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OptiYard - Optimised Real-time Yard and Network Management

Deliverable D2.2

Draft Recommendations for Improved Information and Communications for Real-Time Yard and Network Management

Task leader for this deliverable: Prof Ronghui Liu

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Report contributors		
Name	**Company**	**Details of Contribution**
Dr Fangni Zhang Prof Ronghui Liu, Dr Anthony E Whiteing	UNIVLEEDS	Drafting sections 1 and 2, and editing the whole document
Dr Raphael K David	UNEW	Drafting of section 3

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Executive Summary

This deliverable sets out the findings of OptiYard's Task 2.3. It builds on the project’s understanding of the physical characteristics of rail freight yards and terminals and the data required for the successful implementation of new concepts of real-time management of rail yards and their interfaces with the rail network.

The functions of rail yards and the typical operations performed in such yards, previously identified in Deliverable 2.1 are summarised and categorised in order to identify key issues affecting yard efficiency and capacity utilisation. Patterns for two-way interactions between yard and network in real-time are defined, so that the information about the current state-of-play in the yard can feed forward to the decisions on how to manage the network. The discussion of required enhancements in order to progress beyond the current state of the art is divided into two sections; firstly issues relating to the real-time operation of the yards themselves, and secondly improved two-way communications in real-time between the yards and the rail network.

The results of the above analyses are then summarised as a set of draft recommendations for improved yard and network information communication and management systems to be considered in subsequent work packages in the OptiYard project.

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Abbreviations and acronyms

ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
IM	Infrastructure Manager

1. Scope and Purpose

OptiYard works towards an integrated simulation model for detailed simulation of rail freight processes in yards and networks in real-time. This requires a detailed knowledge of both the rail operating process of single wagon load transport and communication methods between freight train operating companies and Infrastructure.

Rail yards are an essential element for Single Wagonload Transport. They receive hundreds of freight trains and handle thousands of wagons a day. Specifically, the freight wagons arrive at the yards with incoming freight trains in train sets. Once in the yard the wagons are divided into blocks, registered, re-ordered to form new blocks, if needed, sorted over a hump or by a shunting locomotive to form new freight trains and then routed to leave the yard to their next destination. Hence yards typically consist of different areas, namely a arrival yard, where the incoming trains are received, a set of sorting sidings, also called the classification yard where the wagons are classified and sorted and a departure yard, where the newly formed freight trains are inspected and prepared to leave the yard. The process of arrival and dispatching trains into/from the yard needs to be fully synchronised with the operating processes over the lines connecting the yard with the rail network. This is extremely important for providing a reliable service.

1.1. Objectives

The main purpose of this deliverable is to build the bridge between the current state of play and new development concepts that have been triggered. Specifically, it provides an understanding and draft recommendations of how we can go beyond the current operation patterns for rail freight yard and for network management when the focus is on those time-dependent activities and the importance of efficient data and information management mechanism in place. These recommendations will be further exploited in WP3, WP4 and WP5.

The key contribution of this deliverable is to reconsider and redefine the operating processes and data requirements to allow operations to be fully managed in real-time. A key rationale for real-time, integrated yard and network operation is to take advantage of opportunities on the network, which suggests a greater focus on organizing the work at the yard in such a way as to offer greater flexibility in the departure procedures for the outbound freight trains.

Hence, we need to develop a full understanding of how management objectives are influenced by the opening up of real-time network information. For example, a key objective at present might be to minimize shunting resources required in the yard, or to smooth the overall flow to prevent bottlenecks, taking train departure schedules into account as a constraint. Taking full advantage of real-time information on the network may mean a change of focus towards yard working to maximize flexibility in departure times instead.

We tackle this using a two-stage approach, in terms of roll-out of the real-time yard and network management system:

- The first stage is to define patterns for real-time yard operation, pulling real-time information from the network (e.g. on ETA, train formation), to optimize yard operations;

- The second stage is to define patterns for two-way interactions between yard and network in real-time, so that the information about the current state-of-play in the yard feeds forward to the decisions on how to manage the network.

Such a two-stage approach will allow full consideration of the issues set out above including those relating to potential changes in objectives, whilst allowing incremental implementation of the integrated system to the market.

1.2. Current yard operating processes/patterns and related information/data handling

We start from the current yard operating processes set out in Deliverable 2.1, which defines existing yard operating processes and information and data requirements for those. The current operation patterns for yard, and strategies (or lack of them) for network management are discussed with a focus on the extent to which any time-dependent considerations are considered.

In order to manage and control freight trains efficiently a significant number of activities need to be performed in the different parts of the rail yards (Figure 1) in order to reducing travel times and necessary transfer.

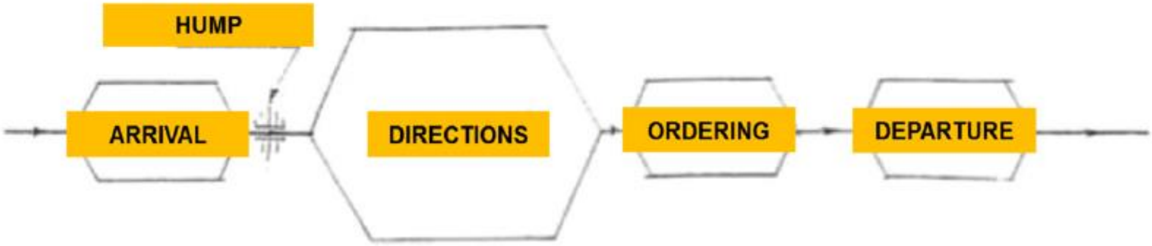

Figure 1: Rail yard processes (source: Marinov et al., 2013)

The full processes for the above rail yard operations are presented in Deliverable 2.1. We summarise the procedures relevant to OptiYard information and communication managements below, and have re-produced the relevant processes below.

Main operational procedures relevant to OptiYard information and communication managements, and the detailed processes are as follows:

(1) Train arrival and train split. Trains arrive in tracks of the arrival yard, where wagons and documents are checked. The train is split into groups of wagons, according to their final

destinations. The line loco moves away, while the shunting loco takes place behind the groups of wagons to shunt.

Activities performed on the arrival and the data required/ generated are as follows (adapted from OptiYard Deliverable 2.1)

Process	Resource(s)	Required data	Generated data
Decoupling of line locomotive	line loco driver, coupler, line loco, wagons of arriving train		
Moving line loco away	line loco driver, line loco	available route	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement
Splitting train for practical issue (e.g short arrival track)	yard loco driver, yard loco, coupler, brakeman, wagons of train	current status of topography elements of arrival part, track lengths	decoupling & marshalling of train part needed
Evacuate train brakes	brakeman, wagons of arriving train		
Preparing couplings between blocks for decoupling	coupler, wagons of arriving train	wagon list with characteristics	
Further handling processes?	wagons of arriving train	wagon list with characteristics	moving wagons to "suitable" tracks?
Decoupling of blocks for non-humping	coupler, wagons of arriving train	wagon list with characteristics	
Moving yard loco from yard loco location to arrival track	yard loco driver, yard loco	available route	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement
Moving non-humping blocks into sidings	yard loco driver, yard loco	available route for non-humping block	

Process	Resource(s)	Required data	Generated data
Moving hump loco from hump loco location to arrival track and moving blocks to hump	hump loco driver, hump loco	available route	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement
Decoupling of blocks at hump	coupler, wagons of arriving train	wagon list with characteristics	
Cut blocks into classification part	hump loco driver, hump loco	available route for block	

(2) Train classification and train build. Uncoupling of incoming trains' wagons refers to the separation of wagons or wagon blocks that do not share the same destination. Wagons that appear sequentially on a track and share the same destination are called a block. In most cases, those blocks stay together and are processed jointly throughout the yard. After the separation is completed, the wagons are pushed over the hump by a shunting engine. The hump enables the wagons to enter the classification bowl without any further external propulsion by following a downhill system of tracks and automated switches. When required they are braked using retarders placed alongside the tracks. In the classification yard tracks, sorted wagons accumulate to reach the critical size for a departing train.

On the classification tracks the activities performed are described in the following table (adapted from OptiYard Deliverable 2.1)

Process	Resource(s)	Required data	Generated data
Moving coupled blocks from hump into classification part	block, hauling facilities?	available route	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement, classification, mass, axle count, length, priority, load
Braking blocks	block, retarders	wagon list with characteristics, wind speed, wind direction, temperature	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement, classification, mass, axle count, length, priority, load

Process	Resource(s)	Required data	Generated data
Closing-up and coupling of blocks	blocks, coupler, closing-up systems	wagon list with characteristics	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement, classification, mass, axle count, length, priority, load
Decision for departure train composition	blocks	wagons with characteristics, positions on classification tracks, possible train paths	wagon list for departure train, potential demand for re-ordering of blocks (e.g. regional freight trains in order to decouple blocks in the order of passing loading points or long distance freight trains in order to reduce the sorting effort at highly frequented MYs). Can be done through second humping or shunting in classification part
Second humping or shunting of certain blocks in case of re-ordering	block, yard loco, yard loco driver	available route	real-time: time stamps, locations, velocities
Moving yard loco from yard loco location to classification track	yard loco driver, yard loco	available route	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement

(3) Train departure preparation. Wagons are moved to tracks in the departure yard, where documents are commonly checked, the line locomotive is coupled to the wagons, the brakes are tested, all other preparations are completed and the train is ready to depart.

The activities performed on the departure line are as follows (adapted from OptiYard Deliverable 2.1):

Process	Resource(s)	Required data	Generated data
Moving coupled blocks into departure part	block, yard loco, yard loco driver	available route	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement, classification, mass, axle count, length, priority, load

Process	Resource(s)	Required data	Generated data
Technical inspections	inspector, wagons	wagon list with characteristics	Clearance or on-hold or withdrawing defect wagons
Moving line loco to wagons	line loco driver, line loco	available route, topography of tracks, switches, signals	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement
Filling train brakes	brakeman, wagons of departure train		
Brake test	brakeman		Clearance or on-hold
Further handling processes?	wagons of departing train	wagon list with characteristics	moving wagons to "suitable" tracks?
Moving line loco to the departure wagons	line loco driver, line loco	available route	real-time: time stamps, location (long + lat, track number, yard part), velocities, direction of movement
Coupling of line loco	line loco driver, coupler, line loco, wagons of departure train		
Simplified brake test	brakeman, wagons, line loco, line loco driver		Clearance or on-hold

(4) Surrounding networks. The OptiYard eco-system includes an explicit simulation of the networks surrounding a yard, to model the train arrivals and departures for real-time updates on ETA and ETD.

The following table shows the process performed on line section (adapted from OptiYard Deliverable 2.1):

Process	Resource(s)	Required data	Generated data
Moving train from surrounding network to yard	line loco driver, line loco, wagons	ETA	real-time: time stamps, location (long + lat), velocities, distances, direction of movement

Process	Resource(s)	Required data	Generated data
Moving train from yard onto surrounding network	line loco driver, line loco, wagons	available and locked route, topography of tracks, switches, signals, requested train path for departure time from yard, timetable of available freight train paths	real-time: time stamps, location (long + lat), velocities, direction of movement, distances static: wagon list with characteristics

2. Beyond the State-of-the-Art

Here we present a list of issues to be considered, with a focus on time-dependent activities where a key obstacle to finding solutions lies in inadequate communication (in real-time) with the network, and in the need for integrated yard-network management.

2.1. Real-time optimisation of yard processes

As reviewed in the Real-Time Yard Management Deliverable 2.1, currently daily activities in yards are routinely planned in advance. However, many disturbances as well as deviations from regular plans appear, resulting in the need for ad hoc decisions and changes/adaptions of planned activities. Moreover, current practice is mainly based on experience of planners and dispatchers for the allocation of assets and personnel. For example, at Hallsberg MY planners and dispatchers plan the shunting of wagons for the departing trains approximately one day prior to the departure. The operational tasks are usually planned in the morning when the utilisation of the yard is at a relatively low level. The composition of trains changes as the operation date approaches. In fact, new orders from customers might cause the composition of trains to change as late as two hours before the departure time of a train. This complicates planning as the preconditions and constraints are constantly changing.

However, marshalling itself is a complex process, and making the most appropriate capacity allocation and prioritisation decisions is difficult. If there is only one railway undertaking using the yard, all decision processes and operations will be internal, but when multiple operators share the yard, some sort of cooperation or delimitation agreement must exist between different parties.

The yard processes/decisions that can benefit from real-time information and optimisation include the following:

- Obtaining approval from the infrastructure manager to run trains with non-regular train parameters. This is normally caused by the insufficient braking percentage and excessive train weight;
- Ad-hoc changes to the sequence/ prioritisation of yard operation to account for delay of incoming trains and lack of personnel resources;

- Ad-hoc additional planning/running of special trains caused by delays to incoming trains, delays to outgoing trains, or lack of personnel resources;
- Prioritisation of outgoing trains to accommodate delay of incoming trains, delay of outgoing trains, or lack of personnel resources;
- Path selection for delayed incoming trains to the arrival yard in case of early / late in relation to the departure times of the wagons;
- Track selection for incoming trains depending on direction of arrival;
- Sequencing of hump operations for the various arriving trains, in order to respect the times when the outbound trains need to be ready to be moved to the departure yard;
- Handling of damaged wagons if damaged wagons are detected in advance;
- Movement planning in the arrivals yard, given that other train movements such as the positioning of the hump shunting locomotive may conflict with the inward path of an arriving train;
- Developing transparent and effective procedures for unbiased handling of freight trains irrespective of train operating company.

2.2. Real-time network and yard communication

For both incoming and outgoing freight trains to and from the yard, there is currently limited digital information exchange between the main stakeholders involved such as yard operators, railway undertakings and network infrastructure managers. This implies that the yard operator cannot accurately know the exact ETA of either freight trains or wagons. Whilst there is normally an ETA for arriving freight trains, it is not necessarily updated in real time by railway undertakings and network infrastructure managers. Moreover, due to the various IT-systems and analogue routines for information exchange between yard and network, the yard operator cannot always be informed in advance regarding the loads on the trains, thus making the decisions regarding the planning of sorting and shunting cumbersome [Real-Time Yard Management Deliverable 2.1].

The information exchange required between network and yard is as follows;

- Real time traffic information
- Timetable of trains
- Information about trains approaching the yard
- Delay of incoming trains
- Train decomposition and wagon transfer/interchange
- Wagon groups and ordering within trains
- Trip plan for each wagon
- Wagon routes
- Wagon bookings on trains

From yard to network:

- Estimated departure time of sorted trains
- Information relating to trains and their wagons, such as train composition, train and wagon characteristics, for example braking capabilities, loading gauge, maximum axle loads and total weight
- Administration of timetable and shipment information

It can be expected that Real-time Yard Management in combination with an interacting Real-time Network Management will contribute to automation and digitalisation of monitoring and decision processes along the freight rail supply chain. Based on an advanced simulation/optimisation approach, positive impacts can be expected on punctuality, system efficiency and the overall competitiveness of freight rail transportation.

3. Draft Recommendations for Improved Network-Yard Information Communication and Management

Automatic and optimising decision support systems that can inform about the consequences of potential decisions are a good foundation for achieving enhanced yard capacity and efficiency and for the cooperation required at yards. The efficiency of yard operations is likely to be increased if good optimising planning is practised, which would reduce the capacity problems of shared resources.

An important element of such a system is the capabilities for handling information and communication among the main stakeholders i.e. the infrastructure manager, railway undertaker, and yard operator. Today the automation and digitalisation level, as mentioned above, is very low, which for instance implies that the yard operator cannot know accurate arrival times of neither freight trains nor wagons. In fact, the ETA is hardly viable for yard operators in the current system - considering the whole transport chain, it is an inefficient way to steer the allocation of yard resources in case of deviation. Regarding deviations on the ETA of incoming trains, the IT applications provide the trains' current position, but do not provide an ETA taking into account real traffic conditions during the train run (possession works, change of locomotive and staff, etc.). In addition, the current system does not cover the last mile from the main track to the yard infrastructure. Hence, secondary delays might be difficult to foresee for yard operators.

Moreover, with regard to delayed incoming and outgoing trains, several stakeholders need to be informed (such as yard operator, railway undertakings and infrastructure manager). Due to the various IT-systems and analogue routines for information exchange between yard and network, the yard operator cannot always be informed in advance regarding the loads on the trains, thus making the decisions regarding the planning of sorting and shunting cumbersome [Real-Time Yard Management Deliverable 2.1].

In current practice, the yard operator receives manually transferred information on the progress of the train from the IM. Moreover, information on train composition typically arrives quite late. This forces yard managers to preserve extra resources to face unexpected constraints due, e.g., to the volume and the concentration of arrivals, to operate safely and effectively. In order to provide a fully functional software module where real-time yard management, interaction with the network and ad-hoc timetable planning needs to be carried out in real-time. Several elements are needed:

- Optimisation module and algorithms at large and complex yard infrastructures. Furthermore, these must integrate well with the existing IT environment and with activities toward yard automation, e.g. intelligent assets and automated shunting in yards.

- Long distance monitoring of incoming trains from the external network on screens enabling to prepare pre-advanced work planning.

- Interaction with the IM to obtain a more accurate ETA as soon as the train enters the relevant network, enabling refined planning. This is done thanks to an algorithm enabling optimised operations and to return a new proposed ETD and ETA to the IM.

- Interaction with IM to find the best possible solution for yard management, train management and the client's demand.

- Interaction with the IM using real-time optimisation to deal with unexpected events during the approach of the train or the operation in the yard

- Reset the work plan and new ETD and ETA accepted by the IM, thus enabling the client to have accurate updated information on the situation and the future progress of the train.

In order to reduce the negative consequences of having trains running outside planned timetable slots, there are at least two approaches. One approach is to forbid trains to run outside the slots, forbidding trains to depart too early and possible penalize trains departing too late. However, operational experience with forbidding too early departures has shown that it is very hard, and may even have increased negative consequences [Real-Time Yard Management Deliverable 2.1].

Another approach is to improve the preparedness of the trains that do run outside the planned timetable slots, which is the cornerstone of proposed development scenario. The scenario for improved coordination between line and yard planning and operation includes the following aspects:

- As soon as the RU knows that it needs to operate a train outside the planned timetable slot, the RU reports this to the IM.

- Before departure for trains running outside the original timetable slot, a new conflict regulated, operational timetable slot should be created that secures that the train does not create and is not exposed to any unforeseen problems along the way to its destination.

- The new timetable slot should be the best possible, given the operational situation of the day and the allowed adjustments on other trains' timetable slots.

- Before departure, the arrival capacity of the arrival yard should be secured so that the trains should never have unplanned waiting time along the line, caused by limited arrival capacity of the yard.

The changes that are needed to enable the scenario include:

- Earlier and clearer communication between RU and IM about foreseen deviations in departure times – regarding departures that are moved forward as well as backward in time.

- Better coordinated decisions regarding deviating departure times and its consequences, both within the RU and within the IM (so that it is not just an agreement between the train driver and the local train dispatcher).

- When changing a departure time, the consequences of this on the line all the way from departure to destination should be analysed and understood.

- Better understanding of the consequences of the changed departure time also at the arrival yard.

- The risk of unplanned waiting along the line caused by limited arrival capacity at the arrival yard should be reduced.

- Better coordination and prioritisation of the RU's trains.

- Better coordination of the dispatching process at IM.

- Incorporation of clear rules for handling freight trains of different railway undertakings.

To conclude, there is a great potential for better coordination and making better informed decisions regarding the operational departure times for freight trains from yards. The development scenario includes both automation – mostly regarding information processing and communication – and optimisation/simulation – primarily regarding timetable calculation, yard capacity calculation and handling time estimation. The benefits from the improved scenario would be shared by the railway undertakings, the infrastructure manager and the railway system as a whole.

This innovative approach will enable stakeholders to optimize the use of the network capacity and yard resources whilst enhancing client satisfaction through delivery of accurate and timely information.

4. References

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