of AM showing part of added journey planning assets

Finally, Figure 3 shows the page of one of the assets related to IP4MaaS that are stored on the AM. In particular, it shows the service provided by ZTM in Warsaw regarding the retrieval of network data (see also Table 37).

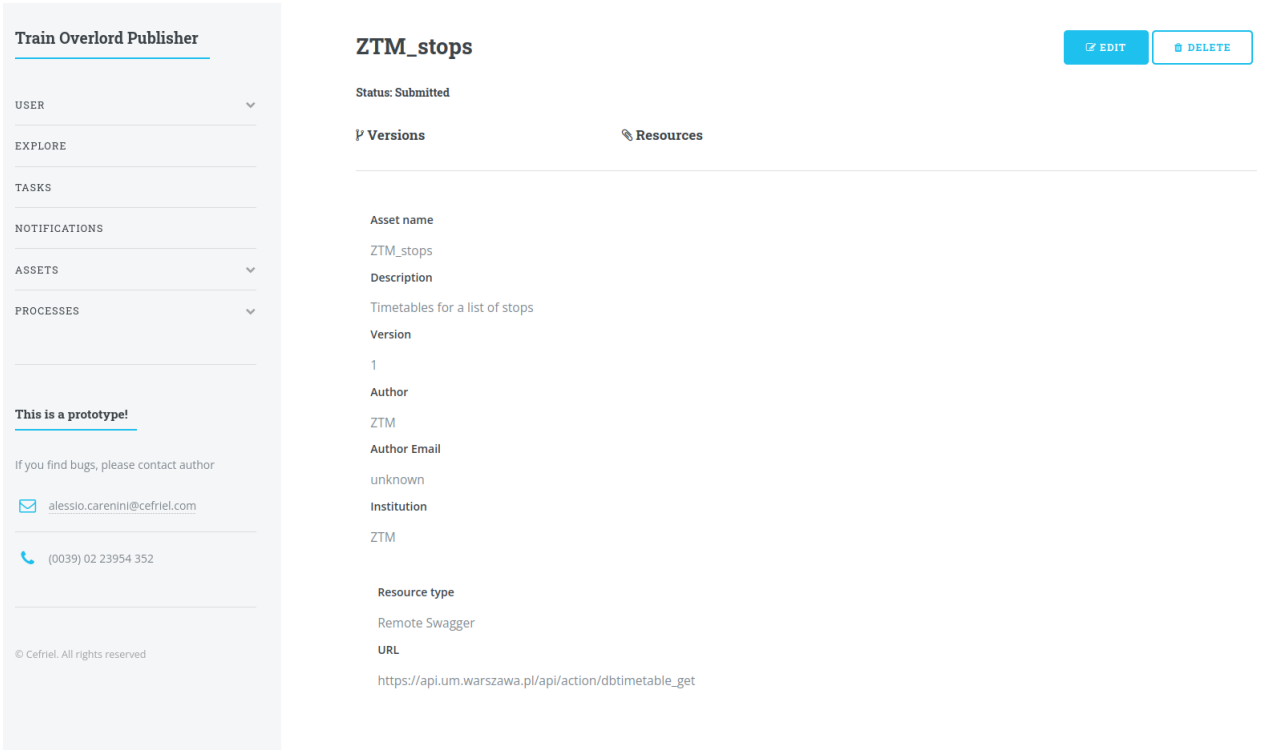

Figure 3 – Screenshot of AM showing the entry related to the ZTM service providing information about stops (see also Table 37)

The information of each of the assets (i.e., services) listed in this deliverable has been added to the catalogue stored in the AM.
For completeness' sake, Annex 3 lists all information that was present in the Asset Manager when this deliverable was finalized.

13. Conclusions

This document constitutes deliverable D2.1 “Technology Survey, C-REL” of the IP4MaaS project. The main goal of the document is to collect the available information about the services provided by IP4MaaS TSPs that can be integrated in the S2R IP4 ecosystem.

The deliverable first listed the functions provided by the S2R IP4 ecosystem, to provide the reference framework in which services should be integrated. Then, it analysed the services provided in each IP4MaaS demo site (Barcelona, Padua, Athens, Osijek, Liberec, Warsaw), and it briefly described how the information about available services has been stored in the S2R Asset Manager.

This report presents the picture of available services at the time of the release of the deliverable. This picture will be further refined and completed with the release of deliverable D2.3, “Demonstration requirements and scenarios, F-REL”.

The survey shows that basic services such as journey planning are available in all demo sites. Many TSPs do not offer booking services, because indeed booking is not part of the design of their transport services (typically because they focus on local public transport). The presence of services that can be considered as “more advanced” (such as validation and real time information) is more patchy. It is not the role of this deliverable to evaluate the impact that this can have on the actual realization of the demonstrations. Instead, such analysis will be carried out, based on the information contained in this deliverable and in the companion deliverable D2.2 “Demonstration requirements and scenarios C-REL” in the framework of WP4. In particular, Deliverable D4.2 “Demonstration Execution Plan, C-REL” includes an analysis of the risks that could hinder the successful realization of the demonstrations. Indeed, the survey of services provided by this deliverable will be the basis for the design of the demonstrations, which will be carried out in WP4.

14. References

[1] Sadeghi M., Buchníček P., Carenini A., Corcho O., Gogos S., Rossi M., Santoro R., SPRINT: Semantics for performant and scalable interoperability of multimodal transport, in: 8th Transport Research Arena TRA 2020, pp. 1–10.

15. Annexes

The following annexes contain additional, complementary information regarding this deliverable:

- Annex 1 contains the questionnaire that was distributed among IP4MaaS service providers to collect the initial information about available services.
- Annex 2 contains the Excel file that has been compiled according to a template provided by CFM project partners, and which lists the main details of the services that are available in each demo site.
- Annex 3 contains the information regarding the Ip4MaaS TSPs that was stored in the Asset Manager at the time of delivery of this deliverable.