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Preface

Acronym:	LinkingAlps
Title:	Innovative tools and strategies for linking mobility information services in a decarbonised Alpine Space
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Glossary[1]

Terms	Definition
Active system	The active system integrates the routing information from several local journey planners to a combined seamless route. It is composed of a passive system and a distributing system. It communicates through an OJP interface. It's a journey planning engine with OJP capabilities. Via the distributing system it is able to detect journeys through adjacent or remote regions and able to create OJP Trip Compositions. Alias OJP Router.
Distributing system	System that distributes journey planning enquiries to other systems. It sends the request for journey-parts through areas to the corresponding passive servers, receives the responses and is able to create OJP Trip Compositions. It has the knowledge about gazetteers and is able to collect information about exchange points for the whole system.
End user	User of an end-user service; travellers.
Enquirer system	Alias home-system. It is the participating system called by the end user application. It is the system that takes care of the end user travel information request and provides an answer.
Exchange point	It's a stop or a station where the local connection of one system is linked to the long distance connection of another system. This includes regional stops which match with stops for long distance or regional stops from adjacent regions. Exchange points are mainly but not exclusively located at borders and in bigger cities.
Gazetteer	It's a directory of common objects across the local journey planner systems and its system borders. It enables the active system to find the passive system for all geolocations (stops, stations, points of interest, address etc.).
GUI	The Graphical User Interface is a form of user interface that allows users to interact with electronic devices through graphical icons.
IFOPT	Identification of Fixed Objects in Public Transport, a logical data model for the fixed objects relevant for public transport, in particular for stops and points of interest.

[1] Most definitions are from the LinkingAlps official Glossary

JP	Journey Planner, a system that is calculating the journey for a given request. It is able to accept requests directly from end-user services.
Local Journey Planner (LJP)	A system with a routing engine and access to multimodal data with a particular local, regional or national coverage; "local" underlines its focus on a specific coverage that is limited. LJPs have no OJP routing capabilities.
Local region	The territory for which the journey planner can plan trips itself without information from other systems.
NeTEx	Network Timetable Exchange (CEN/TS 16614 ff).
OJP	OJP is an Open API for distributed journey planning that allows a system to engineer just one interface to exchange accurate and timely information about public transport (PT) services and to implement systems able to provide multi-modal information for longer-distance journeys.
OJP implementers	Travel information service providers that are implementing an OJP service exchange (in most cases on the back-end system of an end user service).
OJP Interface	Application Programming Interface (API) based on CEN/TS 2017: OpenAPI for distributed journey planning and specified in D.T1.5.1 Specification of the API interface (including a LinkingAlps OJP Profile).
OJP user	An end user service provider that is using OJP services from local JPs to provide an end-user service.
OSM	OpenStreetMap is an open source street level map of the world.
Participating system	A system (service) that is part of a decentralised network of JPs established through OJP.
Passive system	Alias OJP responder, responding system. A Local Journey Planner (LJP) with a OJP interface (API) being able to respond to requests from distributing systems. It is an information source within the system without distributed journey planning capabilities. It communicates through an OJP interface as a responding system.
Real time data	The real time of a particular means of transport at a particular stop; only sent after the arrival/departure of the vehicle to/from that stop.
Responding system	The generalized term for a system that responds to questions from the distributing system.
Service	Technical, self-sufficient unit that bundles related functionalities into a complex of topics and makes them available via a clearly defined interface.
SIRI	Service Interface for Real time Information (CEN/TS 15531).

OJP implementers

Territory (Country)	Organization (Acronym)	Journey Planning System	Active or passive system
Austria	The Verkehrsauskunft Österreich (VAO)	routenplaner.verkehrsauskunft.at	Active
Provincia autonoma di Bolzano (ITA)	Strutture Trasporto Alto Adige Spa (STA)	Südtirolmobil http://www.suedtirolmobil.info/	Active
Switzerland	Schweizerische Bundesbahnen (SBB)	https://www.sbb.ch/de/	Active
Regione Lombardia (ITA)	Azienda Regionale Innovazione e Acquisti S.p.a. (ARIA)	Muoversi in Lombardia http://www.muoversi.regione.lombardia.it/	Passive
Regione Piemonte (ITA)	Città Metropolitana di Torino (CMTo) via the in-house 5T	Muoversi in Piemonte https://www.muoversinpiemonte.it/	Passive
Slovenia	Regionalna razvojna agencija Ljubljanske urbane regije (RRA LUR)	AtoB Ljubljana http://www.atob.si/	Passive

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1 Introduction

The objective of WPT1 - A.T1.1 “Ex-ante Analysis and current uptake of Journey Planners (JPs)" can be summarized in two main activities.

Task 1 deals with the ex-ante analysis of the current features of local JPs and the uptake of innovations (such as the Open Journey Planning API - OJP). The action intends to summarize the main technical information on the participating systems involved in LinkingAlps as the basis for the interoperability of the OJP services and the development of the distributed system.

Task 2 deals with the current uptake of travel information services and aims to collect information about the current use of the participating systems (e.g. type of requested information , frequency of accesses, type of users and end users, etc.) and about potential OJP users’ needs and requirements for multimodal travel information services.

Deliverable D.T1.1.1 shows the results obtained in Task 1 through the JPs ex-ante analysis.

2 Ex-ante analysis methodology

The ex-ante analysis is based on the data collected through a questionnaire that was specifically designed and distributed to the six OJP implementers (SBB - Switzerland, VAO - Austria, STA - Bolzano Province, IT, LUR - Slovenia, ARIA - Lombardia Region, IT, CMTo/5T - Piemonte Region, IT) involved in LinkingAlps project and currently developing and managing the local JPs that will be linked together through the implementation of a distributed system based on OJP.

In particular, the analysis was carried out through specific steps requiring:

1. the identification of the relevant aspects and features needed for the interoperability of OJP services and for information exchange;
2. the design of a questionnaire to collect information for all the local JPs about the aspects identified in the previous step and to provide a conceptual knowledge about what information existing JPs can offer/process and what information can be queried with OJP schemas;
3. the collection of the requested information;
4. the assessment and analysis of the provided responses and the identification of commonalities and differences between the participating systems and of the current gaps and interoperability problems.

The main features to be investigated were selected by the LINKS Foundation and University of Maribor mainly based on interoperability aspects with regard to the syntax and the content of the services (schema, modelling of IDs, terminology, etc.). Furthermore, relevant features for providing a complete overview on the available modes, request options, geographical coverage and governance of data of the local JPs were considered.

Most features were defined and described with reference to the OJP Schema as defined in the Open API for Distributed Journey Planning (CEN/TS 17118:2017). Furthermore, European Standards and Technical Specifications were considered: Transmodel (Public Transport Reference Data Model), IFOPT (Identification of Fixed Objects in Public Transport), SIRI (Service Interface for Real Time Information) and NeTEx (Network and Timetable Exchange).

The selected features were organised in a questionnaire with 3 main tables to be filled in by OJP implementers:

1. the first table includes all the features, that can be supported by the **routing engine** and implemented by the **local JP services,** related to 3 main topics:
   - 1.1. **Transport modes**
   - 1.2. **Request options**
   - 1.3. **Geographical details**
2. the second table includes features and questions related to the JPs **system architecture;**
3. the third table requires a description about **data governance.**

During the questionnaire design process several comments were collected from consortium partners in order to integrate their feedback in the final form.

More in detail, the table dedicated to routing engine and local services includes the features reported in Table 2.1. OJP implementers were required to provide two separate answers for each feature: one for those that can be supported by their **routing engine** and another for those that have been implemented and that are currently provided to end-users by their local **JP service.**

Table 2.1 Ex-ante questionnaire table 1 related to the routing engine and JP service

Features	Description
Name	
Provider	
Transport Modes	
Public transport mode and submode[2]	Transport modes (air | bus | trolley bus | tram | coach | rail | intercity rail | urban rail | metro | water | cableway | funicular | taxi) and public transport submodes
Transfer mode[3]	Types of transfer modes dedicated to perform transfers (walk | park and ride | bike and ride | car hire | bike hire | protected connection

[2] Reference to standards: as defined in Open API for DJP (PTMode and PTSubmode section 8.4.3) and Transmodel 6 (MODE, and SUBMODE)
[3] Reference to standards: as defined in Open API for DJP (TransferModes section 8.4.3)

	guaranteed connection | remain in vehicle | change within vehicle | check in | check out)
Private modes[4]	Mobility modes offered by private persons (e.g. car pooling)
Individual modes[5]	Modes of transport which an individual powers himself and/or serving individual transport (walk | cycle | taxi | self-drive-car | others-drive-car | motorcycle | truck).
Continuous modes[6]	modes that run at any time without a timetable (demand and response services, replacement services – bus replacing rail)
Modes that are not modelled within one of the previous standards	(e.g. hiking, car sharing and other sharing modes or other activities related to mobility)
Request options	
Requesting O/D pairs[7]	Point to point/multipoint trip solutions from 1 or more origins to 1 or more destinations. Each feature can have ordered series of via points, which the trip has to pass through.
	Filtering[8] by departure/arrival time | mode | stops |operators | branding/product categories
O/D search optimization criteria[9]	(e.g. fastest path |shortest path | least number of exchanges, lowest fare | least walking, etc.)
Accessibility requests and information	Accessibility information for special needs users[10] (e.g. ramp | lift | escalator, etc.) Level of detail (e.g. information for stops, platforms, transport mean)
	Other accessibility information (e.g. incident and service disruption information, road works, availability to transport bikes on-board)
Requesting a stop timetable[11]	Departures from a specific stop within a specified time window
Requesting times for all intermediate stops in a trip[12]	To help a passenger follow the progress of a trip along the route besides displaying its boarding and alighting stops and times, it is also possible to ask for trips to be described with details of all stops between the boarding and alighting points and the times at which these stops are expected to be reached
Requesting expected events at a particular stop[13]	With an increasing number of operations having real-time monitoring and prediction systems, the departure times of vehicle journeys can be obtained not only in the form of a timetable, but also in the form of predicted departure times calculated in real time

[4] Reference to standards: as defined in Open API for DJP (PrivateMode section 8.4.3) and Transmodel 6 (category of MODE)

[5] Reference to standards: as defined in Open API for DJP (IndividualModes section 8.4.3) and Transmodel 6 (category of MODE)

[6] Reference to standards: as defined in Open API for DJP (ContinuosModes section 8.4.3) and Transmodel 6 (category of MODE)

[7] Reference to standards: section 5.2.1 as described in Open API for DJP

[8] Reference to standards: sections 8.7.3.3 and 8.7.3.4 as described in Open API for DJP

[9] Reference to standards: section 8.7.3.3 as described in Open API for DJP

[10] Reference to standards: section 5.2.3 as described in Open API for DJP

[11] Reference to standards: section 5.3.1 as described in Open API for DJP

[12] Reference to standards: section 5.3.2 as described in Open API for DJP

[13] Reference to standards: section 5.3.3 as described in Open API for DJP

Requesting information about the fares and ticket options for a particular trip[14]	As journey planning systems increasingly provide at least basic information about fares and tickets so a DJP system should be able to interrogate such systems and convey the relevant information to enquirers. Optionally, also information about return tickets, multi-trip tickets, multi-person tickets etc. could be provided
Other possible question[15]	Some journey planning systems may ask for supplementary information if it is available. Examples might be to seek a "rain safe" trip, or to ask for an estimate of energy usage for each leg of a trip
Location for the start and end of a trip[16]	Ability to identify trip O/D from a user input on: - Any stop, station or other public transport terminal - A topographic place (city, suburb, town, village or hamlet) - A wide range of different types of points of interest (POIs) - A named street - The postal street address of an individual property - A postcode (particularly relevant where these are very precise, as in the UK where a postcode typically covers no more than about 50 addresses on a specified street) - A point on a map.
Geographical details	
Topographic map for route calculation	The journey planner will also need a topographic map which allows the routing of trips to follow appropriate roads, alongside the ability to plan walk legs along all available pedestrian routes, and the ability to present the origin, destination, interchanges and stops, and routes (e.g. GoogleMaps, OpenstreetMap, Here, customized maps)
Customization of network topology for routing	Detailed information for routing (e.g. inclusion of underground stations, stairs, lifts, etc.)
Public Transport (PT) network representation	Stop hierarchy (e.g. meta stations, stop areas, stop points, etc.). Existing repositories for stops.
	Route paths representation (real geometries of routes and lines | approximated representation of routes)
Types of identifiers used for PT network elements[17]	Coding system: a common understanding of identifiers of stops, lines, journeys, vehicles, transport operators etc. has to exist across system boundaries including identification of objects beyond system borders
PT network dimension	number of transport operators, lines, stops included in the service
Geographical coverage	(e.g. national / regional / province / urban level)
Transnational coverage	Countries/Regions/ Provinces already connected within the JP
	Ways of managing interconnections/ transnational services in route calculation (e.g. interchange points in distributed systems, centralized DB, pooling)
Provided languages	Default language, preferred language for text elements and other available languages
	Default language for origin and destination points (e.g. original location names needed also when setting a foreign querying language)

[14] Reference to standards: section 5.3.4 as described in Open API for DJP
[15] Reference to standards: section 5.3.5 as described in Open API for DJP
[16] Reference to standards: section 6.3 as described in Open API for DJP
[17] Reference to standards: section 8.2 and section 8.4.5.1 as described in Open API for DJP

The features included in the **system architecture** and in the **data governance** tables are listed in Table 2.2 and Table 2.3.

Table 2.2. Ex-ante questionnaire table 2 related to the system architecture

Features	**Description**
Data exchange formats	Data object request and delivery (e.g. GTFS, NeTEx, etc.)
API endpoints "What JP can provide to other services via API "	Identify all the requests that APIs can fulfill (e.g. travel solutions by O/D, stop, mode, departure times, position, etc. including additional potential requests not provided in the front-end)
Available APIs/web service parameters	The parameters needed for the requests (inputs needed to fulfill the request)
Output, message content format	(e.g. XML, JSON,etc.)
Schema of the output message	(e.g. XSD, XML schema definition, DTD)
Data transfer protocols	(e.g. SIRI, HTTP, REST, FTP, JDBC)
Service publication	GUI (e.g. desktop website, mobile app, etc.)

Table 2.3. Ex-ante questionnaire table 3 related to data governance

Features	**Description**
Data owners	(e.g. transport operators, provinces)
Data providers	(e.g. transport operators, provinces)
Frequency of data update	(e.g. every day, every week)
Current major gaps in input data	(e.g. lack of route geometries, fare data, etc.) Quality of input data

A summary of the main commonalities and differences among all the participating systems' features, is provided in the next chapter and has been obtained as a result of the detailed analysis and comparison of the responses provided by the OJP implementers, aimed at identifying interoperability information and data gaps.

3 Summary of JPs' main features, commonalities and differences

3.1 Services and engines

3.1.1 Transport Modes

- All possible public transport modes and submodes can be supported by the routing engines of each participating system, provided that mode data are available and can be associated to a timetable. However, **only two PT modes are provided by all the JP services: rail** (short distance, long distance, intercity, urban) **and bus** (regional, urban) as shown in fig. 3.1.
  Tram, metro, water and cableway/funicular modes are also provided by most services, if available: SBB, VAO, and ARIA provide all of them, CMTo/5T provides tram and metro, STA includes cableways and funiculars.
  SBB, VAO, STA and ARIA also provide detailed information about train categories (e.g ICE/TGV/RJX, EC/IC, etc.).

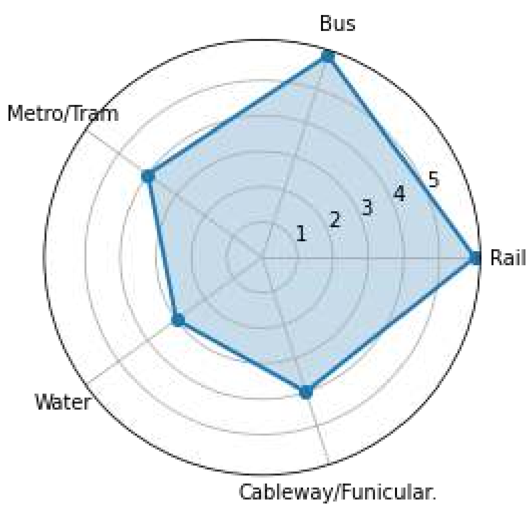

Figure 3.1: Radar chart indicating the public transport modes

- **All JPs have walking as the main common transfer mode** (even if engines would support more modes, if data are provided). ARIA JP only provides walking between some stops with pre-defined "foot walks", from the trip origin to the first boarding stop or from the last alighting stop to the final destination.

STA and VAO services provide additional transfer modes like remain in vehicle, guaranteed connection, protected connection. VAO also considers further modalities: park and ride, bike and ride, bike hire.

- **Private modes have not been implemented by any of the JP** yet. However, SBB and STA foresee their implementation (through the EFA routing engine which supports private modes, if data is provided) or at least their integration.
- As shown in fig. 3.2 **VAO, LUR and CMTo/5T support walking and cycling as individual modes**. In VAO and CMTo/5T services also the car mode is available.
  SBB, ARIA and STA have not implemented any individual mode yet, but **foresee their implementation** in the next few years.

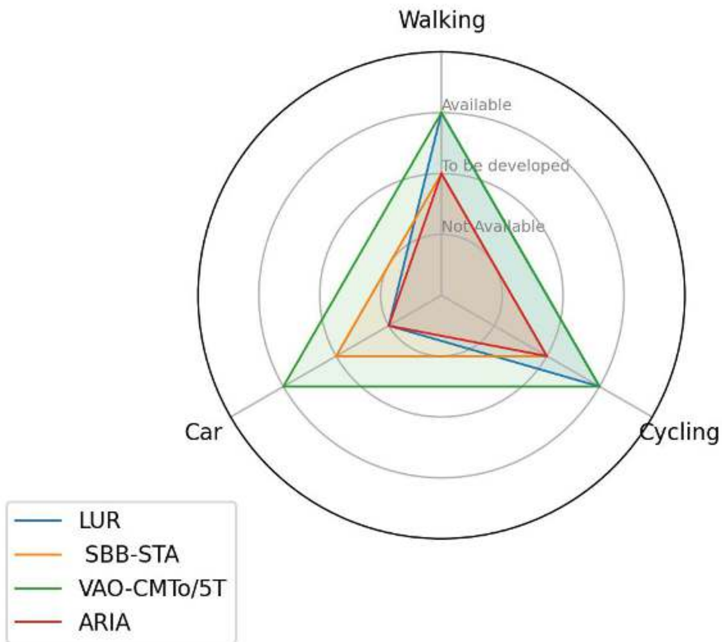

Figure 3.2: Radar chart indicating the individual modes for each JP

- SBB, VAO and LUR engines are supporting **continuous modes** like demand responsive transport (DRT) and replacement services. However, **only VAO JP currently provides DRT services**, included into route calculation by defining a pseudo timetable. **Bike sharing systems are also included in VAO** routing service as a kind of bike hire.

3.1.2 Request Options

Requesting O/D pairs:

- **All LJPs support point to point requests**. **None** of the services **supports multipoint trip solutions** from more origins to more destinations. Only 2 JPs have implemented and are currently providing the **via routing** option with one or more intermediate stops.
- Most routing engines support filters to customize the O/D pair requests at least by departure/arrival time and by mode. However, the only option that has been **implemented by all LJPs**, except for LUR, is **the filter by departure/arrival time**.
- **Location for the start and end of a trip (ability to identify O/Ds from a specific user input):** requests by address is supported by all the OJP implementers. Most JPs also support requests by stop/stations, topographic place, POI (Point of Interest), point on a map.
- **O/D search optimization criteria:**
  LUR and CMTo/5T do not support any additional search optimization criteria.
  The other JPs support further criteria based on transfer time, the fastest path, the least walking and on the number of interchanges (e.g maximum or minimum number of transfers, only direct connections).

Filters and optimisation criteria require different computational times and can affect the response times and the service performances: this represents an open issue needing more detailed discussion to define which filters and criteria need to be implemented in the future distributed system in order to avoid very time consuming O/D requests.

Accessibility request and information

- **Accessibility information for special needs** users is supported by all the engines if data are provided. However, **only the active JPs have implemented such functionality: VAO** service provides information about ramps, lifts, escalators and low floor vehicles (not with the same quality for all Austria), **STA** allows to exclude stairs and or lifts **and SBB** currently supports the filter "with" or "without" restrictions for special needs users.
- Other accessibility information is supported by VAO and STA that provide accident, service disruption information and availability to transport bikes onboard. VAO also includes roadworks information.

Requesting planned and expected events at a particular stop

- **All JPs** support **requests of planned stop timetables** and provide planned **times at intermediate stops** of a trip.
- **Real time (RT) information at stops is provided by SBB, VAO and STA** (foreseen in short terms both for rail and part of road services). CMTo/5T does not provide RT information but could support it, provided the GTFS RT data are available.

Requesting information about the fares and ticket options for a particular trip

- The routing engines of four participating systems on six support fares and ticket options if data are available. However, **only the active systems currently provide fare information** mainly for their local region, but not for long distance connections. SBB foresees a future connection to the digital sales hub for Switzerland.

Other possible questions

- CO_2 emissions request (providing indications about emission savings with respect to cars) is supported by two engines but not yet implemented.
  Bike carriage with public transport is supported by the active systems engines. Other currently supported options include: direct connections with sleeping car or couchette car, bike transport , group transport, occupancy level in train 1st and 2nd class, walking speed (fast, normal, slow), exclusion of stairs, elevators, escalators of long distance transport modes.

3.1.3 Geographical details

The participating systems are currently covering areas with different geographical scales and extensions and this is reflected in their network dimension:

- SBB and VAO cover an extended national scale including, respectively, Switzerland and Austria plus a greater area (buffer) around the national borders.
- LUR covers the national scale.
- ARIA and CMTo/5T cover the regional scale including, respectively, Lombardia and Piemonte. ARIA also manages national and international long distance trains with at least one station inside Lombardia Region. CMTo/5T covers also part of Lombardia, including the left side of the region until Milan and the railway services provided by the Trenord operator.
- STA covers the province scale (Bolzano Province and South Tyrol plus Trentino, Belluno and Tyrol).

Topographic map for route calculation

- All LJPs support and use OpenStreetMap (OSM), except for VAO which uses the Austrian traffic graph and reference system. ARIA does not manage routing on a map.

PT network representation

- **Stop hierarchy** can be considered an open issue to be dealt with for the development of the LinkingAlps distributed system since network stops are currently modelled in different ways by the different JPs.
- **Route paths representation**
  Four on six JPs support real geometries of routes and lines, two do not manage real route paths in their services.

Types of identifiers for PT network elements

- This is an open issue that needs to be further discussed for the development of the LinkingAlps distributed system: at present, **all the JP services are using different types of identifiers (IDs)**: from global and/or national official IDs to local and numeric ones.

3.1.4 Languages

- **All JPs provide at least their native language and English** on their website/apps for text elements. SBB, STA and ARIA provide four different languages.
- **LUR, ARIA, CMTo/5T require their native language to indicate trip origins and destinations**. The active systems support multilingual identification of O/D points.

3.1.5 System Architecture

- **Most JPs support the traditional GTFS format**, however, it is evident that they are **increasingly** supporting and **switching to more standardised exchange formats** (NeTEx and SIRI).
  The prevailing output message content formats are XML and JSON.
  HTTP REST API is the prevailing method for transferring data.

3.1.6 Data governance

- The frequency for updating data can be considered as an open issue since it varies depending on the JPs and on the information provided, for instance, timetables are updated daily, weekly, monthly or even with less frequency, when there are relevant changes, depending on the services. Also timetables availability varies among the different countries and services: they can be available for the full year or only for six months and this affects the lapse in information provision.
- The **most common gaps in input data concern missing real time and fare information**, mainly due to the difficulties in collecting complete data from transport operators. Other problems are related to **missing accessibility information and real geometries for route paths**. Moreover, new and alternative transport modes (e.g. DRT services, ski lifts and other services not based on timetables) are not integrated enough in the routing calculation.

3.2 Open API Requests

Data from six JP owners/implementers in the project were collected to assess to what extent their JPs support the seven standardised Open API Requests: Location Information Request, Exchange

Points Request, Trip Request, MultiPoint Trip Request, Stop Event Request, Trip Info Request and Fare Request.

Based on the results collected, following can be concluded for particular requests.

(1) Location Information Request

Only matching text input against possible origin and destination locations is supported by all JPs. Other supported options (only by some JPs) are: geographical context service that provides location objects within a bounding box, reverse address resolution service that delivers the nearest address for a given coordinate, finding the nearest stops/stations for a given coordinate, matching text input against the names of locations near a given coordinate.

(2) Exchange Points Request

The request is only supported by one JP, others don't support it.

(3) Trip Request

Three on six JPs support the OJP API request, while the others support it with proprietary functionality.

(4) MultiPoint Trip Request

None of the JPs currently supports it. Instead several distinct parallel trip requests can be issued and wait for the response.

(5) Stop Event Request

Only one JP provides the OJP API request. Two support it with proprietary functionality.

(6) Trip Info Request

Only one JP provides the OJP API request. Three support it with proprietary functionality.

(7) Fare Request

No OJP API support from the JPs.

Two JPs support proprietary fare requests for all transport modes, but not for long distance trains. Other JPs don't support it because functionality is not implemented or agencies don't provide this information. SBB foresees a future connection to NOVA, the digital sales hub for Switzerland.