SMART RAIL

Smart Supply Chain Oriented Rail Freight Services

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Executive summary

In order to facilitate modal shift from road to rail, as set out in the European Commission's White Paper on Transport, the rail freight sector faces the challenge of providing the capacity for affordable and attractive services. The complexity of the European rail sector hampers the development of such services. Smart-Rail intends to define, implement and monitor new shipper-oriented rail freight concepts improving the competitive position of the rail sector through a Living Lab approach.

This Work Package aims to improve the quality of rail services by reducing round-trip times, better rail capacity use, improving reliability and reducing transport costs. To this end, **the Logistic Service Provider's (LSP) existing logistic Control Tower IT-tool, which at present does not cover rail transport, will be extended with a rail freight service add-on: Control Tower Rail (CT-Rail)**. Implementing, testing and rolling out the solution will be carried out through the Continuous Improvement Track (CIT); the CIT iterative process will point out what is necessary for the deployment of the CT-Rail, what are the pitfalls and to what extent it could be rolled out and if not, what should be the changes in order to improve and promote the solution at first to the Bettembourg-Le Boulou corridor but later to potential other corridors.

This Deliverable proceeds with setting out the main starting points for the required data exchange, and the key steps for implementation. Next, the operation of CT-Rail is discussed, including governance structure and architecture. This is followed by detailed description of the control tower's Key Performance Indicators (KPIs) as well as their measurements. Finally, baseline measurement results are presented.

Data exchange is to be established at three levels: from **LSP to CT-Rail**, from **Railway Undertaking (RU) to LSP**, and from **Infrastructure Manager (IM) to CT-Rail**. Therefore this CT-Rail will be a virtual platform of combining these three levels of different management systems in which each level will exchange data and managed by these three stakeholders. The data exchange can be based on direct interfacing (e.g. XML), RailData and on TSI TAF. Implementation, consequently, requires **rules of data sharing and ownership**, a **governance model**, (understanding of) the **right data systems and interfaces**, as well as **launching and testing**.

The governance structure is twofold, concerning CT-Rail itself and concerning the data used. Platform governance, however, falls within the scope of further deliverables and WP5 – Information availability. Concerning data, all data producing stakeholders are owner of their own data, and able to classify at will. Platform architecture revolves around event-driven ('milestones') data sharing towards the LSP. Rail data will be used for tracking & tracing of wagons.

In order to assess the impact of the operational CT-Rail, KPIs are used.

- **KPI 1: Increased predictability through swift notification of delays.**
- **KPI 2: Increased awareness of shipment status through regular and precise status updates.**
- **KPI 3: More stable lead times through increased predictability.**
- **KPI 4: Reduced TCO through increased predictability.**
- **KPI 5: Availability of real-time status updates on the corridor.**

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Definitions & Abbreviations

CIT	Continuous Improvement Track
CT-Rail	Control Tower Rail
DoW	Description of Work
ERA	European Railway Agency
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
IM	Infrastructure Manager
KPI	Key Performance Indicator
LL	Living Lab
LSP	Logistics Service Provider
RNE	RailNetEurope
RFC	Rail Freight Corridors
RU	Railway Undertaking
TCO	Total Cost of Ownership
TSI TAF	Technical Specification for Interoperability relating to the Telematics Applications for Freight
WP	Work Package
UML	Unified Modelling Language

1 Introduction

1.1 Background Smart-Rail and LL2

Modal shift from road to the rail sector, mentioned in the White Paper on Transport [1] as well as other European and national policy papers, faces the challenge of providing the capacity for affordable and attractive services. The current European rail freight market is a complex system involving a great number of public and private stakeholders, such as infrastructure managers, rail operators, terminal operators and freight forwarders who jointly manage the operation of running trains from A to B. This complexity in the rail sector hampers the development of efficient and competitive rail freight services.

Smart-Rail intends to contribute to European policy targets by defining, implementing and monitoring new shipper-oriented rail freight concepts improving the competitive position of the rail sector. In line with the Living Lab approach, the activities start with simple measures and in next steps these will be more complex and cover a wider scope. In addition, the Smart-Rail project is aligned to the objectives of SHIFT²RAIL[1] and its results will be used, in further, in this programme.

More specifically, the objectives of Smart-Rail are:

- to contribute to a mental shift of the rail sector toward a client and supply chain -oriented focus;
- to develop working business models for cooperation of different stakeholders;
- to develop a methodology and architecture for exchange of data/information required for the optimisation process, between stakeholders, making use of existing initiatives where available (for instance the European Corridor Management and national logistical information centres);
- to establish three Living Labs that each focus on different aspects and markets and develop tools, methodologies and concepts. The purpose of the Living Labs[2] is to test, monitor and improve the innovative measures in real life conditions, thus enabling a Continuous Improvement Track (CIT) approach. Specific and more dedicated business models, information systems and new rail services will also be tested.

The objective of this Work Package (WP) is to **improve the quality of rail services** (reduce round-trip times, better rail capacity use, improve reliability and reduce transport costs) **in the total supply chain** from shippers point of view on a specific European corridor. Furthermore, the objective is to transfer, in a later stage, the solution to other European corridors.

In this regard, **an add-on for rail freight transport** will be added to the currently existing logistic **Control Tower**. This add-on will be developed and implemented, by means of the Continuous Improvement Track approach. This CIT will use the Seacon Control Tower as starting point for the improvement cycles. Chapter 2 introduces Seacon's existing Control Tower.

A total of seven tasks were predefined to structure the work in this Work Package:

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[1] SHIFT²RAIL is a rail joint technology initiative focussed on turning research and innovation (R&I) actions to market-driven solutions and accelerating the integration of new and advanced technologies into innovative rail product solutions (http://www.shift2rail.org/).

[2] A Living Lab or Continuous Improvement Track is a test environment for the cyclical development and evaluation of complex, innovative concepts and technology, as part of a real world, operational system, in which multiple stakeholders with different backgrounds and interests work together towards a common goal, as part of medium to long-term study.

1. Problem analysis, link with other studies and design of control tower concept;
2. Potential impact of the control tower concept and involvement of participants;
3. Information exchange required for the control tower concept;
4. Alignment of the value case of involved stakeholders;
5. Implementation of the control tower concept and design of monitoring approach;
6. Monitoring and adjustment of the control tower concept;
7. Conclusions and recommendations.

This deliverable will describe the process and findings of Task 5: implementation of the Control Tower (CT-Rail) concept: architecture, KPIs and measurement. First, the main starting points for the required data exchange are established, as well as the key steps for implementation. Second, the operation of CT-Rail is discussed, including governance structure and architecture. Third, the control tower's Key Performance Indicators (KPIs) are derived, and their measurement set out. Finally, baseline measurement results are presented, allowing for comparison with CT-Rail’s operational performance at later stage of this Living Lab.

2 The Control Tower implementation

2.1 WP 7.5 description in DoW

For the corridor involved, the control tower will be implemented based on results of the previous tasks. In addition, relevant results from WPs 3, 4 and 5 will be used for the implementation. Special attention will be paid to the creation of IT interfaces between the control tower and systems of infra managers, terminals and rail operators.

In addition, the monitoring approach will be designed based on the implemented control tower concept. The KPIs established in WP2 will be measured and evaluated within the Living Lab and further refined if necessary to give objective figures about its success. Within the Living Lab, the KPIs inherent to the real operation and real business are to be evaluated, as well as travel times and speeds, handover times, round-trip times, dwell times, etc. Furthermore, some non-objective KPIs may be evaluated as the customer's satisfaction or smoothness of the transport. Here the goal is to improve the real-time operation of the transport connections/services and that of each leg, to reduce the time necessary for the transport, and to improve the utilisation of assets (wagons, engines, and train sets), which is in direct coherence with the operator's costs and therefore with the costs of the transport service. Also the KPIs associated with the traffic exceptions/events will be evaluated, as the diversions and their impacts, delays directly and indirectly caused by the events, idle times between identifying the event and its handling, etc. Here the goal is to shorten times necessary for handling the exceptions, to eliminate stochasticity using pre-defined scenarios and processes on the operator's side, and as the final result to improve the reliability of the transport services.

Furthermore, a lot of attention will be given to create a mental shift of stakeholders towards new working methods. The different stages of transition will be addressed in interactive sessions. The aim is to go from 'shared observation' towards 'shared understanding' and finally to 'shared action'.

2.2 Deviations from original DoW

As stressed in WP 7.1, for this Continuous Improvement Track Seacon selected the long distance corridor U.K. – Poland at first. However, due to developments on this corridor, Seacon had to stop this service in the first year of this Continuous Improvement Track.

Four alternative corridors have been selected by Seacon, i.e.:

- U.K. – Milano
- Bettembourg – Le Boulou
- Rotterdam – Milano
- Rotterdam – Budapest

These were selected for the substantial volume Seacon already has or has quick access to. Bettembourg – Le Boulou is the corridor with ~~-~~a high amount of traffic from Seacon and has a frequent connection of three trains leaving each end of the corridor per day. It is the corridor where Seacon has good connections with the trucking and railway undertakings which is also an advantage for the research.

The biggest amount of volume which Seacon ships on the Bettembourg – Le Boulou corridor comes from the Ruhr area in Germany and the southern part of the Netherlands. The destinations are for 90% in the Barcelona and Valencia area of Spain. Only around 10% is delivered in the southern part of France. The loads from Le Boulou to Bettembourg follow a similar pattern.

Seacon orchestrates the transport from the loading addresses by truck to the rail terminal, the rail transport from terminal to terminal and the road transport to the unloading location. These facts make this corridor a logical first choice for Continuous

Improvement Track 2. However, at a later stage, other corridors may be added to the CIT.

To implement the cooperation, data exchange and the CT-Rail Seacon has held multiple stakeholder meetings to engage their suppliers on the corridors. Currently stakeholders of the first three mentioned corridors have been contacted to discuss a possible collaboration on rail data exchange within SmartRail to improve visibility, reliability and to by this reducing cost.

- On the corridor UK-Milano a stakeholder meeting is held with OBB and GBRF.
- With VIIA and Lorry Rail similar meetings were organised on the corridor Bettembourg Le Boulou.
- And finally with TX Logistik the engagement to realize this kind of cooperation was discussed on the corridor Netherlands-Milano.

All these rail partners showed interest and possibilities to start small with exchanging required data. The first corridor to achieve objectives of improving visibility, increase reliability and reducing cost is the corridor Le Bettembourg – Le Boulou.

Somewhat different to the Description of Work, the CT-Rail system will not be a one single new system that controls everything by one stakeholder. It will be developed based on (re) use of current systems and new interfaces between the different systems that control different levels and parts of the supply chain. By choosing this setup the feasibility of the solution to realize and roll it out in practice increases.

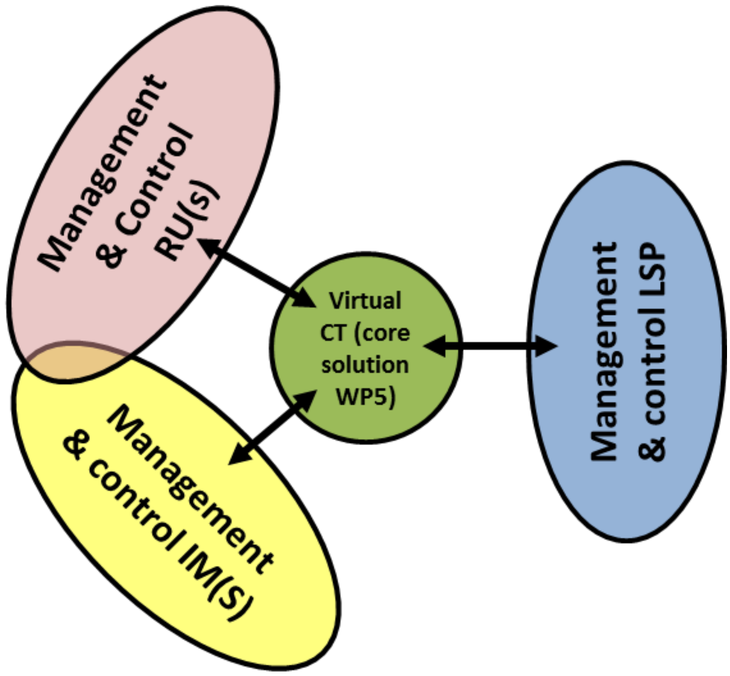


Figure 2.1: Relationship between different actors, WP5 and WP7

The diagram depicted above suggests the general architecture of the CT-Rail, with focus on the communication and data exchange with all the involved stakeholders:

- **LSP** – the "data consumer" from this point of view controls the transport as a whole;
- **RU** – the railway undertaking responsible for the railway leg or its part;
- **IM** – an infrastructure manager on which the RUs are operating;
- **RailData** – the international body covering the "national" Cargo RUs, here presenting a specific data source.

The necessary communication interfaces of the CT-Rail are shown in the architecture as realised in WP5 in the figure below. WS means a web service as the preferred way of communication (Request/ Response).

Several methods for communicating between the RU and CT-Rail (i.e. mostly for providing data from the RU for the partners) are employed with the following meaning:

- **SetReferenceFiles:** updates the given reference files in CT-Rail on behalf of the RU;
- **SetTrains:** updates the identified train on behalf of the RU, this way a train may be introduced, modified, or cancelled;
- **SetTrainLocation:** updates the confirmed position of a train in the railway "space time" (time position and geographical location);
- **SetTrainCompositon:** updates the train composition, upon each change and as requested by TAF TSI;
- **SetTrainETA:** updates the ETA parameter of a train (Estimated time of arrival);
- **SetTrainETD:** updates the ETD parameter of a train (Estimated time of departure);
- **GetKPI:** gets a set of defined KPIs for a given calendar month.

2.2.1 Time deviations from original DoW

Certain deviations were observed compared to the original planning as described in D7.1.

Due to the change of corridor, as described in D7.1, a renewed process of stakeholder participation was considered, requiring additional time. Also, the unfamiliarity in the rail sector in general with data sharing, as well as judicial and practical issues, proved to lead to a more lengthy negotiating process than anticipated. Together, these factors accounted for a deviation from planning of -about 3 months-. Consequently, the expected operational status of the CT-Rail has shifted to - +/- September 2016-.

2.3 Implementation of data exchange

As was set forth in D7.3, realising information exchange requires the right interfaces and connections and alignment of working procedures. The main interfaces and accompanying working procedures are described in the following paragraphs.

2.3.1 Level 1: Information exchange between LSP and CT-Rail

- **LSP to CT-Rail** regarding pre- and end- haulage. Interfaces for third party tracking and tracing have to be designed, specified, built and tested. The data from these interfaces then has to be visible on the transport management system of the LSP. Thus, visibility and predictability of pre- and end- haulage – from production site to terminal and from terminal to warehouse – is enhanced, in order to be able to better manage deviations from planning. Description of and agreement on the business rules for sharing and interpret shared – or enriched - data, as well on actions taken on the basis of these data, should be agreed between the stakeholders.

- **LSP to CT-Rail** regarding intermodal terminal services. Interfaces for third party tracking and tracing have to be designed, specified, built and tested. The data from these interfaces then has to be visible on the transport management system of the LSP. Thus, visibility and predictability of terminal services is enhanced, in order to be able to better manage deviations from planning. Description of and agreement on the business rules for sharing and interpret shared – or enriched - data, as well on actions taken on the basis of these data, should be agreed between the stakeholders.

- **LSP (via CT-Rail) to RU/IM**. Interfaces for third party tracking and tracing have to be designed, specified, built and tested. The data from these interfaces then has to be visible on the transport management system of the LSP. Thus, expected and actual departure and arrival times of the train on the terminal is more accurate and better visible, in order to be able to better manage deviations from planning – as well as possible re-planning of pre and end haulage. Description of and agreement on the business rules for sharing and interpret shared – or enriched - data, as well on actions taken on the basis of these data, should be agreed between the stakeholders

2.3.2 Level 2: Information exchange between RU and CT-Rail

The information exchange between a RU and CT-Rail comprises of the following six messages:

- **SetReferenceFile** – updates the values in a reference file; message not included in the TSI TAF standard
- **SetTrains(train)** – defines the users who have the access rights to the train data on behalf of a RU and of a LSP; based on the train identification, more information are exchanged thereafter; message not included in the TSI TAF standard
- **TrainCompositionMessage** – sent from a RU to an IM, defines the composition of the proposed train; a TSI TAF message
- **TrainRunningInformationMessage** – a TSI TAF message on the last known train position on the railway network, sent by the RU to the CT-Rail in this case
- **WagonETI_ETA_Message** – a TSI TAF message on the last known ETI/ETA, sent by the RU to the CT-Rail in this case
- **SetTrainETD** – a message to set the train ETD (Expected Time of Departure), in this case by the RU

With an exception of the first and second mentioned items, the interface and its messages are based on TSI TAF standard; however, for the data exchange to be deployed successfully, also the corresponding data provider (e.g. railway undertaking) has to implement the data interface based on TSI TAF. Required data can also exchanged by direct interfacing (e.g. XML) or via e.g. RailData if required data based on TSI TAF can not be exchanged or integrated easily. SmartRail currently has an agreement with Raildata to provide data of France, the Netherlands, and Germany. Railway Undertakings provide data to Raildata.

2.3.3 Level 3: Information exchange between IM and CT-Rail

The information exchange between IM and CT-Rail comprises of the following four messages:

- **GetTrains** – list of the trains defined for a given RU; message not included in the TSI TAF standard
- **TrainCompositionMessage** – a TSI TAF message on the train composition, sent by the RU to the IM
- **TrainRunningInformationMessage** – a TSI TAF message on the last known train position on the railway network, sent by the IM to the RU
- **WagonETI_ETA_Message** – a TSI TAF message on the last known ETI/ETA.

With an exception of the first mentioned item, the interface and its messages are based on TSI TAF standard; however, for the data exchange to be deployed successfully, also the corresponding data provider (e.g. the infrastructure manager) has to implement the data interface based on TSI TAF. Required data can also exchanged by direct interfacing (e.g. XML) or via e.g. RailData if required data based on TSI TAF can not be exchanged or integrated easily. SmartRail currently has an agreement with Raildata to provide data of France, the Netherlands, and Germany. Railway Undertakings provide data to Raildata.

2.4 Implementation process

To implement the data exchange measures, the following iterative process on the different exchange levels 1, 2 and 3 shall be followed:

1. **Understanding the data exchange issues:** defining the rules to provide the data, data ownership, data access, data and processes related to the improvement paths
2. **Adopting the governance models:** determining the communication partners, i.e. who is the data provider, who is the data receiver or consumer, solving the contractual issues of the data access
3. **Adjusting the internal processes:** who will handle the data, who will produce the data, who will use them; in what ICT systems is the data to be employed and for what purpose; in what mode is the data to be accessible
4. **Implementing the communication messages:** understanding the data contents of the communication messages; understanding the processes and internal ICT systems; implementing the communication messages and interfaces; testing the communication in specified test scenarios
5. **Development of test scenario's :** understanding the test scenarios or test cases defined by the messages provider; verification of all the test scenarios in the test environment of the data provider
6. **Launching the test operation:** defining the environment, setting up the system, installation; test operation
7. **Go-live:** defining the stakeholders; starting the data exchange; evaluating the improvements

In the chart below the foreseen implementation of the different levels is described.

Period Highlight: 23

Plan

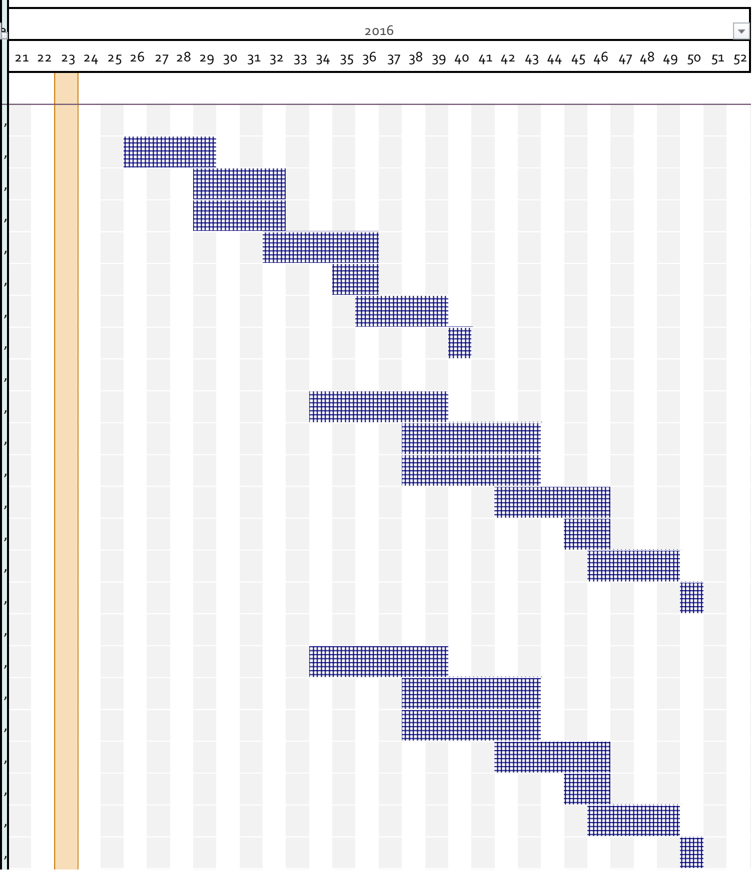
Actual

% Complete

Actual (beyond plan)

% Complete (beyond plan)

ID	DESCRIPTION	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION
	Level 1 LSP-CT Rail				
	Understand data issues	26	4		
	Adopting models	29	4		
	Adopting processes	29	4		
	Implementing interfaces	32	5		
	Define testscenario's	35	2		
	Testing	36	4		
	Go Live	40	1		
	Level 2 RU-CT Rail				
	Understand data issues	34	6		
	Adopting models	38	6		
	Adopting processes	38	6		
	Implementing interfaces	42	5		
	Define testscenario's	45	2		
	Testing	46	4		
	Go Live	50	1		
	Level 3 IM- CT Rail				
	Understand data issues	34	6		
	Adopting models	38	6		
	Adopting processes	38	6		
	Implementing interfaces	42	5		
	Define testscenario's	45	2		
	Testing	46	4		
	Go Live	50	1		



3 The operation of the Control Tower

3.1 International border crossings

In the "borderless Europe", the freight trains (and any trains, for that matter) should be able to travel seamlessly through the member state boundaries without any excessive idle time, organisational or commercial issues. However, the inherent incompatibility attributes still remain, and cannot be always too easily overcome.

This is to say, that on an international border crossing multiple processes are to take place, being categorised as follows:

- **IM or infrastructure handover processes:** those pertinent to the traffic control in both neighbour states and on the European level:
  - requesting a train path for the next member state or infrastructure (shall be done in advance, preferably well before the train comes to the border station)
  - negotiating and setting the train route (pertinent to the path request or its pre-negotiation phase)
  - international harmonisation of the train path (in case of requesting the path via RNE, this is done as an inherent part of the path request process)
  - confirming the path and/or the Train Ready message
  - in case of delay or disruptions, requesting a new path has often to be done (especially in the states with strict train scheduling as the Netherlands)
  - the train handover itself on the traffic control level (between both operation centres).
- **RU handover processes:** those pertinent to changing the RU on the border (if necessary and therefore if applicable; may take place also in the "hinterland"):
  - agreeing on the handover, together with the time and place
  - based on the agreement, requesting the separate train paths, or participating on the path harmonisation process of RNE
  - changing the engine in a suitable station
  - changing the driver in a suitable station (together with the engine or separately)
  - train documentation handover (if necessary and if applicable)
- **Technical handover processes:** may be characterised as the processes or actions necessary to overcome the technical incompatibility or un-interoperability:
  - changing the engine – most typically necessary for a different voltage system in the other state, if multisystem locks are not used (an example being Brenner pass between Italy and Austria)
  - changing the driver – most typically necessary due to the language differences, regulation differences, and the required route knowledge (if the driver is not "versatile" enough to cover both infrastructures by his or her knowledge)
  - miscellaneous technical issues – e.g. attaching protective wagons next to the dangerous goods

All these processes may take place simultaneously, but may be also separated; they may also take place in the "hinterland", i.e. on a different border than on the state border or infrastructure border (e.g. usual operating borders of the RUs, borders of the electricity systems etc.).

Pertinent to this handover processes is also the necessary communication and data exchange between the stakeholders (most importantly between the IM, RU, and LSP), reflecting each action in the corresponding ICT systems. This is also reflected in the data exchange defined in TSI TAF and/or in the messages defined in Smart-Rail. Required data based can also exchanged by direct interfacing eg. XML or via e.g. RailData if required data based on TSI TAF can not be exchanged or integrated easily.

Significant lag time is resulting from the handover processes; therefore the interoperable solutions (as the multi-system locks, the "versatile" trained drivers etc.) are used to avoid this and to achieve better transit times.

3.2 Governance structure

Governance basically considers two aspects, namely governan**ce of the SmartRail Platform** and **data governance**. Platform governance is out of scope of the Living Lab, it will be discussed in the context of Work Package 5 and dissemination/exploitation of the results. Therefore, currently only data governance is considered. The content of this section will be updated with detailed governance specifications provided by SmartRail D5.2.

With respect to data governance, each data owner is in control of its own data. Thus, each stakeholder producing data can indicate whom can access or subscribe to this data. A particular data classification does not imply that a subscription is generated; only by subscribing itself, another stakeholder will receive the applicable data.

The following data classifications are applicable within SmartRail:

- **Open data**: data is publically available to anyone. For instance, many IMs provide the structure of their infrastructure and maintenance data as open data; some also provide real-time data.
- **Community data**: data is available to a known community, e.g. all relevant stakeholders in a particular corridor. One could state that for instance TIS (Train Information System) of Rail Net Europe serves as a community, with particular rules of who can access real-time position data.
- **Logistics operation data**: data is available to stakeholders participating in a logistics chain, e.g. an RU shares relevant data with its LSPs.
- **Bilateral data**: data is only shared between any two stakeholders that have some type of relation, either contractual or transactional. For instance, an RU and its customer, an LSP, share the reference and data of a consignment note.
- **Organisational data**: data is only available according access control rules within an organisation.

A stakeholder might also decide not to provide particular, but only provide a Boolean answer (yes/no) to a request. An example would be an LSP requesting whether or not a delay occurs, without knowing its cause or duration.

3.3 IT Infrastructure

The basic principle on which the IT infrastructure will be based is hiding complexity of information sharing between Railway Undertaking and Infrastructure Manager. A Railway Undertaking provides only relevant data to a Logistics Service Provider and not all details of for instance path allocation as supported by TAF/TSI.

Data sharing as specified by the Interoperability Architecture for the rail sector (D5.1) identifies four phases, namely booking phase resulting in a contract, execution planning comprising ordering, execution with reporting, and cancellation to handle disruptions. D5.1 also identifies various data exchange mechanisms. The scope of the IT structure of this deliverable comprises execution with reporting based on events, where these events reflect milestones in the execution of processing. The IT structure consists of the following elements: relevant milestones, data sharing platform and its functionality, and event data structures. These will be discussed hereafter.

3.3.1 Milestones

These milestones reflect the physical structure of rail transport. Whereas D5.1 provides a generic list of milestones, the following are considered applicable to this Living Lab:

Milestone	Location	Description
Arrive	A train (empty or with its wagons and their load) arrives at a location at a time. Its identification, location, timestamp is given.	
	Destination station	Arrival at the station at which wagons are removed from a train and/or cargo is discharged from the wagons. This station acts as multi-modal terminal.
Depart	A train (empty or with its wagons) departs at a location at a time. Its identification, location, timestamp is given.	
	Departure station	Station at which a train with its wagons departs using an allocated path. This station acts as multi-modal terminal.
Load	Loading of cargo (liquid/dry bulk, chemicals, containers, packages, trailers) on wagons. In this particular case, trailers are loaded on wagons.	
	Station	A station acting as terminal with capabilities of loading cargo on wagons.
Discharge	Discharging cargo (liquid/dry bulk, chemicals, containers, packages, trailers) on wagons. In this particular case, trailers are discharged from wagons	
	Station	A station acting as terminal with capabilities of discharging cargo on wagons.

It is assumed that trailers are loaded and discharged at stations. These are the stations at which a train departs and arrives.

Within the context of the Living Lab, these milestones are currently classified as 'community data': the data is shared (by events) with all LSPs that subscribe to them. An LSP will only receive those milestones that are relevant to its objects.

This list of milestones does not include any intermediate stations, nor a border crossing station. There are two options with respect to these milestones:

1. Milestones of particular stations can be included, if required. These milestones provide position data at particular times. In case of a delay at a border, the arrival and departure times of a train at a border station needs to be given (two milestones). It can also be the case that a milestone of arrival of a train at a station at one side of the border and departure at a station at the other side.
2. Events for intermediate milestones are only generated in case of delay, where the delay exceeds a particular maximum. This maximum can be set by the LSP.

Another option is to provide the train composition to the LSP, i.e. provide data on which trailer is loaded onto which wagon, including the wagon sequence of the train.

3.3.2 SmartRail platform

The data sharing platform has an event driven architecture for data sharing with a Logistics Service Provider (LSP). For each of the previously identified milestones, a particular event will be generated. Raildata is going to be used as a source for tracking and tracing of wagons.

Raildata provides a web service for retrieving the status of a wagon of a train. This status can be mapped to a milestone specified for SmartRail. The content of a wagon is provided by a consignment note. Wagon data includes train position data retrieved by Raildata from the Rail Net Europe (RNE) Train Information System (TIS). SmartRail currently has an agreement with Raildata to provide data of France, the Netherlands, and Germany. Railway Undertakings provide data to Raildata.

In this respect, the following data should be known:

- Trailer number: identification of a trailer.
- Wagon number: wagon identification used for carrying a trailer.
- Train number: identification of a train of which a wagon is a part.
- Corridor: identification of a corridor with its start and end station. A corridor consists of a number of tracks. Paths can be allocated on a particular corridor, whereas a path is the timeslot allocated to a Railway Undertaking on a corridor.

Relevant infrastructure data is available as open data (http://www.navitia.io/datasets, which also states to provide disruption and maintenance data). To extract relevant data from the Raildata data set, either received as batches from Raildata or by a specific query to Raildata, the following situations occur:

1. An LSP provides a trailer number to the platform, since it has not received a consignment note. In this particular case, an RU is to provide the wagon number that can be used. At least, an LSP should provide the identification of an RU to the platform to be able to track and trace wagons.
2. An LSP has received the consignment note of a RU and provides wagon numbers to the platform. The wagon numbers are used to extract data from the Raildata data set.
3. An LSP has received the consignment note of a RU and provides the identification of the consignment note to the platform. This identification can be used to select the appropriate wagon number.
4. An LSP provides a schedule of a train on a corridor, where the schedule is part of a timetable. The platform should know the timetable.

Additionally, one (or more) Infrastructure Manager(s) provides maintenance and disruption data on a selected corridor. In this particular Living Lab, this data may have to be extracted from a website of SNCF, the relevant Infrastructure Manager, or is provided in a structured manner (see for instance https://data.sncf.com/api, that provides an overview of available APIs provided by SNCF).

Applying these approaches may give Unified Modelling Language (UML) sequence diagrams. The next figure presents an example where an LSP provides a trailer or container number (or more generic: a number identifying cargo) and will receive events relevant to that trailer or container.

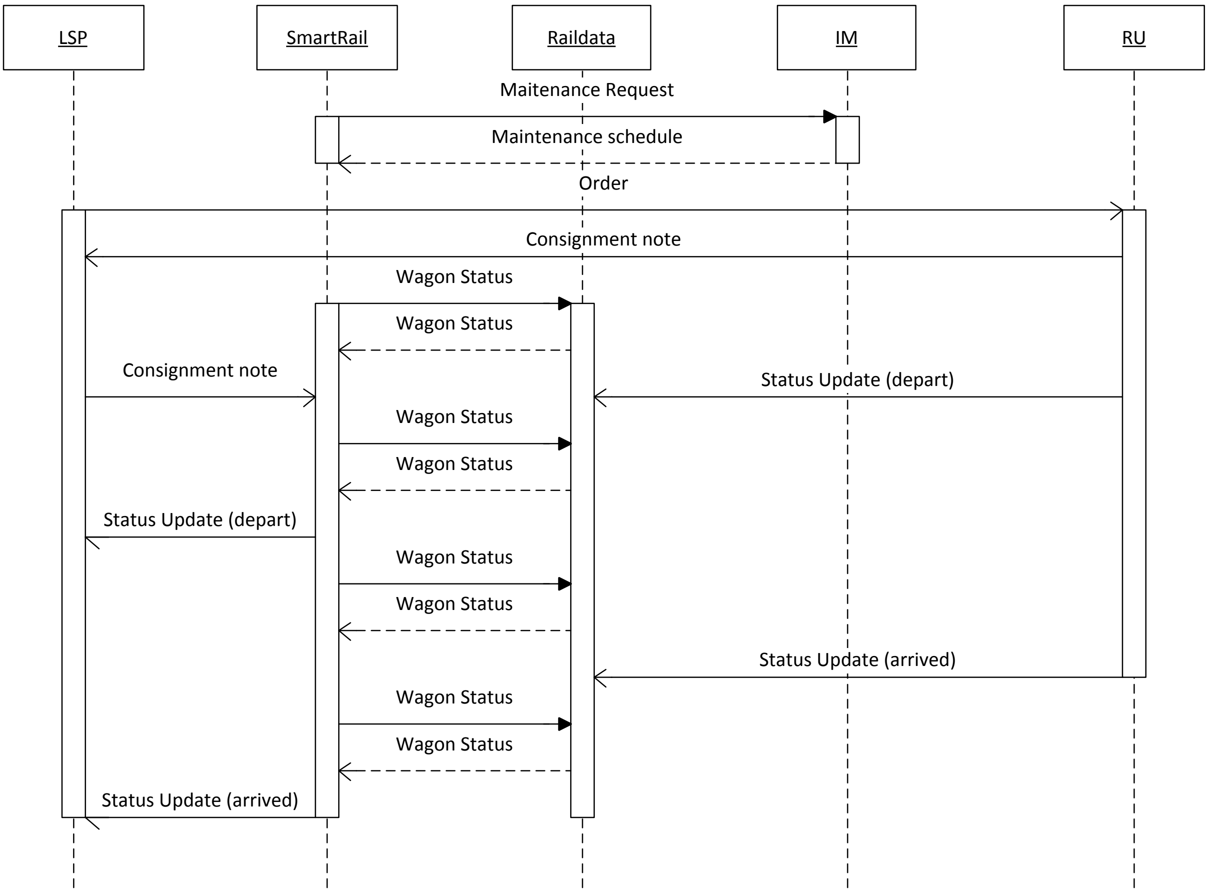


Figure 3.1: Example of a sequencing diagram for sharing milestones

The previous figure shows that maintenance data is shared between an IM and the SmartRail platform, based on an API (Application programming interface). An API is also used to retrieve Raildata data on a regular basis (wagon status data). Furthermore, it shows that an LSP and RU share a consignment note, which is registered with the platform as an object to be followed. As such it is indicated that only departure and arrival need to be signalled.

Sharing wagon status data between the SmartRail platform and Raildata may not always contain the latest status data, since a status update can be submitted by an RU between two API calls for Raildata. The maximum delay of the status update is the processing time of Raildata and the time interval between two API calls.

It is assumed that an LSP already knows the timetable of a train with wagons on which the cargo is loaded. The SmartRail platform may be extended to process delays caused by interruptions. In that particular case, disruption data and a timetable with its itinerary needs to be available to the SmartRail platform. It will result in the following sequence diagram, in case disruptions are submitted via events by an IM and the SmartRail Platform is able to subscribe to disruptions on behalf of an LSP. The delay caused by a disruption on a track passed by a train increases the Estimated Time of Arrival.

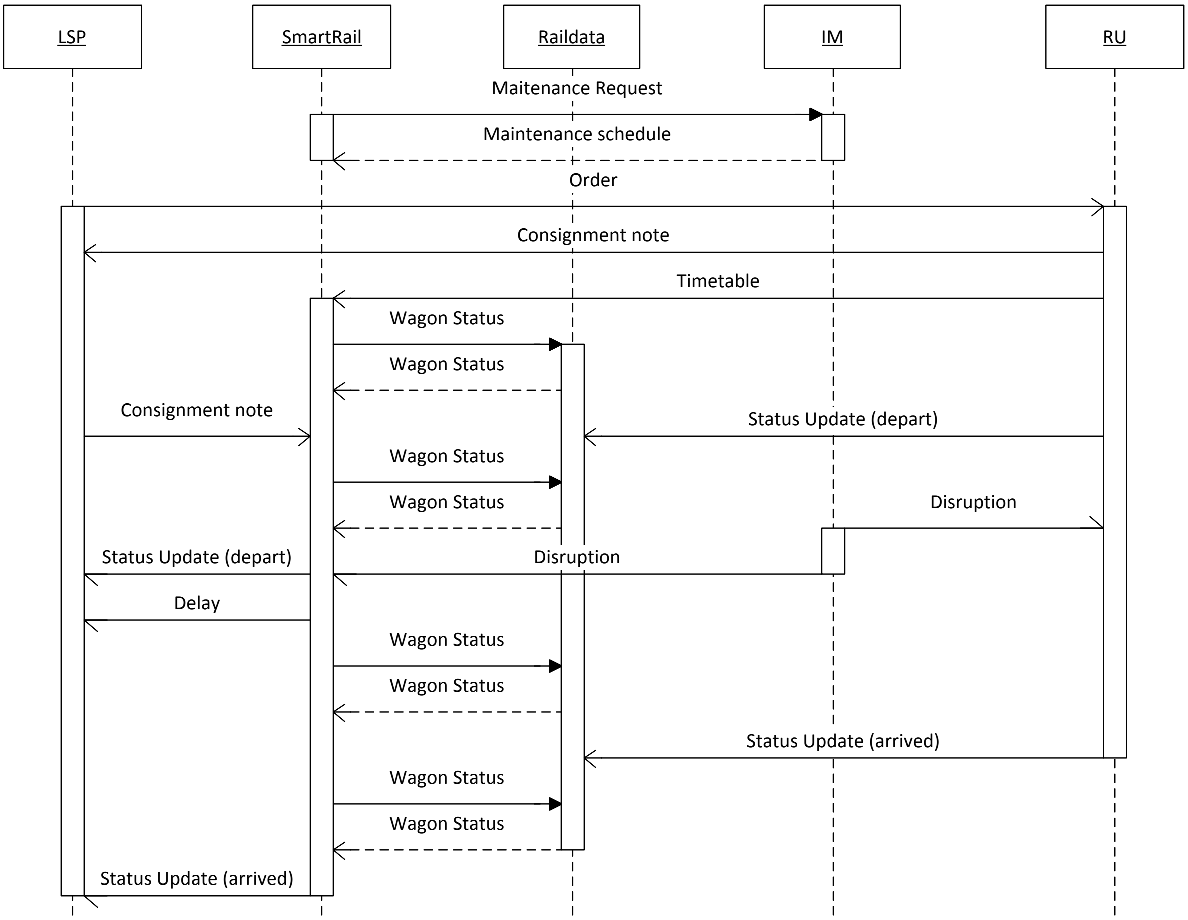


Figure 3.2: Sequence diagram for handling disruptions

Timetables can be uploaded anytime by an RU or can be retrieved based on an (open) API. Only if these timetables have itineraries, it will be feasible to process a disruption at a particular location.

It may also be possible that the end of a disruption is signalled by an Infrastructure Manager. The previous figure only visualizes a disruption occurrence with an estimated delay. The delay forecasted to an LSP relates to the object followed by an LSP, in this example a consignment note.

The previous figures don't show that an LSP has to register itself with the SmartRail Platform. During registration, an LSP will be able to configure:

- Object: choice between train, wagon, cargo (trailer identification) or consignment note.
- RU: identification of an RU(s) that are partners of the LSP.
- Corridor: relevant corridor on which cargo will be transported by rail. A corridor may be linked to one or more RUs.
- Milestones: identification of the milestones to be signalled. The milestones are relevant to an object, a corridor or an RU.

The next figure shows the overall infrastructure with its interfaces.

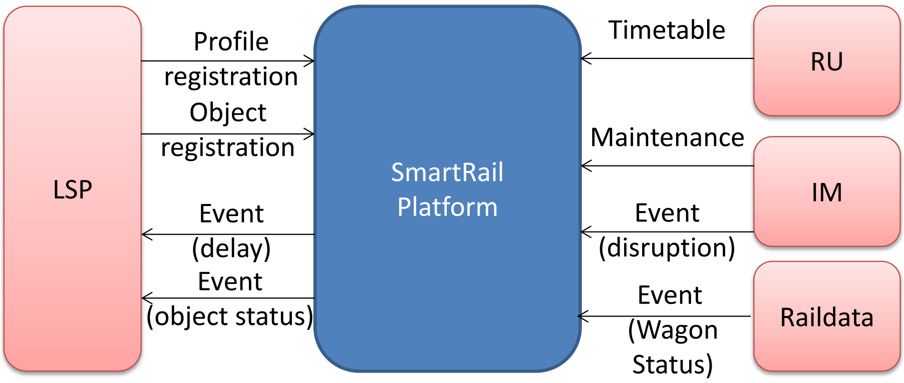


Figure 3.3: Overall IT infrastructure with interfaces

This infrastructure will not be implemented completely. There is a gradual implementation by adding functionality according the planning of the Living Lab.

The same figure can be depicted as a UML package diagram showing the roles and packages (functionality) of the SmartRail Platform. Each package will have a use case diagram.

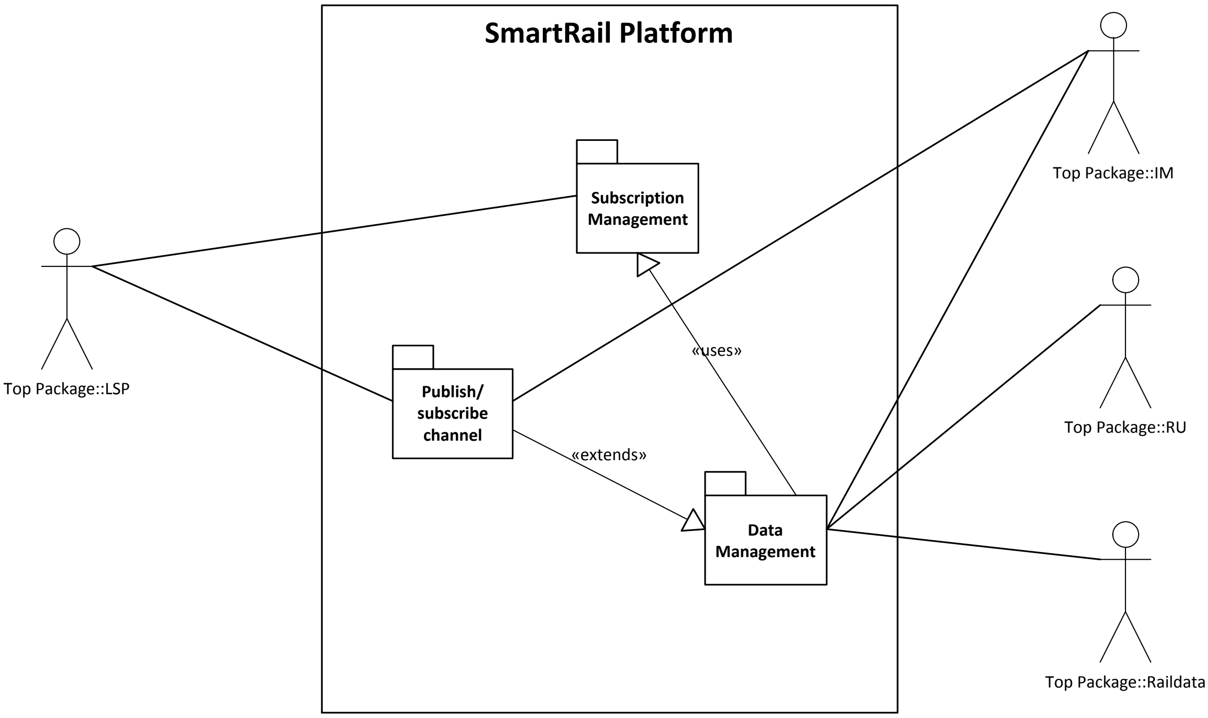


Figure 3.4: Package diagram of the SmartRail platform

The platform consists of three separate packages:

- **Subscription Management**: it allows an LSP to register with the platform and store its particular subscriptions. Those are for instance the milestones. These subscriptions functions can be a type of template applied to particular objects like trailers, wagons or consignment notes that need to be tracked and traced.
- **Publish/subscribe channel**: the actual channel that distributes events to the proper recipients according subscriptions. Disruption events of IMs use timetables to generate potential delays to the relevant LSPs (and possibly to RUs, although these are currently not registering their subscriptions).

- **Data Management**: storage of (temporary) data like maintenance schedules and timetables required as a basis for generating events to LSPs. Data Management generates these events on behalf of RUs, IMs, and Raildata.

The use cases of these packages will be elaborated in Deliverable D5.1 – SmartRail Interoperability Architecture.

3.3.3 Data structures of the platform

The data structures of the platform will be used to store subscriptions, timetables, and maintenance schedules that are the basis for generating events. Timetables are associated with corridors and the underlying infrastructure. It is assumed that details of the infrastructure are available as open data, which can be retrieved via an API. Infrastructure data is therefore not stored by the platform (it could be an optional feature, but only relevant data is retrieved to support visualization of timetables).

This section presents conceptual data structures; technical data structures will be developed for realizing the SmartRail Platform.

3.3.3.1 Subscription profile

The following figure visualizes the data structure for storing subscriptions.

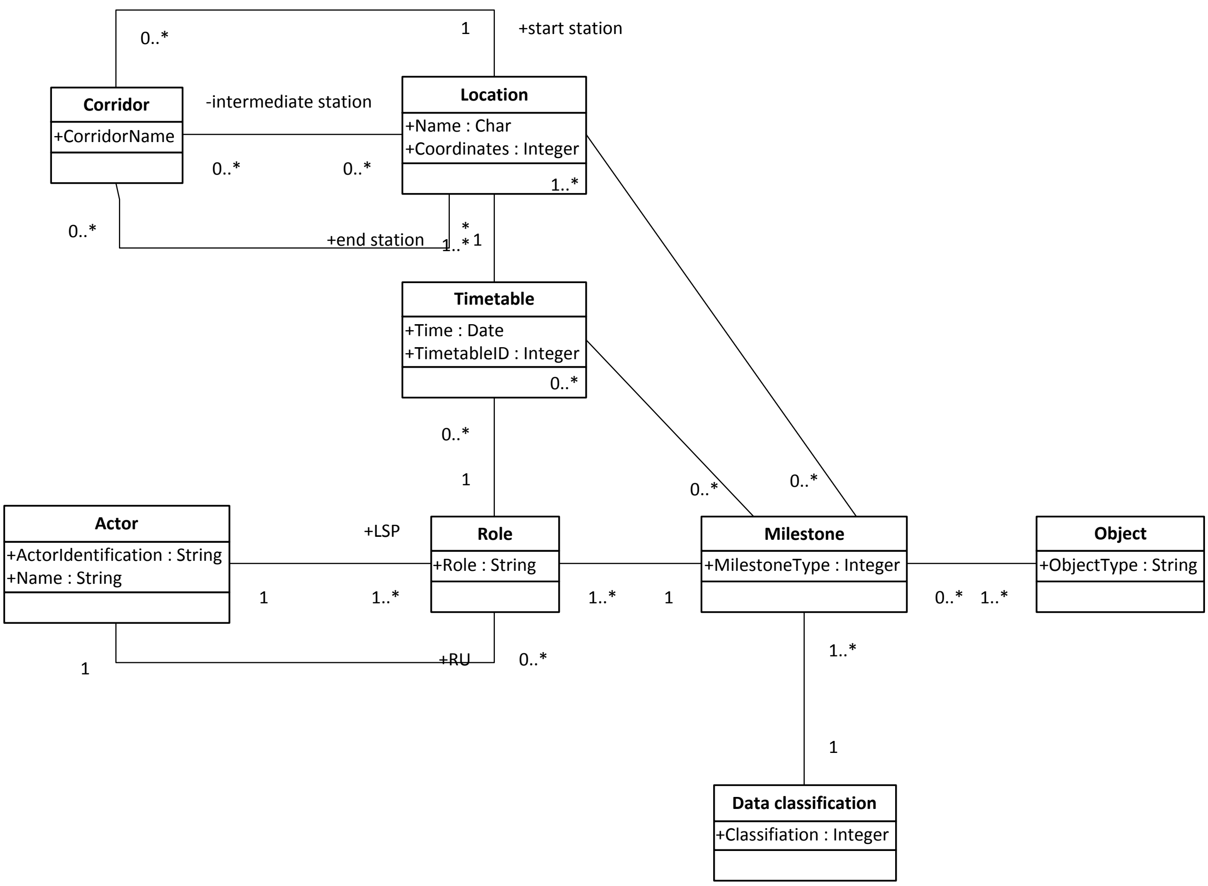


Figure 3.5: Conceptual data structure for storing subscriptions

The UML class diagram shows that two actors can have a relationship in their role as LSP and RU. In the role of LSP, an actor can set milestones, where these milestones may have a data classification set by the provider of these milestones. As stated before, these milestones are open within the SmartRail community.

In its role as RU, an actor can provide a timetable connecting various stations. The start and end station have at least to be given (mandatory: two stations) and intermediate stations can be given to provide an itinerary. Basically all times with an identical identification (timetableID) have an association with a location that can also be a yard or terminal.

A milestone can have a reference to locations (stations, yards, terminals) or a timetable (with its start and end station and potentially its itinerary). A milestone always concerns an object type. At the moment an LSP requires to receive events according to its subscriptions, the object identification must be provided. The supported object types are currently consignment note, trailer, wagon, and train.

3.3.3.2 Event data structure

The next figure shows the event data structure. Each event is published by an actor at a certain date. Currently, the SmartRail platform acts as publisher of events. These events refer to the milestones of an object, e.g. a consignment note, a trailer or a wagon. Milestones are either measured by sensors that for instance an LSP has attached to its trailers loaded on wagons or are provided by or extracted from data sets of another actor. For instance, the data sets of Raildata can be used to extract data of milestones, where the SmartRail Platform acts as publisher of the event.

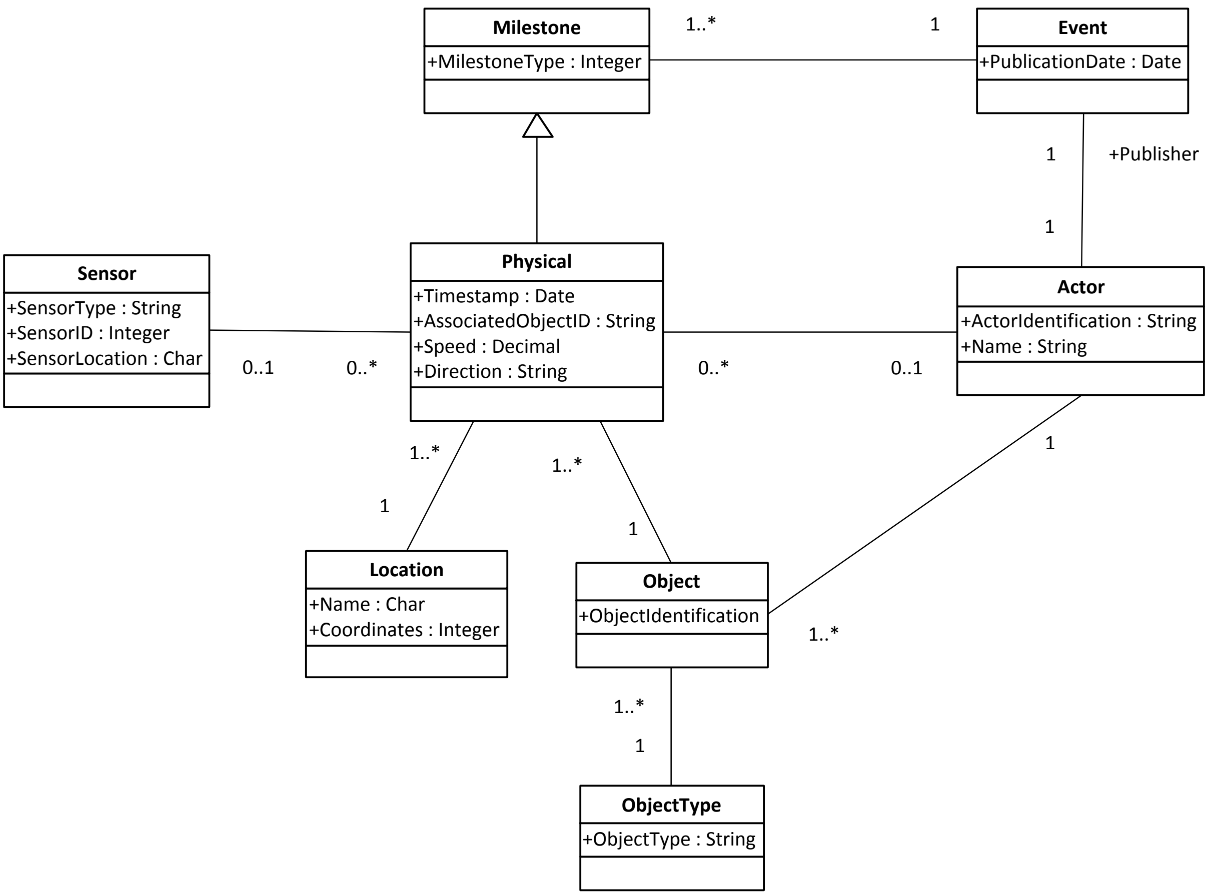


Figure 3.6: Conceptual data structure of events

Having the SmartRail Platform as an actor allows referring to the basic data set used to generate events. In the future, the platform can act on behalf of a data set provider or as on behalf of a user like an LSP extracting events out of data sets. In both cases, the platform is a technical facility either configured by a data set provider or user and is not an actor by itself. This needs further elaboration in the Interoperability Architecture (D5.1).

A physical milestone refers to locations (stations, etc.) and objects with their identification and type. The object type to which an identification refers and the locations must be associated to the subscription milestones (see before). When registering the object identification, only a type can be selected that is stored as subscription data.

4 KPIs and monitoring

4.1 KPIs in the Smart-Rail project

Key Performance Indicators (KPIs) are widely used for benchmarking and assessment. KPIs will be useful to:

- Create awareness of the service and its quality by showing its current performance;
- Contribute to find weak points as a straightforward way of improvement

In the Smart-Rail project, KPIs are being used to assess and monitor the evolution of the Living Lab and the potential effect of such solution. A KPI Working Group has been settled, to discuss the most applicable KPIs to measure the performance of the solution implemented.

4.2 KPIs for CT-Rail

As was already set forth in WP7.1, in this Living Lab the effect will be monitored of the information sharing among different stakeholders in the rail freight business. The aim is to show the impact of providing regular - and ultimately real-time - status updates and, through this, the ability to make rail freight a better product. As was also established in detail in previous tasks, issues hampering rail freight transport from the LSP's perspective are:

- Today, **delays on the train corridor are often reported to the LSP without sense of urgency**, or sometimes not at all. This results in unexpected changes of schedule at the terminal, causing further delay, as well as additional costs. Timely notification enables the terminal and LSP to adjust schedules and inform customers where due.
- The **LSP does not have at its disposal up-to-date information** concerning the shipment, and is informed only after unloading has taken place, mostly by subcontractors. Thus, although the market often demands it, no quick status updates to the customer are available.
- As **scheduled lead times are often not honored**, Time of Delivery at the customer is volatile. Maintaining lead times is augmented by better predictability. Increased informational flow will not lead to a reduced lead time, however, the agreed lead time is honoured more often and the lead time agreed with the end client can be given with decreased volatility.
- **Total Cost of Ownership (TCO)** is increased by mistakes and re-plan actions, hampering efficient use of assets and personnel. This decreases rail transport's overall competitiveness.
- Communication concerning disruptions and shipment status is poor, increasing TCO and hampering the performance of rail freight transport. Being informed more often enables the LSP to get a better grip on their processes and work in progress. It allows the LSP to approach the current state of the execution close to the reality, enabling flexibility on transhipment points[3]. **Real-time status updates** towards the LSP and the customer is considered best.

[3] Cargo terminals and country crossings

Therefore, the KPIs for CT-Rail on the corridor Bettembourg-le Boulou are derived as follows:

KPI 1: **Increased predictability through swift notification of delays.**

KPI 2: **Increased awareness of shipment status through regular and precise status updates.**

KPI 3: **More stable lead times through increased predictability.**

KPI 4: **Reduced TCO through increased predictability.**

KPI 5: **Availability of real-time status updates on the corridor.**

4.3 KPI measurement

In this section, the measurement of CT-Rail's KPIs is established. Also, its desired results are described. However, consistent with the Living Lab approach, where quantifiable, no estimation is given of the desired results.

In the next diagram, the transport corridor is shown schematically. In table 4.1, the monitoring points are specified. This enables us to formulate exact measures for CT-Rail's KPIs. The information on the described monitoring points can be gathered from all the different parties in the supply chain who do have access to it. Ideally, information per monitoring point will come from a minimum of two parties, which allows for verification.

Table 4.1: CT-Rail monitoring points

Monitoring point	Description
C1A	Actual time of departure from loading location (production site or DC)
C2E	Estimated arrival on rail terminal of loading
C2A	Actual arrival on rail terminal loading
T1E	Estimated time unit loaded on train
T1A	Actual time unit loaded on train
R1E	Estimated departure of train at terminal of loading
R1A	Actual departure of train at terminal of loading
R2E	Estimated arrival of train at terminal of unloading
R2A	Actual arrival of train at terminal of unloading
T2E	Estimated unit available for pickup at terminal of unloading
T2A	Actual unit available for pickup at terminal of unloading
C3E	Estimated departure from rail terminal of unloading
C3A	Actual departure from rail terminal of unloading
C4E	Estimated unloading at end destination (production site or DC)
C4A	Actual unloading at end destination (production site or DC)
CD	Carrier disruption notification
TD	Terminal disruption notification
RD RX RT	Rail disruption notification Rail updates on pre defined critical points (e.g. border crossings) Real time tracking of the shipment

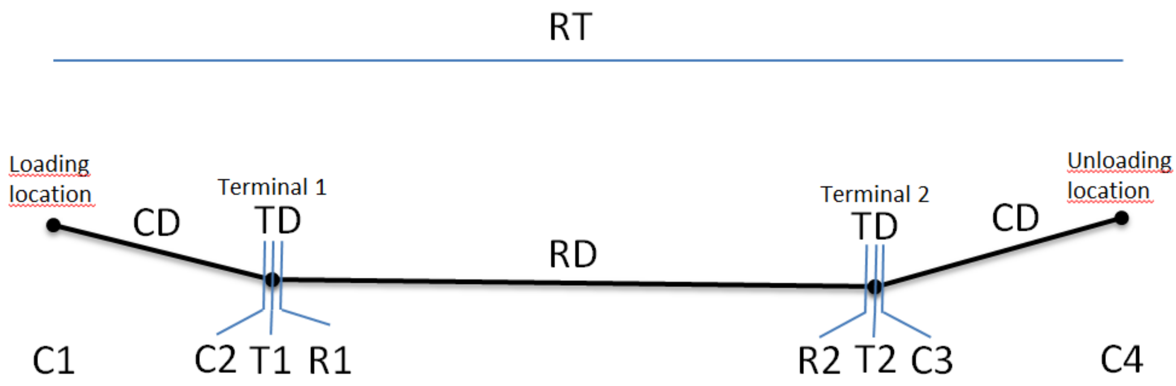


Figure 4.1: Schematic overview of intermodal corridor with monitoring points

For reasons of availability, implementation and monitoring will take place in three different phases. The first phase will include the starting point and end point of the shipment. These points are the most important in the supply chain and therefore in rail freight transport's performance. Availability of precise status updates on these points, and monitoring thereof, will provide insight in the performance on the corridor.

In the second phase, status updates on the rail leg(s) and Notification of Disruption are included. This allows for better predictability and visibility, as well as for identifying specific legs of the supply chain as causes of delays.

The third phase increases the level of detail further. Status updates on critical points in the chain, e.g. the delivery of the transport unit on terminal or border crossings, will become available. Thus, visibility is further enhanced and causes of delays specified in more detail. Also, real-time status updates will be part of the third phase.

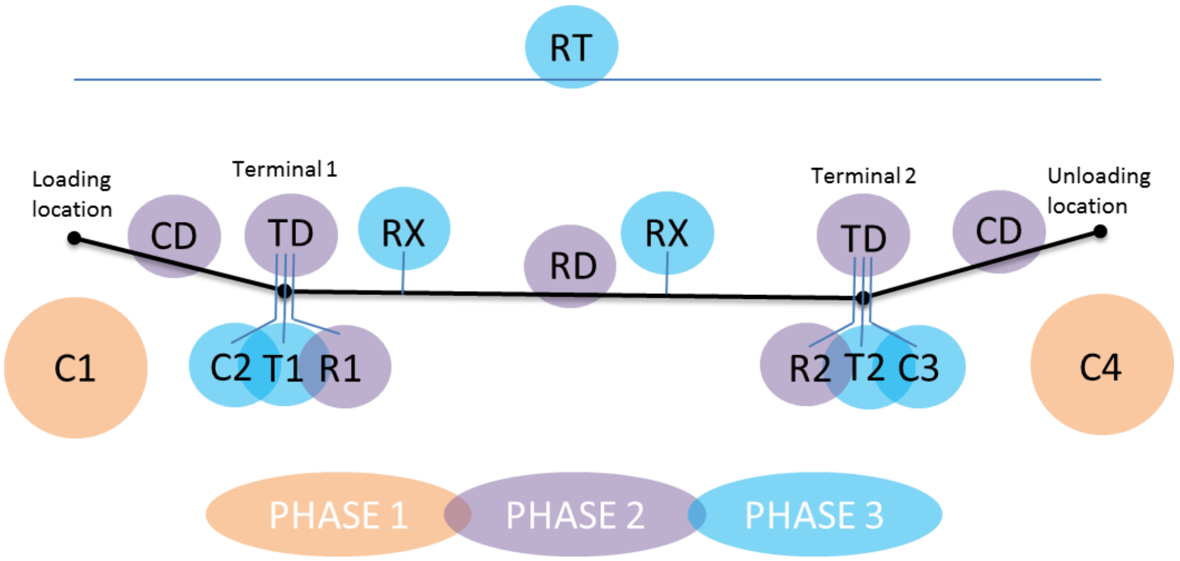


Figure 4.2: Three phases of data collection and measuring the KPIs

The setup each EDI (data interchange) connection and implementation of it with all the stakeholders on one of the selected corridor will take between two weeks to two months, depending on the complexity of the connection and the used system. The number of total connections and connections per monitoring point depends on the availability of the information and the engagement of the stakeholders. In order to measure all the milestones, it is foreseen that for each corridor a minimum of three connections and a maximum of five connections have to be realized.

Consequently, the measurement of the KPIs, and the desired results from the milestones monitored the functioning of the CT-Rail, are as stated in table below. These KPIs correlate to those in WP 4.4. Per KPI the correlating topic of 4.4. is stated.

Table 4.2: CT-Rail KPIs

KPI 1 Correlates to 4.4 KPI topic	**Increased predictability through swift notification of delays.** 6-4
Measurement	a) Share of cases of delay in which Notification of Delay takes place. b) Average time lapse (hours) between Notification of Delay and Original ETA.
Desired result	CT-Rail monitoring should show a) A palpable increase of the share of cases of delay in which Notification of Delay takes place (percentage). b) A palpable *increased* average time lapse compared to baseline in cases of Notification.
KPI 2 Correlates to 4.4 KPI topic	**Increased awareness of shipment status through regular and precise status updates.** 6-5
Measurement	Availability (yes/no) of information per monitoring point. a) C1 – C4 b) R1 – R2 and CD, TD, RD c) C2, T1, T4, C3, RT/RX
Desired result	Regular and precise updates per monitoring point are available through CT-Rail.
KPI 3 Correlates to 4.4 KPI topic	**More stable lead times through increased predictability.** 6-1, 6-2
Measurement	The variance per week of deviations in train lead times in hours.
Desired result	CT-Rail monitoring should show a palpable improvement in % of stability of lead times.
KPI 4 Correlates to 4.4 KPI topic	**Reduced TCO through increased predictability.** 6-3
Measurement	a) TCO calculated by the average delay per shipment (ETA – ATA at the unloading location in hours) and a standard hour rate (euros). b) TCO per leg.
Desired result	CT-Rail monitoring should show a palpable reduction of TCO.
KPI 5 Correlates to 4.4 KPI topic	**Availability of real-time status updates on the corridor.** 6-5
Measurement	Availability (yes/no) of RT information on the corridor.

Desired result	RT information available through CT-Rail.

5 References

[1] European Commision, “White Paper - Road to a Single European Transport Area - Towards a competitive and resource efficient transport system,” 2011.

Annex A Baseline monitoring results

This section presents the baseline monitoring results, based on KPI measurements as described in section 4.3 in separate document with restricted dissemination level.