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INVESTIGATION OF STANDARDS IN PUBLIC TRANSPORT AND GAP ANALYSIS

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Executive Summary

This deliverable is developed as part of Task 6.7 within Work Package 6 (WP6) of the EU-Rail FP6 FutuRe project, a strategic initiative aimed at revitalizing regional railway networks across Europe. WP6 is dedicated to the specification phase, laying the groundwork for the solutions that will later be implemented and demonstrated by WP11.

Task 6.7 aims to foster the standardization processes within the EU. It therefore identifies which data interfaces between components are necessary to provide the information which power the multimodal travel solutions designed in WP6. It analyses if standard interfaces specifications are used and if they already fulfil completely the requirements. If no standard interface specification is available, it is assessed if a standardization process for this interface is advisable. The focus was hereby put on the data exchange between different system components and therefore on data interface specifications.

For task 6.7, it was envisaged that it will develop an alpha release of the final deliverable. The final version will be developed by task 11.7. During the work on the alpha release, in total six data interfaces / data formats were identified where it might be advisable to amend existing standard data specifications or create new specifications. For the final release, a more detailed gap analysis will be elaborated.

List of abbreviations, acronyms, and definitions

Abbreviation / Acronym	Definition
AE	Affiliated Entity
API	Application Programming Interface
BEN	Beneficiary
CEN	Comité Européen de Normalisation
CSV	Comma-separated values
CT5	Cooperation Tool 5
DRT	Demand Responsive Transport
ERA	European Railways Association
ERJU	Europe's Rail Joint Undertaking
ERTMS	European Rail Traffic Management System
FP	Flagship Project
GA	Grant Agreement
GTFS	General Transit Feed Specification
IPR	Intellectual Property Rights
ITCS	Intermodal Transport Control System
LPT	Local Public Transport
NeTEx	Network Timetable Exchange
OSDM	Open Sales and Distribution Model
OJP	Open API for distributed journey planning
PIS	Passenger Information System
POI	Point(s) of Interest
PRM	Passengers with reduced mobility
R&D	Research & Development
RT	Real-time
SIRI	Standard Interface for Real-time Information
SP	System Pillar
TCO	Total Cost of Ownership
TMS	Traffic Management System
TOMP	Transport Operator Mobility-as-a-service Provider
TRIAS	Travellers Realtime Information Advisory Standard
TSI	Technical Specification for Interoperability
URL	Uniform Resource Locator
WP	Work Package

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1. Document Scope

Task 6.7 aims to foster the standardization processes within the EU. It identifies the necessary data interfaces between components to provide the information that drives the multimodal travel solutions designed in WP6. The focus is, hereby, on the data exchange between different system components and, therefore, on data interface specifications. Out of scope in this analysis are e.g.

- processes to generate data,
- responsibility for data provisioning,
- domain ontologies,
- interfaces between human and machine (HMI).

Task 6.7 analyses if standard interfaces specifications are used and if they already fulfil completely the requirements. If no standard interface specification is available, it is assessed if a standardization process for this interface is advisable. The main results of this ongoing analysing process are included in this deliverable. There will be a final version of the analysis as part of task 11.7 in WP11.

The deliverable is structured as follows: Section 2 includes sub chapters for each of the tasks and/or sub tasks where software developments are executed. Each of the subchapters is structured in the same way:

- A system architecture overview is given which highlights the foreseen data interfaces.
- Specifications used for external data interfaces.
- A gap analysis regarding existing data interface specification.

Section 3 provides an outlook beyond the scope of informing the traveller about different multimodal travel options and provides first experiences of the implementation of a multimodal ticketing solution. Section 4 summarises the gap analysis and explains which findings and suggestions are forwarded to WP2 for presentation towards the System Pillar. The Appendix A provides a brief overview of the standardisation activities in FP1.

2. Data interfaces in the specified software systems

2.1. Task 6.1.1: Integration of demand responsive transport services (DRT)

Task 6.1.1 specifies a multimodal travel solution focusing on demand responsive transport (DRT). The task compiles requirements and outlines concepts and specifications for:

- The integration of DRT into a passenger information system (PIS), confer use cases UC-FP6-WP6-1.1.1 and UC-FP6-WP6-1.1.2,
- The calculation of an optimal fleet size of a DRT service applying a simulation system which is informed by demand for DRT trips derived from a first/last mile demand analysis based on trip requests to an existing PIS, confer use case UC-FP6-WP6-1.1.3, and
- Distributed journey planning that enables users of a PIS for region A to query trips including DRT legs from a PIS for region B using the OJP protocol, confer use case UC-FP6-WP6-1.1.4

In the following Subsection 2.1.1, an overview of the high-level architecture of the specified solution is given to identify external data interfaces. These data interfaces are described in Subsection 2.1.2, informing about standards that are planned to be used for the data transfer. In Subsection 2.1.3, interfaces for which no standard exists are considered. The respective gap is defined and recommendations regarding potential new standards are derived.

2.1.1 System architecture overview

Figure 1 gives an overview of the architecture for the PIS focusing on the integration of DRT service. The diagram shows

- actors (traveller, DRT provider) that interact with the system in blue boxes,
- components of the system (e.g. PIS frontend, PIS backend) that have been specified in WP6 and will be developed in WP11 FP6 FutuRe in white boxes,
- functions of each component depicted in green boxes,
- data flows between functions illustrated by red arrows.

The overview does not include external systems. In the following section, it will be described where the system interfaces with external systems.

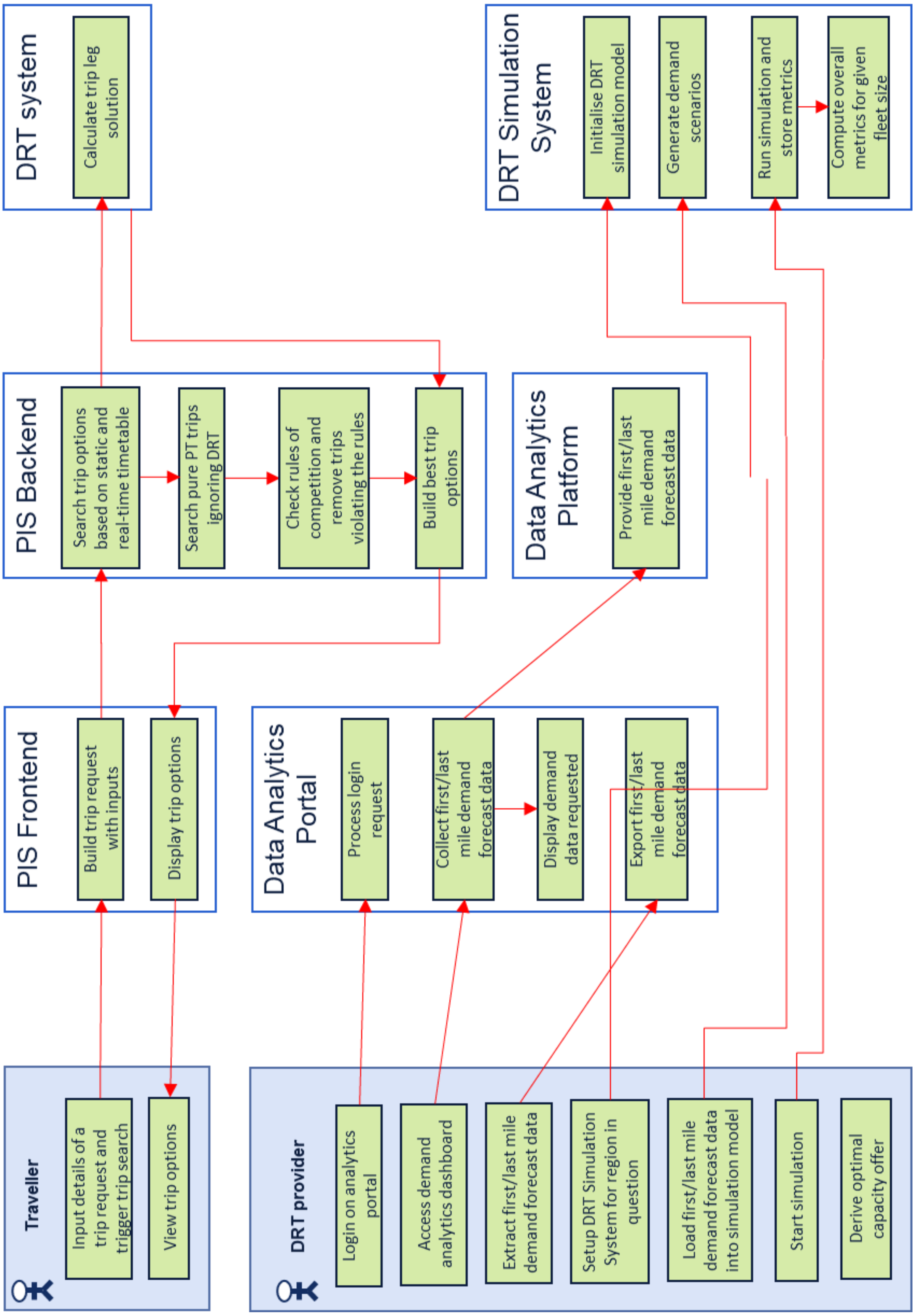

Figure 1: Architecture overview for Task 6.1.1 Integration of DRT services

2.1.2 External data interfaces

In this subsection, data interfaces of the PIS are identified and the standards that can be used or that are planned to be used are listed.

- **Static timetable data:**
  A foundation of the PIS is timetable data. Both static and real-time timetable data are used to calculate trip options upon a trip request from a traveller. Static timetable data are usually provided by Transport Service Providers (TSPs) such as rail operators or local transportation authorities. In Figure 1, static timetable data are a basis of the PIS backend and are needed for the function "Search trip options based on current ad-hoc timetable". The data are fed into the system by the TSP.
  For static timetable data, several standard formats exist allowing to define stops, trips, fare information etc. A European standard is NeTEx (Network Timetable Exchange)[1].NeTEx is based on XML documents and built upon the Transmodel model of public transit. Transmodel itself is also a European standard and known as "Reference Data Model For Public Transport"[2]. Another common standard format for static timetable data is GTFS (General Transit Feed Specification), which is based on a collection of CSV files containing schedule information. For the PIS, a HAFAS system will be set up as trip planner. It is provided by the beneficiary Hacon. HAFAS uses its own proprietary static timetable data format, the so called HAFAS Raw Data format. It is based on a set of text files. This format is widely used, especially by rail operators within Europe but also by smaller public transportation authorities. The envisaged demonstration partner can provide HAFAS Raw Data. Hacon also provides tools for converting from one format into another.
- **Real-time timetable data:**
  See Section 2.2.2.
- **Basic/static DRT data:**
  The PIS backend in is fed with basic data about the DRT service. These basic data comprise amongst others:
  - service area where a DRT service is offered,
  - stops where travellers can be picked up and dropped off,
  - time windows in which a service area is served.

  This basic DRT data is needed by the function "Search trip options based on current ad-hoc timetable" of the PIS backend so that the PIS backend can decide whether a first or last mile leg can be covered by DRT. Usually, the DRT service provider or the local transportation authority responsible for the region where DRT is offered provides the basic DRT data.

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[1] For more information about NeTEx, see https://netex-cen.eu/.

[2] For more information about Transmodel, see https://transmodel-cen.eu/.

For coding and transferring basic DRT data, GTFS Flex[3] will be used. GTFS Flex[3] is a standard maintained by the non-profit organization MobilityData[4]. It extends GTFS. The csv files that describe fixed-route public transportation services have been extended so that the files can additionally contain basic information about DRT services.

- **Dynamic DRT data (availability data)**
  When the PIS backend has identified a first/last mile leg that can be covered by DRT, it will query the DRT system if a DRT vehicle is available at the defined time for a service from a defined pick-up location to a defined drop-off location. This interface is depicted in Figure 1 by the arrow between the PIS backend and the DRT system, emanating from the function "Search trip options based on current ad-hoc timetable" and triggering the function "Calculate trip leg solution". For this interface, no standard format exists, see Section 0.
- **Data describing rules of competition for DRT**
  So called rules of competition for DRT are agreed upon between a public transportation authority and a DRT service provider, especially when the public transportation authority or a municipality has ordered the DRT service, i.e. ordered a DRT service provider to complement the transportation offer in the municipal area. The rules of competition can foresee, for example, that a DRT service must not be offered when there is also an alternative based only on public transport including first/last mile walks close in time. A concrete rule could demand that a DRT option must not be offered and not be shown to the user in the journey planning application in the interval beginning 30 minutes before and ending 30 minutes after the departure time of the purely public transit option.
  The rules of competition are fed into the PIS backend and applied by the function "Check rules of competition and remove trips violating the rules". For these rules of competition, no standard format exists, see Section 0.
- **Trip request data/first and last mile demand data**
  The DRT simulation system that is used to determine an optimal fleet size must be supplied with demand scenarios, which represent a temporal sequence of orders for DRT trips. Each order contains:
  - the time and date of the order (i.e. the time and date when the request for a DRT trip was sent by the traveller to the DRT service provider)
  - the desired pick-up or drop-off time,
  - the desired pick-up location,
  - the desired drop-off location, and
  - the number of passengers.

[3] For more information about GTFS Flex, see https://gtfs.org/extensions/flex/.

[4] For more information about MobilityData, see https://mobilitydata.org/.

For these demand scenarios, data are provided by Task 6.4 via the function "Export first/last mile demand forecast data" of the Data Analytics Portal to the DRT provider who can then feed the data into the DRT simulation system where they are processed by the function "Generate demand scenarios", which is depicted in Figure 1. For this data transfer, no standard format exists, see Section 0.

- **Interface between Journey Planning Systems**
  An interaction between FP1 and FP6 aims to link the PIS of FP1 with the PIS of FP6 so that users of the PIS of FP1 can query trips from the PIS of FP6. For this kind of distributed journey planning, the PIS of FP1 will send trip requests to the PIS backend of FP6, which are processed by the function "Search trip options based on current ad-hoc timetable" (cf. Figure 1). In return, the PIS backend of FP6 will send a response containing computed trip options to the PIS backend of FP1. This is accomplished by the function "Build best trip options" of the PIS backend of FP6 (cf. Figure 1).
  For this data exchange a CEN standard will be used, namely version 2.0 of the Open API for Distributed Journey Planning (OJP) protocol[5]. The OJP protocol supports a request-response scheme using the XML format. It offers several services, e.g.:
    - searching for trips
    - requesting detailed information about a given trip
    - requesting fare information for a given trip
    - requesting arrival and departure boards for a given stop.

2.1.3 Gap analysis to existing standard data interfaces

In the previous subsection, the following three data types were identified for which no standard format or standard interface exists:

- Dynamic DRT data (availability data)
- Data describing rules of competition for DRT
- Trip request data/first and last mile demand data

For these data types, it will be discussed in this subsection if a standard is desired and helpful, or if the potential for use is rather limited, and if a standard can already be sketched or more experience with implementations is required to derive a standard format.

- **Dynamic DRT data (availability data):**
  When a PIS shall query the availability of a DRT vehicle for a leg specified by start location, end location and desired departure or arrival time, it must implement the communication with the API provided by DRT service provider. Software suppliers that develop and market PISs in different regions and countries must implement APIs from several DRT providers because within a country

[5] For detailed information about OJP, see https://github.com/VDVde/OJP.

and sometimes even within a region, more than one DRT service provider operates. Hence, it would be beneficial if suppliers and DRT service providers agree upon a standard format. Since the request for availability of a DRT service is basically a trip search request, there are already formats available that could be used. Potential standard formats could be OJP (see Section 2.1.2) or TRIAS (Travellors Realtime Information Advisory Standard) that is outlined in VDV 431-2[6]. Another potential format is the TOMP API (Transport Operator Mobility-as-a-service Provider API). The TOMP API[7] supports trip planning and booking of vehicles and bikes, unlocking and locking vehicles/bikes and payments. During the preparation of the final release of this deliverable it will be analysed if one of the existing formats can cover the DRT case or if a new format should be specified.

- **Data describing rules of competition for DRT:**
  So far, rules of competition for DRT services are not widespread and if there are rules, they vary from one region to the other. It seems to be too early to define a standard format, and this deliverable recommends waiting for more experience, for more requirements that will come from local transportation authorities and DRT service providers in the future when agreeing upon such rules.
- **Trip request data/first and last mile demand data:**
  When a DRT service shall be introduced to a region for the first time, simulation is applied by many DRT service providers to plan key parameters of the DRT system and to identify benefits of a DRT service in the respective region and present these benefits to decision makers of the municipal administration. The simulations rely on demand data. First and last mile demand data that are derived from trip requests of an existing journey planning system are a valuable input for the simulations. Hence, also a standard format for the first and last mile demand data would be beneficial. It would simplify the tendering process when a municipal administration can provide the same data in the same format to all competitors who participate in the tender. To verify this conclusion, DRT service providers and municipal administrations should be asked to share their view on the benefits of a standard format. If they confirm the need for a standard format, DRT service providers, municipalities and suppliers of journey planning systems should design such a standard.

2.2. Task 6.1.2: Demand related information including those for person with reduced mobility (PRM)

Task 6.1.2 also specifies the multimodal travel solution. The focus of this task is on real-time data and on the support of PRM. The task compiles requirements and outlines concepts and specifications for:

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[6] For details about VDV 431-2, see https://knowhow.vdv.de/documents/431-2/.

[7] For more information about the TOMP API, see https://github.com/TOMP-WG/TOMP-API/wiki.

- the integration of real-time data from rail and bus operators and its consideration for route calculations, confer use cases UC-FP6-WP6-1.2.1, UC-FP6-WP6-1.2.2 and UC-FP6-WP6-1.2.3
- the provisioning of information about facilities of a station for PRM and the display of Points of Interest (POI) on a map in the PIS frontend, confer use cases UC-FP6-WP6-1.2.4 and UC-FP6-WP6-1.2.5, respectively, and
- profiles that match to certain groups of PRM (e.g. wheelchair user, passenger with heavy luggage) and that can be chosen within the PIS frontend by the traveller to obtain appropriate trip options easily, confer use cases UC-FP6-WP6-1.2.6, UC-FP6-WP6-1.2.7 and UC-FP6-WP6-1.2.8.

In the following Subsection 2.2.1, an overview of the high-level architecture of the specified solution is given to identify external data interfaces. These data interfaces are described in sub-section 2.2.2, informing about standards that are planned to be used for the data transfer. In sub section 0, interfaces for which no standards exist are considered. The respective gap is defined and recommendations regarding potential new standards are derived.

2.2.1 System architecture overview

Figure 2 gives an overview of the architecture for the PIS focusing on the integration of real-time data and the support of PRM by profiles that consider specific needs of the passengers for the trip search. The diagram shows:

- actors (traveller) and external systems (real-time data source of TSP) that interact with the system in blue boxes,
- the components of the system (e.g. PIS frontend, PIS Backend) that have been specified in WP6 and will be developed in WP11 FP6 FutuRe in white boxes,
- functions of each component depicted in green boxes,
- data flows between functions illustrated by red arrows.

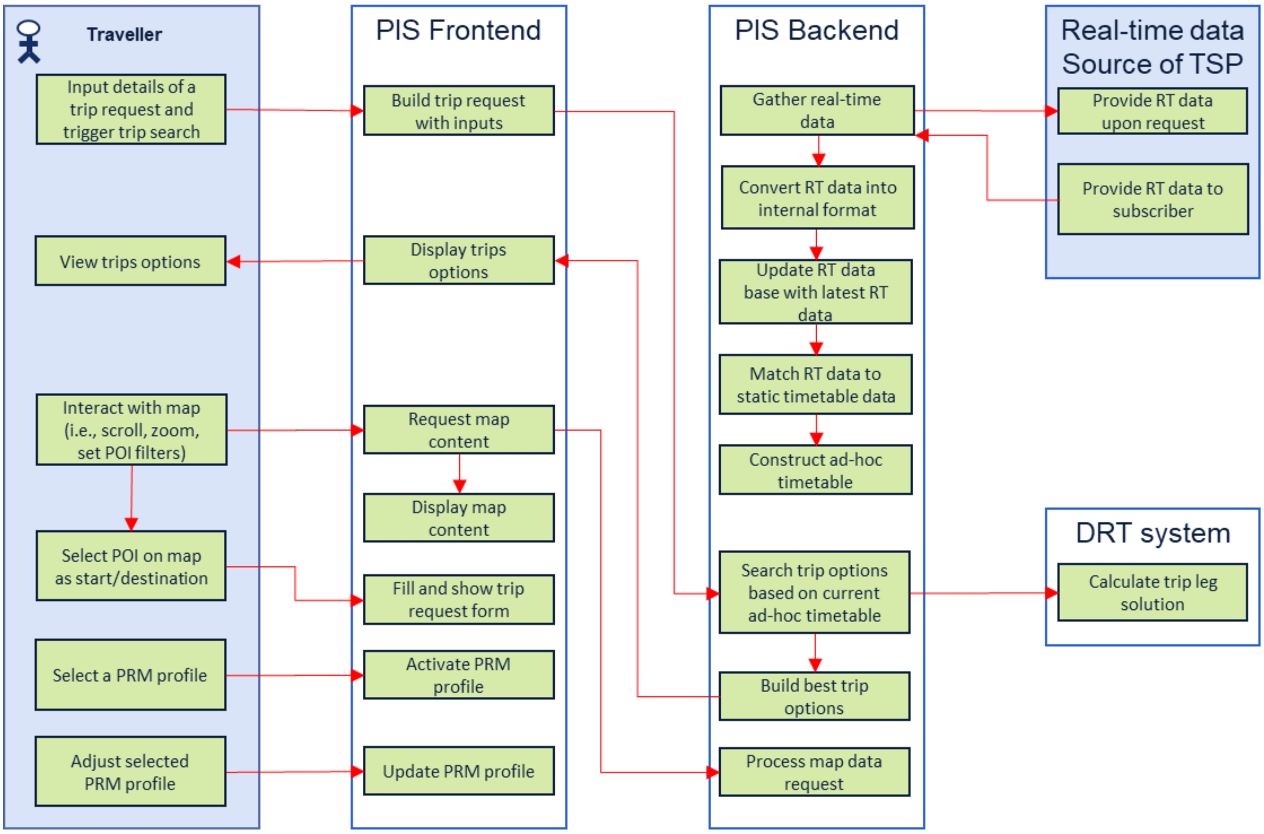

Figure 2: Architecture overview for Task 6.1.2 Demand related information including those for PRM

2.2.2 External data interfaces

In this subsection, data interfaces of the PIS related to real-time data and PRM are identified, and the standards that can be used or that are planned to be used are listed.

- **Real-time timetable data:**
  Real-time timetable data that comprise delay data and information about cancelled stops and cancelled service journeys are provided by external sources to the PIS backend of the journey planning system of FP6. This real-time (RT) data supply is depicted in Figure 2 the three functions "Gather real-time data" (PIS backend), "Provide RT data upon request" and "Provide RT data to subscriber". Often, the external system is an Intermodal Transport Control System (ITCS) that collects data from vehicles and provides delay information etc. to a PIS.
  For this type of interface, several standards exist. One standard is GTFS RT that comes along with four specific feeds, amongst them a trip update feed (delay data), a vehicle position feed (position information) and a service alert feed (incident messages). The GTFS RT feeds are related to the

GTFS standard/format for static timetable data[8]. Another widely used standard is the SIRI protocol, a CEN standard. The SIRI protocol supports request/response services as well as subscription-based services and comprises several functional services. Regarding real-time data, SIRI offers SIRI-ET (Estimated Timetable) for delay data, SIRI-VM (Vehicle Monitoring) for position information and SIRI-SX (Situation Exchange) for incident messages[9]. National standards also exist. For example, VDV 454 is a German standard regarding the transfer of delay data[10]. VDV 454 is used by many German transportation authorities to send delay information to a PIS.
It is expected that the demonstration partner in WP11 uses one of these existing standards.

- **Station facility data:**
  Facilities at stations that are relevant for PRM comprise, for example, stairs, escalators, elevators and assistance staff that helps PRM when transferring at a station in carrying luggage. Several static timetable data formats (see Section 2.1.2) support some information about facilities at stations but there is no general standard that covers all relevant pieces of information. The GTFS standard can record the information whether a wheelchair user can board a vehicle at this stop in the stops.txt file. The pathways.txt file of GTFS allows to model footpaths within a station including information about stairs, escalators, elevators, maximum slope of walkways and minimum width of a pathway. The HAFAS Raw Data format also supports footpath modelling. In addition, it is flexible as arbitrary pieces of information associated with a stop can be transported by attributes, e.g. the telephone number of the luggage carrier service at a station. However, there is no standard format covering all relevant data, see Section 2.2.3.
  Regarding real-time data (see previous item), the situation is similar: Only parts of the relevant data are currently covered by standards. There is, for instance, the SIRI-FM (Facility Monitoring) service that passes the real-time status of escalators, elevators etc.
- **POI data:**
  POI data are very similar to static timetable data (see Section 2.1.2), especially to stop data because POI data are quite stable. They are a crucial ingredient of a PIS because travellers usually do not want to travel from a stop to another stop but from door to door, i.e. from an address or POI to another address or POI. Though, a standard format for POI data does not exist, see Section 2.2.3.
- **PRM profiles:**
  A PRM profile comprises a set of parameters for which values are defined. For example, a profile for a wheelchair user may comprise the following parameters. The respective values are shown in brackets: “stairsAllowed” (no), escalatorsAllowed (no), elevatorsAllowed (yes), “maxDistanceToFromStop” (500 m).

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[8] For more information about GTFS RT, see https://gtfs.org/realtime/.

[9] For more information about SIRI, see https://www.siri-cen.eu/.

[10] For VDV454, see https://knowhow.vdv.de/topics/450-499/.

For PRM profiles, there are some recommendations on national level but no standard formats, Section 2.2.3.

2.2.3 Gap analysis to existing standard data interfaces

In the previous subsection, the following three data types were identified for which to the best of our knowledge no standard format or standard interface exists:

- Station facility data
- POI data
- PRM profiles

For these data types, it will be discussed in this subsection if a standard is desired and helpful or if the potential for use is rather limited, and if a standard can already be sketched or more experience with implementations is required to derive a standard format.

- **Station facility data:**
  As mentioned in Section 2.2.2, station facility data is an umbrella term that covers a wide range of data. Only some of the information is already part of standard formats. To identify areas where a standardized format would significantly improve the current situation, it is planned to closely work with the envisaged demonstration partner in WP11 and to learn from practical needs.
- **POI data:**
  Many applications, especially many journey planning applications and map applications such as Google Maps and Bing Maps entail POI data. And many organizations provide POI data, be it on a commercial basis as in the case of Google Maps (Alphabet)[11] and Foursquare[12], for example, or be it on a non-commercial basis as in the case of OpenStreetMap[13] and Overture[14], for instance. Nevertheless, there is no standard format. Although, basic data elements needed to describe a POI are straightforward (some of the following should be considered as optional elements): identifier, name, category, subcategory, coordinates, address, opening hours, website/URL. A standard would be helpful. And it would have been helpful in the past, e.g. in the Shift2Rail ExtenSive project, where POI data were passed from a component (Location Manager) of one partner to the component

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[11] For more information, see the Google Maps Places API under https://developers.google.com/maps/documentation/places/web-service.

[12] For more information, see https://location.foursquare.com/.

[13] For more information, see https://osmfoundation.org/wiki/Main_Page.

[14] For more information, see https://overturemaps.org/.

(Location Repository) of another partner and it required specification of and mutual agreement about a format for the data exchange, see [EXS-D2.1, Deliverable 2.1 of ExtenSive].

- **PRM profiles:**
  There are also no standard formats of PRM profiles available. On national level, some examples for PRM profiles exist, see [DELFI e.V. (ed.), Handbuch Barrierefreie Reiseketten in der Fahrgastinformation], for instance. In this guide for providing information about accessibility in public transportation, PRM are grouped in two categories: persons with reduced mobility (PRM in the narrower sense, category A) and sensory impaired persons (category B). For category A, the following profiles are suggested:
    - wheelchair user,
    - rollator user,
    - wheelchair user with assistant,
    - persons with walking disabilities, and
    - persons with temporary limitations (stroller, luggage).

  For category B, the profiles are:
    - hearing impaired and completely deaf persons, and
    - visually impaired and blind persons.

  For each profile, relevant information, facilities and requirements are listed.

2.3. Task 6.2: Integration of traffic management systems (TMS) and passenger information services (PIS)

2.3.1 System architecture overview

Figure 2 shows an overview of the architecture for the TMS-PIS interface allowing a provision of up-to-date operational plan and forecast information being made available by the TMS for the PIS on the one hand and consideration of demand forecast information provided by the PIS (data analytics platform) to consider it for traffic management decisions or amendment of timetables in the Capacity Management System connected to the TMS. The figure indicates:

- Actors (traveller) and external systems (e.g. CMS, TMS) that interact with the FP6 system, all in blue boxes,
- The components of the overall FP6 system linked to the TMS-PIS interface (e.g. PIS frontend, PIS Backend) that have been specified in WP6 and will be developed in WP11 of the FP6 FutuRe project, also in blue boxes
- The TMS-PIS interface (white box),
- Functions of each component depicted in green boxes,
- Data flows between functions illustrated by arrows where red colour indicates flows in-scope of the WP6 of the FP6 FutuRe project and blue colour out -of-scope flows.

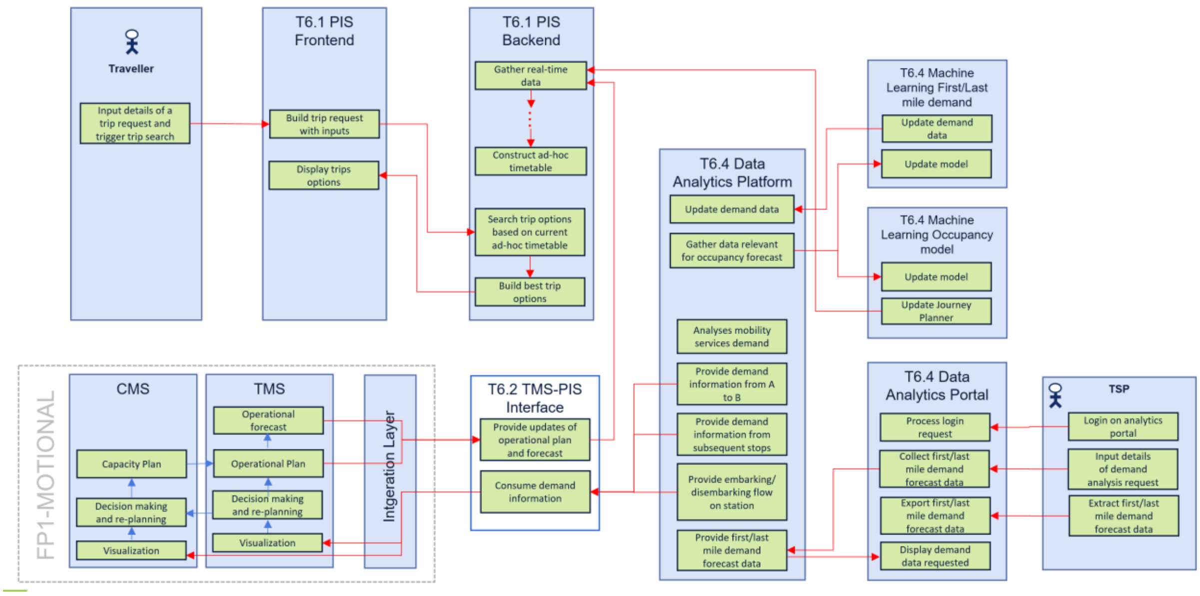


Figure 3: Architecture overview for Task 6.2 TMS-PIS interface in the context of FP1 and FP6

2.3.2 External data interfaces

For sending latest updates of the Operational Plan and related traffic forecasts from TMS to PIS, a specific interface is supposed to be used. The SIRI ET (Estimated Timetable) standard will be assessed for use, see also next subsection.

For sending forecasted travellers' demand information from PIS to TMS, a specific interface will be used to cover the transfer of the following information.

- The forecasted number of travellers expected to travel from one station A to another station B in a certain time interval, e.g., two weeks or one month,
- The forecasted number of travellers expected to use a specific train between any two subsequent stops of the train,
- The forecasted number of travellers expected to disembark/embark at a specific station of a specific train.

2.3.3 Gap analysis to existing standard data interfaces

To this day, there is no standard interface available to transfer forecasted traveller's demand information from PIS to TMS. For transferring timetable data and delay information from source systems like e.g., TMS to consumers like e.g., PIS, the SIRI ET standard is available. In some cases, transferred data elements are also related to existing harmonized standards such as Telematics TSI. The assessments of the standards and consideration of use for the demonstration system will be further assessed and developed in WP11.

2.4. Task 6.4: Provision of short- and long-term travel demands

2.4.1 System architecture overview

The diagram in Figure 4 shows the components and functions developed for demand forecasting in Task 6.4. The "Data analytics platform" uses data from the MaaS platform, focusing on journey planning requests collected from the retailer apps, and potentially vehicle occupancy data from other sources. This data trains the vehicles occupancy and first/last mile demand models, which provide demand information to the MaaS platform, data analytics portal, and traffic management systems (TMS). The most relevant data interface identified on this architecture is the exchange of demand forecast information with the TMS.

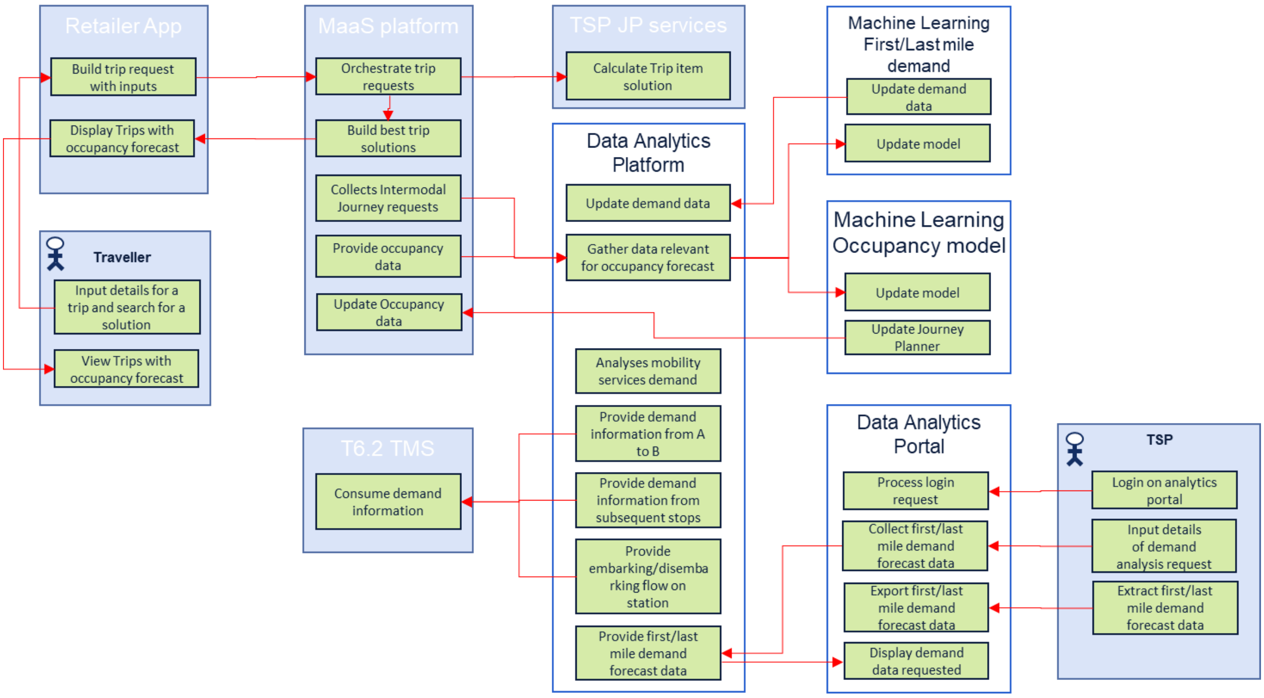


Figure 4: Architecture diagram for demand forecast

Figure 5 shows the components and functions for detecting and predicting unusual spikes in train usage, also covered by task 6.4. The Data Analytics Platform gathers data for the Anomaly Detection and Prediction Component, which trains a model and predicts future anomalies based on events like weather, public events or disruptions. It also sends structured messages with contextual information to the TMS, notifying the TMS operator via the dashboard.

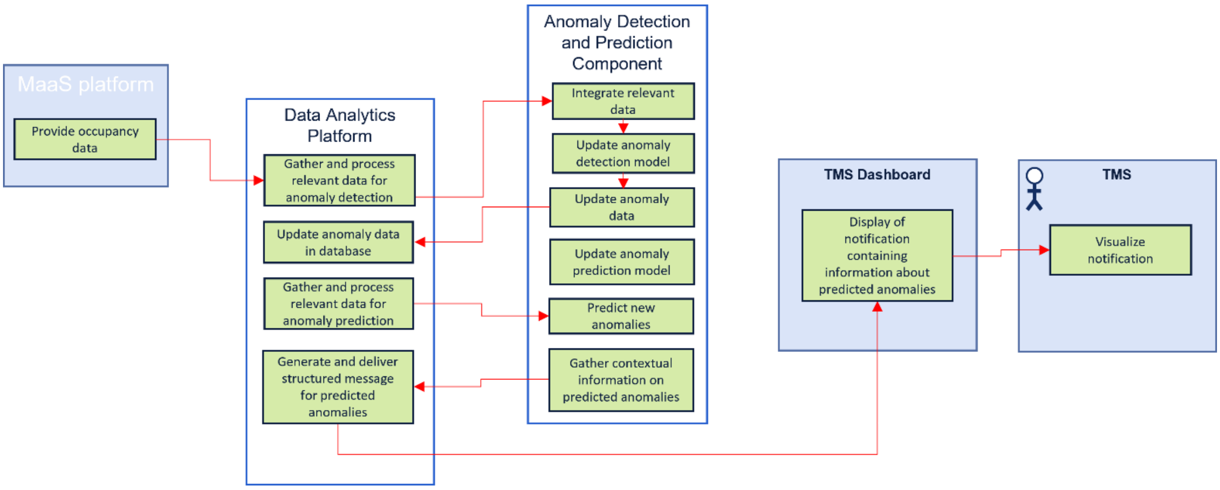


Figure 5: Architecture diagram for detection and characterization of train usage anomaly

2.4.2 External data interfaces

The details related to the external data interface with TMS has been detailed in Section 2.3.2 describing the forecasted travellers' demand information to be transferred from PIS to TMS

To provide the TMS with relevant contextual information related to identified anomalies, a simple data interface utilizing the JSON format will be employed to cover the following details:

- Anomaly: information detailing the identified anomaly, including route identification, type of anomaly and expected occupancy level.
- Contextual information: relevant background data, such as weather conditions (temperature, weather type), event details (location, expected attendance, event time), and historical comparisons (number of similar past anomalies, average train occupancy level for similar conditions, day of the week).

2.4.3 Gap analysis to existing standard data interfaces

As mentioned before, there is no standard interface available to transfer forecasted travellers' demand information necessary to be exchanged between PIS and TMS. Regarding the contextual information that covers identified anomalies, there is also no standard interface available. The data structure used in this context is very simple and can be easily processed even if the structure is not standardized. Therefore, we don't see any argument for standardizing this data.

2.5. Task 6.5: Passenger congestion monitoring

2.5.1 System architecture overview

Figure 6 gives an overview of the architecture for the passenger congestion monitoring system. The diagram shows:

- actors (Traveller, TMS Dashboard, Bus and Rail Operators, Weather Forecast Provider) that interact with the system in blue boxes,
- the components of the system (e.g. Optimisation Software, Data Analysis Tool, Data Manager, etc.) that have been specified in WP6 and will be developed in WP11 FP6 FutuRe in white boxes,
- functions of each component depicted in green boxes,
- data flows between functions illustrated by red arrows.

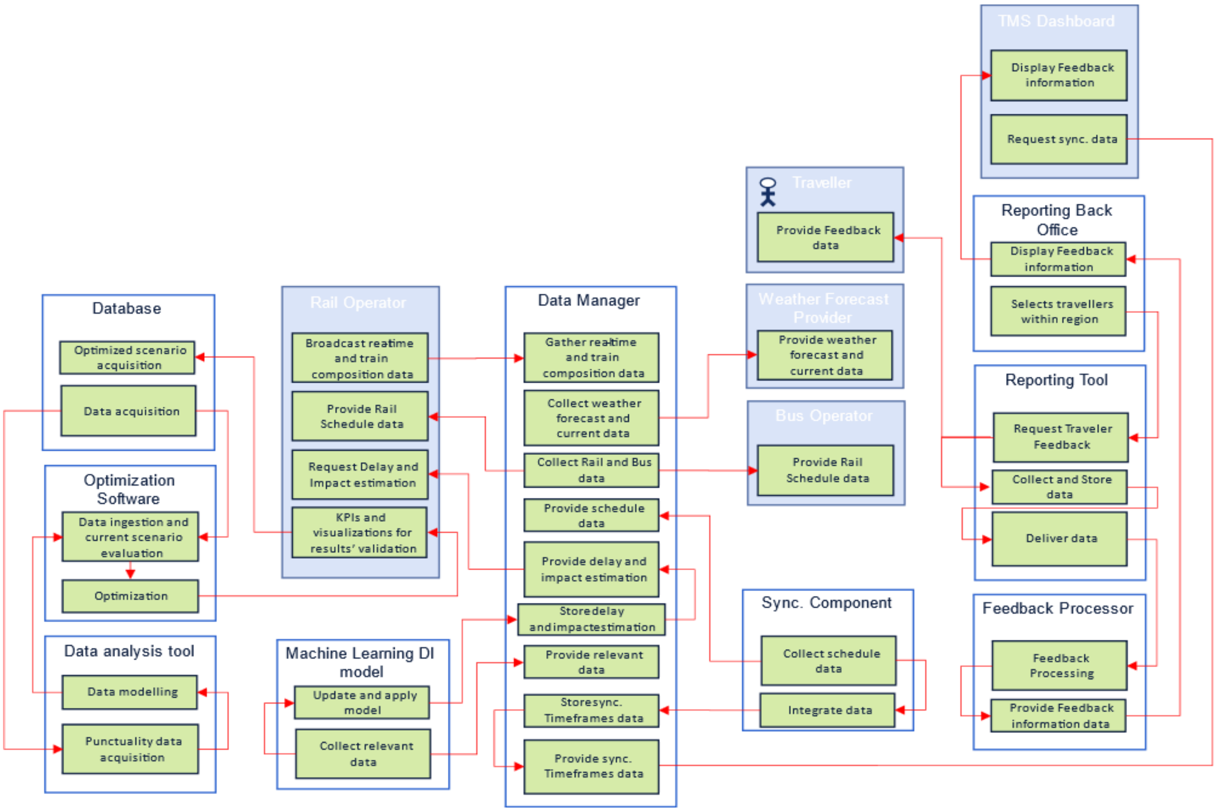


Figure 6: Architecture overview for Task 6.5 Passenger Congestion Monitoring

2.5.2 External data interfaces

The external data interfaces to be used for the passenger congestion monitoring system cover different interactions. This section outlines these data interfaces, which involves using rail schedule data, weather data, traveller feedback, and delay and impact estimation, including the relevant standards and formats.

- **Rail Schedule Data:** rail schedule data, provided by rail and bus operators, follow the GTFS standard. The Data Manager processes and stores this data for system-wide use.
- **Weather Data:** Weather data is delivered by a Weather Forecast Provider, covering forecasts and current conditions. The Data Manager collects and integrates this data for real-time updates. Weather data in this regard only includes information basically about temperature, probability of precipitation for the next days. The data structure therefore is extremely simple and processing can easily be adapted to the provided data.
- **Traveller Feedback:** Traveller feedback is gathered via a web application in a JSON format containing information about perceived passenger congestion. The Reporting Tool stores this feedback, which the Feedback Processor analyses. Processed feedback is then displayed on the TMS Dashboard and Reporting Back Office.
- **Delay and Impact Estimation:** Delay and impact estimation data, formatted in JSON, is derived from rail schedule data, train composition data and weather data. The Data Manager stores and integrates these estimates for accurate system updates and provides them to the rail operator.
- **Synchronized Timeframe Data:** The timetable synchronisation analysis will identify instances where significant gaps or overlaps between arrival time of the feeder and departure time of the fetcher exist, leading to potential synchronization issues. Information about these synchronization issues will be provided to the TMS Dashboard containing especially information regarding the scheduled service journey with its stops, the arrival time of the feeder, the departure time of the fetcher and waiting times for passenger.

2.5.3 Gap analysis to existing standard data interfaces

In the previous subsection, the following four data interfaces were identified for which, to the best of our knowledge, no standard format or standard interface exists:

- Weather data
- Traveller Feedback
- Delay and Impact Estimation
- Synchronized Timeframe Data

For these data interfaces, it will be discussed in this subsection if a standard is desired and helpful or if the potential for use is rather limited. In the former case it will be discussed if a standard can already be sketched up or if more experience with implementations is required to derive a standard format.

- Weather data: As explained above the data structure used in this context is very simple and can be easily processed even if the structure is not standardized. Therefore, we don't see any argument for standardizing this data.
- Traveller Feedback: The feedback data collected is very specific for the use case and therefore a standardized format seems to provide not much of a benefit.

- Delay and Impact Estimation: The delay and impact estimation data might be provided to different rail operators. Therefore, it might make sense to have a standard to secure interoperability. It is not clear if the envisioned type of information regarding delay and impact estimation fulfils the needs of the operator and is ready for widespread usage in the market. Thus, it is planned to closely work with the envisaged demonstration partner in WP11 and to learn from practical needs.
- Synchronized Timeframe Data: The data structure necessary to make the described data accessible is rather simple and might be of moderate effort to process even if not well standardized. However, multiple recipients need this information, such as all involved operators, who should be informed about potential optimization opportunities. Therefore, it might make sense to foresee a standardized data interface so the data exchange could be interoperable between different transport operators and optimization providers.

2.6. Task 6.6: Include freight services to reach regional and rural areas

Task 6.6 specifies a service of the PIS that enables users to find transport options for freight in passenger trains. The PIS calculates trips for freight from A to B and caters two types of users. The first type are private persons who want to send a single parcel:

- from station to station via a single train requiring just-in-time drop-off and pick-up at the respective station (use case UC-FP6-WP6-6.1), or
- from address to address by train including transfers and featuring drop-off at and pick-up from parcel lockers at stations A and B, respectively (use case UC-FP6-WP6-6.2).

The second type of users catered are professional users from logistics companies who want to ship containers from station A to station B and need to know when a transport option with sufficient capacity is offered (use case UC-FP6-WP6-6.3).

In the following Subsection2.6.1, an overview of the high-level architecture of the specified solution is given to identify external data interfaces. These data interfaces are described in Subsection2.6.2, informing about standards that could be used for the data transfer. In Subsection 2.6.3, gaps in the existing standard data formats are highlighted and the need to close these gaps is discussed.

2.6.1 System architecture overview

Figure 7 gives an overview of the architecture for the PIS focusing on the part of the PIS that provides the service for planning freight transport in passenger trains. As in the diagrams before, the figure shows:

- actors (either private person or staff of a logistics company) that interact as a user with the system in blue boxes,
- the components of the system (PIS frontend, PIS Backend) in white boxes,
- functions of each component depicted in green boxes,

- data flows between functions illustrated by red arrows.

Basically, the user enters key data for the request for transport in the PIS frontend which is a browser-based web application. This frontend passes the request to the PIS backend that calls a routing algorithm operating on timetable data to calculate transport options, i.e. trip options for the parcel or container. The calculated results are presented to the user via the frontend.

The overview does not show interfaces via which data from external systems or parties is received. Therefore, we will describe in the following, where the depicted system has interfaces to external systems.

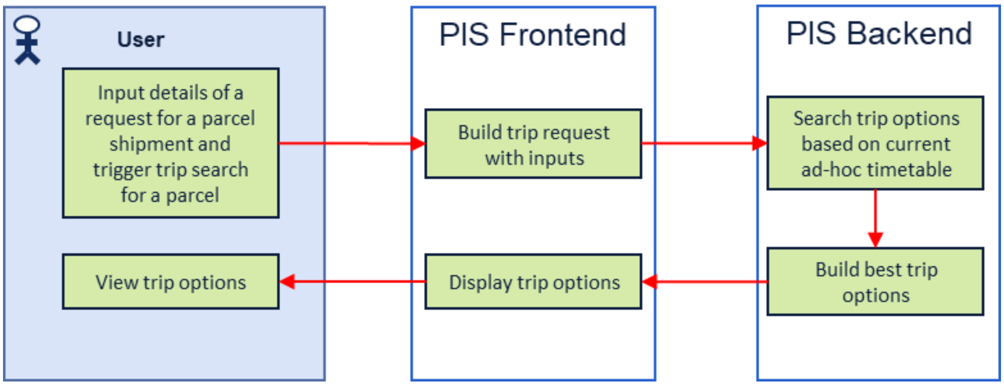


Figure 7: Architecture overview for Task 6.6 Freight transport in passenger trains

2.6.2 External data interfaces

Three important sources of input were identified for the freight transport planning service of the PIS.

- **Static timetable data:**
  The most important input from external parties is static timetable data provided by a TSP. The timetable data must contain specific information about the options to transport freight in the scheduled services for passengers.
- **Dynamic capacity data:**
  Another crucial piece of information is the remaining capacity for containers that shall be considered when a user from a CEP company queries the system for transport options. This kind of information must be provided by the TSP, i.e. by the rail operator who offers transport capacity for freight in its passenger trains.
- **Price data:**
  Finally, postage prices that are shown to users must be provided by a logistics/CEP company that offers the transport service to end customers.

2.6.3 Gap analysis to existing standard data interfaces

In this subsection we analyse for each interface or data source listed in the previous subsection whether a standard format exists and if not whether a standard should be established.

Regarding **static timetable data**, standard formats exist but cover only passenger services. For details see Subsection 2.1.2. For providing timetable information about passenger transport and freight transport that is accomplished simultaneously by sharing the same vehicles, it is advantageous to have a single data source. Hence, a starting point for a common timetable data set are existing standard data formats such as NeTEx, GTFS or the HAFAS Raw Data format. However, these standards cover so far only passenger services and need an extension to also cover freight transport services. The existing standard formats for static timetable data would have to be extended to

- indicate which train service transports also freight and which does not,
- indicate which stop of a service is served about freight and if it is served for loading or unloading or both (or for none of these but only for boarding/alighting of passengers),
- ensure that sufficiently large transfer times are foreseen for freight (not for passengers) at hubs where freight is sorted and consolidated before it is transported further.

Currently, commercial interest by railway undertakings and by logistics companies in using passenger trains for freight transport seems to be low (see [Deliverable D6.7 of FP6 FutuRe]). Consequently, an official extension of mentioned standard formats is not recommended at this time. In a first step, a supplier of a PIS could extend one of the standard formats on its own for internal use, e.g. for a pilot project. Only if freight transport in passenger trains become more common in the future, standardization effort would be beneficial.

For **dynamic capacity data**, the TPS must provide information about remaining capacity for containers in passenger trains to the PIS backend so that capacity can be considered when responding to transport requests coming from staff of logistics companies. To the best of the authors' knowledge, there is no standard format that describes the available space within a compartment of a passenger train for different types of containers such as mobile parcel lockers and swap bodies. In addition, it is unclear in which way, or via which channel, the information would be provided. An option would be to use a real-time feed; however, remaining capacity data would be needed well before departure of the train, whereas real-time data usually only cover the time period between departure and arrival of a train. A more realistic option might be that remaining capacity could be queried by the PIS backend via an API from the TSP. The conclusion for dynamic capacity data is the same as for static timetable data: There is a gap in regard to transport of freight in passenger trains, but it is too early to think about a standard data format.

Showing **price data** for parcel shipments to private users means that the PIS needs to know about the prices. Since these data are expected to be stable over time, a data exchange between a logistics company offering the transport service and determining the prices on the one hand and the PIS on the other hand would happen less frequently and is of less importance than the data exchange for the previous two types of data.

For prices that will be shown to professional users who will book space for one or more containers would need to be passed from the TSP to the PIS as long as the PIS only supports route planning. For booking a professional user might be redirected to a booking service run by the TSP where current prices would be shown to the user.

Again, there is a gap but this gap for price data does not necessitate a standard at this stage and not for a pilot project at a later stage.

3. Outlook towards ticketing

WP6 demonstrates highly accurate multimodal travel solutions with a clear focus on service information for both on-board of regional vehicles and at regional rail stations. When looking at the whole user journey with its planning phase, the booking phase, trip execution phase and after sales services the information is the first phase in this whole process. The next phase – the booking phase – would be the next phase but is not in the focus of WP6.

Despite the clear separation of the phases in WP6 there are of course many connections between the phases. Therefore, in task 6.7 it was agreed on that an outlook on this phase at least regarding standardization should be included. Since the project partners, Ferrovie dello Stato Italiane and Trenitalia collected hands experience with the Open Sales and Distribution Model (OSDM[15]) standard, this experience will be shared here. In the alpha release of the deliverable only short overview is provided in the following of this chapter. The beta Release will include a detailed description.

3.1. OSDM Online

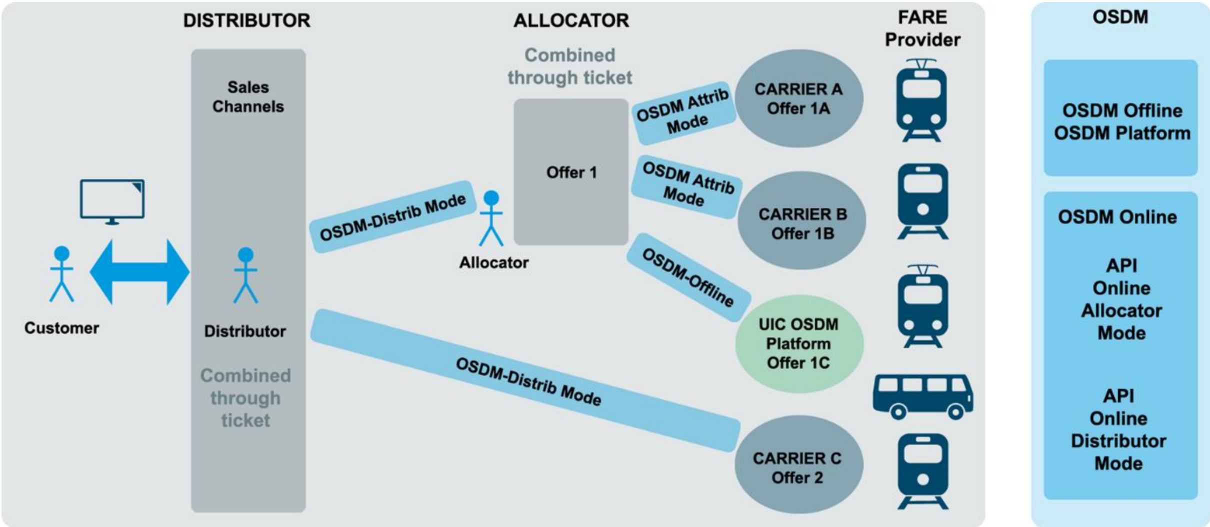
The OSDM Online Guideline provides an introduction for the integration between regional carriers and Local Public Transport service (LPT) for a seamless integration:

OSDM Online is a model thought to integrate different RU sales platforms and is also useful for integrate different mobility services whose key benefits include:

- Unified ticketing – Passengers can purchase a single ticket for multiple modes of transport, such as trains, buses, trams, and metros.
- Real-time information sharing – Transportation companies can share real-time data to improve service coordination.
- Simplified booking – The process of purchasing tickets is made easier for passengers.
- Improved collaboration – National, regional, and local transport providers can work together more effectively.

OSDM Online aims to create an efficient and sustainable transportation network.

[15] For more information about OSDM, see https://osdm.io/



Source: UIC

The specification that could be used by the RU create solid foundation for collaboration and defining the technological infrastructure necessary for system integration.

Here a sample of the preview of main OSDM Online API. The information contained in the new OSDM Reservation on Trenitalia's sales system is as follows:

- **passengerId** (Passenger identifier used in the Sales Platform- OSDM System transaction)
- **controlNumber** (Ticket identifier visible to the traveller)
- **bookingId** (Booking identifier (similar to the PNR))
- **pdfLink** (URL for downloading the ticket's PDF)
- **coachNumber** (Coach number)
- **placeNumber** (Seat number)
- **fulfillmentId** (Transaction identifier)
- **refundOfferId** (Refund offer identifier)

4. Conclusion

To provide the information which powers the multimodal travel solutions developed in WP6, data interfaces between components are necessary. To make the different parts of the system interoperable, standardized interface are preferred.

In this alpha version of the deliverable all external data interfaces between technical components have been analysed. The data to be transported via the interfaces has been described and checked to see if, and which, standard interfaces can be used. If a standard interface is planned to use a preliminary gap analysis was worked out. If no standard interface is available, an assessment was made to determine whether standardization would be useful.

The preliminary gap analysis identified the following potential gaps:

- Station Facility Data: Station facility data is an umbrella term that covers a wide range of data. Only some of the information is already part of standard formats. To identify areas where a standardized format would significantly improve the current situation, it's planned to closely work with the envisaged demonstration partner in WP11 and to learn from practical needs.
- POI-Data: Although many organizations provide POI data there is no standard format for POIs. Basic data elements needed to describe a POI are straightforward, but some data elements cannot be transposed from one format to another without data loss. This is particular the case with the category of a POI.
- PRM profile: A PRM profile comprises a set of parameters describing the needs of the PRM. For each parameter of the profile a value is defined. Only on national level there are some PRM profiles defined. It is planned to further analyse if existing profiles fulfil the needs of the developed solution and if a standard format on EU scale would make sense.
- Demand Forecast: Demand Forecast generated by PIS can be used to adjust service planning on TMS side. Today, there is no standard interface available to transfer this forecasted demand data.
- Static timetable data including information of freight services: Existing standard formats for static timetable data cover only passenger services and need extensions to include freight transport details. A unified data source is beneficial for services that transport both passengers and freight, requiring modifications to indicate freight-specific information and transfer times.
- Dynamic capacity data for freight: For dynamic capacity data, the TPS must inform the PIS backend about remaining container capacity in passenger trains for logistics staff. Currently, no standard format exists for this, and while real-time feeds are an option, querying remaining capacity via an API from the TSP before train departure is more realistic. The conclusion is that there is a gap in standards for freight transport in passenger trains, like static timetable data.

In the upcoming beta-Version of the deliverable all identified data interfaces will be checked again if adjustments needed to take place. Or if multiple standard interfaces are available which one was selected. In addition, the gap analysis will be updated and the experience report regarding OSDM finished.

5. References

- DELFI e.V. (ed.), Handbuch Barrierefreie Reiseketten in der Fahrgastinformation, Frankfurt am Main, 2018.
- Deliverable D6.7 of FP6 FutuRe, Technical specifications for using regional lines for freight services, Version 1, August 2024
- EXS-D2.1, Deliverable 2.1 of ExtenSive, WP 2 Travelers concerns Implementation report & software component, 2023

6. Appendix A: Standardization activities in FP1

In addition to the work described in the previous chapters, Task 6.7 also consolidates the standardization activities from FP1. The combined results are collected and provided to WP2, which forwards them to the System Pillar. Therefore, the status of the standardisation activities of FP1 are documented below.

6.1. General Transit Feed Specification (GTFS)

- General Transit Feed Specification. Open Standard used to distribute relevant information about transit systems.
- GTFS data will be used to feed reference systems and simulators especially within the context of demand forecast.
- Development and testing may lead to the identification of suggestions of extensions in the model.
- First output is expected by end of 2024 with the end of the development period and the associated test activities.
- Second output will be at demo stage in 2026.

6.2. Open API for distributed journey planning (OJP)

- CEN/TS 17118 existing and currently under revision in CEN/TC 278/WG 3
- OJP will be used for cross-platform journey planning queries allowing to test and evaluate the usage in various mobility contexts (e.g. national or city MaaS platforms).
- Potential suggestions for enhancements of the standard could result from this work.
- First output is expected by end of 2024 with the end of the development period and the associated test activities.
- Second output will be at demo stage in 2026.

6.3. Open Sales and Distribution Model (OSDM)

- OSDM Specification and UIC IRS 90918-10
- OSDM will be used for managing offers and booking from heterogeneous distribution systems to retail channels.
- The use of various platforms is likely to lead to change proposal, typically to accommodate the mobility modes in scope.
- First output is expected by end of 2024 with the end of the development period and the associated test activities.
- Second output will be at demo stage in 2026.

6.4. Service Interface for Real Time Information (SIRI-SX)

- CEN/TS 15531-5 existing in CEN/TC 278/WG 3
- SIRI-SX will be used to disseminate information regarding disruptions and the mitigation strategy implemented by the operator (if any).
- Developments and demonstrations are likely to lead to the proposal of enhancement of the standard in relation with inter-modality.
- First output is expected by end of 2024 with the end of the development period and the associated test activities.
- Second output will be at demo stage in 2026.

6.5. Network Timetable Exchange (NeTEx) – Part3: Fare Information

- CEN/TS 16614-3:2015 in CEN/TC 278/WG 3
- NeTEx part 3 usage will be focused on data sets related to sales transactions and their processing within the context of multimodal travels and associated financial/accounting processing.
- As financial processing is key in the delivery of multi-modal / MaaS proposals, the objective is to check whether existing data models comply with the targeted processing.
- First output is expected by end of 2024 with the end of the development period and the associated test activities.
- Second output will be at demo stage in 2026.

6.6. Integrated mobility architecture - Enterprise view

- ISO/TR 4447 Intelligent Transport Systems (ITS)
- The use of ISO/TR 4447 ISO/TR 7878 will be focused on terminology analysis.
- Project activities may lead to suggestions to the TR team

6.7. Integrated mobility architecture - Physical and functional view

- ISO/TR 22625 - ITS - Mobility integration
- The use of ISO/TR 22625 will be focused on terminology analysis.
- Project activities may lead to suggestions to the TR team