Performance Indicators & Expected Benefits

Feasibility Study to Rail Collaborative Decision Making (Rail CDM)

Work Package 2 Report

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1 Introduction

This document is the second deliverable and covers the scope of works of Work Package 2 in the project "Feasibility Study into Rail Collaborative Decision Making (CDM)" in contract 0072-10-20 for Rail Freight Corridor Rhine Alpine (RFC RALP), which started on 15 September 2020, and due to complete in May 2021.

1.1 Purpose of this document

This document describes a methodology for performance assessment of the Rail CDM concept, based on Airport CDM best practices, and provides an initial view on expected benefits.

The document builds further on the project activities in WP1 (Reference 4), in which we have set the scene for a basic approach for Rail CDM implementation along a set of transferability criteria. The conclusions drawn in this document will help to shape a more concrete Rail CDM Implementation Roadmap, foreseen in WP3.

1.2 Intended audience

The prime recipient of this report is the Rail Freight Corridor Rhine-Alpine. The audience for this deliverable consists further of:

- Rail Freight Corridor Rhine Alpine Steering Board, Executive and Management Board, as well as the funding Directorate DG Move in the European Commission;
- Stakeholders who participated actively or passively in this project;
- Other Rail Freight Corridors and interested stakeholders;
- Other stakeholders and their associations,;
- Non-freight rail stakeholders who see an interest in Rail CDM.

The document can be used by international as well as national and local stakeholders for decision making on future programs, international projects, or small-scale projects in different regions or corridors.

1.3 Contents

This document is structured as follows:

- Chapter 2 describes the performance management methodology
- Chapter 3 describes the strategic objectives and business drivers
- Chapter 4 describes the key performance indicators
- Chapter 5 describes the analysis of current rail performance initiatives
- Chapter 6 describes the expected benefits
- Chapter 7 describes the conclusions and recommendations.

Annex A describes references. Annex B provides acronyms for Rail CDM data elements. Annex C contains other abbreviations. In addition, Annex D lists ongoing initiatives and their touchpoints with Rail CDM.

2 Performance Management Methodology

This chapter describes the methodology how to determine performance indicators, as well as the organisation to monitor them and generate recurrent reporting. The rationale is taken from the aviation sector and is applied for Rail CDM performance monitoring in the following sections.

2.1 Rationale and background

A lesson learned from Airport CDM is that the value of performance management is often underestimated and therefore not always fully scoped in implementation projects. On a general level, operational performance monitoring allows:

- A shift from subjective, experience-based decision-making to objective, facts-based decision-making.
- Better detection of improvement areas and drafting focused action plans to mitigate.
- A data-driven approach to discuss and resolve operational issues.

On a Rail CDM-specific level, performance monitoring enables:

- The assessment of adherence to stakeholder requirements on operational procedures.
- The post-event evaluation of the operations, including the impact of adverse conditions and incidents and how to better anticipate in the future.
- The steering, monitoring and management on business objectives that were defined in the decision-making process to implement, and adjustment in the operational phase.
- A higher degree of stakeholder collaboration and transparency to reach common business targets.

Best practices from the aviation industry point out that the principles of transparent collaboration shall also extend to the measurement of Rail CDM performance. It is as relevant in the rail freight industry to move towards a ‘no blame’ culture, where best planned operating stakeholders are incentivised with best service. Performance monitoring and reporting will enable all stakeholders to learn from operational performance through data and facts.

Performance monitoring and reporting shall already prove its value during the implementation phase, as it allows to identify operational improvements in terms of efficiency and predictability in a ‘before and after Rail CDM implementation’ situation. It will also allow assessing the quality of the exchanged data during operational trials and providing an opportunity to adjust the initial procedures before the go-live of Rail CDM.

The way in which Rail CDM performance should be managed needs to take the complexity and multi-stakeholder aspects of European rail freight and its stakeholder landscape into account. Different focus areas and diverging site- or stakeholder-specific objectives require that performance management should be organised on a regional, national and European level, yet according to a harmonised set of criteria.

Rail CDM performance management is the main driver for continuous business process improvement beyond implementation (plan, do, check, act/adjust) as presented in and delivers the return on investment of implementing Rail CDM. It is a dynamic process and its scope and objectives shall be adjusted on a regular basis, within the framework of a performance management organisation

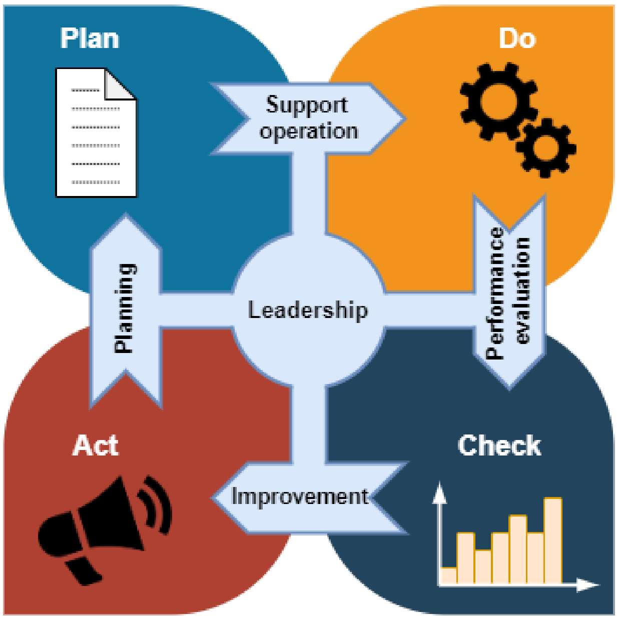

Figure 1: The Plan-Do-Check-Act circle of continuous improvement

2.2 Performance monitoring methodology

In this chapter, a performance monitoring methodology is presented, which consists of consisting of three abstraction levels in Figure 2. This structure finds its roots in operational performance management of airport operations and is applicable to the rail freight industry, based on our analysis of the transferability of Airport CDM to rail freight in WP1 (Reference 4).

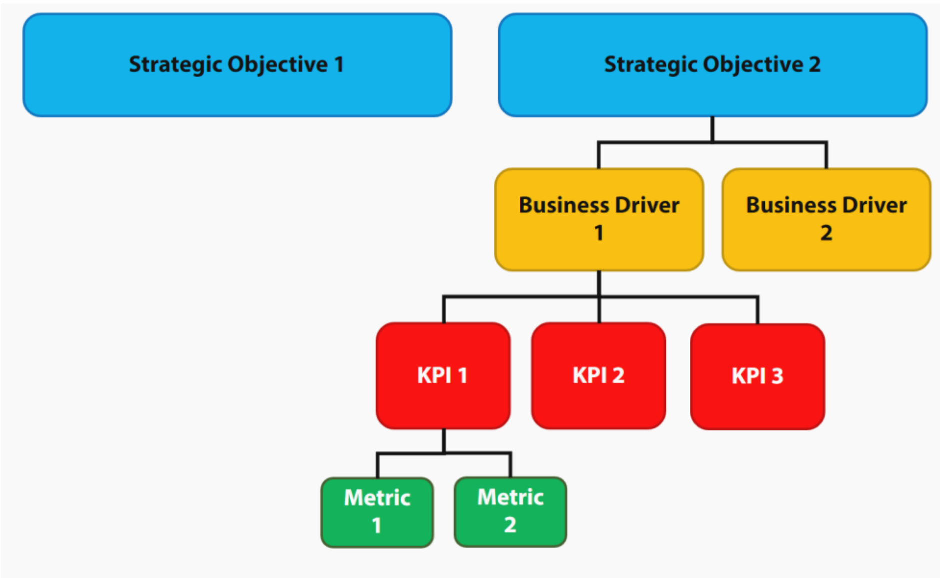

Figure 2: Structure of Strategic Objectives, Business Drivers and Key Performance Indicators and Metrics.

2.2.1 Strategic Objectives

Strategic objectives define what the rail freight stakeholders collaboratively aim to achieve through Rail CDM. This is the business strategy aimed on improving operational efficiency and predictability. Rail CDM strategic objectives may be complementary and partly overlapping to other existing business objectives.

2.2.2 Business Drivers

Business drivers constitute the Key Performance Areas (KPAs) in rail freight operations that can be achieved through Rail CDM and which support the delivery of the Strategic Objectives. Multiple business drivers can support one strategic objective.

2.2.3 Key Performance Indicators

Key performance indicators enable to quantify the operational improvements aimed at in the business drivers. Multiple KPIs can support one single business driver. At this level, each defined performance indicator shall be related to an individual objective of at least one Rail CDM stakeholder.

2.2.4 Metrics

To provide meaningful insights and understandable visualisations of what gets measured, KPIs are eventually expressed according to a standard of measurement parameters.

The scope of this document is limited to the description of proposed set of strategic objectives, business drivers and an initial list of KPIs, with the objective to define a performance baseline.

2.2.5 Working example in Airport CDM

Below is an example of how this methodology is put into practice in airport operations.

The success of Airport CDM is enhanced predictability of aircraft processes, to provide stability of the operations and allow better resource utilisation ('sweating the assets'). As such, predictability is defined as one of five strategic objectives to achieve through Airport CDM.

One of the supporting business drivers to deliver this strategic objective is the definition of indicators to increase the predictability of the expected time of departure of an aircraft. As known, in Airport CDM this is supported by tracking milestones and setting target times in the handling process.

The degree to which the stakeholders live up to setting high-quality departure time targets can be quantified in a KPI. This becomes an instrument to evaluate if the corresponding business driver is contributing to the delivery of its parent strategic objective.

This mechanism makes for a bottom-up justification for monitoring performance, as the results are sourced from the actual operations. This provides a means to continuously improve the operational procedures and processes, and accountability of stakeholders. We elaborate on such a structure in 2.3.

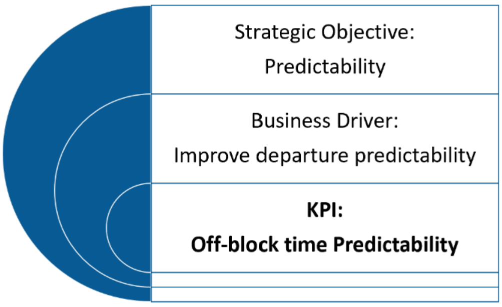

Figure 3: KPI, Business Driver and Strategic Objective definition in aviation

2.3 Performance management organisation

2.3.1 Introduction and justification

This chapter describes the functions that are needed for continuous Rail CDM performance monitoring, evaluation and steering, with the main objective being to achieve the expected benefits for Rail CDM. It discusses why performance monitoring is needed, the roles and modes of operation in the reporting and management mechanism. Finally, an organisational structure is proposed applicable for international, national and local organisation levels.

Monitoring of performance will already prove its value during the implementation of Rail CDM, during which project teams will require frequent performance reports to understand the mode of operation and prepare for testing of new systems and validation of Rail CDM procedures in live trials. Nevertheless, more importantly, it supports long-term steering on benefits through its structure of strategic objectives, business drivers and KPIs. Only long-term steering on compliance to procedures and adherence to accuracy targets will influence the culture of operations and operational behaviour of people.

It has to be noted that the organisation of Rail CDM performance management shall be a collaborative initiative, at all times involving all stakeholders. As such, only collaboratively agreed-upon KPIs and targets will be monitored and discussed.

This performance framework does evidently not replace any existing monitoring on performance indicators, nor does it prevent individual stakeholders to implement performance indicators for internal purposes.

2.3.2 Involved actors in performance reporting

Analysts

Analysts should be appointed by Rail CDM stakeholders and be tasked with the creation of frequent reporting, including visualisation of metrics and descriptions of findings. They will be expected to present their findings to business experts and/or managers to explain how the data is collected, and what can be learned from the results.

Experts

Business or operational experts have a deep understanding of rail freight operations and are aware of the business objectives of Rail CDM. In principal, their role is to interpret data provided by the analysts, determine the causes of identified performance issues and interpret the impact of these issues on the achievement of the objectives.

Experts will collaborate with analysts to determine new performance indicators or re-model existing indicators, focus on adverse conditions operations and recovery, and, where needed, analyse specific incidents to understand their cause.

Managers

Operational managers shall have a clear understanding of the value of operational performance and the impact of inefficiencies on internal and external organisations involved in the process. They will receive recommendations and conclusions from experts, which are in turn based upon the analysts' reports. The managers will steer on strategic objectives and performance targets, guard against any drop in procedure compliance and initiate corrective action when stakeholders are structurally underperforming.

2.3.3 Process and organisation

To reap the benefits from Rail CDM implementation, operational behaviour of stakeholders about procedure adherence and delivery of timely and qualitative data needs to be monitored, reported upon, evaluated and steered when deemed necessary.

A steering function, in which all stakeholders shall have equal involvement and decisive power, and issue jointly agreed-upon instructions, implies that compliance is at least highly encouraged or imposed, if it is generally acknowledged that realisation of strategic objectives is endangered by non-compliant behaviour. Such steering function needs to be organised on international level for international operations and compliance, as well on national and local level where operations need to be optimized. WP3 report Feasibility Study to Rail CDM – Requirements and Implementation Roadmap, chapter 2.5 (reference 5), describes the need for an International Coordination Support Function and multiple levels of stakeholders.

Evidently, a learning curve needs to be factored in when deploying a multi-stakeholder performance organisation. The most effective way to support the business change is to adopt a “Best Planned Best Served” policy, which rewards stakeholders for complying with operational procedures.

Data collection

Data analysts shall design and deploy the KPIs and the calculation methods and collect data from operational systems for that purpose. To make a head start, the initial set of Rail CDM KPIs can be drawn from proposed set of indicators outlined in chapter 4, and later fine-tuned in collaboration with the experts.

The data elements that are retrieved from operational systems should comply with harmonised terminology, acronyms and abbreviations in order to enable common understanding and interpretation by all stakeholders.

Visualisation and reporting

Rail CDM performance reports shall be built in such a way that the business experts can adequately review the results and draw facts-based conclusions. The use of a powerful business intelligence tool to aggregate the data and produce the performance visualisations is indispensable.

Next to post-operational reporting, attempts should be made to present real-time performance results on dashboards for operational supervisors and planning departments, to respectively support decision-making on day 0 and learn from operations to improve day –1 planning and predictions.

Evaluating performance and formulating recommendations

The business experts are the committed interface that translates the performance results into actionable information. It serves as a trigger to decide whether existing KPIs should be adjusted, new KPIs should be developed or, reversely, procedures should be adapted to reflect changing business needs or operational context. On a higher level, this evaluation function is responsible for the creation of management input and pitching this input to management.

This evaluation process is a pivotal function in the overall performance management mechanism.

Steering

Operational performance managers may decide upon mitigation and changes to safeguard the strategic objectives of Rail CDM and to impose adherence tolerances on target values, as well as procedure compliance. These actions shall always be in line with the agreed-upon operational concept for Rail CDM, facts-based (i.e. based on the reporting results) and properly motivated.

2.3.4 Proposed organisational structure

The abovementioned scope, requirements and characteristics for the management of Rail CDM performance result in a structure as presented in Figure 4.

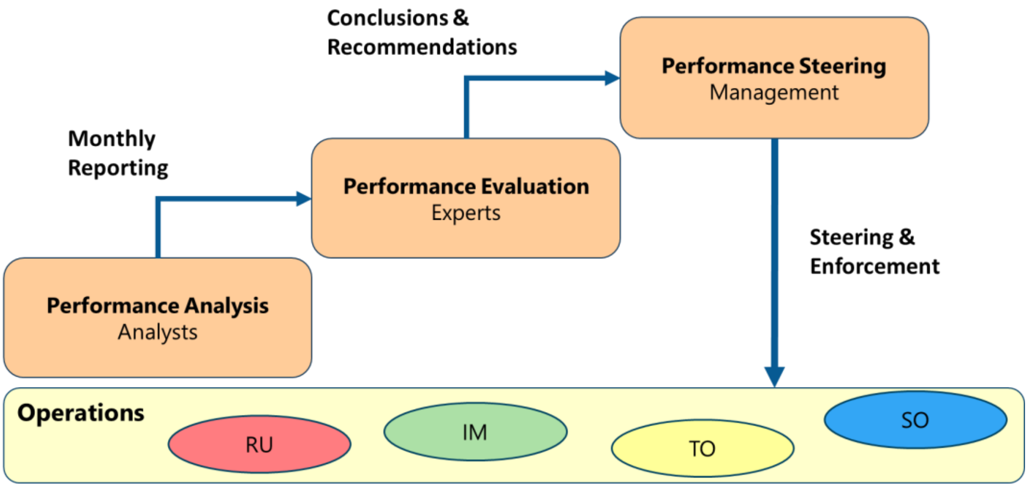

Figure 4: Proposed performance organisation for Rail CDM

Notice the continuous feedback loop, where:

1. Operational data is retrieved from the operational stakeholders and analysed;
2. This analysis is aggregated into reports which get evaluated, in order to whether or not decide on mitigating measures;
3. Behaviour is steered by imposing compliance;
4. The required actions are fed back into the operations;
5. The effectiveness of the actions in a next reporting cycle is assessed.

This reporting cycle and the above-described analysis, evaluation and steering functions make abstraction of any existing forums in which performance management should be treated. The proposed mechanism is adoptable on a regional, national as well as an international level, and the exact organisation shall be decided among the stakeholders.

3 Proposed Strategic Objectives & Business Drivers

This chapter outlines an initial set of strategic objectives and business drivers for measuring the performance of Rail CDM. The purpose of this initial set is to provide a basis that can be elaborated in future projects. In addition, expected benefits and use cases in chapter 6 find their origin in this chapter.

3.1 Input References

Baseline material for this chapter is obtained from the EUROCONTROL Airport CDM Implementation Manual, where detailed performance indicators are described (Reference 2).

Next to this, an online workshop was organised on 02 March 2021, with the aim to seek the active contribution of the Rail CDM stakeholder that also contributed in WP1. During this session, the performance-monitoring concept as described in chapter 2 was presented. The attendees were requested to interactively discuss expectations, priorities and concerns in relation to:

- The proposed performance methodology and monitoring organisation structure.
- The areas of performance that should be monitored and reported within rail freight operations.
- Transparency among all stakeholders to define areas of improvement.
- The design and visualisation of performance indicators.

The workshop proved to be the start for obtaining stakeholder feedback. More iterations by means of bilateral meetings and direct discussions amongst stakeholders are required to obtain more granular and representative input, but also as an opportunity to clearly define what is in scope and what is not.

As an example, one of the stakeholders addressed safety as a strategic objective. Despite being a fundamental aspect of operational activities, increased safety is not an output as such from a collaborative decision making environment. Safety is therefore not defined as a Strategic Objective in this document, yet complementary.

Performance reporting aspects, different in nature from those in the aviation industry, were touched upon as well. In aviation, performance converges on the ‘operational status’ of the aircraft – e.g. punctuality or predictability – and leaves performance on passenger and cargo handling processes out of the loop. However, given the characteristics of rail freight, operational performance in Rail CDM should not only focus on train movements but as well on freight movements and (shunting) locomotives.

To illustrate this, an example was given whereby freight was transported from terminal A to B via two stretches, where it caught a significant delay in at the transfer location. The delayed cargo was loaded onto another train, which arrived punctually at terminal B. This notion of performance management is understood, but not reflected in the proposed KPIs in chapter 5. Evidently, this shall be incorporated in future iterations of the design of the performance-monitoring framework.

3.2 Stakeholders’ business interest in performance monitoring

Following the conclusions of the WP1 deliverables, we have identified five parties in rail freight that have an interest in a good performance of Rail CDM, as they are directly involved in operations / the organisation of the train run:

- **Infrastructure Managers (IM)**: The IMs aim to provide a safe and efficient use of the track and signal infrastructure, such that capacity is maximised and delays are minimised. Better insights in the progress of the loading and unloading process and shunting operations allow the IMs to better manage capacity.

- **Railway Undertakings (RU)**: The objective of the RUs is to execute freight train journeys according to the schedule, but also factoring in late change requests from their customers. Delays cause extra costs to the RUs, such as missed connections, labour and rolling stock idle time. Enhanced situational awareness of e.g. traffic and infrastructure constraints allows the RUs to become more pro-active in order to mitigate delays.
- **Shunting Operators (SO)**: The objective of the SOs is to safely move rolling stock between yards and Transhipment tracks. Train composition also lies within their area of responsibility. More punctual and predictable mainline and terminal operations help to introduce more efficiency in SO processes.
- **Terminal Operators (TO)**: The TOs aim to provide the required on- and offload infrastructure and capacity, for RUs to turnaround freight trains at a minimal cost. Enhanced visibility and predictability of the progress of train journeys supports better resource planning and utilisation.
- **Intermodal Operators (IO)**: The goal of the IOs is to ensure the efficient and safe interchange of rail freight between rail, road and other transport modes. Their operations are highly influenced by the schedules of these transport modes and IOs can benefit from more stable and predictable operations in the rail freight segment of their activities. Often, rail freight wagons belong to intermodal operators, so that they are also concerned about wagon availability according to plans / resource efficiency.

3.3 Proposed strategic objectives

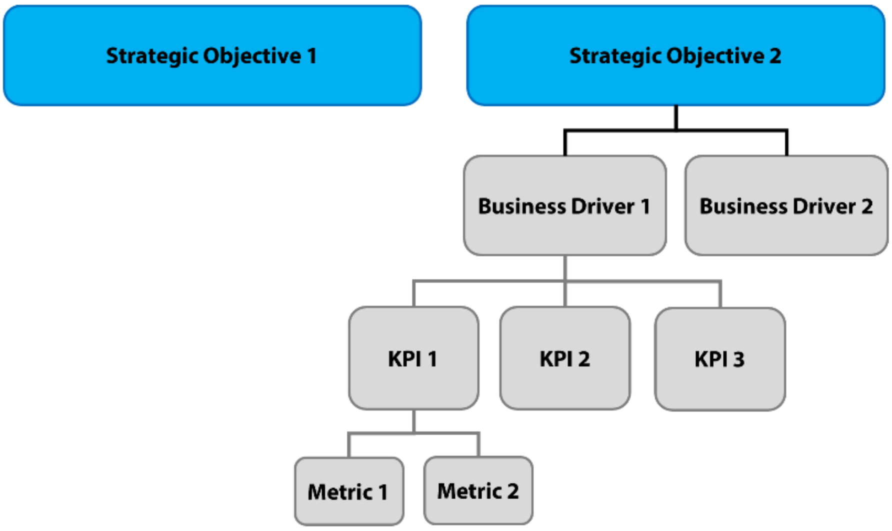

Figure 5: Strategic Objectives level in the performance reporting structure

3.3.1 Strategic Objective 1 – Improve Predictability

Predictability is the timeliness to which an accurate estimate of a milestone can be given. Rail CDM supports this strategic objective by providing estimates for such milestones and by enabling measurements of the accuracy of these milestones. Improving predictability enables better planning, which in turn improves efficiency of the overall rail freight operation.

3.3.2 Strategic Objective 2 – Improve Resource Efficiency

By better planning, enabled through more predictable, hence stable operations, the use of resources like locomotives, loco drivers, wagons, terminal on-/off-load infrastructure can be optimised. This does not only benefit the TOs, the IOs and RUs, but also the shunting operators and the operations/planning of the IMs.

3.3.3 Strategic Objective 3 – Increase Capacity

Accurate planning through Rail CDM supports optimised use of available railway and terminal infrastructure. This optimisation reduces train departure delay in terminals and shunting areas, but also a more efficient utilisation of mainline capacity. This strategic objective delivers benefits across the full rail freight stakeholder landscape, explicitly including IMs.

3.3.4 Strategic Objective 4 – Improve Punctuality

Punctuality is the ability to achieve scheduled times. This benefits the Railway Undertakings as they can offer punctuality as a service to their customer. TOs and SOs can offer punctuality as a service level to the Railway Undertakings. While Rail CDM does not directly aim to improve punctuality, the improvement in efficiency in the planning process is expected to reduce delay and therefore improve punctuality.

3.4 Proposed business drivers

As outlined in 2.2, the strategic objectives can be achieved through improvement of several concrete business drivers. Grouped according to strategic objectives, this chapter describes each of the eight proposed business drivers.

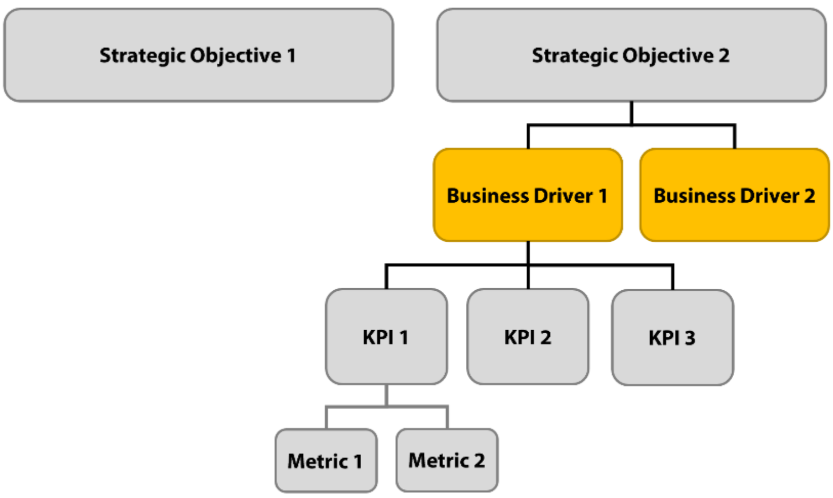

Figure 6: Business Driver level in the performance reporting structure

3.4.1 Business Driver 1 – Improve Arrival Predictability

This Business Driver relates to Strategic Objective 1 – Improve Predictability.

For the purpose of reliable predictions that enable management decision making on resources, predictions need to be assessed on accuracy. Structural reduction of the prediction error compared to the actual enhances the reliability for managers within stakeholder groups.

An improvement in the predictability of train arrival provides more reliable information for the Terminal Operator to manage tracks, cranes, and human resource allocation planning. The Intermodal Operators will have better insights in their predicted freight transfer rate to other modes of transport such as sea ships, barges and trucks. In addition, the Shunting Operators will have better information for their resource planning and decision-making tools.

3.4.2 Business Driver 2 – Improve Turnaround Predictability

This Business Driver relates to Strategic Objective 1 – Improve Predictability.

For the purpose of reliable predictions that enable management decision making on resources, predictions need to be assessed on accuracy. Structural reduction of the prediction error compared to the actual enhances the reliability for managers within stakeholders.

An improvement in the predictability of the turnaround of trains and wagons provides stakeholders more control over their processes and therefore their on-time performance. It enables Terminal and Intermodal operators to improve the planning of their resources.

3.4.3 Business Driver 3 – Improve Departure Predictability

This Business Driver relates to Strategic Objective 1 – Improve Predictability.

For the purpose of reliable predictions that enable management decision making on resources, predictions need to be assessed on accuracy. Structural reduction of the prediction error compared to the actual enhances the reliability for managers within stakeholders.

An improvement in the predictability of departures is of key importance to all main stakeholders. The Terminal and Intermodal Operators can use this as a source for platform planning of subsequent train arrivals, the Shunting operator as a supporting means for their planning tool for planning and resource allocation. The Railway Undertakings can improve the robustness of their network operation and lastly the Infrastructure Managers can optimise infrastructure utilisation and increase capacity. All can move from a reactive to a more pro-active operational planning.

3.4.4 Business Driver 4 – Optimise Resource Utilisation

This Business Driver relates to Strategic Objective 2 – Improve Resource Efficiency

Increased predictability of the start and end times of the sub-processes in terminals and shunting yards creates better situational awareness and, as such, supports better planning by all stakeholders. This improves efficiency of resource deployment and prevents delays in the turnaround process due to last minute movement of equipment or labour (e.g. due to last-minute operational changes).

3.4.5 Business Driver 5 – Optimise Capacity Utilisation

This Business Driver relates to Strategic Objective 3 – Increase Capacity

For the purpose of increased capacity that enables management decision making on planning buffers, reliable predictions need to result in more capacity that is available.

By preventing unnecessary gaps through planning errors, the departure of freight trains can be planned with minimal infrastructure capacity wastage at the IMs. This reduces delay to the RUs and potentially increases effective capacity for the IOs and RUs. Capacity that becomes structurally available will lead to more planning confidence and, as such, to reduced planning buffers, which in turn has a positive effect on capacity.

3.4.6 Business Driver 6 – Reduce Operational Delay

This Business Driver relates to Strategic Objective 4 – Improve punctuality

On a general level, the need for planning buffers will be reduced when the operations become more predictable. Simultaneously, the structural reduction of possible unforeseen delays at all stakeholders, for which buffers are now often included in the operational planning, enhances operational and cost efficiency.

3.4.7 Business Driver 7 – Reduce Reactionary Delay

This Business Driver relates to Strategic Objective 4 – Improve punctuality

Reactionary delay is a delay caused by a delayed inbound train, when the arrival delay plus the minimum time required for loading and unloading exceeds the planned departure time. Enhanced awareness of the arrival time of trains allows a better shunting and terminal resource planning to ensure that the knock-on delay for the next departure is kept to a minimum. For Railway Undertakings as well as Intermodal Operators, network resilience is key and a reduction of reactionary delay provides more robustness to the network

3.4.8 Business Driver 8 – Improve On-Time Performance (OTP)

This Business Driver relates to Strategic Objective 4 – Improve punctuality

Enhanced situational awareness and stable arrival and departure predictions are enablers for on-time performance. OTP is a crucial commercial driver for the rail freight sector. Guaranteeing punctual freight transfers and on-time arrival of cargo at its final destination is going to attract more customers. Additionally, Railway Undertakings, Terminal and Intermodal Operators can demonstrate their ability to deliver punctual services as a key reason for freight customers to select their services.

3.5 Measuring Key Performance Indicators

From a general point of view, performance in Rail CDM is best measured along two main axes. On one hand, the quality of data on which decisions are based and on the other hand the accuracy of the operational estimates, affected by the decisions. Additionally, measurements should also focus on the compliance with procedures on the exchange of operational information.

This chapter provides a preview into the nature of the KPIs and the parameters that should be taken into account when designing the various indicators. A first sub chapter looks at the types of data. Next, there is brief analysis of the appropriate techniques for analysing each type. The last section briefly touches appropriate descriptive techniques for that analysis.

The decoding of the acronyms can be found in annex B .

3.5.1 Parameter types in Rail CDM

The Rail CDM process will generate three or four different types of parameters: milestones, estimations, targets and actuals. Since the functional purpose of these types differ, the analysis for performance differs as well.

Milestones

A milestone is a significant event in the rail freight transport process. Reaching a milestone results in the logging of a timestamp, an actual, that can be collected in an operational database. Post-operationally, these actual times are available for analysis. Examples are AEMT, ARST or ASST.

The analysis of milestone times provides information on actual duration of the different phases. The typical duration between milestones can support estimation of the next milestone (e.g. TMAT). The variation in duration between milestones indicates the predictability of the phase, e.g. the variation of the Actual Shunting Time indicates the ability to predict the Estimated Shunting Time for future operations. Key aspects of the times between milestones are therefore: central value (i.e. mean or median) and variation (e.g. standard deviation or percentiles).

Estimations

During the operation, the time at which a milestone will be reached can be estimated or predicted. This time should be based on the best estimate available at a given moment and are therefore updated whenever better information is available. The estimation may consist of simple static data based on historic analysis but could also follow complex trajectory prediction for example. Accurate estimations enable the development of proactive operations. An example is the Estimated Time of Arrival (ETA).

Estimations follow from an analysis of the typical duration between milestones (e.g. the Estimated Shunting Time) and/or modelling of the remaining processes toward the milestone (e.g. the Estimated Leave Mainline Time). Estimations support pro-active operations and therefore have to be reliable. This requires estimations to be accurate and stable.

Targets

The planning takes further shape through more explicit predictions, reflected in target times at which milestones should be achieved. These targets therefore always involve a decision. A human operator could actively take the decision or it is generated automatically using pre-defined rules. Operational processes support the delivery, accuracy and stability of the target times and serve as an ‘SLA’ between parties. As parties in the turnaround plan their processes to these targets, the targets ideally change as little as possible. Examples are TRST, TMAT, and TRMT.

In order for an operational plan to be adequately robust, it requires stakeholders to meet the target times they have published. Key performance information on the targets expresses whether they are useable to parties (stability) and whether those parties meet them (adherence).

3.5.2 Prediction Differences

An important distinction needs to be understood by stakeholders:

- Estimations are predictions for information only, input for recipient stakeholders to base resource planning on;
- Targets are predictions for accountability. They should meet the agreed accuracy tolerance values, and evaluation accountability may conclude non-adherence by the responsible stakeholders.

Non-adherence has consequences for other operations, since knock-on effects or reactionary delays may follow. The performance steering function may consider acting on non-adherence.

4 Proposed Key Performance Indicators

This chapter describes the Key Performance Indicators, which support the quantification of the business drivers. They are in turn related to the four Strategic Objectives listed in chapter 3.3.

Due to the multi stakeholder structure of the railway sector and the complex nature, a significantly number of milestones have been identified in the rail freight transport process, as presented in Figure 7. Based on the eight business drivers listed in chapter 3.4, many types of KPIs can therefore be designed.

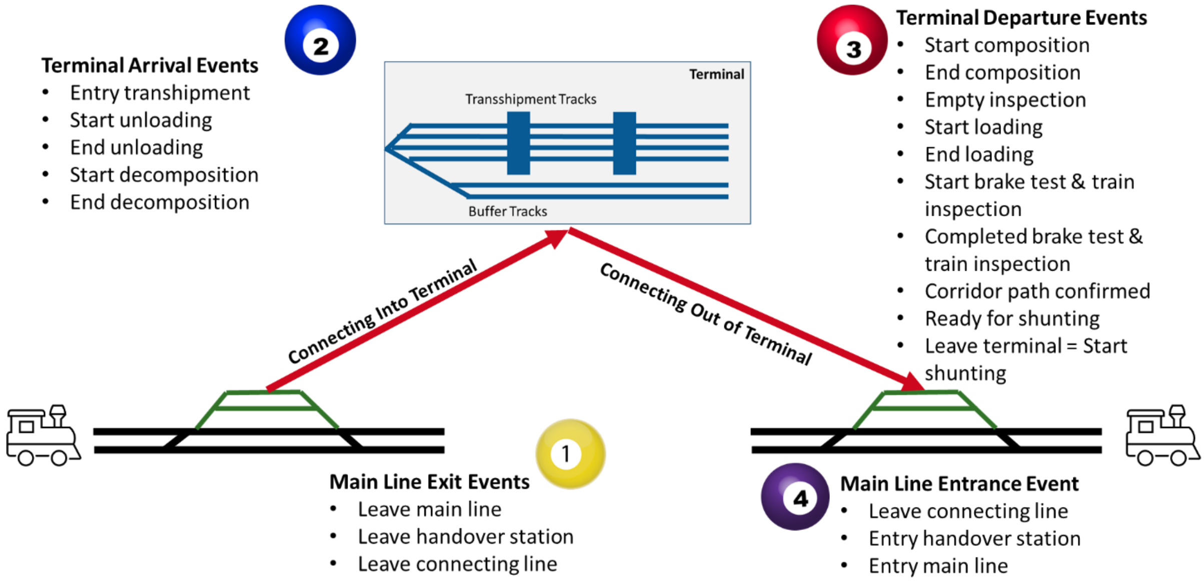

Figure 7: Turnaround Milestones where Actual Events can be assessed against predictions

Taking into account that aligning all stakeholders on which performance indicators to use is not always easy, this chapter covers a non-exhaustive list of initially 27 proposed Key Performance Indicators, for which common understanding and agreement to deploy across the community can be sought.

The proposed KPIs are in any event strongly representative for the most important aspects of Rail CDM, covering the operations of all stakeholders and introducing the crucial predictability component of the concept. The below list of KPIs should therefore be considered as highly recommended and prioritised for implementation.

The KPI IDs reflect their parent business driver in the first digit, the second digit is their sequence number, e.g. KPI3-7 is KPI number 7, related to business driver 3. A glossary for the acronyms is provided in Annex B .

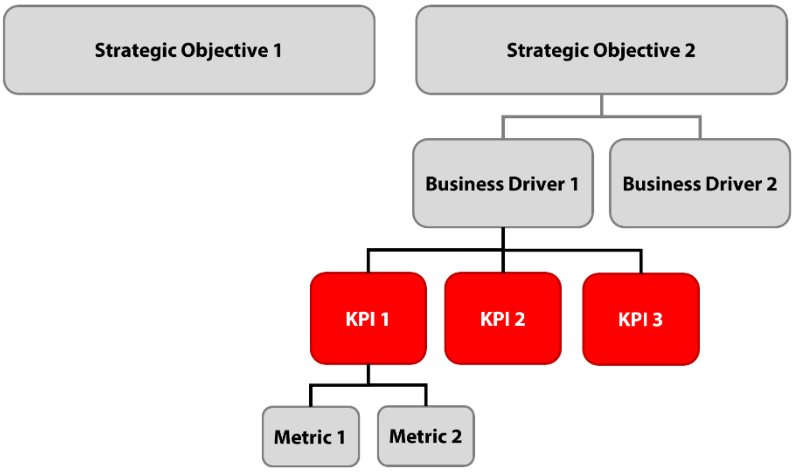

Figure 8: KPI level in the performance reporting structure

4.1 Business Driver 1 – Improve Arrival predictability

The following key performance indicators (non-exhaustive) support the quantification of this business driver:

4.1.1 KPI1-1 – Predictability of the train leaving the mainline

The Actual Leave Mainline Time (ALMT) is a highly recommended milestone, which contributes to accuracy of the Start Unloading Time, Start Decomposition Time and further downstream predictions. The Estimated Leave Mainline Time (ELMT) predicts the milestone that needs to be assessed for accuracy.

ELMT is the starting point for all predictions concerning a turnaround. A large component of the uncertainty in the Estimated Start Unloading Time (ESUT) originates in the uncertainty in Leave Mainline Time. A timely and accurate ELMT will therefore support all further processes and resource allocation planning for all stakeholders.

This KPI is based on train run information from the IMs, potentially depending on additional data sources for predictability, and may not be quantifiable yet. Initiatives on ETA estimations are ongoing and are suitable as a starting point for the development of the Rail CDM performance management.

4.1.2 KPI1-2 – Predictability of the handover time from RU to SO

The Actual Enter Handover station Time (AEHT) is a highly recommended milestone, which contributes to accuracy of Start Unloading Time, Start Decomposition Time and further downstream predictions. The Estimated Enter Handover station Time (EEHT) predicts the milestone that needs to be assessed for accuracy.

The EEHT provides an update of the turnaround predictions that were initially set by the ELMT.

The generation of good-quality EEHTs is crucial, as failing to do so reduces the ability to plan resources in the (un-)loading process. Timely and stable EEHTs will therefore support all further processes and resource allocation planning for all stakeholders

This KPI depends on new data sources and may not be quantifiable yet.

4.1.3 KPI1-3 – Predictability of the train leaving the connecting line

The Actual Leave Connection line Time (ALCT) is a highly recommended milestone, which contributes to accuracy of Start Unloading Time, Start Decomposition Time and further downstream predictions. The Estimated Leave Connection line Time (ELCT) predicts the milestone that needs to be assessed for accuracy.

The ELCT provides an update of the turnaround predictions that were initially set by the ELMT and updated through the EEHT.

The generation of good-quality ELCTs is crucial, as failing to do so reduces the ability to plan resources in the (un-)loading process. Timely and stable ELCTs will therefore support all further processes and resource allocation planning for all stakeholders

This KPI depends on new data sources and may not be quantifiable yet.

4.2 Business Driver 2 – Improve Turnaround Predictability

The following key performance indicators (non-exhaustive) support the quantification of this business driver:

4.2.1 KPI2-4 – Predictability of the start of unloading

The Actual Start of the Unloading Time (ASUT) is a highly recommended milestone, which contributes to accuracy of the planning of the loading phase and further downstream predictions. The Estimated Start of Unloading Time (ESUT) predicts the ASUT milestone that needs to be assessed post-operationally for accuracy.

The ESUT triggers updates of the turnaround predictions that were initially set by upstream estimates such as ELMT and EEHT.

The generation of good-quality ESUTs is crucial, as failing to do so reduces the ability to plan resources in the loading and departure process. Timely and stable ESUTs will therefore support all further processes and resource allocation planning for all stakeholders

This KPI depends on data sources and may not always be quantifiable. Data from TO business information systems could be used as starting point for the development of the Rail CDM performance management.

4.2.2 KPI2-5 – Predictability of the start loading time

The Actual Start of the Loading Time (ASLT) is a highly recommended milestone, which contributes to accuracy of the planning of the departure phase of the train, and further downstream predictions, e.g. on entry of the mainline. The Estimated Start of Loading Time (ESLT) predicts the ASLT milestone that needs to be assessed post-operationally for accuracy.

The ESLT triggers updates of the turnaround predictions that were initially set by upstream estimates such as ELMT, EEHT and ESUT.

The generation of good-quality ESLTs is crucial, as failing to do so reduces the ability to plan more predictable departure times and provide planning stability. Timely and stable ESLTs will therefore support the execution of downstream processes.

This KPI depends on new data sources and may not be quantifiable yet. Data from TO business information systems could be used as starting point for the development of the Rail CDM performance management.

4.2.3 KPI2-6 – Predictability of the end of loading time

The Actual End of the Loading Time (AELT) is a highly recommended milestone, which contributes to accuracy of the planning of the departure phase of the train, and further downstream predictions, e.g. on entry of the mainline. The Estimated End of Loading Time (EELT) predicts the AELT milestone that needs to be assessed post-operationally for accuracy.

The EELT highly contributes to the prediction of train readiness and increases the quality of earlier departure predictions that were set through upstream estimates such as ELMT, EEHT, and ESUT and ESLT.

The generation of good-quality EELTs is crucial, as failing to do so reduces the ability to plan more predictable departure times and provide planning stability. Timely and stable EELTs will therefore support the execution of downstream processes.

This KPI depends on new data sources and may not be quantifiable yet. Data from TO business information systems could be used as starting point for the development of the Rail CDM performance management.

4.3 Business Driver 3 – Improve Departure Predictability

Arrival and turnaround predictability are monitored for purpose of resource utilisation (see KPI section 4.4), yet also to enable departure predictability. When arrival or turnaround predictions are inaccurate, so will be the departure predictions.

In Figure 9 the Airport CDM indicators are presented based on the milestones, in a timeline for departure flights. From the described milestones in the Rail CDM, the approach for KP's for departure predictability can be determined in a similar manner. A timeline is drafted in the WP1 report for Rail CDM approach (Reference 4), see Figure 10.

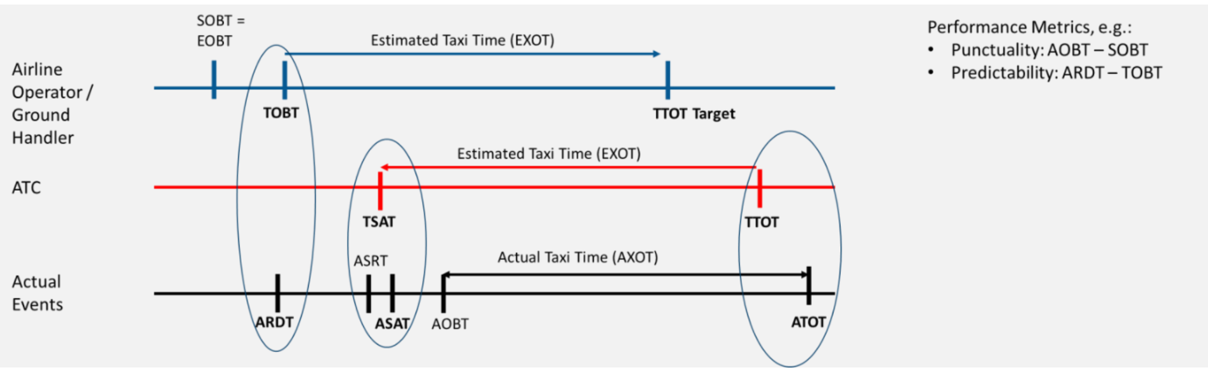

Figure 9: Airport CDM Departure Prediction Indicators per stakeholder

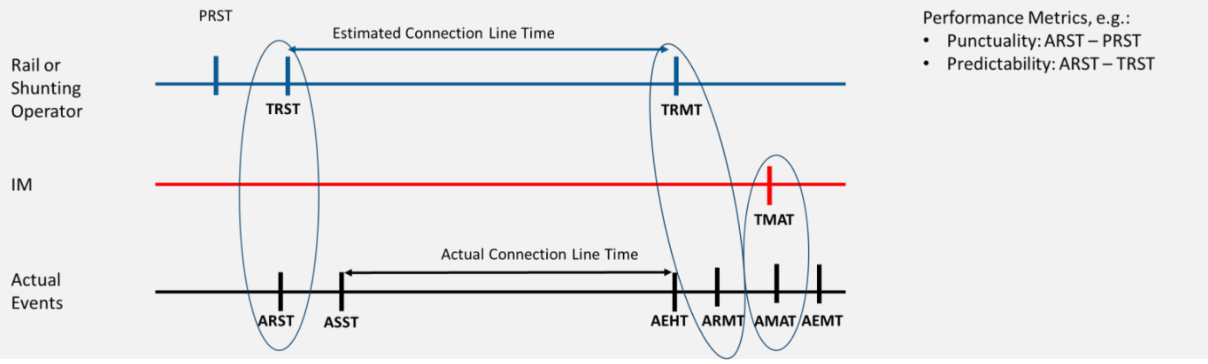

Figure 10: Departure Predictions of Actual Train Journey Milestones for multiple stakeholders

The following key performance indicators support the quantification of this business driver.

4.3.1 KPI3-7 – Predictability of ready-time for shunting to handover station

The Actual Ready for Shunting Time (ARST) is a highly recommended milestone, which fine-tunes the accuracy of the planning of the departure phase of the train, and further downstream predictions, e.g. on entry of the mainline. The Target Ready for Shunting Time (TRST) predicts the ARST milestone that needs to be assessed post-operationally for accuracy.

Furthermore, the ready for shunting time is the first target time in Rail CDM (TRST) that needs to be set, managed and shall be evaluated on accuracy and stability.

The TRST provides a critical indication of the expected entry of the train on the mainline and increases the quality of earlier departure predictions that were set through upstream estimates such as ELMT, EEHT, ESUT, ESLT and EELT.

The generation of good-quality TRSTs is crucial, as failing to do so reduces the ability to plan more predictable departure times and provide planning stability. Timely and stable TRSTs will therefore support the execution of downstream processes.

This KPI depends on new data sources, automated calculations and may not be quantifiable in early implementations.

4.3.2 KPI3-8 – Predictability of the ready-time to enter the mainline

The Actual Ready for Mainline Time (ARMT) is a highly recommended milestone and expresses confirmed readiness to enter the mainline. The Target Ready for Mainline Time (TRMT) predicts the ARMT milestone that needs to be assessed post-operationally for accuracy.

Furthermore, the ready for mainline time is the second target time in Rail CDM (TRMT) that needs to be set, managed and shall be evaluated on accuracy and stability.

The TRMT provides a critical indication of the expected entry of the train on the mainline and increases the quality of earlier departure predictions that were set through upstream estimates such as ELMT, EEHT, ESUT, ESLT and EELT and TRST.

The generation of good-quality TRMTs is crucial, as failing to do so reduces the ability to plan more predictable departure times and provide planning stability. Timely and stable TRMTs will therefore support the execution of downstream processes.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.3.3 KPI3-9 – Predictability of the approval time to enter the mainline

The Actual Approval for Mainline Time (AMAT) is a highly recommended milestone and announces confirmed entry to the mainline. The Target Approval for Mainline Time (TMAT) predicts the ARMT milestone that needs to be assessed post-operationally for accuracy.

Furthermore, the ready for mainline time is the third target time in Rail CDM (TMAT) that needs to be set, managed and shall be evaluated on accuracy and stability.

The TMAT provides a final estimated of the expected entry of the train on the mainline and increases the quality of earlier departure predictions that were set through upstream estimates such as TRST and TRMT.

The generation of good-quality TMATs is crucial, as failing to do so reduces the ability to plan more predictable departure times and provide planning stability. Timely and stable TMATs will therefore support the execution of downstream processes.

This KPI depends on new data sources and may not be quantifiable in early implementations.

Figure 11 displays how the predictability KPIs relate to their parent business drivers and are supported by the performance calculations in the underlying metrics, as elaborated upon in chapter 3.2.

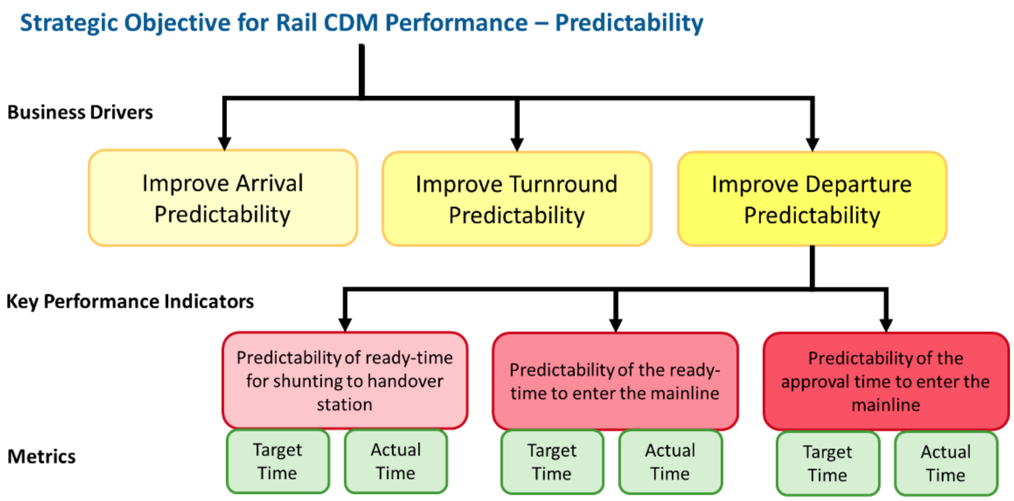

Figure 11: Visualisation of predictability KPIs, in relation to their parent business drivers

4.4 Business Driver 4 – Optimise Resource Utilisation

The following key performance indicators (non-exhaustive) support the quantification of this business driver:

4.4.1 KPI4-10 – Crane operator Utilization

Accurate predictions of the start and end times of the terminal sub processes support better planning by the Terminal and Intermodal Operators. This improves efficiency in the deployment of resources and prevents idle time of terminal staff because of waiting on assignments or due to last minute re-planning of labour.

This KPI depends on new data sources and may not be quantifiable in early implementations. Data from TO business information systems could be used as starting point for the development of the Rail CDM performance management.

4.4.2 KPI4-11 – 'Under the crane' time ratio

Accurate predictions of the start and end times of the terminal sub processes support better planning by the Terminal and Intermodal Operators. This enables more efficient utilisation of train handling equipment, prevents idle time and ultimately increases terminal capacity and throughput.

This KPI depends on new data sources and may not be quantifiable in early implementations. Data from TO business information systems could be used as starting point for the development of the Rail CDM performance management.

4.4.3 KPI4-12 – Locomotive operating time ratio

Accurate predictions of various sub processes in the train journey enable better planning by the Railway Undertakings and Shunting Operators. This enables more efficient utilisation of locomotives, prevents idle time and ultimately increases transport capacity.

This KPI depends on new data sources and may not be quantifiable in early implementations. Data from RU business information systems could be used as starting point for the development of the Rail CDM performance management.

4.4.4 KPI4-13 – Wagon operating time ratio

Accurate predictions of various sub processes in the train journey enable better planning by the Railway Undertakings, Intermodal Operators and Shunting Operators. This enables more efficient utilisation of wagons, prevents idle time and ultimately increases transport capacity.

This KPI depends on new data sources and may not be quantifiable in early implementations. Data from RU and IO business information systems could be used as starting point for the development of the Rail CDM performance management.

4.4.5 KPI4-14 – Locomotive driver Utilization

Accurate predictions and increased awareness of start and end times of the terminal processes support better driver planning by the Shunting Operators and the Railway Undertakings. This improves efficiency in the deployment of resources and prevents idle time because of waiting on assignments or due to last minute re-planning of labour.

This KPI depends on new data sources and may not be quantifiable in early implementations. Data from RU staff management systems could be used as starting point for the development of the Rail CDM performance management.

4.5 Business Driver 5 – Optimise Capacity Utilisation

The following key performance indicators (non-exhaustive) support the quantification of this business driver:

4.5.1 KPI5-15 – Slot-missed ratio

This KPI describes the degree to which allocated terminal slots for loading and unloading are adhered. With a more accurate upfront planning of the terminal and shunting operations, it is expected that slots will be less frequently missed due last-minute changes. A reduction of missed slots favours terminal and shunting area throughput as trains will less frequently block resources due to delayed departures.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.5.2 KPI5-16 – Slot duration

Better visibility of, and hence increased efficiency in the turnaround operations allow shortened slot windows for terminal loading and unloading slots, as there will be a decreased need to factor buffer time in slots to mitigate last-minute changes. This KPI monitors to which degree the average slot lead times evolve as stakeholders start to familiarise with Rail CDM procedures.

This KPI depends on new data sources and may not be quantifiable in early implementations. Data from TO business information systems could be used as starting point for the development of the Rail CDM performance management.

4.5.3 KPI5-17 – Slot availability

Shortened slot durations unlock Terminal Operator capacity, as they enable a higher loading and unloading throughput. This will reflect in a higher number of slots to be allocated on a daily basis. This KPI monitors the increase in available slots as stakeholders start to familiarise with Rail CDM procedures.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.5.4 KPI5-18 – Reserve capacity of locomotives

Unstable planning and uncertainties in the operational processes due lack of situational awareness require the Railway Undertakings and Shunting Operators to prepare for unforeseen changes by reserving assets to anticipate. These actions eat up operational capacity.

Enhanced predictability however shall reduce the need for considerable asset buffers. This KPI will therefore monitor the decrease of stand-by locomotives.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.5.5 KPI5-19 – Reserve capacity of wagons

Unstable planning and uncertainties in the operational processes due lack of situational awareness require the Railway Undertakings, Terminal and Intermodal Operators to prepare for unforeseen changes by reserving assets to anticipate. These actions eat up operational capacity.

Enhanced predictability however shall reduce the need for considerable asset buffers. This KPI will therefore monitor the decrease of stand-by wagons.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.5.6 KPI5-20 – Reserve capacity of locomotive drivers

Unstable planning and uncertainties in the operational processes due lack of situational awareness require the Railway Undertakings and Shunting Operators to prepare for unforeseen changes by reserving assets to anticipate. These actions eat up operational capacity.

Enhanced predictability however shall reduce the need for considerable asset buffers. This KPI will therefore monitor the decrease of stand-by locomotives.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.6 Business Driver 6 – Reduce Operational Delay

The following key performance indicators (non-exhaustive) support the quantification of this business driver:

4.6.1 KPI6-21 – Delay share of staff unavailability

This delay share index provides an indication of the degree to which the unavailability of operational staff affects operations. It sets the balance of the staff unavailability delay fraction off against the total delay attributed to a stakeholder. More efficient resource planning shall reduce the delay share, generated in such situations.

On metric level, the delay share can be measured on individual stakeholder level.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.6.2 KPI6-22 – Delay share of locomotive unavailability

This delay share index provides an indication of the degree to which the unavailability of locomotives affects operations. It sets the balance of the staff unavailability delay fraction off against the total delay attributed to Railway Undertakings and Shunting Operators. More efficient resource planning shall reduce the delay share, generated in such situations.

On metric level, the delay share can be measured on individual stakeholder level.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.6.3 KPI6-23 – Delay share of wagon unavailability

This delay share index provides an indication of the degree to which the unavailability of wagon affects operations. It sets the balance of the staff unavailability delay fraction off against the total delay attributed to Railway Undertakings and Shunting Operators. More efficient resource planning shall reduce the delay share, generated in such situations.

On metric level, the delay share can be measured on individual stakeholder level. This KPI depends on new data sources and may not be quantifiable in early implementations.

4.7 Business Driver 7 – Reduce Reactionary Delay

The following key performance indicators (non-exhaustive) support the quantification of this business driver:

4.7.1 KPI7-24 – Time recovery

To reduce reactionary delays, trains that arrive later than scheduled should depart with less or no outbound delay. By using an average lead-time required for off- and on loading at the terminals as a reference for the desired duration of the turnaround, the recovered time shows resilience in the operations of the Terminal Operators.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.8 Business Driver 8 – Improve On-Time Performance (OTP)

The following key performance indicators (non-exhaustive) support the quantification of this business driver:

4.8.1 KPI8-25 – Arrival punctuality

The punctuality of the operations in the arrival phase of trains supports the evaluation of the predictions for arrival, turnaround and subsequent departure that were set in the upstream process. This KPI evaluates the timeliness of arrivals against a target punctuality objective. On metric level, the punctuality can be measured on sub-process milestones such as ALMT, AEHT and ALCT.

This KPI depends on new data sources and may not be quantifiable in early implementations. Quality management initiatives are ongoing or planned (e.g. Q-ELETA) and could be suitable as a starting point for the development of the Rail CDM performance management.

4.8.2 KPI8-26 – Turnaround punctuality

The punctuality of the operations in the turnaround phase of trains supports the evaluation of the predictions that were initially set for the turnaround and subsequent departure in the upstream process. This KPI evaluates the timeliness of the activities in the turnaround sub-process against a target punctuality objective on milestones such as ASUT, ASLT and AELT.

This KPI depends on new data sources and may not be quantifiable in early implementations.

4.8.3 KPI8-27 – Departure punctuality

The punctuality of the operations in the departure phase of trains supports the evaluation of the predictions that were initially set for the departure in the upstream process. This KPI evaluates the timeliness of the published departure time of trains against a target punctuality objective. On metric level, the punctuality can be measured on sub-process milestones such as ARST, ARMT and AMAT.

This KPI depends on new data sources and may not be quantifiable in early implementations. Quality management initiatives are ongoing or planned (e.g. Q-ELETA) and could be suitable as a starting point for the development of the Rail CDM performance management.

5 Analysis of current initiatives

The success of an implemented Rail CDM is dependent on the right methodology and supporting solutions for each of the concept elements (CE).

- CE#1 - Information exchange
- CE#2 – Milestone Approach
- CE#3 – Last Mile Prediction
- CE#4 – Pre-departure Sequencing
- CE#5 – Adverse conditions
- CE#6 – International Coordination Support Function

For some of them, the sector does not have to start from scratch, but can build on existing tools, projects and initiatives. How these can support the Rail CDM development and setup, will have to be assessed in detail in the process of preparing and coordinating the implementation manual. The detailed solution for each concept element has to be agreed first with all stakeholders in a transparent process. This chapter of the feasibility study provides a first glance of ongoing European projects that complement or overlap with Rail CDM, or otherwise relevant. This list makes no claim to completeness. Purpose of this chapter is to show exemplary where synergies exist and knowledge can be efficiently used to strengthen efforts.

5.1 Methodology

Based on the public available information, it has been pre-checked per concept element if the initiatives/projects are supporting it directly. This contribution can be of different kind.

Either standards for data exchange are developed, negotiated and agreed on a complete sector basis. The key example for this is for sure TAF TSI as European legislative initiative trying to provide the necessary basis for interoperable systems.

On the other hand, organisational topics are treated supporting the later setup and operation of a Rail CDM, including the procedures of coordination and collaborations, between the various involved stakeholders. In combination with this, also the institutional setup like in aviation has to be considered.

For several concept elements, also the existence or development of the right technology is of importance. The developments performed by the technology providers in the framework of the joint European Shift2Rail undertaking will play a major role, as they are tackling operational improvements and predictability on an interoperable cross country and cross sector level, with easy exchange between new systems and legacy systems (either from different countries and/or different suppliers).

This preliminary analysis will have to be extended in the implementation phase in horizontal direction (additional projects/initiatives) and in the level of detail and deepness.

The overview table of ongoing initiatives and their touchpoints with the Rail CDM Concept Elements can be found in Annex D .

In addition to the concept elements, also the link of the initiatives to some requirements and supporting functions, which have been identified for international collaborative decision making, is indicated in the table.

- Stakeholder Equity;
- Data Transparency;

- Corridor and Network Operations;
- Conflict detection;
- Conflict solving/prevention;
- Cross-border (real time) planning;
- Train Monitoring;
- ETA-Rail prediction;
- Prediction accuracy assessment;
- Last mile monitoring/optimisation;
- Stakeholder Communication;
- Mitigation plans;
- Political pressure and support.

5.2 Brief introduction of selected projects and initiatives

5.2.1 TAF TSI

The TAF TSI (Technical Specification for Interoperability relating to Telematics Applications for Freight Services) aim to define the data exchange between individual Infrastructure Managers (IMs) and also between IMs and Railway Undertakings (RUs). In general, this TSI defines from a technical point of view, WHEN data has to be exchanged, WHAT has to be exchanged, to WHOM the data shall be send and in which format it has to be exchanged.

In addition to data exchange, the TAF TSI describes business processes involving IMs and RUs. For this reason, the TAF TSI deeply impacts existing international rail infrastructure business processes. There are continuous working groups from the sector organized by ERA, which are dealing with the revision process of the TSIs, e.g. for adding further actors like terminals.

5.2.2 RNE TIS

The Train Information System (TIS) operated by Rail Net Europe (RNE) is a commercial system, which is providing real-time train run related information such as timetable data, forecast (by external service providers or/and selected IMs in their national systems), running advice and delays, for international and partly national trains. As RNE is a European association of rail infrastructure companies and authorities, TIS is an IM owned tool, which benefits from easier access to data from national IM systems. The data provision in TIS is realised via a commercial common interface and is using TAF TSI conform messages. In addition to TIS, a number of IMs also have national monitoring solutions and calculate ETA. The data is provided either directly to other IMs and RUs or via TIS.

5.2.3 Train Monitor

Train Monitor was the first Train Monitoring System, which was/is combining national and international sources to provide a complete monitoring of trains for complete fleets and networks. It was developed within the CREAM project, by Hacon together with several European RUs, IOs and their associations to show how cross European monitoring from the Benelux to Turkey can be realised and be used for understanding operational problems and supporting improvement measures. Since then, it is in productive use at the operation control of Kombiverkehr. Within CREAM also first predictions for the Estimated Time of Arrival have been developed.

5.2.4 ELETA (Electronic exchange of Estimated Time of Arrival)

The ELETA project managed by UIRR and performed by the Hupac, Mercitalia, Lineas, RCA, Kombiverkehr, Novatrans and the two service providers Hacon and Synfioo, has continued the work on ETA calculation for the last point of the train run on the main line of the infrastructure providers. Besides applying new algorithms and AI-methods for the prediction itself, a core component of the project was related to the accuracy of the predictions. Functions for the accuracy assessment and comparison of the ETA quality were developed and implemented in the ETA Management Platform of Hacon, as well as functions and special views for the operator's dispatchers to use the information in a real-time scenario.

5.2.5 PSA Call – MOVE/C4/2020-62 Activity 2 "ETA4Rail"

The main aim of this activity, which is based on the ELETA project, is the processing and improving of ETA information on basis of the data provided through TIS. This includes a common calculation of the ETA accuracy as well as agreed quality targets. ETA predictions are based on historical information as in the preceding projects and not on real-time operations handled by a TMS system, which will include predictable conflicts on a detailed level in future.

5.2.6 PSA Call – MOVE/C4/2020-62 Activity 3 "Initiate data sharing with terminals"

The main aim of this activity coordinated by UIRR and RNE is to analyse and test potential automated, real-time data exchange between different platforms by means of a respective data interface. Part of the activity is also dealing with the translation of terminal legacy messages (e.g. EDIGES) into TAF TSI compliant messages for real-time information on first/last mile operations.

5.2.7 PROMI

The PROMI project of Fraunhofer IML, Kombirail, Bentheimer Eisenbahn, IGE, Siemens, Hacon and Catkin covers improved ETA predictions for the main line and the last mile action points. Besides further developing AI models, especially the improved communication and data exchange between the involved stakeholders via a standardised tool will support operational improvements. The project is closely connected to the Rail CDM approach and will most likely be started in June 2021.

5.2.8 Q-ELETA

The planned Q-ELETA project is developed by several sector organisations under the lead of UIRR in close collaboration with the shippers, IMs and RUs (Rail Freight Forward) as a follow-up project of the ELETA project. It will deal with the development of a quality management tool, which ensures transparency and is jointly accepted by all stakeholders including end customers. Part of the project shall be the development of a best practice guideline on quality monitoring. The project shall start in 2022.

5.2.9 Rail Freight Forward (RFF)

RFF is a coalition of European rail freight companies that are committed to drastically reduce the negative impact of freight transport on the planet and mobility, through innovation and a more intelligent transport mix. RFF is pushing certain innovations and raise political awareness.

5.2.10 Rail Freight Corridors

Regulation (EU) 913/2010 establishes Rail Freight Corridors (RFCs) along European transport axes, with the purpose of increasing competitiveness and quality of international rail freight transport. Their aim is to ensure adequate capacity and priority for freight in line with market needs and improved international coordination between the IMs and with market stakeholders to improve the services for international rail freight

5.2.11 Guidelines for Train Performance Management on Rail Freight Corridors

Since 2009 the IMs and since 2013 more specifically the RFCs have developed and updated Guidelines for Train Performance Management on RFCs (RFC TPM Guidelines) from an infrastructure manager perspective. The latest version has been updated in 2019. Their aim is a common approach to punctuality analysis connected to the RFCs. The existing IM working groups per corridor could provide input to the preparation of the R-CDM implementation manual.

5.2.12 Shift2Rail IP2 TD 9

The Technology Demonstrator 9 of the Innovation Program 2 in Shift2Rail is dealing with modern Traffic Management Systems and their interconnection. This includes on one-side functions and interfaces needed for a real time simulation of the operational situation incorporating detailed live information from the IM networks, but also from other relevant systems like terminal management systems or RU systems. With the developed functions, also interconnected cross-border conflict detection and traffic management will be possible in future. To achieve seamless freight operation, the developments will be continued and extended in the future “Europe’s Rail Joint Undertaking (ERJU)”.

5.2.13 RNE ETMN project

In January 2021, RNE started an internal infrastructure manager project to prepare a concept paper as a guideline for a future traffic management (European Traffic Management Network, ETMN). This paper comprises virtual structures, rules, processes and tools for improved cooperation between IMs to thereby create a network based on a strong IT backbone. The paper foresees a rough implementation roadmap and timeline, including necessary developments concerning tools and data.

6 Benefit Expectations

This chapter describes the expected benefits for Rail CDM. The most relevant inspiration for Rail CDM is the aviation sector, where Airport CDM has a long record of accomplishment of benefits collection with more than 30 airports implemented. Rail CDM is expected to learn and collect similar benefits, since both transport sector have strong similarities as concluded in WP1 (Reference 4).

6.1 Airport CDM Benefits

EUROCONTROL published a report on the Airport CDM impact assessment, after a significant amount of airports completed their implementation and are now operating Airport CDM operations permanently. The latest report dated March 2016 presents an up-to-date evaluation of the impact of Airport CDM implementation at local/airport level as well as at network level considering 17 fully implemented CDM airports (Reference 3).

The assessment lists local benefits with an impact on operations, which do however not necessarily apply for each airport. The most important are:

- Reduction in taxi time duration (7.0%), hence less fuel burn (7.7%) and reduced NOx emissions (7.7%);
- Overall reduction in start-up delay;
- Improved predictability;
- Increased peak departure rates from the runway;
- Increased adherence to take-off slots;
- Reduced network delay (ATFM delay reduced by 10.3% saving 9,8% compared to the costs incurred in the past);
- Quicker recovery from reduced capacity situations.

6.2 Use Cases

This section describes three typical use cases, listing actions and events describing the interaction between the different involved stakeholder groups on an intermodal freight service. The use case format is not sufficient to describe in detail the complex sequence of operational actions that together compose a transport. Its only intention is to highlight the most important processes of the transport leading to potential benefits.

The roles of the stakeholders are visualised in the figure underneath. For reasons of simplification, RUs bring electric main line locomotives, wagons and the driver, SOs bring a diesel powered shunting loco and the driver, TOs add the terminal including transhipment tracks, cranes as handling equipment and the required staff.

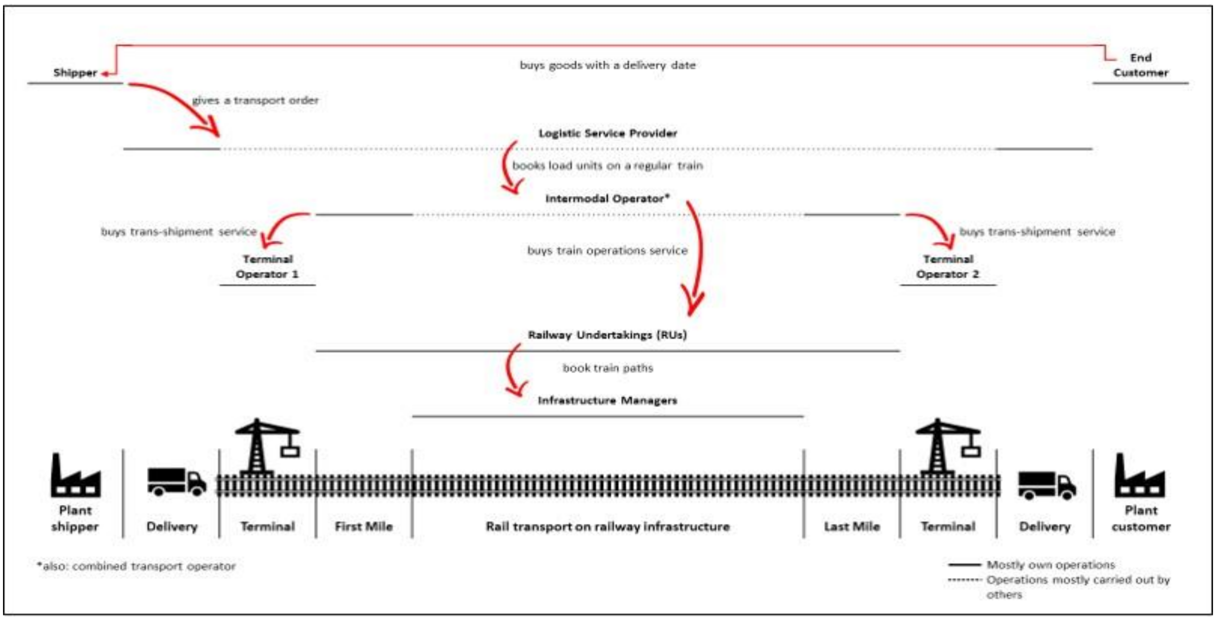

Figure 12: Stakeholders in the intermodal transport chain

The use cases start with a short introduction and a description of the operational situation. Please be aware that in the beginning of each use case Rail CDM is not in operation. This changes about half way through. The right column provides alternative actions.

6.2.1 Use Case A: Late Inbound

Operational description: Loco of inbound train remains in handover station and waits for the allocated outbound train. Inbound train is late.

Rail CDM: is not in operation.

#	Stakeholder(s) directly involved	Issue	Alternative
01	IM, RU	Undetermined delay of inbound train.	
02	SO	Loco and driver have arrived in handover station. Since actual arrival of inbound train is unknown, loco and driver wait causing idle-time for resources.	SO changes the order of jobs and handles other train first.
03	TO	Transhipment capacity in terminal is not utilised, track, cranes and staff wait causing idle-time for resources.	TO changes order of jobs and handles other train first.

04	IO	Due to the undetermined delay, customers receive information about undetermined delayed delivery of loading units.	
05	IM, RU	Delayed train arrives in handover station 1h late.	
06	SO	Shunts train to transhipment track inside terminal.	Resources are blocked; delayed train receives additional delay.
07	TO	Starts work on delayed train.	Transhipment track is blocked; delayed train receives additional delay.
08	IO	Customers receive new information about 1h delayed delivery of loading units.	Customers receive new information about undetermined delayed delivery of loading units.

Rail CDM: is in operation.

#	Stakeholder(s) directly involved	Issue	Alternative
01	IM, RU	Delay of train is predicted to be 1h.	
02	SO	SO re-plans resources, gives priority to refuelling the locomotive.	
03	TO	Since delay is predicted to be 1 hour only, TO re-plans staff-deployment and gives priority to pauses. Track and cranes remain unused.	In agreement with IO, TO changes order of jobs and handles other train first.
04	IO	Customers receive information about 1h delayed delivery of loading units.	Customers receive information about 6h delayed delivery of loading units.
05	IM, RU	Delayed train arrives in handover station 1h late.	
06	SO	Shunting loco arrives in handover station 1h later and runs train in transhipment track of terminal.	Shunting loco arrives in handover station 6h later and runs train in transhipment track of terminal.

07	TO	Starts work on delayed train.	Starts work on delayed train.
08	IO	Customers receive confirmation about 1h delayed delivery of loading units.	Customers receive confirmation about 6h delayed delivery of loading units.

Summary of use case A:

Due to improved information sharing, all stakeholders know well in advance that the inbound train is delayed and that the delay is predicted to be 1 hour. ETA algorithms calculate the delay as accurate as possible taking into account train as well as network capacity parameters. All stakeholders reorganise their internal planning in order to meet the updated train arrival as good as possible.

IOs are part of the information chain and inform their customers as soon as possible on the predicted delay.

The alternative actions show a different decision making process. Central element is the decision taken jointly by IO and TO to change the order of trains in the transhipment area of the terminal. For the specific train described in the use case, this would add another 5 hours of delay. On the other hand, idle-times inside the terminal and for the SO are minimised.

6.2.2 Use Case B: Trackside disruptions

Operational description: Trackside disruptions on main line that would prevent a scheduled departure of outbound train. All terminal and last-mile related operations normal without disruptions.

Rail CDM: is not in operation.

#	Stakeholder(s) directly involved	Issue	Alternative
01	TO	Train loading without special incidents	
02	Other	Technical train inspection without special incidents	
03	SO	Shunting from terminal to handover station without special incidents	
04	RU	Outbound train preparation without special incidents. RU declares train ready for main line entry	

05	IM	IM cannot provide actual main line approval due to trackside disruptions causing an undetermined delay	
06	IO	Customers receive information about undetermined delayed delivery of loading units.	
Rail CDM: is in operation.			
#	**Stakeholder(s) directly involved**	**Issue**	**Alternative**
01	IM	By adjusting the respective milestone, all other stakeholders are informed about the trackside disturbance.	
02	IO	Customers receive information about undetermined delayed delivery of loading units.	
03	TO	Since there is sufficient terminal capacity available, train stays on transhipment track. This enables the extension of the loading time and waiting for possibly late loading units	Transhipment capacity is needed for handling of next train. Train has to leave the terminal as planned.
04	Other	Wagon inspector changes the order of jobs and handles other train first.	Wagon inspector continuous as planned.
05	SO	Loco and driver wait in the vicinity of the terminal causing idle-time for resources	Shunting continuous as planned.
06	RU	Loco and driver wait in the handover station causing idle-time for resources	Outbound train preparation without special incidents and RU declares train ready for main line entry. However, loco and driver have to wait for main line approval causing idle-time for resources.
07	IM	• IM internally receives prediction about removal of trackside disturbance and plans restart of all operations on main line • Concerning the departure of the delayed intermodal train waiting	

		in the handover station, pre-departure sequencing optimises the prediction of the new main line approval time • IM adjusts as soon as possible the corresponding milestone	
08	All stakeholders	Adjust the milestones in order to meet the new main line approval time.	
09	All stakeholders	Perform operations according to the updated milestones	
10	RU	Leaves handover station and enters main line.	
11	IO	Customers receive information about delayed delivery of loading units based on real-time information.	

Summary of use case B:

Due to improved information sharing, all stakeholders know well in advance before the next outbound train is supposed to leave that the main line infrastructure is blocked. The use case describes two different scenarios for the stakeholders working on the terminal how they could take their decisions.

Key element is the prediction from the IM on the reopening of the route. In addition, pre-departure sequencing optimises the new train enters main line timestamp for the RU.

6.2.3 Use Case C: Late Loading Units

Operational description: Planned capacity utilisation of the train is not achieved due to delayed arrival of several loading units; IO wants to postpone departure of outbound train even though the closing time for acceptance has already passed. All terminal and railway related operations normal without disruptions.			
Rail CDM: is not in operation.			
#	**Stakeholder(s) directly involved**	**Issue**	**Alternative**
01	IO	Informs TO and RU about the 1h delay of the outbound train by email.	Empty loading slots remain unoccupied.
02	TO	Transhipment capacity is blocked; cranes and staff wait causing idle-time for resources.	

03	Other	Wagon inspector changes the order of jobs and handles other train first.	No alternative job available; wagon inspector waits.
04	SO	SO re-plans resources, gives priority to refuelling the locomotive.	Loco and driver wait causing idle-time for resources
05	RU	Informs IM, SO and wagon inspector about the expected delay. Locomotive and driver wait for arrival of outbound train in the handover station	
06	IM	Takes note of the expected delay.	
07	Other	Technical train inspection is finalised	
08	SO	Performs shunting from terminal to handover station.	
09	RU	Train preparation of outbound train and ready for entering main line notice towards IM	
10	IM	Since train has missed the planned path, IM checks availabilities and declares next possibility for departure will be available 2h later.	
11	RU	Locomotive and driver wait further 2h before entering the main line Delay of train 3 h.	
Rail CDM: is in operation.			
#	**Stakeholder(s) directly involved**	**Issue**	**Alternative**
01	IO	By adjusting the respective milestone, all other stakeholders are informed prior to the occurrence of the delay. Delay of outbound train 1 h	Empty loading slots remain unoccupied.
02	All other stakeholders	Asses proposed adjustments, adapt internal planning and provide consequences by further adjustment of milestones. For example:	

		• TO: There is sufficient capacity for transhipment • SO: is able to meet the request • RU: has to wait causing idle-time for resources; since 1h delay can be compensated in the destination terminal RU files no objections • IM declares that the train will miss the timetable slot; next possibility for departure will be available 2h later. • RU: files objection, since 2h delay cannot be compensated	
03	IO	Confirms consequences and takes the decision to wait for the missing loading units. Customers receive information about expected 2 h delay.	
04	TO	Transhipment capacity is blocked for 1h; cranes and staff wait causing idle-time for resources.	
05	Other	Wagon inspector changes the order of jobs and handles other train first.	No alternative job available; wagon inspector waits.
06	SO	SO re-plans resources, gives priority to refuelling the locomotive.	Loco and driver wait causing idle-time for resources
07	RU	Locomotive and driver wait 1h for arrival of outbound train and an additional 1h before entering the main line Delay of train 3 h.	

Summary of use case C:

Due to road congestion, several loading units are bound to arrive late on the terminal for transhipment to the next outbound train. Rail CDM offers the possibility for stakeholders to discuss and negotiate a collaborative decision between all stakeholders involved. The use case describes how the IO is starting decision making.

Attention is drawn to points 2 and 3 of the 2nd part of the use case describing the consensus building. At first, all stakeholders seem to accept the delay and to wait for the missing loading units. However, the RU files an objection as soon as the additional delay becomes transparent.

Since common agreed rules for decision making are not yet developed and there is no body which is entitled to take an overall decision the use case follows today's process; IO overrules RU, which, by the way, also reflects the contractual relations. Compensation measures cannot be part of this feasibility study and stay unreflected.

However, this points out one of the essential topics to be tackled during the extensive preparation of the implementation of Rail CDM. Apart from the need to decide on how transparency is going to be created and how communication is going to work in detail, the sector needs to develop a method for collaborative decision making!

The use case incorporates one additional detail. By using Rail CDM and its pre-departure sequencing function, the IM can better predict the train journey on the main line compared to the estimation without Rail CDM.

6.3 Expected Rail CDM benefits

Rail CDM is going to be a joint venture between all stakeholders along the transport chain involved in the operations of trains. This list of stakeholders includes but is not limited to IMs, RUs, SOs, TOs and IOs and complements by all other necessary operational staff. Additional staff belongs either to the aforementioned stakeholders or, because of their self-employed status, they can also form an additional stakeholder group.

In general, Rail CDM aims to improve the operational efficiency of rail transport as a whole. This includes reducing delays (see strategic objective “punctuality” in 3.3.4), increasing the predictability of events during the progress of a train journey (see strategic objective “improve predictability” in 3.3.1) and optimising the utilisation of resources (see strategic objective “improve resource efficiency” in 3.3.2). In addition, Rail CDM increases the capacity of all railway infrastructure utilised (see strategic objective “increase capacity” in 3.3.3). The connected infrastructure starts and ends in terminals, extends to the last-mile infrastructure and of course includes the whole railway network in between. For the achievement of the goals, it is necessary to implement in the railway sector a set of operational procedures and automated processes including concepts and concept elements.

6.3.1 Introduction

Basis for the quantification of benefits is the implementation of a Rail CDM Performance Monitoring. This enables measuring the required KPIs.

Due to the missing overall respected performance monitoring, most of the benefits for rail freight transportation cannot be calculated or even assumed today. In the meantime, a qualitative analysis has to be sufficient/to do the job.

As most of the KPIs for the proposed milestones are not monitored today, it is not possible to define clear start values/benchmarks and consequently it is not possible to estimate detailed savings in this feasibility study.

It has to be taken into account that especially for the main line transport there will be effects (positive and/or negative) which can or cannot be allocated directly to the implementation of a Rail CDM methodology.

As far as possible, we have tried to estimate quantitative benefits. However, a simple quantification of benefits cannot be calculated directly as various benefits interact. This can either multiply or diminish the effect.

There will be direct, measurable and assignable benefits, but also indirect benefits that cannot be clearly allocated to stakeholder groups or quantified.

6.3.2 Information Sharing

The most important benefits of all are the improvements connected to information sharing. Information sharing means to create the same situational awareness for all stakeholders with the purpose to have at disposal the right information at the right time with the right people in order to take the right decisions.

Information exchange in the railway sector is a subject already discussed for quite some time. At the same time as the European Ministers of Transport signed the "Rotterdam Declaration" (Reference 6) during the 2016 TEN-T days, the railway sector adopted the sector statement titled "Boosting International Rail Freight" (Reference 7). Both initiatives identify 10 priorities describing additional efforts, designed to contribute to achieving the European Commission's 2011 White Paper (Reference 8) goal to shift 30% of road freight volume over distances of more than 300 km to rail and waterborne transport by 2030.

The sector statement mentions: "Under the protection of confidentiality clauses, IMs and RUs agree to make information on estimated time of arrival available (for handover points and final destination) to their contract partners, including terminals and intermodal operators for optimizing the use of resources such as rolling stock and terminal capacity, and to provide freight forwarders and shippers with up-to-date information about the status of their freight and an estimated time of arrival."

Nobody neglects the importance of information sharing and many projects have achieved huge improvements already. However, information exchange today is mostly limited to information sharing between two stakeholders and solves specific matters between those two stakeholders only.

Anyone who thinks that there is no need to talk about self-evident matters is unfortunately mistaken. During the work on the feasibility study, many stakeholders were able to express their concerns in workshops, interviews and other formats. The most often mentioned findings are:

- Stakeholders are not informed about the progress of shunting or running of in- or outbound trains;
- Stakeholders are not informed about the progress of train preparation for shunting or departure;
- In case of delays, there is no coordination about the (new) order of the departing trains.

6.3.3 Potential overall benefits for the railway sector

Implementation of Rail CDM allows each stakeholder to optimise their decisions in collaboration with other stakeholders, knowing their preferences and constraints and the actual and predicted situation.

Rail CDM enables proactive operations by negotiating consequences prior to the occurrence of the issue between all involved stakeholders. Examples taken from stakeholder consultations are:

- Every stakeholder plans its own operations. There is an order for train transports, shunting processes are planned in a specific order, transhipment is optimised and therefore put in a certain order of sequence, etc. Result of every planning phase is the alignment of all internal processes to form an operational plan for the main line, for the handover station, for the connecting line, for the terminal, etc.
  However, on the day of operations itself, the actual situation is different and assumed optimisations cannot be realised. Solving these issues requires transparent discussion of preferences and constraints for each stakeholder. Changing the order of processes compared to the

plan can help in solving these issues: the order of outbound trains can be adapted by applying pre-departure sequencings; the order of work in the terminal may be changed.

- Staff shortages affect all stakeholders for different reasons. Since the operation of resources and monitoring as well as control activities almost always involve staff, a missing team member implies an operational delay or, even worse, an at least temporary interruption of the transport progress. Although every stakeholder focuses on the deployment of its own staff and on finding a replacement as quick as possible, discussing implications with other stakeholders may lead to different, more suitable solutions (see business driver "optimise resource utilisation" in 3.4.4).
  A delayed train may help to dissolve a jam in the handover station or on the transhipment tracks of the terminal; due to an overloaded section of track, the train will soon clear the main line anyway; the maritime vessel onto which the containers are to be loaded is also delayed.
- Loading units arrive late in the terminal for transhipment. A description of possible preferences and constraints is included in Chapter 6.2 in use case C.

However, it is not possible to anticipate all issues and often the occurring events will be a surprise. Rail CDM offers the possibility for immediate real-time notification of all involved stakeholders in case of surprising events. This accounts especially for technical breakdowns of resources such as locomotives, cranes and others, blocked infrastructure due to accidents or weather impact, etc. All stakeholders receive updates on the actual operational situation and informed about their predicted development.

All actors in the railway sector in general acknowledge the condition of the railway system described especially concerning the lack of transparency. All are prepared to contribute to improvements, some more and others less. However, what is generally still underestimated is the time available for realisation of the necessary improvements.

For the sector, it is important to improve on reliability, and accuracy (see business drivers on "predictability" and "punctuality" in 3.4) as soon as possible in order to increase the overall quality of rail transports and to improve situational awareness for all stakeholders. Improving the quality helps regaining trust from stakeholders itself and most valuable of all from clients. Altogether, Rail CDM can deliver a substantial contribution to the fulfilment of the objectives of the European Green Deal by supporting modal shift to rail.

6.3.4 Expected Benefits for Infrastructure Managers

The gain of transparency providing better quality of service, decreasing overall delay minutes for the IM network, predictable operations and a more effective management with less corrections are the main benefits for IMs. These points can contribute to an improved capacity management and in turn to an increase of the capacity available on the existing infrastructure.

Today, different sections of the railway infrastructure utilised for running trains are connected to each other physically, but they are sometimes not connected related to information sharing between all stakeholders. The link/information exchange between transhipment tracks inside an intermodal terminal and the connecting line is missing or takes place manually. The connecting line itself has no digital link with the handover station. Apart from last-mile infrastructure, the same principle is applicable for main line infrastructure for freight, such as shunting yards, as well.

For intermodal trains, these missing information links have the following significance: it interrupts the flow of information and creates "black holes" for those stakeholders, which are not directly involved with the operation of the sections concerned. Additionally, it is not possible for RUs to apply for end-to-end train paths, starting in the transhipment track of the origin terminal and ending in the transhipment track of the destination terminal.

Rail CDM changes the situation by creating awareness for all parts of the infrastructure to all stakeholders. The gain of transparency in connection with increasing automation is going to provide better quality of service and by reducing buffers additional capacity on European railway networks. The information chain starts and ends in the transhipment tracks of the terminals and enables the IM to have exactly the same transparent information about the progress of loading a train as the TO itself. Of course, the same applies to all other involved stakeholders.

If information sharing is considered to be the first step, than end-to-end train paths could be a logical second step, reducing the number of interfaces and thus resulting in less complex operations. This will inevitably improve transport times, also due to international train paths with less stops and transparent operational processes at border crossings. A more fluid flow of a specific freight train on the main line is going to decrease the occurring overall delay minutes for the network of the IM and for each RU separately (please compare chapter 6.3.4 and business drivers on “punctuality” in 3.4).

The implementation of Rail CDM allows each stakeholder to optimise their decisions in collaboration with other stakeholders, enabling real-time monitoring and proactive re-planning of a freight train journey, taking into account preferences and constraints of other stakeholders and the actual and predicted situation.

A resulting benefit for IMs and RUs jointly concerns the adjustment of planned driver change points. Should due to a delay a driver change point need to be adjusted or an additional one has to be planned, this can be optimised by taking into account the occupancy of side- or station tracks on IM side and the working hours, the place of stay of the replacement driver and follow-up costs for staff-deployment on RU side.

A second example focuses on predictability (see business drivers on “predictability” in 3.4). The most important point of contact for IMs and RUs is the start of the train, defined as the exact time when the train leaves the handover station and enters the main line. Even though there should not be any departure delay at all, daily operations provide other insights. The setup of use cases B and C consider the aspects, how IMs and RUs possibly influence each other and why discussing a collaborative train departure helps both stakeholders directly and other stakeholders indirectly.

6.3.5 Expected Benefits for Railway and Shunting Operators

Already touched upon in the previous chapter was the more fluid flow of a freight train decreasing the delay minutes for the IM network and for each RU separately. However, there is a significant additional benefit for RUs and in the end for the sector as a whole. Energy consumption contributes with more than 15% to the total cost of a specific rail transport (Reference 9). A reduction of energy used therefore provides room for increased profitability for the train operating companies and for even lower CO_2 emissions. Each eliminated restart of a freight train saves according to our own calculations an average of 250 – 300 kWh for a typical intermodal train.

More automation will provide simplification of railway processes and greater reliability, higher safety and more cost-efficient operations. Cost savings for resources can achieve an even bigger effect. For a specific rail freight service, costs for resources (locomotives, wagons and drivers) amount to around 50% of the total transportation costs (Reference 9). Different RU business models concerning the financing of resources (purchase, financing or renting) may provide different values. However, there is one thing that applies to all: they are expensive. A better resource utilisation and a shorter allocation for locomotives, wagons and personal to a transport will enable more cost-efficient operations (see business driver on "resource utilisation" in 3.4.4).

This aspect is also transferable to the allocation of reserve capacities for transports. Depending upon the size of the companies, reserve capacities are kept available per transport, per terminal, per region or using a different allocation. Less reserve capacity at the same time increases resource utilisation for locos and wagons (see business driver on "capacity utilisation" in 3.4.5).

For RUs and SOs, the implementation of Rail CDM enables real-time monitoring and proactive re-planning of freight train journeys and shunting activities internally or together with other stakeholders. Already described were the benefits for the stakeholder combination IMs and RUs:

- The optimisation of the interface between main line and handover station for in- and outbound trains concerning the possible rearrangement of the departure order and the exact prediction of the departure times (see business drivers on "predictability" in 3.4);
- The coordination of stops on the main line transport concerning the alignment of different stakeholder perspectives.

For RUs and SOs it will be easier to predict implications on staff deployment and to optimise the utilisation of driver working hours including necessary pauses. Due to the improved prediction of upcoming train stops, a pause is integrated more easily in the normal course of operations. The same accounts for SOs and their last mile-operating schedule. Furthermore, both stakeholders are able to coordinate better regarding the transition from trains to shunting units in the handover station and vice versa. Reducing the number of additional working hours saves approx. 80 EUR per driver hour (Reference 10).

Together with the TO, SOs will be enabled to better coordinate the exact handover times of wagon sets on transhipment tracks (see KPIs "1-3" in 4.1.3 and "3-7" in 4.3.1).

Since a majority of rail freight transports involves several RUs, the exchange of operational data between two RUs is facilitated. In case of delays, the corresponding new predicted arrival time helps for coordinating handover procedures at borders and other points of transfer.

6.3.6 Expected Benefits for Terminal Operators

Delays of trains approaching the transhipment area of terminals influence their utilisation in two different ways. First, the track together with cranes and staff runs the risk of remaining unused for the duration of the delay. Second, parking trucks waiting for loading units congest the truck approach, both in the approach area on the terminal and possibly the public road space near the terminal as well. This also has a negative effect on the operational processes in the terminal, restricting the performance and impairing the service quality.

The implementation of Rail CDM allows TOs to optimise their decisions in collaboration with other stakeholders, knowing their preferences and constraints and the actual and predicted situation. Trucking companies are informed via IOs enabling improved management for arriving trucks as well as traffic management on the terminal itself.

Increasing the utilisation of the transhipment equipment provides additional capacity (see KPI "5-17" in 4.5.3). Missing capacity is a problem in many maritime terminals as well as large hinterland terminals. Even though a lot has been accomplished to optimise the slot booking for trains, the booking system remains rigid relying on fixed start- and end-times. A delayed train misses its allocated slot (see KPI

“5-15” in 4.5.1) and in heavy utilised terminals, finding a replacement slot will cause additional follow-up delays (several hours up to days) for the delivery of loading units.

Rail CDM enables a better predictability of train arrivals and consequently on the occupancy of the transhipment tracks. Changing wagons sets will also work more smoothly due to the early information to the SOs. Consequently, TOs are able to optimise the slot booking by reducing the buffer times for unexpected events. Based on an average slot duration of 6 hours, which provides four possible slots per 24 hours, a reduction of 20% already provides five possible slots per 24 hours, increasing the capacity and the utilisation of the gantry cranes per track by 25%.

As soon as the TO receives reliable arrival predictions for all inbound trains, a possible future step could be to develop a slot booking system based on flexible on demand slots. This would imply that a train has no specific slot allocated before its departure at the origin terminal. By automated continuous processing of all pre-announcements, the TO initiates a collaborative decision with all involved stakeholders optimising the complete train journey from origin to destination terminal.

Apart from the overall increased resource utilisation for tracks, cranes and staff working hours, Rail CDM enables better coordination with other stakeholders, especially with SOs and with IOs. Use case C included in chapter 6.2.3 describes a possible approach for handling the late arrival of loading units by adjusting start and end of loading times.

6.3.7 Expected Benefits for Intermodal Operators

In the intermodal business today, IOs are the only stakeholders with direct contact to the clients. They therefore play the key role in information sharing along the intermodal transport chain and take the greatest advantage from the implementation of Rail CDM.

All elements of Rail CDM are designed to improve the transparency of the railway sector. The term transparency itself already means to operate in such a way that it is easy for others to see what actions are performed. Rail CDM therefore creates situational awareness by providing a clear picture of the complete transport chain including transparency in capacity and resource assignment. Introducing predictions eliminates planning uncertainties because a clear picture is transmitted about the actual operating scenario and its predicted development. Rail CDM enables proactive collaborative decision making between all stakeholders and finally a timely and complete information to the client.

In future, IOs will therefore be able to better meet the expectation of their customers. For example concerning higher requirements for the reliability of rail freight transports and concerning transport information, which is essential for just in time transport chains. In the intermodal business, IOs are the key factor for further enhancing existing products, developing attractive new products and thereby attracting even more customers in order to facilitate a shift to rail.

Already described in previous paragraphs were examples where IOs are connected directly to the process of collaborative decision making:

- Changing the order of trains in the terminals (together with TOs);
- Adapting the loading and unloading tines (together with TOs);
- Changing the exact order of departing trains (together with RUs).

7 Conclusions and Recommendations

This chapter describes the conclusions and recommendations for this report. They should be read in combination with the Feasibility Study to Rail CDM related references 4) and 5).

7.1 Conclusions

The following conclusions can be determined:

- Airport CDM provides performance-monitoring methodology that is transferable to the Rail sector, since many strategic objectives, business drivers, and key performance indicators are applicable to other forms of transport and resource management including Rail.
- Business Drivers related to Predictability of train milestones are the most relevant improvement provided by Rail CDM, and complementary to existing Business Drivers.
- Key performance indicators require more data to be collected, and should be validated in trial implementations initiatives for Rail CDM, in order to quantify and report predictability benefits that are expected.
- Benefits are expected from collaboration, information sharing, and monitoring the performance indicators. All stakeholders will experience benefits.
- The stakeholders involved in the WP 2 discussions recognises the expected benefits and taken notice of the proposed methodology.

7.2 Recommendations

The following recommendations apply, in combination with conclusions drawn in the WP3 report of this Feasibility Study into Rail CDM: requirements and Implementation Roadmap (reference 5):

- Performance monitoring organisation should be set up by the stakeholders on each level: international, national and local, as soon as an initiative is launched for development or implementation of Rail CDM.
- Existing initiatives as listed can be used and expanded with
- The methodology for performance monitoring needs to be applied to validate the expectations on benefits and costs, e.g. through a means of Cost Benefit Analysis.
- Where a lack of data points is observed to apply in various key performance indicators listed in this document, creation of such data points for purpose of collection and analysis enables development of metrics.
- Rail CDM data shall be exchanged in good quality meeting all European standards, free of charge, meeting update frequency and definition through defined interfaces and protocols.
- Performance monitoring requires an initiative to validate expected benefit in multiple regions and corridors.
- The audience of this report should decide upon launching initiatives for implementation trials in combination with performance analysis in order to learn lessons and apply. See also reference 5).

A References

This list of reference documents is used to develop this report.

1) RFC Rhine Alpine EEIG Contract Hacon-To70, Frankfurt/M., September 2020
2) EUROCONTROL Airport CDM Manual, version 5, EUROCONTROL Brussels, 2017
3) EUROCONTROL - Airport CDM Impact Assessment, Final Report, EUROCONTROL, 2016
4) Feasibility Study to Rail CDM - Approach – WP1 deliverable, HACON/To70, Hannover, January 2021
5) Feasibility Study to Rail CDM - Requirements and Implementation Roadmap – WP3 deliverable HACON/To70, Hannover, June 2021
6) Ministerial Declaration, Rail Freight Corridors to boost international rail freight, TEN-T Days, Rotterdam, 2016
7) Sector Statement on Rail Freight Corridors, Boosting International Rail Freight, Brussels, 2016
8) EUROPEAN COMMISSION WHITE PAPER, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, Brussels, 2011
9) Analyse staatlich induzierter Kostensteigerungen im Schienengüterverkehr am Beispiel von ausgewählten Relationen, Im Auftrag von IBS und UIRR, hWh, Karlsruhe 2015
10) RFC Rhine-Alpine, TMS 2018, Frankfurt/M., 2018

B Rail CDM Data Element Acronyms

This annex provides a list of acronyms relevant to develop detailed metrics and abbreviations.

Acronym	Meaning	Ownership & Source
AEBT	Actual End Braketest Time	TO
AEBT	Actual End Braketest Time	TO
AECT	Actual End Composition Time	TO
AECT	Actual End Composition Time	TO
AEDT	Actual End Decomposition Time	TO
AEDT	Actual End Decomposition Time	TO
AEFT	Actual Enter Final IM Time	IM
AEFT	Actual Enter Final IM Time	IM
AEHT	Actual Enter Handover station Time	SO
AEHT	Actual Enter Handover station Time	SO
AEIT	Actual Empty Inspection Time	TO
AEIT	Actual Empty Inspection Time	TO
AELT	Actual End Loading Time	TO
AELT	Actual End Loading Time	TO
AEMT	Actual Enter Mainline Time	IM
AEMT	Actual Enter Mainline Time	IM
AEMT	Actual Enter Mainline Time	IM
AEMT	Actual Enter Mainline Time	IM
AEUT	Actual End Unloading Time	TO
AEUT	Actual End Unloading Time	TO

ALCT	Actual Leave Connection line Time	TOo
ALCT	Actual Leave Connection line Time	To
ALHT	Actual Leave Handoverstation Time	RU/SO
ALHT	Actual Leave Handoverstation Time	RU/SO
ALMT	Actual Leave Mainline Time	IM
ALMT	Actual Leave Mainline Time	IM
AMAT	Actual Mainline Approval Time	IM
AMAT	Actual Mainline Approval Time	IM
ARMT	Actual Ready for Mainline Time	RU
ARMT	Actual Ready for Mainline Time	RU
ARST	Actual Ready for Shunting Time	TO/SO
ARST	Actual Ready for Shunting Time	TO/SO
ASBT	Actual Start Braketest Time	TO
ASBT	Actual Start Braketest Time	TO
ASCT	Actual Start Composition Time	TO
ASCT	Actual Start Composition Time	TO
ASDT	Actual Start Decomposition Time	TO
ASDT	Actual Start Decomposition Time	TO
ASLT	Actual Start Loading Time	TO
ASLT	Actual Start Loading Time	TO
ASST	Actual Start Shunting Time	TO/SO
ASST	Actual Start Shunting Time	TO/SO
ASUT	Actual Start Unloading Time	TO

ASUT	Actual Start Unloading Time	TO
EEHT	Estimated Enter Handover station Time	SO
EELT	Estimated End Loading Time	TO
ELCT	Estimated Leave Connection line Time	TO
ELMT	Estimated Leave Mainline Time	IM
EMAT	Estimated Mainline Approval Time	IM
ERMT	Estimated Ready for Mainline Time	RU
ERST	Estimated Ready for Shunting Time	TO/SO
ESLT	Estimated Start Loading Time	TO
ESUT	Estimated Start Unloading Time	TO
TMAT	Target Mainline Approval Time	IM
TMAT	Target Mainline Approval Time	IM
TRMT	Target Ready for Mainline Time	RU
TRMT	Target Ready for Mainline Time	RU
TRST	Target Ready for Shunting Time	RU
TRST	Target Ready for Shunting Time	RU

C Other Abbreviations

Acronym	Description
Airport CDM	Airport Collaborative Decision Making
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
B2B	Business-to-Business
BLU (= product name)	(Betriebsleitsystem für Umschlagebahnhöfe) Operating management system for transfer stations and terminals
C#1 – C#5	Transferability Criteria
CE#1 – CE#6	Concept Elements
DAC	Digital Automatic Coupling
ELETA	Electronic Exchange of ETA information
ETA	Estimated time of arrival
KPI	Key Performance Indicator
LeiDis (= product name)	(Leitsystem zur Netzdisposition) Network scheduling control system
LU	Loading Unit
NMOC	Network Manager Operations Centre
OCR	Optical Character Recognition
OTP	On-Time Performance
P#1 – P#14	(Railway) Processes
PROMI	Process Optimisation through ETA-Management in Intermodal Transport
RAG	Railway Undertaking Advisory Group
Rail CDM	Rail Collaborative Decision Making
RFC RALP	Rail Freight Corridor Rhine-Alpine

RNE	Rail Net Europe
TAF/TAP TSI	Technical Specification for Interoperability relating to Telematics Applications for Freight/Passenger Services
(RNE) TIS	(RNE) Train Information System
TSI OPE	Technical Specification for Interoperability relating to Operations

D Selection of Rail CDM related projects and initiatives

Overview of selected Initiatives / Projects / Products (living non-exhausting list)			Concept Elements						Requirements and supportive functions													
Nr.	Name	Owner/Participant	Information Exchange	Milestone Approach	Last Mile Prediction	Pre-departure sequencing	Adverse Conditions	Coordination Support Function	Stakeholder Equity	Data Transparency	Corridor and Network	Conflict detection	Conflict solving / prevention	Cross-border planning	Train Monitoring	ETA-Rail Prediction	Prediction accuracy assessment	Last mile monitoring /optimsation	Stakeholder Communication	Mitigation plans	Political Pressure and Support	Comments
1	TAF TSI	ERA / European Railway Stakeholder	X							x									x			
2	RNE TIS	RailNetEurope	x	x							x				X	x	x					
3	Train Monitor	Kombiverkehr	x	x							x				X	X						
4	ELETA	UIRR/Hacon/Synfioo/Kombiverkehr/RCA/ Hupac/ Lineas/Mercitalia/Novatrans	x	x							x				X	X	X					
5	PSA Call - ETA4Rail	UIRR/RNE/Hacon/Synfioo/IO	x	x							x				X	X	X					
5	PSA Call - Initiate data sharing with terminals	UIRR/RNE/IO/TO	X	x											X	X	X		x			
6	PROMI	Hacon/Siemens/Catkin/Fraunhofer IML/Kombirail/Bentheimer Eisenbahn	X	X	X	x	X	x	x	X	x	x	x		X	X	X	X	X	x		Project to be started mid 2021
7	Q-ELETA	UIRR & other stakeholders tbd		x					x	x					x							Project not started / only basic idea available
8	RailFreightForward	CEO of RU																			X	
10	RFC	IMs					x	x						x					(x)	X	X	
11	Guidelines for Train Performance Management on RFCs	IMs / RFCs	x																			
12	Shift2Rail IP2 TD 9	IMs, RUs and System Suppliers	x					x			x	x	x	x	x	x		x				Technical focus e.g. integration layer between legacy systems
13	RNE ETM	Infrastructure Managers	x					x			x			x					x	x		Conceptual / organisational focus