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Optimised Real-time Yard and Network Management

D 3.1 Definition of suitable simulation environment

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EXECUTIVE SUMMARY

This deliverable sets out the findings of OptiYard's Task 3.1. It develops an understanding of the physical characteristics of rail freight yards and terminals and the data required for their management. It addresses the development needs for the Villon simulation environment, available to the project through the partner SIMCON. It specifies the requirements for a generally applicable simulation environment, considering yard and relevant network, to be applied for demonstration to the Česká Třebová and Trieste rail yards and interacting modes and rail network.

The rail freight yards and terminals represent a variety of situations present across Europe. The purpose of this analysis is to assess the capabilities of Villon in simulating the different situations.

Additionally, the data exchange and data analytics requirements analysed in OptiYard's WP2 are considered. The purpose of this analysis is to identify requirements that need to be implemented in the OptiYard simulations.

The results of the above analyses are then summarised as requirements to be implemented in OptiYard.

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LIST OF ACRONYMS

AGV	Automatic Guided Vehicle
PCS	Path Coordination System (RNE tool) or Port Community System
RMG	Rail Mounted Gantry cranes
RNE	RailNetEurope
SWL	Single Wagonload
TAF	Telematics Applications for Freight
TIS	Train Information System (RNE tool)
TSI	Technical Specification for Interoperability

1. INTRODUCTION

This deliverable sets out the findings of OptiYard's Task 3.1. It develops an understanding of the physical characteristics of rail freight yards and terminals and the data required for their management. It addresses the development needs for the Villon simulation environment, available to the project through the partner SIMCON. It specifies the requirements for a generally applicable simulation environment, considering yard and relevant network, to be applied for demonstration to the Česká-Třebová and Trieste rail yards and interacting modes and rail network.

2. INFORMATION ON EUROPEAN RAIL FREIGHT YARDS AND TERMINALS

2.1 TYPES OF FACILITIES

Rail freight transport can be divided in two main typologies of services: conventional rail freight and intermodal transport.

Conventional rail freight or wagonload includes trainloads and single wagonloads. The traditional trainload is the simplest form of wagonload: it needs only a load/unload terminal, and it has no change in train composition during the trip. Loading/unloading terminal operations and facilities for the handling of goods are strongly dependent on the type of goods, in spite of the fact that integration with other modes is not needed. Single wagonload (SWL) is a sophisticated product by which a wagon or a group of wagons are shunted into the facilities of a shipper, and once loaded, they are shunted back and marshalled to form trains that run over longer distances. This production method is now being relaunched.

Railway facilities for train formation such as auxiliary freight stations, junction railway stations and marshalling yards are necessary for the SWL production system and for the combination of different wagons and wagon blocks that share destinations.

Single wagonload generally requires marshalling yards. A typical example is a hump yard. Different groups of tracks characterize this terminal typology. Trains arrive in sidings, where wagons documents are checked. They are split into groups of wagons, according to their final destination; the line locomotive moves away, while the hump locomotive takes place behind the groups of wagons to be shunted. The wagons move, pushed by a manoeuvring locomotive, over a hump in a direction group (of tracks), where they are braked using hump retarders placed along the tracks, finally reaching departure sidings where they cumulate to reach the critical mass or the scheduled time for a departing train. There train documents are checked, the line loco is coupled to the wagons, the brakes are tested and the train is ready to depart. In smaller terminals, wagons could be moved between different sidings by shunting locomotives . This excludes necessity to realize a hump.

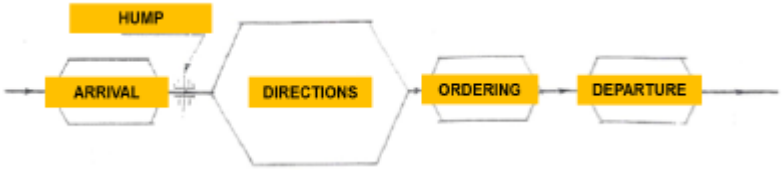


Figure 1. Typical layout of a hump (marshalling) yard

Intermodal transport involves the movement of goods in the shape of standardized loading units, i.e. containers, semitrailers and swap-bodies, transferred between at least two modes without handling the goods as such. This type of transport offers the possibility of an easy and rapid transhipment of goods, through the use of transferable loading units (container, swap bodies, semitrailers, even trucks themselves, in case of accompanied transport). This implies the shipment of goods from an origin to an intermediate destination, and from there to another destination.

Transhipment takes places in terminals or hubs where the freight is consolidated or deconsolidated. Transhipment makes also possible the change of the modes of transport during the journey without handling the goods as such. The transhipment of freight is a common prerequisite in order to make unimodal transports more efficient, and operationalizes in consolidation/deconsolidation terminals or hubs. Another reason for transhipment is to change the modes of transport during the journey.

Typical intermodal terminals are:

- port terminals;
- large, medium and small intermodal terminals;
- industrial intermodal terminals;
- end terminals and liner train terminals.

In Figure 2, Figure 3, Figure 4, the typical features of the frequently-encountered sea-rail and road-rail terminals are shown. Figure 5 shows the freight flows in intermodal terminals and marshalling yards, which further illustrates the layout of such facilities.

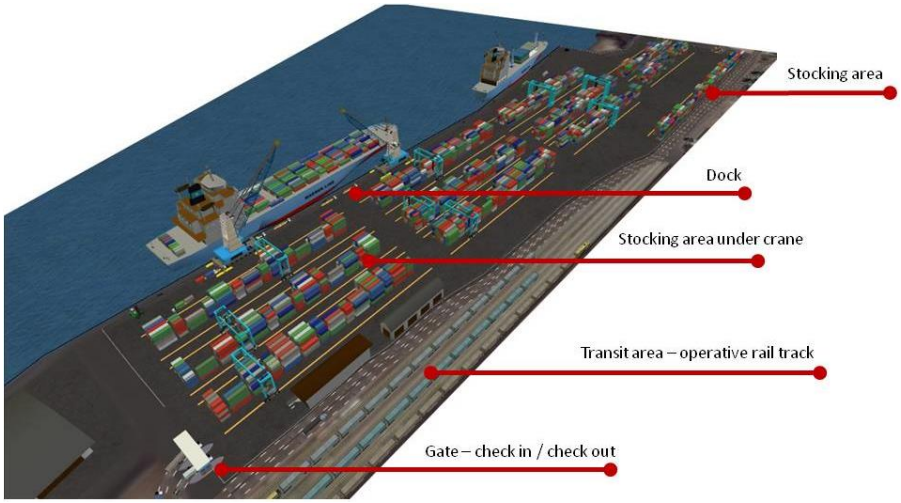


Figure 2. Typical layout of a sea-rail terminal and reference terminology (source: Capacity4Rail project)

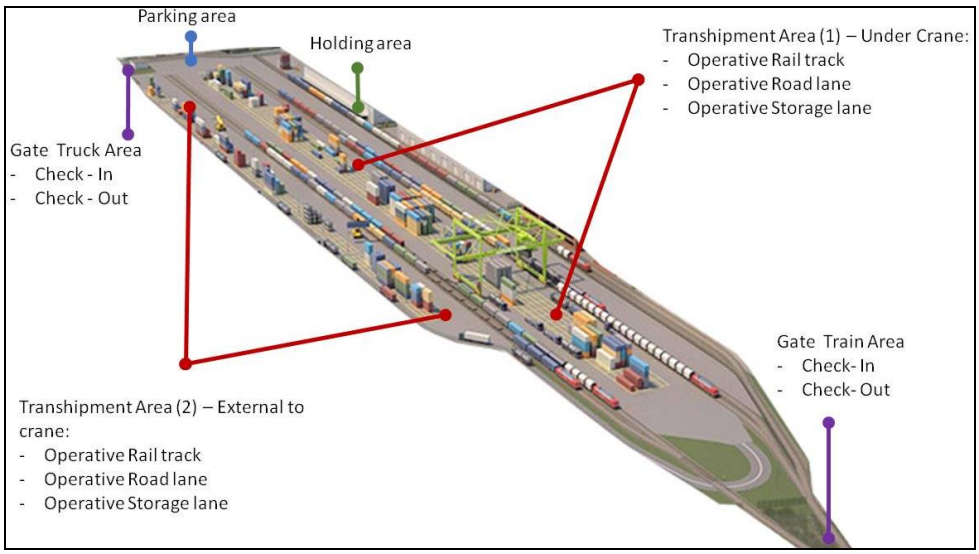


Figure 3. Typical layout of a road-rail terminal and reference terminology (source: Capacity4Rail project)

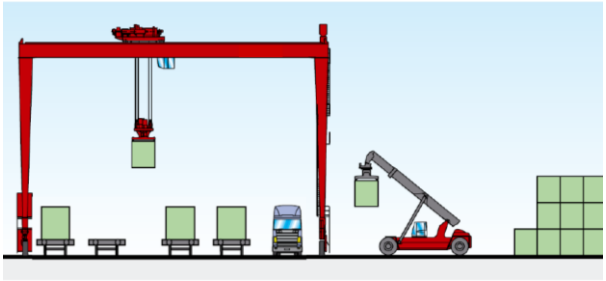


Figure 4. Example of typical intermodal operations in a road-rail terminal (source: Capacity4Rail project).

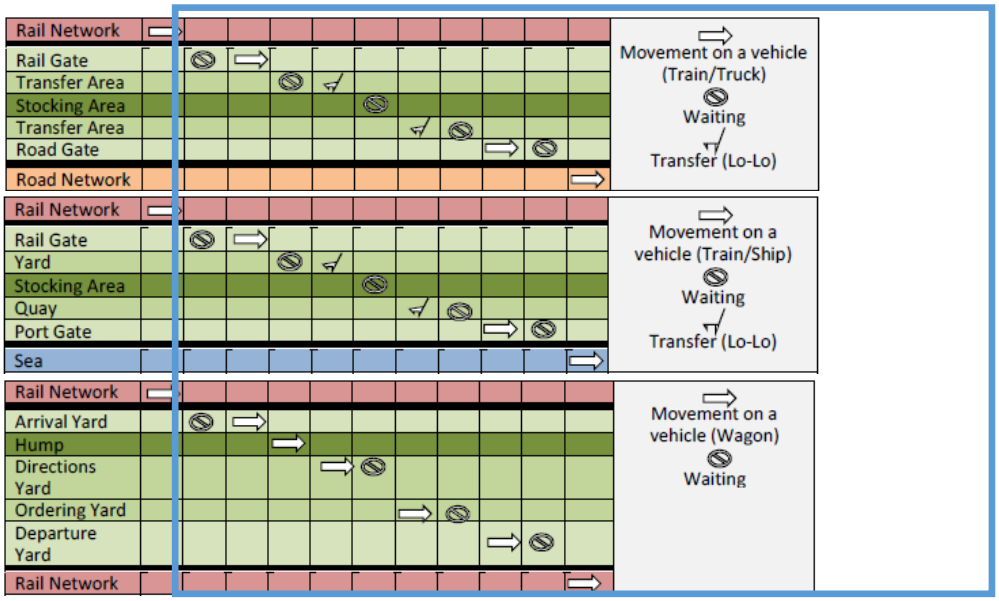


Figure 5. Freight flows through the areas of: an inland terminal (rail-road), a maritime terminal (rail-sea), a marshalling yard (rail-rail - source: Capacity4Rail project)

A possible classification of terminals in which the rail transport mode is involved is given in Table 1.

Table 1. Types of rail terminals.

Intermodal terminal • Rail-road • Rail-rail • Rail-waterways	**Internal rail system** • Marshalling yards • Shunting yards • Stations, sidings
Train load terminals • Timber • Coal • Oil	**Single wagon load** • Rail-industry • Rail-truck • Rail-ship

In intermodal terminals, loading units are moved from the vehicles of one mode to the other, or within the same mode as it can be the case for rail-rail terminals. In the terminals that are internal to the rail system, the wagons may be moved (shunted) along with their load (be it an intermodal unit or not) - as in the case of marshalling and shunting yards - or the goods may be loaded onto or unloaded from the wagon - stations, sidings. If loading/unloading involves a whole train, we speak of train-load terminals (for which in the table only a few goods types are indicated as examples - of course many other different types are possible, all with the characteristic or requiring large volumes). When production or transport volumes are not so large, single wagon load may be convenient.

All these terminal types are characterised by loads being moved from the production sites, the rail mode or other modes to rail wagons, and the rail wagons being shunted to form trains that exit and enter the terminals to/from the surrounding rail network.

In principle, therefore, simulation environments that are capable of representing this are capable of simulating all types of yards. In order to confirm this, in the following a number of terminals for which information was readily available (from the Capacity4Rail project) are described. These terminals were checked to make sure that it is possible to represent them through a simulation environment based on the Villon software.

2.2 DESCRIPTION OF TYPICAL YARDS AND TERMINALS

In addition to the two case-study yards of the OptiYard project, five facilities from the Capacity4Rail EU project were analysed in order to grasp the general-applicability issues that might arise from different layouts, network connectivity and other issues:

- Antwerp Combinant road-rail terminal (Belgium);
- Antwerp HTA road-rail terminal (Belgium);
- Hallsberg marshalling yard (Sweden);
- Riem road-rail terminal (Germany);
- Valencia port terminal (Spain).

In the following a brief description is given for each of these.

2.2.1 Antwerp Combinant road-rail terminal

The Antwerp "Combinant" terminal (joint venture between Hupac, Hoyer and BASF) - see Figure 6 - carries out services for containers, dangerous goods, power supply (reefer), semi-trailers, swap bodies.

It includes:

- 5 rail tracks;
- 3 rail mounted gantry (RMG) cranes;
- 10 to 12 trains per day;
- 150,000 units on a yearly basis.



Figure 6. Antwerp Combinant road-rail terminal

2.2.2 Antwerp HTA road-rail terminal

The Antwerp HTA (Hupac) terminal - see Figure 7 - carries out services for containers, semi-trailers, swap bodies.

It includes:

- 5 rail tracks;
- 3 rail mounted gantry (RMG) cranes;
- 235 trucks daily from 6 a.m. to 9 p.m.;
- train arrival/departure on average every 6 hours.

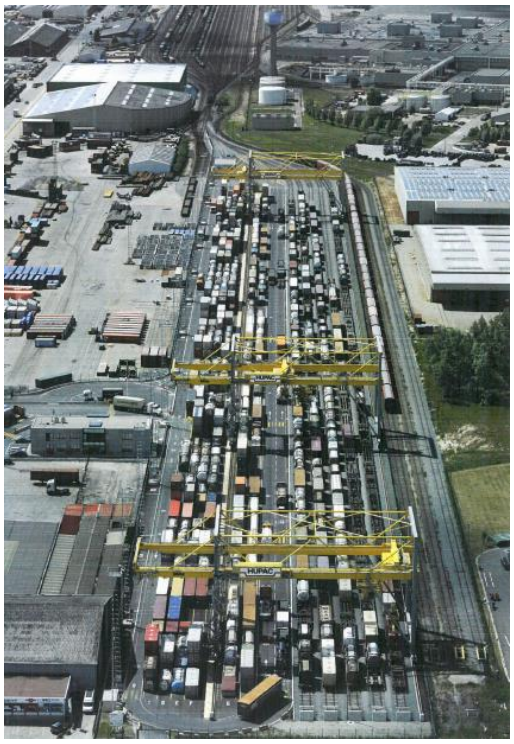


Figure 7. Antwerp HTA road-rail terminal

2.2.3 Hallsberg marshalling yard

The layout of the Hallsberg marshalling yard is visible in Figure 8. It is characterised by:

- number of operative tracks of the reception sidings 8 tracks;
- number of operative tracks of the direction sidings 32 tracks;
- number of operative tracks of the departure sidings 12 tracks.

which makes the facility capable of shunting over 25,000 wagons per month.

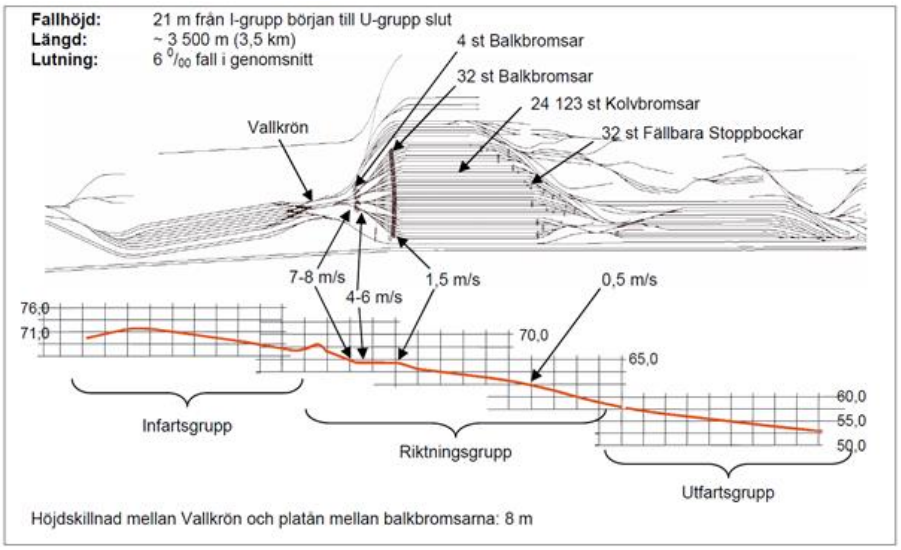


Figure 8. Layout of the Hallsberg marshalling yard

2.2.4 Riem rail-road terminal

The main features of Riem terminal (Figure 9) are:

- 5 arrivals railway tracks in the holding area;
- 3 operative modules covered by the gantry cranes;
- 14 operative railway tracks for loading/unloading;
- 6 truck lanes;
- 8 storage lanes;
- 6 rail-mounted gantry cranes (2 per operative module).



Figure 9. Riem road-rail terminal

2.2.5 Valencia port terminal

The Principe Felipe dock is located at the South end of the Port of Valencia and relies on a container terminal of more than one million square metres of operative surface.

The railway infrastructure (Figure 10) consists of five lines coming from the right branch of the main line and coming into the Port area through a double track (entrance/exit).

The railway terminal of the Principe Felipe dock is located in the southeast part of the public container terminal. Some of the most relevant characteristics of the terminal are:

- loading/unloading area with 4 railway tracks;
- extra railway track to perform the manoeuvres of the locomotive;
- electrified railway tracks up to the loading/unloading area;
- two-road access to the railway terminal;
- two storage areas with 9,000 m^2 and 20,000 m^2.

The equipment and machinery utilised in the loading and unloading processes does not operate exclusively in the railway terminal. The RTGs, reach stackers and the other equipment needed in the railway terminal return to the public container terminal once the loading/unloading operations have finished.

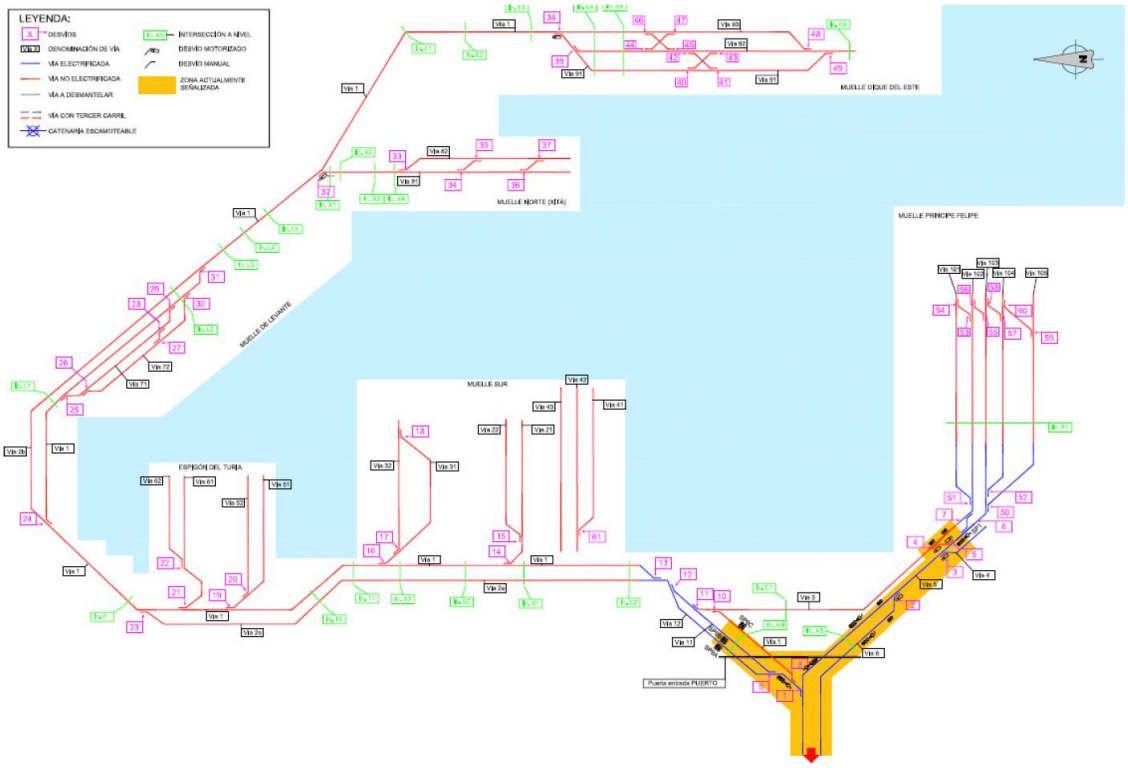


Figure 10. The Port of Valencia's Principe Felipe Railway Terminal - rail track layout

2.3 CONSIDERATIONS

Although the five facilities, selected because of the availability of information, do not cover all the types identified inTable 1, they do represent a sample covering both conventional and intermodal transport. For conventional transport, the most complex situation (a large marshalling yard) is considered. For intermodal transport, the consideration of three different road-rail terminals and a sea-rail terminal introduces some diversity but does not cover all the possible types.

However, of the terminal types of Table 1 that are not included in the list, rail-rail intermodal terminals show a type of operation that is similar to road-rail terminals - moreover without any need to model the characteristics of two different modes. Stations and sidings are generally simpler terminals than the ones that are being considered here. Train load and single wagon load terminals comprise loading operations of the conventional wagons themselves that are actually out of the scope of OptiYard. In any case, all of the above terminals are made up of components that may be modelled in a Villon-based environment, as shown in §4.1, and therefore would pose no particular problem in being simulated and optimised in the future based on OptiYard results.

3. REQUIREMENTS DERIVING FROM DATA EXCHANGE FORMATS AND DATA ANALYTICS TECHNIQUES

An important part of optimising operations within a rail yard or terminal consists of managing the flows of data on which the optimisation is to be based. This involves the following aspects.

Exchange of information inside a rail yard.

- Independently of whether or how in-yard data is gathered and distributed today, the system should be able to work with real-time yard data such as yard status on a wagon / wagon load basis and personnel as well as infrastructure bases

Exchange of information between rail network and rail yard.

- RNE Tools TIS and PCS (TAF TSI compliant)
    - capability of using the information coming from such systems
    - consideration of the fact that yards are/should be using these systems increasingly in the future
- national Infrastructure Manager IT systems
    - OptiYard results should be independent of such systems
- use of new or adapted data structures and communication protocols where needed, building standards where needed

Exchange of information with other modes and rail yard.

- Port Community Systems
    - capability to use the information coming from such systems
- TAF TSI compliance

use of new or adapted data structures and communication protocols where needed, building standards where needed

General data exchange formats

- RailML
    - considerations on compatibility requirements

Representation of the infrastructural elements of the rail network and rail yard.

- RailTopoModel
    - yard model not developed using RailTopoModel
    - analysis of what should be done after OptiYard if RailTopoModel compatibility is to be sought

The OptiYard yard simulation environment is directly affected only by the representation of the infrastructural elements. In fact, the issues of information exchange need to be managed by the network model and the optimisation model. The Villon software used in OptiYard at the moment is not directly compatible with RailTopoModel - i.e. the infrastructural input data (such as track layout, distances between key points of the infrastructure, switch position and characteristics etc.) is not represented with the model but with other methods. This is not required for the demonstration to be developed in OptiYard, but could be considered as recommended for future industrial applications. Therefore OptiYard **should** propose a roadmap towards compatibility with RailTopoModel.

The network model concept developed in OptiYard **shall** take into account RailTopoModel in its development. It **shall** also take into account the data exchange issues involving national Infrastructure Manager IT systems, RNE tools, other modes and the use of general formats (e.g. RailML).

In D2.1 - Definition and selection of suitable methods for real-time data analytics - further requirements connected with data exchange and analytics are indicated. Meeting these requirements (below) is not considered to impair the general applicability of a simulation environment based on Villon:

- requirements regarding data update rate (update rates may be different, sometimes updates are sporadic)
- requirements regarding data horizon
- requirements regarding data distribution (between different stakeholders)
- requirements regarding inputs/outputs
- requirements regarding data faults and loss (insensitivity to a certain degree)
- requirements regarding data fusion.

4. REQUIREMENTS FOR THE GENERAL APPLICABILITY OF VILLON

4.1 VILLON FEATURES

Villon is the software simulation tool chosen for yard simulation in OptiYard. It is a tool for creation and application of universal and detailed simulation models of transportation logistic terminals and their technological processes.

Villon supports microscopic modelling of various types of transportation logistic terminals containing railway and road infrastructures (e.g. marshalling yards, railway passenger stations, factories, container terminals, depots, airports, etc.).

Villon’s prime features are flexibility, detailed microscopic modelling of operation of various types of terminals, flowchart driven definition of operational procedures, user interaction, selection of decision strategies, 3D animation output, extensive result evaluation possibilities.

Therefore it is quite suitable for the purposes of OptiYard, in which the main upgrades required are the implementation of real-time functionalities and communication with the optimisation module.

Villon's modelling abilities cover broad range of transportation logistic terminals not limited to rail transport mode only, but comprising also road and other transport modes (e.g. cranes, special storage equipment, etc.).

The type of transportation logistic terminal, which is to be investigated, plays an important role. Typical types of systems are:

- marshalling yards
- passenger stations
- maintenance centre
- industrial sidings
- small railway networks (regional)

- production facilities
- container terminals
- harbour terminals
- road traffic (in limited area)
- airports (ground handling)
- storages
- and various combinations of above mentioned systems.

Villon's modelling abilities encompass rail, road as well as special (e.g. cranes) transport modes, respecting their distinct properties. In a single simulation model, all supported modes can be combined in order to evaluate their mutual interactions (e.g. blocking of road crossings by trains, occupation of shared unloading slot by trucks). This enables, for example to completely model the transportation processes inside a production facility including factory sidings operation (trains, locomotives), road traffic (trucks, fork-lifters, cars) and also other transportation (AGVs, cranes, conveyor belt systems).

Villon also supports modelling of storage systems found in production facilities, warehouses, logistic centres, container terminals and other transportation systems.

4.2 APPLICABILITY OF VILLON

The following table matches the characteristics of the terminals and yards identified in §2 with the characteristics of Villon required.

Table 2. Characteristics of the terminals/yards and Villon capabilities

Terminal / Yard	Type of traffic	Type of facility	Villon capabilities
Antwerp (Combinant)	intermodal units	road-rail terminal	synchronous and discrete-event simulation of: • intermodal operations • rail and road vehicles • utilisation of personnel
Antwerp (Hupac)	intermodal units	road -rail terminal	synchronous and discrete-event simulation of: • intermodal operations • rail and road vehicles • utilisation of personnel
Česká Třebová*	conventional trainload/wagonload	large marshalling yard	synchronous and discrete-event simulation of: • locomotive and wagon movement* • utilisation of personnel
Hallsberg	conventional trainload/wagonload	large marshalling yard	synchronous and discrete-event simulation of: • locomotive and wagon movement • utilisation of personnel
Riem	intermodal	road-rail terminal	synchronous and discrete-event simulation of: • intermodal operations • rail and road vehicles • utilisation of personnel
Trieste*	intermodal/ conventional trainload	port terminal with shunting yard connecting 3 docks and industrial sidings to the rail network	synchronous and discrete-event simulation of: • intermodal operations • rail* and road vehicles • utilisation of personnel
Valencia	intermodal/ conventional trainload	port terminal	synchronous and discrete-event simulation of: • intermodal operations • rail and road vehicles • utilisation of personnel

**OptiYard case studies and minimum simulation capability requirements*

This analysis shows that Villon does not need any particular requirements for its general applicability to all the cases described in §2; in terms of terminal layout, network connectivity and other relevant characteristics it is capable of simulating even more than is required for the purposes of OptiYard. No limitations were identified in this sense.

For the Česká-Třebová case study, the modelling will regard only rail operations, given the type of facility (marshalling yard). Regarding the Trieste case study, on-going work will lead to the detailed decisions on the degree, if any, to which the intermodal operations and road vehicle circulation would need to be modelled for the purposes of OptiYard.

5. CONCLUSION: REQUIREMENTS TO BE IMPLEMENTED IN OPTIYARD

In conclusion, the following main general requirements are identified in order to set up a suitable simulation environment for real-time yard and network management in OptiYard.

Yard simulation

- The *yard simulation module*, in connection with the *optimisation module* and the *network model*, **shall** be capable of real-time functionalities.
- The *yard simulation module* **shall** be capable of effective communication with the network and optimisation modules in the OptiYard architecture.

Network simulation

- The *network model concept* developed in OptiYard **shall** take into account RailTopoModel in its development.
- The *network model concept* **shall** take into account the data exchange issues involving national Infrastructure Manager IT systems, RNE tools (essentially TIS and PCS), other modes (most importantly Port Community Systems) and the use of general formats (e.g. RailML).

OptiYard project

- The *OptiYard project* **should** propose a roadmap towards compatibility of its yard simulation module with RailTopoModel.