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Transforming
Europe's Rail Freight

D1.5 First KPI Report

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1 Executive Summary

Rail freight transport faces a number of challenges, such as a lack of network capacity and productivity. Rail transport must use new digital technologies to meet the needs of customers. The Flagship Project FP5 - TRANS4M-R was launched to cope with these challenges. TRANS4M-R, a consortium project of the Europe's Rail Joint Undertaking EU-Rail JU) and funded within Flagship Area 5 of the Innovation Pillar, for a period from 2022 to 2026, will develop, validate, and demonstrate TRANS4M-R technical enablers (TE).

This document constitutes Deliverable 1.5 “First KPI Report” of FP5 TRANS4M-R and provides an estimation of how the technical enablers of the project will impact the Key Performance Indicators (KPI), given in the Multi Annual Work Programme and further detailed out in the Grant Agreement of FP5 TRANS4M-R. To this aim, the relevant KPIs are first described in this deliverable for the project. Second, the methodology to map the KPIs to the different technical enablers is described. In the main part of this document, reference values are summarized which provide the basis for comparison for future improvements. These numbers consider the railway system of the years 2024 as baseline. It is important to concretely specify the measuring process of these reference values since future improvements can only be compared based on the same process.

Based on these considerations, future improvements given as the impact of the technical enablers on improved KPIs are estimated. The presented KPI estimations reflect the target state of full digitization. The results shown in this deliverable give a first indication on which effects could be expected in the future. The presented values will be monitored continuously and validated in lab and field tests. For a harmonized approach, a strong collaboration with the work packages (WPs) on cost-benefit-analyses (WP19) and test planning and execution (WP13-WP18, WP20, WP21, WP24, WP33 and WP34) is crucial. A way of collaboration was set-up during the process of writing this deliverable.

In the target process, a significant improvement compared to the baseline will be enabled by the technical enablers developed in FP5 TRANS4M-R. The estimated benefits presented in this document focus on non-disruptive processes. However, the technical enablers probably also will increase robustness of the processes at hand further improving the KPI on average. An assessment of the impact of an increased robustness on the KPI will only be possible in commercial use with a broad data base to reach a statistically valid assessment.

Keywords:

FP5 TRANS4M-R, KPI, Key Performance Indicator, Rail Freight Transformation, FDFTO, Seamless operations, Reference Values for Rail Freight

2 Abbreviations & Acronyms

Abbreviation / Acronym	Description
ASO	Automatic Shunting Operations
DAC	Digital Automatic Coupling
EDDP	European DAC Delivery Program
EP	EU-Rail Operational Procedure, see FP5 D2.1
EU-Rail	Europe's Rail
FDFTO	Full Digital Freight Train Operation
FP	Flagship Project
JU	(Europe's Rail) Joint Undertaking
KPI	Key Performance Indicator
LCC	Life Cycle Costs
MAWP	Multi-Annual Work Programme
TE	Technical Enabler
TRL	Technology Readiness Level
WP	Working Package

3 Background

The present document constitutes the Deliverable D1.5 “First KPI Report” in the framework of the FP5- TRANS4M-R as described in the EU-RAIL MAWP [2].

The scope of FP5- TRANS4M-R, namely developing, validating, and demonstrating technical enablers (TE) with high TRL for the automation and digitalization of rail freight transport, requires a project structure that reflects the complexity of this task. The WP structure is shown in Figure 1 below.

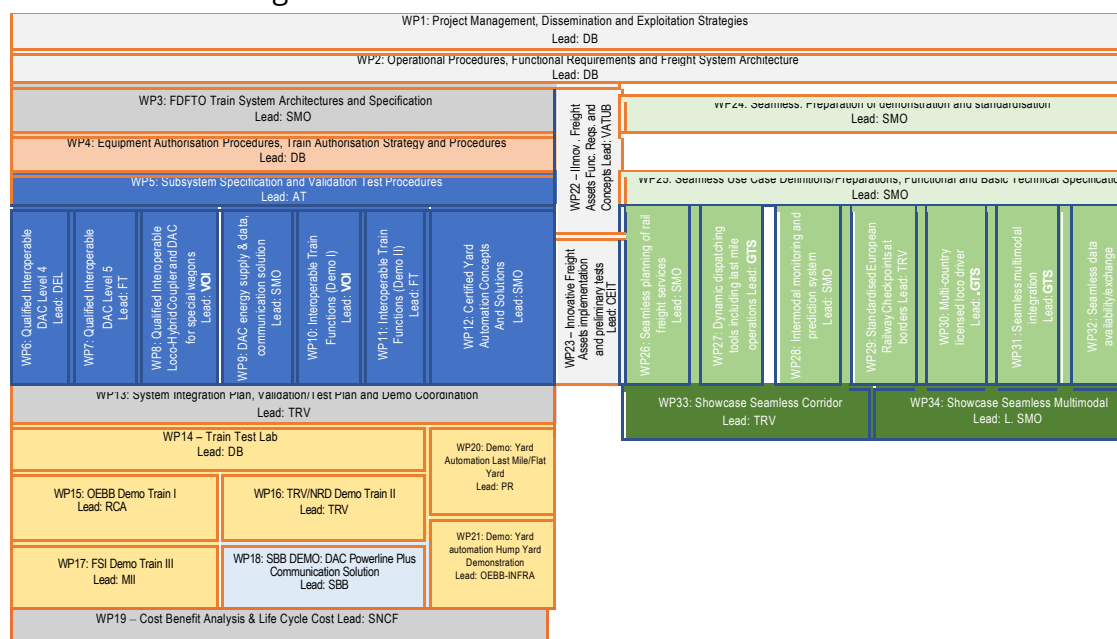


Figure 1: WP-structure in TRANS4M-R

One main structural aspect of the project is the division into two subprojects: 1) Full Digital Freight Train Operation (FDFTO) and 2) Seamless operations. While FDFTO comprises mainly developments related to the enabler Digital Automatic Coupler (DAC) and respective train functions as well as Automatic Shunting Operations (ASO), seamless operation covers technical and organizational developments for facilitating a more intuitive and easy planning of rail freight services, especially in the international and intermodal context.

Within this context, this Deliverable D1.5 (and the related task 1.8) covers the different levels of the project by integrating the different work streams. One important aspect for future developments within FP5- TRANS4M-R is the definition of a common working basis, also for the test planning (WP13) and Life Cycle Cost (LCC) calculation (WP19). Accordingly, as part of WP1, this Deliverable 1.5 comprises the definition of a reference for the measuring process of the projects KPIs as well as a first estimate of potential improvements. This Deliverable 1.5 follows the clustering of the project in FDFTO and seamless which is especially important due to the different TRL both subprojects are aiming for.

4 Objective/Aim

The objective of this document is to provide the project's KPIs, the respective measuring process as a clear reference basis as well as a first estimation of how the KPI will improve by the project's developed technical enablers (TE). For this reason, an alignment with WP13 for test planning as well as WP19 for LCC analyses is important.

4.1 Task Description

Task 1.8 started in month three and the outputs of this task are included in this document. The following table gives the direct match of the task definition from the proposal with the output and a link to the section where more details can be found.

Table 1 Task description matched with output in deliverable

	Task definition from GA (Task 1.8)	Output of deliverable
Task 1.8	This task will describe the specific metrics and methods to measure and achieve impacts of the FP5-TRANS4M-R Project.	Chapter 5: FP5 TRANS4M-R KPI Chapter 6: Methodology: process to measure success of our FP5
Task 1.8	It will align and integrate the developed KPIs with FP1, FP2, and FP3 to measure the ERJU impact of technologies and projects as listed in DoA Part B Section 2.3.2.	Chapter 5: FP5 TRANS4M-R KPI Chapter 0: Alignment within Europe's Rail
Task 1.8	This task will provide, upon request and at least on a semi-annual basis, input in the most appropriate format to the KPI to quantify the impacts for developing the KPI- collator at Europe's Rail program level. Project KPIs will be reported in the Public Summary section of the REPA.	Chapter 0: Alignment within Europe's Rail Chapter 9: Conclusion and Next steps
	Deliverable definition from GA (D1.5)	Output of deliverable
D1.5	Specific metrics and methods to measure and achieve impacts of the FP5-TRANS4M-R Project.	Chapter 5: FP5 TRANS4M-R KPI Chapter 6: Methodology: process to measure success of our FP5 Chapter 7: Initial estimation of the KPIs

5 FP5 TRANS4M-R KPI

In the following, the KPIs to be measured by FP5 TRANS4M-R are listed as described with their intended target values in Annex 1 of the projects Grant Agreement [1], based on the MAWP [2].

Table 2 List of KPIs

5.1	Decrease train formation/ decomposition (shunting/coupling/uncoupling) time	Expected time reduction targeting 40-50%
5.2	Decrease train preparation/ departure process time	Expected time reduction targeting 40-70%
5.3	Increased average train length [m] up to maximum length in existing infrastructure limitations or higher loads	Train length increased up to 1.500 m
5.4	Reduce average transportation time on reference corridor	Time reduced targeting 10-20%
5.5	Reduce operational dwell time at borders and other handover points	Dwell time reduced targeting 50%
5.6	Reduce the number of non-added value additional operational stops	Reduced number of operational stops targeting 20%
5.7	Reduce handling/ response time for ad-hoc cross border path requests	Reduced time by targeting 70%.
5.8	Reduce handling/ response time for connected comprehensive intermodal offers	Reduced time by at least 50%.
5.9	Reduced energy consumption and reduced footprint through less stops at borders	Reduced energy consumption by a minimum of 10 %

6 Methodology: process to measure success of our FP5

Measuring the improvements of the project's KPI comprises three important aspects, as shown in Figure 2. First, it is important to define the (technical) improvements that will be achieved by the project activities. These improvements are represented by the project's WPs, demonstrators and finally the various technical enablers. Second, a clear reference process is crucial. It is important to define what is measured and in what way. Third, the measurement of the KPIs at the different project stages needs to stick to this very same process for the different measurements being truly comparable.

These three different steps are interfacing each other as indicated by the arrows in Figure 2. Following these principles, the following chapters present these interfaces. First, the KPIs (see chapter 5) are mapped to the projects technical enablers as described in chapter 6.1. In chapter 6.2 the clear reference measuring process is defined by mapping the KPI to the Operational Procedures that were developed and aligned within the sector (see Deliverable 2.1 "Preliminary Operational. Procedures" of FP5, [4]). Finally, the process steps are identified that will be improved by the different technical enablers. Within the scope of the European DAC Delivery Programme (EDDP), such an impact analysis was performed for the DAC and documented in a report [5]. Since it is important to standardize these measurements within the sector, the approach within this deliverable is harmonized with the approach taken in the report [5] as presented in in chapter 6.3.

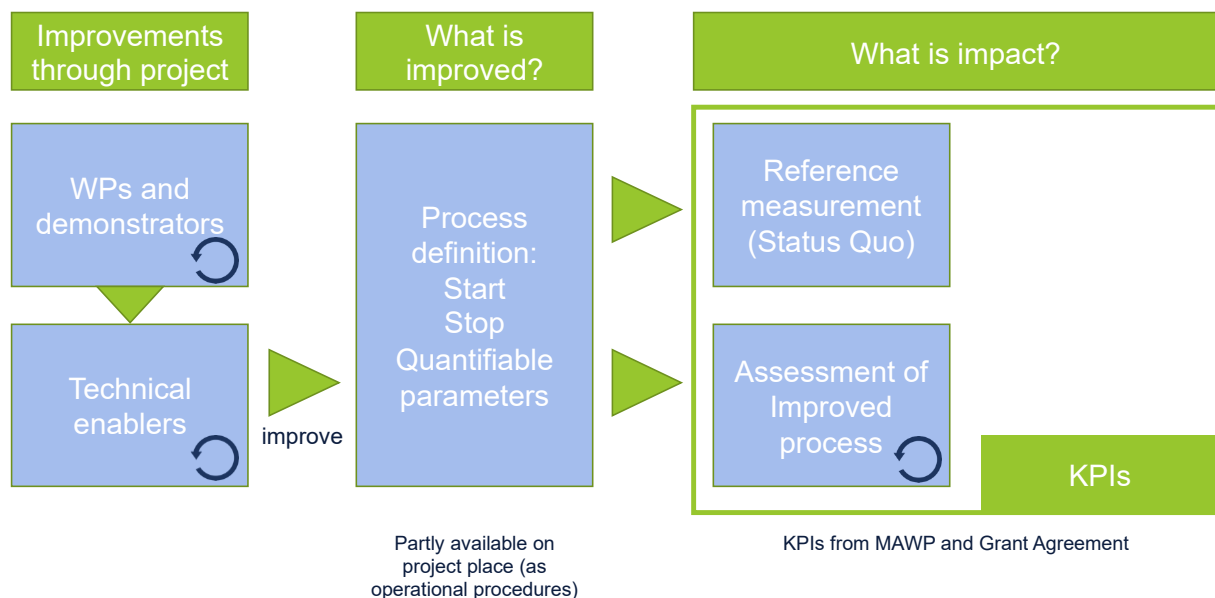


Figure 2: FP5 KPI measuring process

The described approach is based on the aim that the KPI shall measure the improvement reached through the project's technical enablers and not be biased by differences in

existing processes. Currently, the underlying processes that will be affected by the TE vary largely (see e.g. [5]). For example, the shunting processes and process times vary partly to a large extent due to for example shunting yard size, type (flat shunting, hump shunting, combined transport terminals). In addition, average values vary highly between entities or railway undertakings, respectively, up to a factor of 1.5 [5]. Since the KPI measurements shall reflect the different functional capabilities of the developed solutions (the better the solution, the better the KPI) and not measure the differences in existing processes, the described KPI measuring approach is based on the identification of single tasks within the processes that will be improved or made even obsolete by the different TE. Procedural improvements can be assessed via assumptions on time savings for the single tasks. In the further course of the project, tests (see chapter 0 for an alignment with the test planning and execution WPs within FP5-TRANS4M-R) will verify these assumptions on time savings for the single tasks. Accordingly, the KPI measurement focuses on the average improvement of the processes achieved. An analysis on whether the processes will get more robust due to better controllability of failures and thus lead to a further improvement, is beyond the scope of this study. Analogously, an assessment of the process times in commercial use is also beyond the scope of this project.

6.1 Mapping the KPI to the technical enablers

As a first step, the KPIs are mapped to the projects Technical Enablers (TE) to identify the fields in which the project developments (embodied by the TE) will have an impact that will lead to an improvement of the according KPI. As described in the introduction (chapter 3), the methodology and the results will be separately described for the two subprojects FDFTO and Seamless Operation.

6.1.1 FDFTO

The KPIs 5.1. to 5.3 (see chapter 5 and Figure 3) are related to FDFTO. In addition, KPI 5.4 is an overarching KPI that is mostly relevant to Seamless Operation on mainline operations, but it is also influenced by FDFTO. These KPIs are mapped to the projects TE. The relevant TEs are TE1-TE7 as summarized in Figure 3.

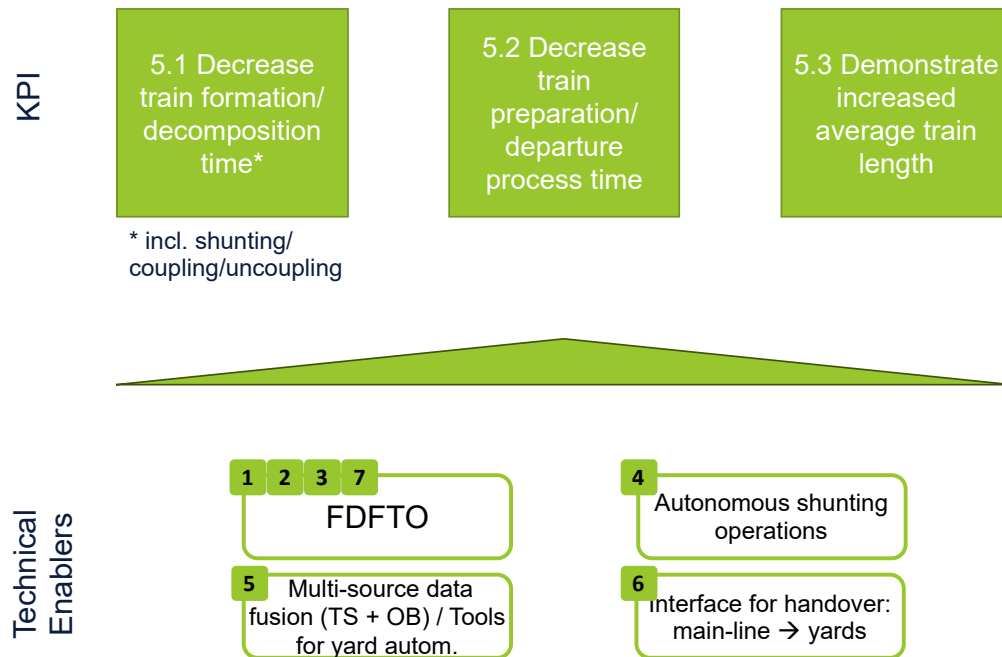


Figure 3: Mapping FDFTO KPI to Technical Enablers.

The detailed description of the TEs TE1-TE7 is shown in the following Table 3, alongside with a concise naming. Based on this mapping, the relevant operational procedures could be identified as described in the following section in chapter 6.2.

Table 3 Details of Technical Enablers TE1-TE1 relevant for FDFTO KPI

Technical Enabler	Description, acc. to Grant Agreement [1] and [6]
1. Interoperable DAC type 5 ready	Development of an EU-harmonized DAC, plus the necessary freight consist of backbone system including a solution for both the energy supply as well as data/communication (...).
2. Development of DAC-enabled train functions	Developing a train composition detection (train inauguration)/ management system, automated/ automatic brake test system, Train integrity monitoring and train length determination (...).
3. Preparation for additional train functions	Automated parking brake system, digital wagon inspection, DAC based telematics applications, distributed power system, electro- pneumatic brake and cover important preparatory works incl. train dynamics with higher TRL for the future set of demonstration (...).
4. Autonomous shunting operations	Development of systems and solutions for basic autonomous shunting operations. Development of solutions for yard automation including digitalization that enable automated train composition and dispatching (Automated Shunting Operations), including necessary wagon identity system for automated shunting and cover important preparatory works with higher TRL (...).
5. Multi-source data fusion (TS + OB)	Integrative deployment of video gates, wayside check points, visual recognition methodologies and AI-Tools for yard automation.
6. Interface for handover: main-line → yards	Achieving expected consolidation of the expected new freight capabilities, providing requirements and giving feedback to Destination 2 for new automation technology solutions for the automated driving and decision-making as well as automating functions, such as train preparation and basic automatic yard shunting.
7. DAC for T3000 wagons	Developing DAC based wagon concepts incl. multi-modal transport applications (...).

6.1.2 Seamless Operations

The TEs considered in Seamless Operations and their mapping towards the KPIs are presented in Figure 4 and the details and TEs presented in Table 4 :

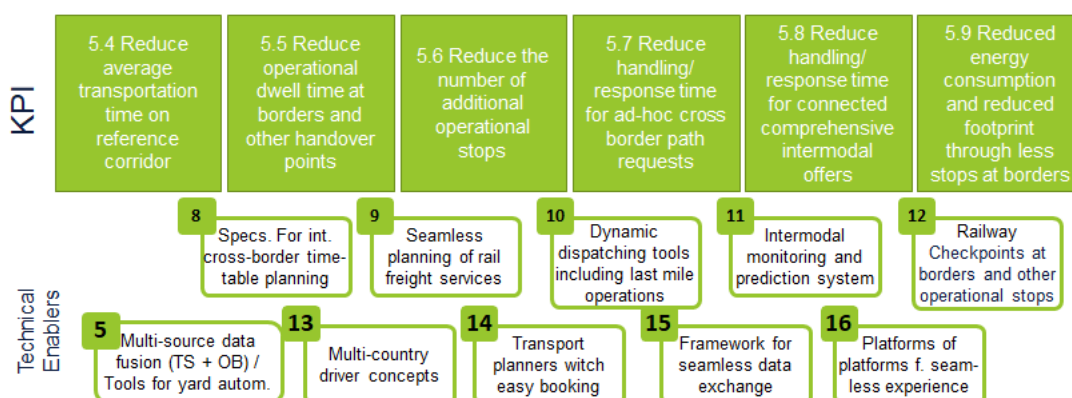


Figure 4 Mapping the Technical enablers considered in the Seamless cluster of FP5 and the KPI's.

Table 4 Details of Technical Enablers TE8-16 relevant for Seamless Operations KPI

Technical Enabler	Description, acc. to Grant Agreement
TE 08: Freight-specific requirements for cross-border timetable planning	Specify and deliver freight specific requirements for integrated cross-border timetable planning, management and path ordering systems (including requirements for covering also the last mile) suitable for development in destination 1
TE 09: Seamless planning of rail freight services	Setting up the respective models and systems to test and demonstrate the destination 1 developments for integrated timetable planning on selected part of a European corridor and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
TE 10: Dynamic Dispatching tools including last mile operations	Develop dynamic yard/terminal management systems and test their integration with dynamic TMS based on agreed interfaces that will be specified among destination 1 and the TMS development will come from destination 1 and cover important preparatory works with higher TRL for the future

	set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
TE 11: Intermodal monitoring prediction system	Specify and develop intermodal monitoring and prediction systems, which shall work in combination with dynamic TMS and other resource management systems using AI based models, accuracy and computational learning functions and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
TE 12: Railway Checkpoints at borders and operational stops	Specify and develop Railway Checkpoints that will automate Freight Train Transfer Inspections at borders or other operational stop points, digitalising and automating processes through innovative sensors, specialised adapted video gates and handheld devices, in combination with harmonized procedures and regulation across European rail network and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
TE 13: Multi-country driver concepts	Finalise R&I development of certified secured translation tools ¹⁰⁰ to enable in combination with multi-country driver licensing and appropriate rostering concepts a harmonised cross-country operation and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
TE 14: Multimodal Integration	Specifications for the development of integrated multimodal transport planning, management and operational systems enabling easy access to rail-base (intermodal) services and dynamic demand responsive service offering, network planning and capacity management based on agreed interfaces with TMS –with Destination 1 – and the specific freight development to support this functionality. And cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions

TE 15: Framework for seamless data exchange	Analysis and coordination of requirements for seamless data exchange / data availability for the various Destination 5 developments and planned demonstrations, considering existing/proposed data standards (if applicable) and regulations e.g., TAF TSI. Specification and development of required processes/tools (e.g., interfaces/ converters.) and cover important preparatory works with higher TRL for the future set of demonstration foreseen in the Multi- annual Work programme in view of the evolutions of the solutions
TE 16: Platform of Platform for Seamless experience	Analysis and coordination of required technology upgrades of legacy/national systems to be able to provide/consume/process harmonised data from/for international (European) applications/innovations. Development of an implementation plan.

6.2 Mapping the KPI to operational procedures and creating a clear reference

Since the developed technical enablers will not be commercialized during the project duration, the measurement of the benefits of the introduction of the technical enablers can only be measured under testing and demonstration conditions. To this aim, it is important to define where the technical enablers will improve the underlying processes. As a first step, in the previous chapter, the mapping of the technical enablers to the KPIs is shown. In the following sections, it is defined which processes are affected by which KPI. It is important to use a standardized basis for all the processed. Within TRANS4M-R, such European wide standardized operational procedures have already been defined in FP5 D2.1 Operational Procedures [4]. In the following, these processes of D2.1 are used.

6.2.1 FDFTO

KPI 5.1

Decrease train formation / decomposition time

For KPI 5.1 the Operational processes *EP01 Shunting Preparation* as well as the *EP02 Wagon Processing* are relevant. In D2.1 [4], these are detailed out step by step and described for every potential case. EP hereby stands for EU-Rail Procedure to indicate the processes that will be available at the end of TRANS4M-R, assuming all technical enablers being developed and in place¹. For reference, the flow charts of the relevant operational

¹ Within the framework of ER JU FP5-TRANSM-R, not all developments that represent the target state are carried out. For this reason, semi-automated processes, called "ER JU Process", are defined [4].

procedures are shown in the annex (chapter 11.1). The single steps of the procedures EP01 and EP02 that will improve KPI 5.1 are shown in Table 5. A clear definition of the start and end of the processes is hereby important.

Table 5 Details of Operational Procedures EP01 and EP02 as important to KPI 5.1

EP01 Shunting Preparation	EP02 Wagon Processing
Start: Train arrived in target track End: Wagon is ready for shunting Activities*: 1.1 Check additional wagon data 1.2 Confirm wagon set 1.3 Secure wagon set against rolling away 1.4 Adjust rear end signal 1.5 Switch wagons of set to FDFT mode shunting 1.6 Ensure rolling capacity 1.7. Uncouple traction unit 1.8 Initiate movement of traction unit – leaves wagon (set) 1.9. Movement of traction unit – leaves wagon (set)	Start: Wagon is ready for shunting End: Wagons of set are (coupled), secured against rolling away in target tracks and the wagon set processing is completed Activities*: 2.1 Initiate movement of traction unit to wagon set 2.2 Movement of traction unit to wagon set 2.3 Couple traction unit 2.4 Secure to be removed wagon (set) against rolling away 2.5 Uncouple at uncoupling point of shunting composition 2.6 Confirm wagon set 2.7 Compile additional wagon data 2.9 Update/create cut list information 2.10 Send cut list information and wagon target track data 2.11 Receive cut list information and wagon target track data 2.12 Remove / release planned braking means 2.13 Ensure enough brake power is available 2.14 Shunting composition is ready for shunting 2.15 – 2.18 Hump/Fly shunting/Flat shunting drop-off/Pick up 2.19 Initiate movement of traction unit to wagon set 2.20 Movement of traction unit – leaves track 2.21 Secure wagon (set) against rolling away 2.22 Uncouple traction unit 2.23 Initiate movement of traction unit to wagon set 2.24 Movement of traction unit – leaves target track
* Decision paths acc. to D2.1 [4]	

KPI 5.2

Decrease train preparation/ departure process time

For KPI 5.2 the Operational process *EP03 Train Preparation* is relevant. The single steps of the procedure EP03 that will improve KPI 5.2 are shown in Table 6. A clear definition of the start and end of the processes is hereby important.

Table 6 Details of Operational Procedures TP03 as important to KPI 5.2

EP03 Train preparation	
Start: Wagons of set are (coupled), secured against rolling away in target tracks and the wagon set processing is completed End: Train is ready for departure Activities (Decision paths acc. to D2.1):	
3.1 (Detect wagon set is ready for train preparation and) Initiate train preparation 3.2 Manually / automatically connect to wagon set 3.3. Initiate movement of traction unit to wagon set 3.4 Movement of traction unit to wagon set 3.5 Couple traction unit to wagon set 3.6/3.7 Build up pressure up to operating pressure 3.8 Detect/check if shunting composition is ready for the following steps 3.9 Confirm wagon set 3.10 Remove / release planned braking means 3.11 Perform brake test 3.12 Perform manual/technical wagon inspection 3.13 Initiate brake calculation 3.14 Brake calculation 3.15 Check technical wagon inspection and brake power	3.16 Activate rear-end signal 3.17 Uncouple traction unit 3.18 Initiate movement of traction unit 3.19 Movement if traction unit – leaves track 3.20 Manually / automatically disconnect stationary device 3.21 Initiate movement if traction unit 3.22 Movement of traction unite to wagon set 3.23 Couple traction unit 3.24 Confirm wagon set 3.25 Remove / release planned braking means 3.26 Perform brake test 3.27 If necessary adjust G/P lever position 3.28 Compile, check and send all necessary train data to (Traction unit) and to Yard Legacy System and FDFT Yard 3.29 Check if train is ready for departure 3.30 Detect train is ready for departure 3.31. Switch to FDFT mode Train Run

KPI 5.3

Demonstrate increased average train length

The length of freight trains is limited on the train side mainly due to two reasons: 1) The maximum train weight is limited by the operational (tensile) forces of the couplers. 2) From a certain length, long trains can no longer be braked purely pneumatically.

As a rule of thumb, the maximum train weight and thus, – ceteris paribus – the train length can be increased proportionally to the maximum operational forces of the coupler systems. Today's screw coupler systems with a maximum operational force of 450 kN do not allow for riding freight trains in double traction in Germany that require operational forces up to 600 kN. For the DAC, a recommended maximum operational force in day use of 850 kN is currently under discussion (see also FP5, D5.2 [10]). The potential train length thus would increase accordingly. This potential is especially high for trains that are rather short due to very heavy loads – for example freight trains carrying metal-coils have already a load around 3500t at a length of 500 m.

In addition, the DAC can act as an enabler for further technologies. With the introduction of an ep-brake (or Distributed traction with decentralized ventilation) for example, the natural length limit of trains for purely pneumatic braking would be lifted. However, since such technologies need further investigation and are not part of the development of TRANS4M-R, these are out of scope for this document.

Please note “that the main limitation of train length today is infrastructure rather than the coupling technology (or any other low-cost/soft constraint).” [5] Accordingly, the relevance of heavier trains is similarly important for the freight sector and is thus included in the discussion of this KPI.

Which specific steps of the different processes are impacted by the different technical enablers?

This question is the last important step to concretely identify where improvements can be expected. Accordingly, it is the important basis for the estimations on the KPI improvements shown in chapter 6.3.

In Table 7, the impact of every technical enabler is shown. For every technical enabler (column 1), each step which is affected by the according technical enabler is shown as a matrix, distinguished for the three relevant processes EP01, EP02, and EP03.

Table 7 Technical enabler and process step impact matrix

Technical Enabler	EP01 Shunting Preparation	EP02 Wagon Processing	EP03 Train Preparation
TE1-3: DAC	(uncouple traction unit); Confirm wagon set; Secure wagon set against rolling away; Bleeding	Couple/Uncouple traction unit; Remove wagon; Couple (in shunting process); Confirm wagon set Remove braking means; Ensure enough brake power is available; Secure wagon set against rolling away	Couple/Uncouple traction unit/stationary device; Confirm wagon set; Perform brake test; Detect wagon set is ready for train preparation; Build up pressure up to operating pressure; Remove/release braking means; Detect train is ready for departure
TE4: Autonomous shunting operations	Confirm wagon set	Update cut list information; Update wagon set data, wagon destination data and cut list information in FDFT Yard; Shunting process	Confirm wagon set
TE5: Multi-source data fusion (TS + OB)	Confirm wagon set	Compile additional wagon data	Confirm wagon set; Perform technical Wagon inspection; Brake calculation
TE6: Interface for handover: main-line → yards	Relevant for ATO traction unit, not discussed in this document		

Table 8 Details of the Operational Procedures relevant for Seamless operations

Technical Enabler	EP10 - Confirm Wagon Set	EP11 Technical Wagon Inspection
12. Standardised European Checkpoints at Operational stops 5. Multi-source data fusion	10.1 Collect planned data of wagon set 10.2 Initiate collection of consist status data** 10.3 Collect and provide consist status data** 10.4 Match planned and current data** 10.5 Update plan data to accommodate deviations 10.6 Error handling process 10.7 Check wagon set data	11.1 Initiate technical wagon inspection routine 11.2 Perform technical wagon inspection routine ** - WI11.2 Perform manual wagon inspection routine** 11.3 Collect additional infrastructure data on wagon(s) in set 11.4 Calculate reliability and accuracy of inspection and calculation WI 11.5 Perform manual inspection to complement missing data 11.6 Check if all wagon(s) passed inspection and save results

As the majority of the TEs considered in Seamless operations are not directly related to a specific operational procedure, an alternative methodology is proposed for the assessment on their impact on the KPIs. The methodology is called “The Seamless Virtual Freight Train” and the assessment is carried out in the following steps:

1. Identification of use cases within the TEs/WPs in Seamless operations, as illustrated by Figure 6
2. Allocation of the use cases’ impact within the transport chain and relevant planning horizon, as illustrated by Figure 7
3. Aggregating the combined impact of the use cases on the KPIs, for results see Table 17 and Table 18. With reduced deviations and increased predictability, rail freight operations can closely follow the initial schedule and thus decrease inefficiencies and resulting operational costs.

As described above, first the different use cases are identified for the different WPs, as shown in Figure 6. The use cases are color-coded by WP to make them traceable in Figure 6 to Figure 8.

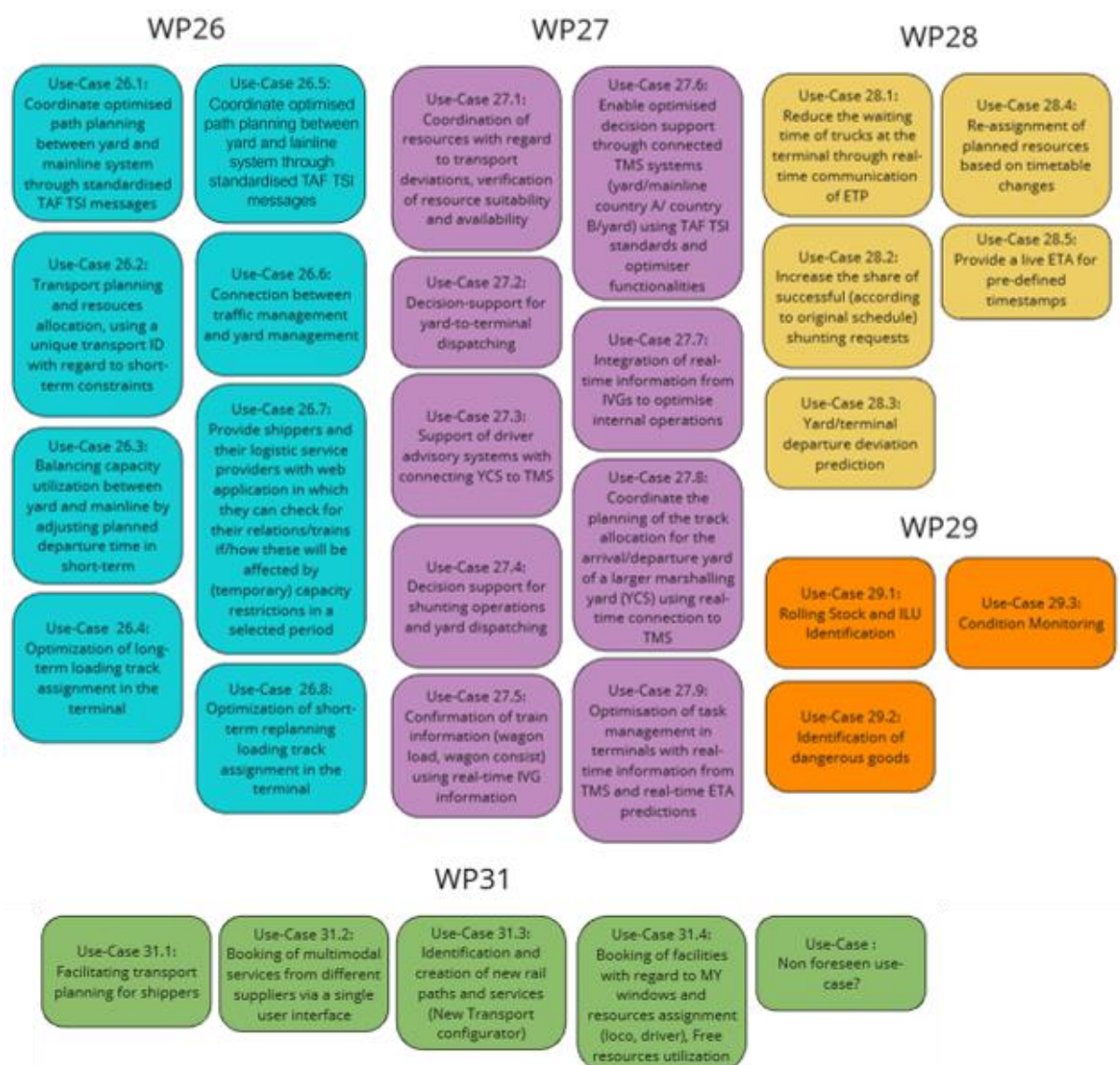


Figure 6 Identification of Use cases considered in WPs of Seamless operations

Figure 7 allocates the use cases to their impact within the transport chain and the respective planning horizon; long-term planning (strategic planning >1 year), short term planning (tactical planning, <1 year on monthly and weekly basis) and Live Operations (Operational planning on daily and real time basis). For use case numbering and colouring please refer to Figure 6.

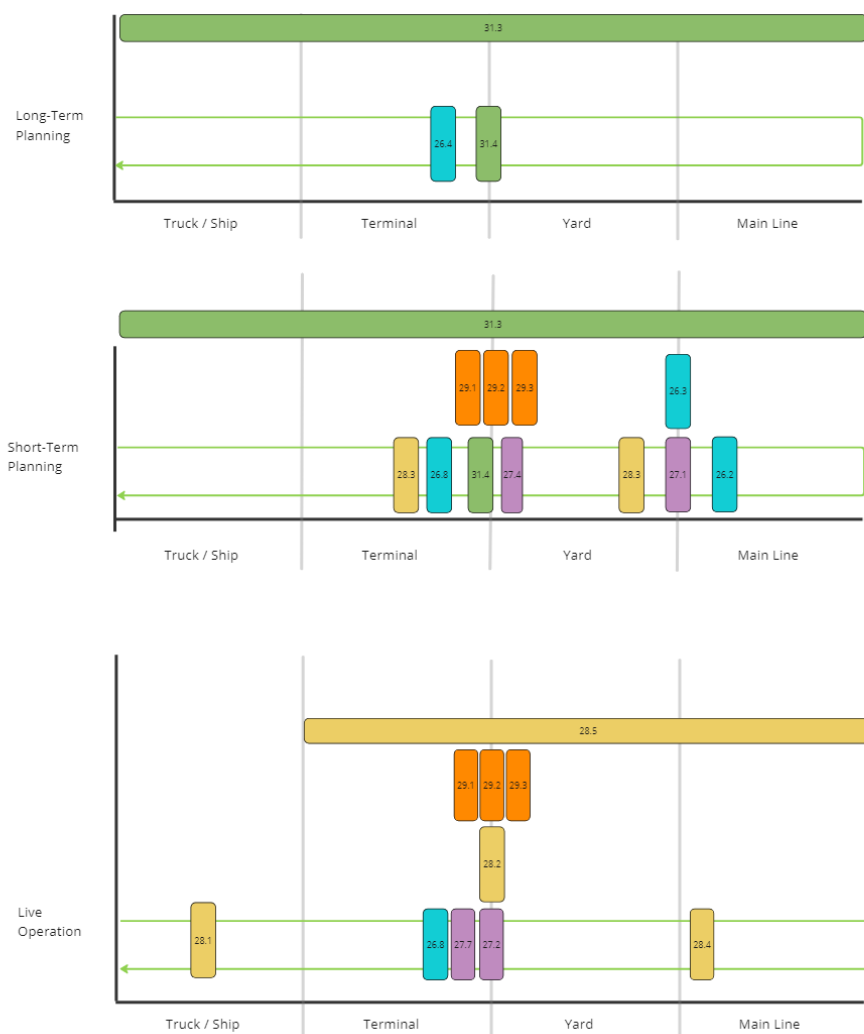


Figure 7 Allocation of the use cases' impact within the transport chain and relevant planning horizon.

Finally, the use cases are allocated to the relevant KPI. Table 18 in Appendix illustrates the allocation of the identified use cases to relevant KPIs as well as specific reference values and expected improvements for each use case.

In order to quantify the combined effect of the use cases in Table 18 and how they correspond to the target values expressed in Table 2, a theoretical reference train is constructed for the reference corridor "Malmö-Alnabru", a section of the ScanMed corridor. The characteristics of the reference train is presented in Table 9, the input parameters are derived from a cost model developed by KTH. [7]

Table 9. Reference train used for assessing the combined effect on the KPIs of the use cases within the Seamless cluster.

Reference Intermodal freight train				Train loading unit capacity			
Locomotive				Loading unit capacity	# LU	88	
Type				Load factor - train	% → # LU	80%	
TRAXX				Wagons	#	22	
Electric				Average loaded units	#	70	
Traction				Average gross weight/unit	tonne	12,0	
Tractive effort	KWh	5600		Tare weight/loading unit	tonne	2,3	
Axles/locomotive	#	4		Payload/loading unit	tonne	9,8	
Weight	tonne	82		Train tare weight	tonne	698	
Axle load	tonne	21		Payload weight	tonne	686,4	
Length	meter	18,9		Total load weight (Payload + tare for LUs)	tonne	845	
Energy consumption	KWh/locokm	5,0		Total gross tonne excl. loco	tonne	1 522	
Wagons				Total gross tonne incl. loco	tonne	1 543	
Type		Sggrss		Axles per train	#	136	
Axles		6		Train length	meter	606,3	
Max gross weight	tonne	135		Operational data			
Tare weight	tonne	28		Line length	km	631,5	
Payload	tonne	107		Timetable time	h	10:53	
Number of TEUs per wagon	#	4		Average speed	km/h	58	
Loading length	feet	80		Infrastructure data			
Loading length	meter	24,52		Maximum train length	m	630	
Total length	meter	26,7		Max axle load	tonne	22,5	
Energy consumption	KWh/grosstonnekr	0,0152		Max speed	km/h	100	

A methodology is presented in Figure 8 for the final assessment of the combined effect of the use cases within the Seamless cluster, that will be carried out in D1.6, where the use cases are demonstrated within so called “Demonstration groups” (DG). The main idea for the final assessment of the KPIs is for four demonstration groups to demonstrate the use cases (within the framework of the Showcase of WP33) and to evaluate them, gather measurements and assess how they contribute to KPIs 5.4-5.9.

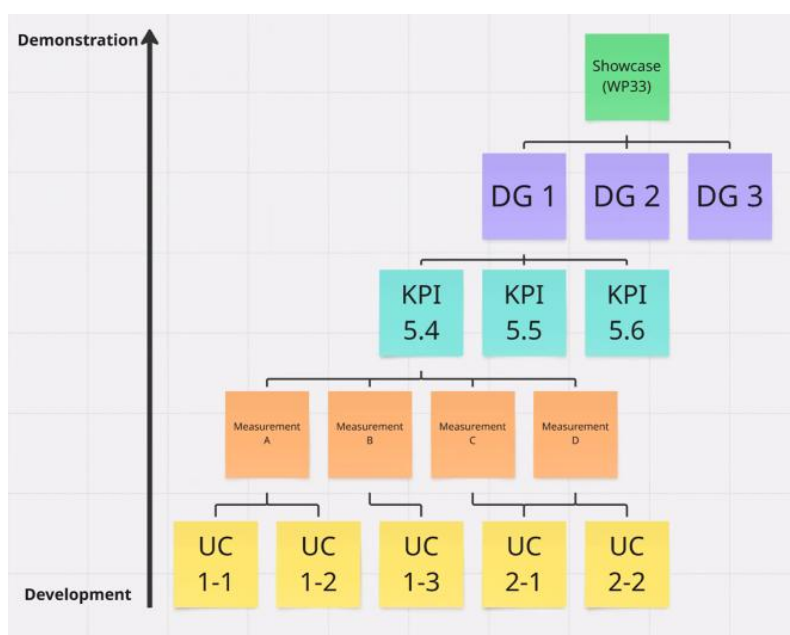


Figure 8 Development from use cases to Showcase

Figure 9 describes the four demogroups within the Seamless cluster, which have initiated mapping of measurements towards the impact on the KPIs. Table 10 presents the KPIs that the demo groups expect to have impact upon. Figure 13 in the appendix presents an elaborated description on the expected impact of demo groups.

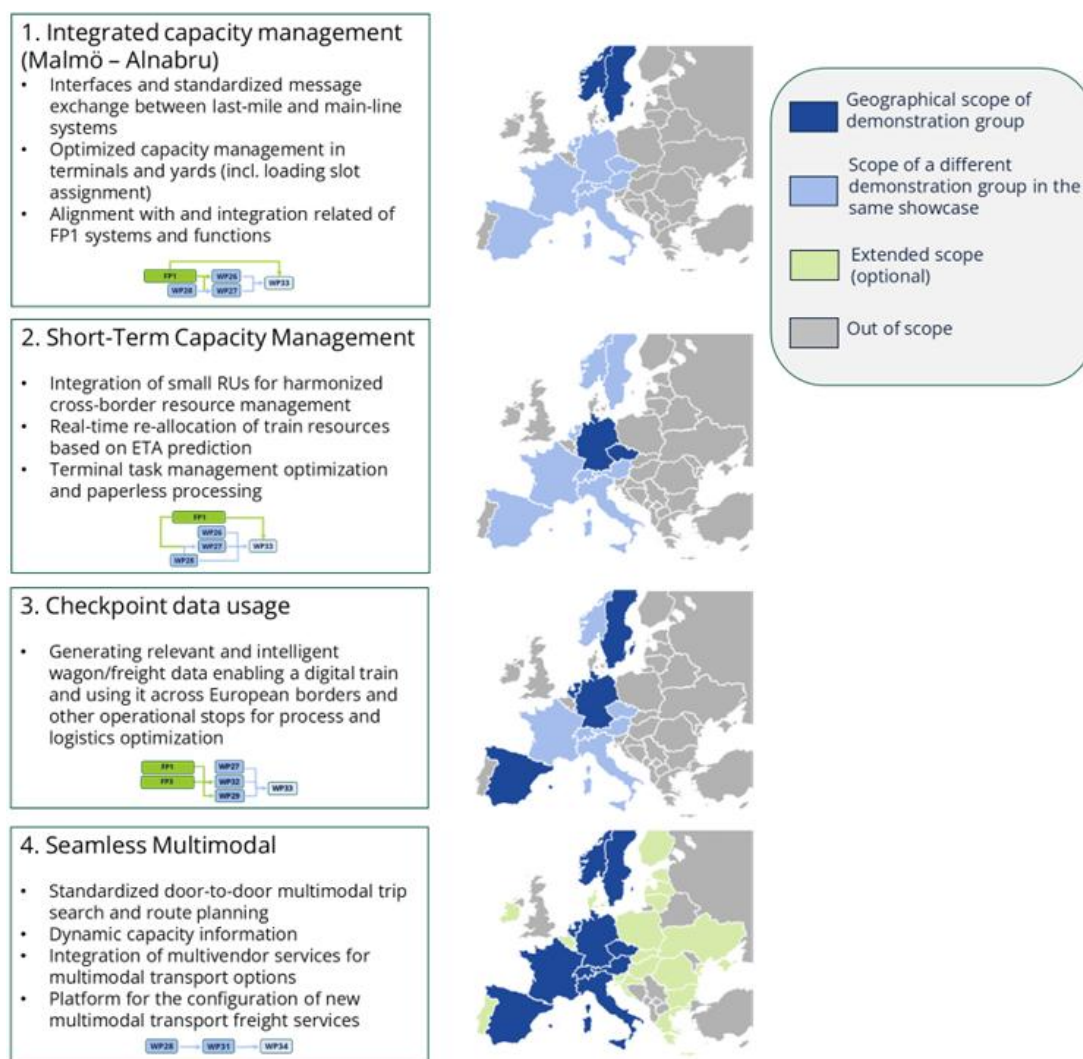


Figure 9. The four demonstrations groups within the Seamless cluster

Table 10. Mapping the KPIs towards the expected impact of demo groups.

	KPI 5.4	KPI 5.5	KPI 5.6	KPI 5.7	KPI 5.8	KPI 5.9
Demo group 1	x	x	x	x	x	
Demo group 2	x	x	x	x		
Demo group 3		x	x			
Demo group 4					x	x

6.3 Estimated impact of the technical enablers on the measured processes

In this chapter, it is estimated how much improvement can be expected for the single process steps by applying the different technical enablers. In this deliverable, we state all expected improvements in the target processes. The estimated improvements will be validated for the functions available during the course of the project, namely the EDDP basic package.

6.3.1 FDFTO

For FDFTO, such an analysis of how much today's processes will be improved by the developments of the DAC and its enabled functions such as automated brake tests has been performed in the EDDP context. The report *Digital automatic coupling – cost benefit analysis (initial report)* [5] describes in detail today's processes and expected improvements for different technical packages and provides a solid data basis for today's baseline processes². The analyses performed there can be directly mapped to the processes that are necessary to the KPIs within this report. Accordingly, the process description and reference data of [5] are adopted. This is crucial to allow for a harmonized approach and comparability among the different European Rail projects. The defined processes in the CBA report [5] can be mapped to the operational procedures as presented above. EP01 Shunting Preparation corresponds to *train splitting up/shunting* in [5], EP02 Wagon Processing to *Train preparation / shunting* and EP03 Train preparation corresponds to *train preparation*. Accordingly, KPI 5.1 – which comprises the operational procedures EP01 Shunting Preparation, EP02 Wagon processing and EP03 Train preparation – can be mapped to the sub processes train splitting up/shunting and Train preparation / shunting (see also Table 11). KPI 5.2 – comprising EP03 Train Preparation – can be mapped to the process train preparation / shunting.

The following table shows the expected time savings for the different process steps. Time savings are shown combined for small and big marshalling yards, as well as for Combined transport terminals. Data is taken from [5], where data is shown separately. *The potential benefit is either given through a relative value (% of decrease of the time) or in absolute value (new time)*. [5, p. 53]. In the original document, the process step “handover of shipping document” was listed but without any impact. Here, it was left out.

² The report states on this: “a spreadsheet form was circulated as part of the survey in order to collect data on the time it takes for each sub-process today. This was then used for estimations of time savings as a percentage of overall operation time. (...). In total, 9 organizations contributed, located across Europe, representing approximately 30 to 55% of total European rail freight. [5], p. 48.

Table 11 Time Gains of FDFTO in Small and Big Marshalling yards and combined transport terminals. Data Source: [5]

Small Marshalling Yards/Big Marshalling Yards/Combined Transport Terminal	DAC 4	DAC 5 actuator	communication system	automated venting device	automated park brake system	automatic brake test device	train integrity / eot system	automated wagon inspection
<i>If the number is the same for all three options, only one number is given</i>								
train de-initialisation			0,2					
arrival notice			-100%					
putting safety stop					-100%			
Uncoupling Loco	-20%	-80%						
train inspection at train arrival								-50%
optional: check/recording train composition			-100%					
Couple Shunting Loco	-100%							
Remove rear train end signal							-100%	
removal of safety stop (wagon)					-100%			
Train arrival								
putting safety stop (wagon)					-100%			
Loosening of couplings	-/-/-20%	-/-/-80%						
Venting				-/-100%/-100%				
removal of safety stop (wagon)					-/-100%/-			
Uncoupling Shunting Loco	-20%	-80%						
Uncoupling	-20%	-80%						
Train splitting up/ shunting								
check/recording of wagon list			-100%/-/-100%					
Couple Shunting Loco	-100%	-						
Backing mov. of wagons (by shunting loco)								
Coupling	-100%	-						
Train inspection before coupling								-/-/-50%
simplified brake test within shunting operations						6		
- each time you couple a wagon								
- check if brakes are released								
Uncouple Shunting Loco - shunting mode end	-20%/-20%/-	-80%/-80%/-						
Train preparation / shunting								
Couple Main Line Loco	-100%							
full brake test						8		
train inspection full after coupling								-50%
check/recording train composition			-/-/-100%					
simplified brake test						-/6/6		
Train preparation								
Putting train rear end signal							-100%	
train initialisation			0,2					
removal of safety stop (wagon)					-100%			
departure notice in IT system			-100%					
Train departure								

On the limitations of KPI 5.3 “Increased average train length [m] up to maximum length in existing infrastructure limitations or higher loads” please refer to chapters 6.2.1 and 7.1.

For every entry of Table 11, the assumed time savings will be validated within the planned tests. For example, it is assumed that automated uncoupling will reduce uncouple time for a DAC5 by up to 80%. By measuring the time needed for the decoupling processes in the tests with the available components, this assumption can be validated by comparing these measurements to today's reference.

6.3.2 Seamless

As stated, regarding the assessment of technical enablers considered in Seamless Operations, two operational procedures are directly influenced; EP10 Confirm wagon set and EP11 Technical wagon inspection. These are affected by TE12 Railway Checkpoints at borders and at other operational stops. Reference values for these operational procedures are gathered from the same source as Table 11 and validated with values from a large yard in Sweden, Hallsberg marshalling yard [8]. EP10 is considered to last 0.5 min/wagon and EP11 3.5 min/wagon for full technical wagon inspection before departure and 1 min/wagon for arrival inspection. Reference values for EP11 have been validated by operators within WP29/TE12.

Table 18 in the appendix, presents reference values and expected improvements of each use case to the KPIs and thus the estimated impact of seamless virtual freight assessment methodology, as presented in section 6.2.2. These detailed use cases will allow for a validation approach of the estimated improvements comparable to the approach for FDFTO, as described in the previous chapter.

7 Initial estimation of the KPIs

Finally, the measured baseline data as well as the estimated improved KPI are presented in the following.

7.1 FDFTO

The time spent per train on site is an important basis for the calculations. In [5], these times are distinguished per production system and the average is given as follows (5, p. 52):

- Block Trains: 4,97 h on site per train on average
- Intermodal Trains: 3,61 h on site per train on average
- Single Wagon Load Trains: 4,30 h on site per train on average

For the assessment of the impacts of the different developed functionalities, in [5], different technical packages are defined and their impact on process times is evaluated. For sake of comprehensibility, we show this approach in the following. However, for the monitoring of the KPI within the scope of FP5 TRANS4M-R, only the EDDP basic package will be relevant. This approach might be adapted if necessary. The packages contain the following functionalities ([5], p. 44):

- Package 1:
DAC4, communication backbone, Train composition detection, Draining valve for auxiliary air tanks, Automated air valve
- Package 2:
Package 1 + DAC 5
- Package 3
Package 2 + Automated Brake Test
- Package 4
Package 3 + Automated Technical Wagon Inspection, Automated Parking Brake, Tail Light (control device)

The different packages have no direct equivalent in the technical enablers (see Table 3) but mostly comprise different stages of development of all technical enablers TE1-5. However, the developed technologies within the TRANS4M-R project can be mapped to reach the status of “Package 3”. Namely, the DAC basic package will be developed within TRANS4M-R, “which includes the following DAC functionalities:

- Train composition detection, including safe train length determination
- Train integrity monitoring
- Automated brake testing
- Decoupling of consists from a locomotive and via local push buttons” ([14], p. 28).

The time gains for the time on site for the different packages are summarized in the following Table 12.

Table 12 Expected Time Gains of FDFTO functions compared to baseline. Data Source: [5]

	Package 1	Package 2	Package 3	Package 4
Block Trains	-19%	-23%	-39%	-77%
Intermodal Trains	-19%	-23%	-38%	-58%
Single Wagon Load	-22%	-28%	-45%	-77%

As stated above, KPI 5.1 can be mapped to the subprocesses train splitting up/shunting and Train preparation / shunting (see also Table 11). The time gains for that process are shown in the following Table 13. As shown for the expected target values for package 3, the intended improvements can be reached.

Table 13 Expected Time Gains of FDFTO functions for train preparation /shunting and Train splitting up compared to baseline. Data Source: [5]

	Package 1	Package 2	Package 3	Package 4
Block Trains	-22%	-32%	-35%	-65%
Intermodal Trains	-35%	-49%	-55%	-65%
Single Wagon Load	-36%	-50%	-56%	-61%

KPI 5.2 can be mapped to the subprocess train preparation (see also Table 11). The time gains for that process are shown in the following Table 14. As shown for the expected target values for package 3, the intended improvements can be reached.

Table 14 Expected Time Gains of FDFTO functions for train preparation compared to baseline. Data Source: [5]

	Package 1	Package 2	Package 3	Package 4
Block Trains	-12%	-12%	-47%	-83%
Intermodal Trains	-9%	-9%	-35%	-53%
Single Wagon Load	-6%	-7%	-44%	-85%

The following diagrams illustrate the time savings for block trains (Figure 10), intermodal trains (Figure 11) and single wagon load trains (Figure 12).

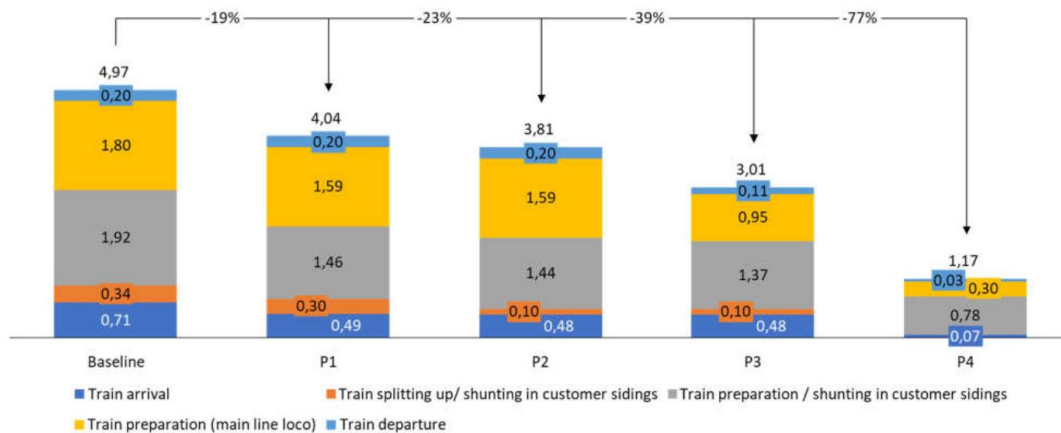


Figure 10 Time gains for block trains and different FDFTO functions. [5], p. 56.

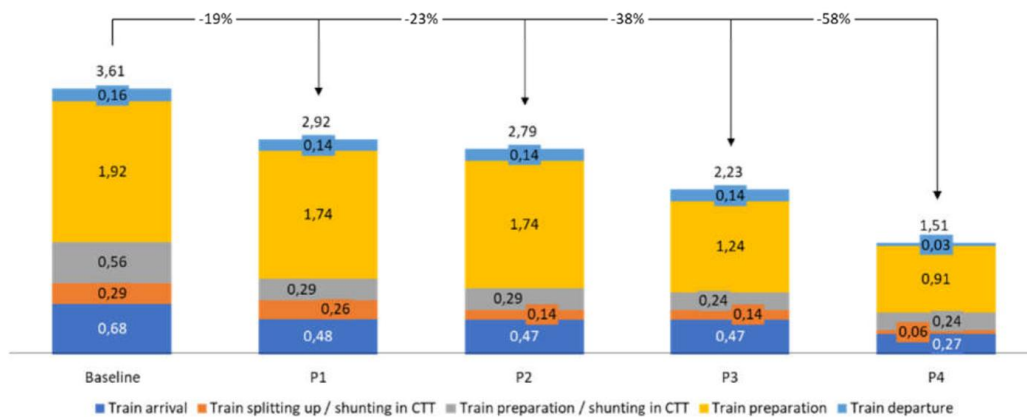


Figure 11 Time gains for intermodal trains and different FDFTO functions. [5], p. 56.

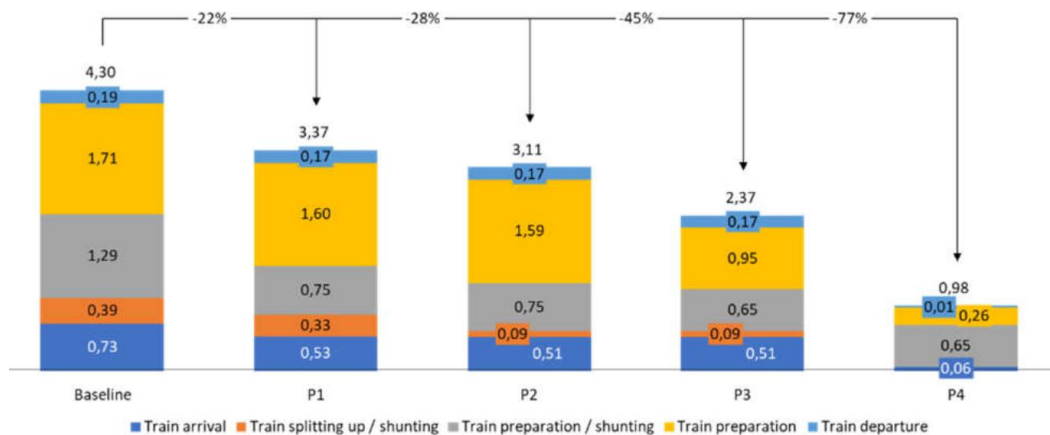


Figure 12 Time gains for single wagon load trains and different FDFTO functions. [5], p. 57.

For KPI 5.3 Increased average train length, mainly two technological parameters of the DAC are relevant 1) the increased operational forces (see chapter 6.2.1) that allow for higher loads and accordingly longer trains and 2) the maximum train length as limited by the maximum length of the data and energy line. Both parameters will be validated within component function tests. For this KPI, no reference measurement is necessary.

In addition, the following demonstrator trains will provide validation in an operational setup for the increased operational forces:

1. Demonstration train in commercial traffic between the Port of Gothenburg and Nässjö intermodal terminal

The train is operated by SHN Cargo and consists of 22 freight wagons (three wagon pairs equipped with DAs from different DAC suppliers). The tests study coupler behavior over time and in winter conditions. The demo train is already in operation and will run for two years, covering about 300 000 kilometers in total.

2. A commercial steel shuttle from SSAB's steel mill in Luleå to the production site in Borlänge.

The train is operated by Green Cargo, Sweden's largest freight rail operator. Daily departures with steel slabs with the heavy load of 3800 tonnes will test DACs under challenging conditions. The demo train is already in operation and will run for two years, covering about 300 000 kilometers in total.

Regarding the demonstration of the feasibility of the data and energy supply for long trains, the following tests and demonstrations will be carried out:

3. A static test to measure the performance of the energy and data connection

In the so called "104 vehicle test", the performance of the energy and data network are measured in real environment: data communication stability, maximum latency, train composition detection. The tests are performed in the Train Test Lab in Berlin as static tests in standstill. The tests refer to a 50-wagon set-up in two steps that will e.g. evaluate the voltage drop over (longest) train composition.

4. Demonstration train on public tracks (main shunting hubs, tracks and EU freight corridors) in Austria

The train is operated by Rail Cargo Austria, Austria's largest freight rail operator. The demonstration focuses on operational procedures with train functions on public tracks. The train set-up is composed of 2 Locomotives, 24 DAC Wagons and 2 Adapter Wagons, built-up in 2 phases. Phase 1 will run from Q4 2025 to Q1 2026, followed by phase 2 from Q2 2026 to Q4 2026.

5. Demonstration train on public tracks (main shunting hubs, tracks and EU freight corridors) in Italy

The train is operated by Mercitalia Rail, Italy's largest freight rail operator. The demonstration focuses on operational procedures with train functions on public tracks. The train set-up is composed of one Locomotive with EDDP DAC basic package and 40 wagons with EDDP DAC basic package. Phase 1 will run from Q1 2026 to Q2 2026, followed by phase 2 from Q2 2026 to Q4 2026.

Please note that the limitations described before (chapter 6.2.1) hold. Today, the main limitation for train length is infrastructure rather than coupler technology. For example, the length of intermodal terminals is shorter than 650 m in more than 60% of the cases ([5], p.54).

7.2 Seamless

As stated above, the reference value for EP10 is considered to last 0.5 min/wagon and 3.5 min/wagon for EP11 and technical wagon inspection in the train preparation phase for departing trains and 1 min/wagon for arrival inspection. EP10 is estimated to be reduced by 100% to 0 with automated detection provided by TE 12 Railway checkpoints. EP11 is estimated to be reduced by 50% for arrival inspection as automating all arrival inspection functions cannot be achieved in the first call of FP5 by TE12. Regarding full wagon inspection for departing trains, this is estimated to be reduced by 25% through TE12 due to higher degree of necessary manual checks as well as safety protocols for departing trains.

Table 15 illustrates the expected impact of the above-mentioned operational procedures related to the technical enabler 12, Railway Checkpoints.

Table 15. Expected impact of the operational procedures related to technical enabler 12, Railway Checkpoints.

Operational Procedure	Data Source	Reference data	Estimation of improvement
EP10 Confirm wagon set	CBA EDDP, ÖBB, DB	30 sec/wagon	100%
EP11 Technical wagon inspection	CBA EDDP, ÖBB, DB	1 min/wagon (arrival), 3.5 min/wagon (full inspection)	50%, 25%

As illustrated by Table 16, average reference values for the relevant KPI's have been gathered from partners within TRANS4M-R and other sources. It should be noted that

these values are representing selected sections of the European rail network and will be used as reference base and validation in the KPI assessment. The presented KPI 5.6 – 5.8 constitute a first estimation among the FP5 partners. During the project, they will be critically examined and adjusted if necessary. Table 18 in the Appendix shows specific reference values and expected improvements for each use case.

Table 16 Reference values for KPI measurements for Seamless operations

KPI	Area	Main measurements	Value	Source	Comment
5.4	Main Line	Average transportation time on reference corridor	21:44h Alnabru – Pisa (10:53h Alnabru – Malmö) 22:20h Stockholm – Pisa // (1) 60 km/h ScanMed (2) Alnabru - Malmö- 57,7 km/h.	RNE [12], ScanMed	(1) ScanMed North- and Southbound (2) Southbound
5.5	Main Line	Operational dwell time at borders and other handover points	30-50 min (planned stops), 30-65 min (real)	RNE [12], ScanMed	Average waiting time at borders
5.6	Main Line	Number of non-added value additional operational stops	3-5	FP5 Partners	Intermodal Trains; non-operational stops. (Defined as: train does not move for >1 minute)
5.7	Main Line	Average handling/ response time for ad-hoc cross border path requests	5-7 hours (request for same day), 24-48 hours	See Table 18 in appendix, FP5 partners	See Table 18 in appendix
5.8	Supply Chain Mgt.	Handling/ response time for connected comprehensive intermodal offers	45 - 120 min (contracted assignments), 24-72 h (adhoc requests for assignments in non standard trains)	FP5 partners	Time for carriers to accept an assignment from Transportation planner

KPI 5.9 –“Reduced energy consumption and reduced footprint through less stops at borders and increased use of multimodal railway transports” – is estimated through the impact of KPI 5.4-5.8. The relative reduction of energy consumption and related emissions during the train run and stops will be proportional to the reduction of time measured in KPI 5.4-5.8. However, due to the high efficiency of modern locomotives during standstill, the effect on overall energy consumption for rail freight might be limited for 5.5-5.6. Moreover, it should be noted that the definition of 5.9 has been updated from the original MAWP, from “Reduced energy consumption and reduced footprint through less stops at borders” to “Reduced energy consumption and reduced footprint through less stops at borders and increased use of multimodal railway transports”, thus this KPI is also taking into consideration the improvements of the train run and not only the effects on the nodes.

However, it is important to note that this KPI is special and needs further alignment due to its societal scope and impact. The reduction of stops and the better plannability should also lead to increasing competitiveness of rail freight and thus to a higher modal split. Assessing these potential emission reductions is complex (see e.g. [13]) and out of scope of this document and needs to be re-investigated in the final KPI assessment in D1.6. However, an alignment with Academic4Rail (see also chapter 0) has already started and a further alignment on emissions is envisaged.

A first estimation on this KPI is presented in Table 18 for the reference train (presented in Table 9), also summarized in Table 16. The combined effect on the KPIs by the use cases within seamless is presented in Table 18 in the appendix, Table 16 below summarizes the estimated KPI improvements for the Seamless cluster.

Table 17. Summary of the first KPI estimations by the Seamless cluster.

KPI 5.4: Reduce average transportation time on reference corridor. Target value: Time reduced targeting 10-20%	Reference value: Transportation Time at reference corridor: 10:53:11 + (45 min each for service time at Malmö and Alnabru)
Estimated improvement in %	12%
KPI 5.5: Reduce operational dwell time at borders and other handover points -	Reference value: 45 min
Target value: Dwell time reduced targeting 50%	Improvement included in first KPI estimation
Estimated improvement in %	78%
KPI 5.6: Reduce the number of additional operational stops.	Reference value: 3-5 stops, 45 min each
Target value: Reduced number of operational stops targeting 20%	Improvement included in first KPI estimation
Estimated improvement in %	49%
KPI 5.7: Reduce handling/ response time for ad-hoc cross border path requests	Reference value: 5-7 hours (request for same day), 24-48 hours
Target value: Reduced time by targeting 70%	Improvement included in first KPI estimation
Estimated improvement in %	75%
KPI 5.8: Reduce handling/ response time for connected comprehensive multimodal offers	Reference values: 45 - 120 min (contracted assignments), 24-72 h (ad-hoc requests for assignments in non standard trains)
Target value: reduced time by at least 50%.	Improvement included in first KPI estimation
Estimated improvement in %	50%
KPI 5.9: Reduced energy consumption and reduced footprint	Reference values: 17 967 KWh, 1797 kg CO ₂
Target value: reduced by at least 10%.	Improvement included in first KPI estimation
Estimated improvement in %	19%

8 Alignment within Europe's Rail

Within EU-Rail, a continuous alignment especially with the following stakeholders is necessary:

1. FP5-TRANS4M-R WP 13 *System Integration Plan, Validation/Test Plan and Demo Coordination*
2. FP5-TRANS4M-R WP 19 *LCC and Benefits Inputs for CBA*
3. Academics4Rail

The alignment with the project's WP13 is important to make sure that the estimations of improvements impacting the KPIs can be achieved. Within the tests, the time savings through the DAC will be validated. Such an alignment meeting was held in Q1/2024. To ensure that the tests will deliver the necessary results for the KPI monitoring, an according requirement will be added to the project's requirements management platform Polarion. Analogously, the alignment with WP19 (in Q2/2024) serves for using the same data basis and assumptions for the calculations.

The project Academics4Rail supports EU-Rail, among others, with the "methodology of program assessment using KPIs and impact estimation towards the objectives set out in the EU-Rail masterplan." [9] To this aim, FP5 is already giving input on how the project's KPI will influence the strategic metrics analyzed by Academics4Rail. FP5 was part of a workshop (06/24) bringing together the KPI experts of the different FAs. Especially for the KPI 5.9, Reduced energy consumption and reduced footprint through less stops at borders, further alignment will be fruitful, as described in chapter 6.

9 Conclusion and Next steps

This document constitutes Deliverable D1.5 - First KPI Report of EU-Rail JU Flagship Area 5 project FP5-TRANS4M-R and lays the basis for a standardized measurement of the projects KPIs which will allow to monitor the project's progress. The focus of this document is on harmonizing the methodology for all technical enablers that vary widely in their core characteristics. Mainly, the two subprojects FDFTO and Seamless Operations worked closely together to pursue an as comparable approach as possible. Wherever possible and meaningful, the KPI measurement process was mapped to the project's Preliminary Operational Procedures (D2.1, [4]), that constitute an agreed harmonized basis within the project. In addition, the concept of a virtual freight train is introduced to account for processes of seamless operation.

In addition, reference values have been provided against which the improvements over the course of the project will be measured. For this definition of this baseline, existing approaches are used as far as possible to allow for a comparability also beyond the project. For FDFTO, the report "Digital automatic coupling – cost benefit analysis (initial report)" [5] constitutes the most important database. Where harmonized data was not available, reference data was collected. Finally, a first alignment with the important stakeholders within the project and EU-Rail has been initiated.

Within the scope of this deliverable, the KPIs will illustrate the improvements that can be reached for single process steps of an average reference process. A validation of the solution for commercial use is beyond of the scope of this deliverable. Due to the variety in processes (e.g. the different shunting processes) and different conditions (e.g. for different countries), for such an analysis wide-ranging measurement for the different conditions is necessary. In addition, a large data population is necessary for the data to be meaningful. This also especially important to account for the robustness of the solutions in commercial use.

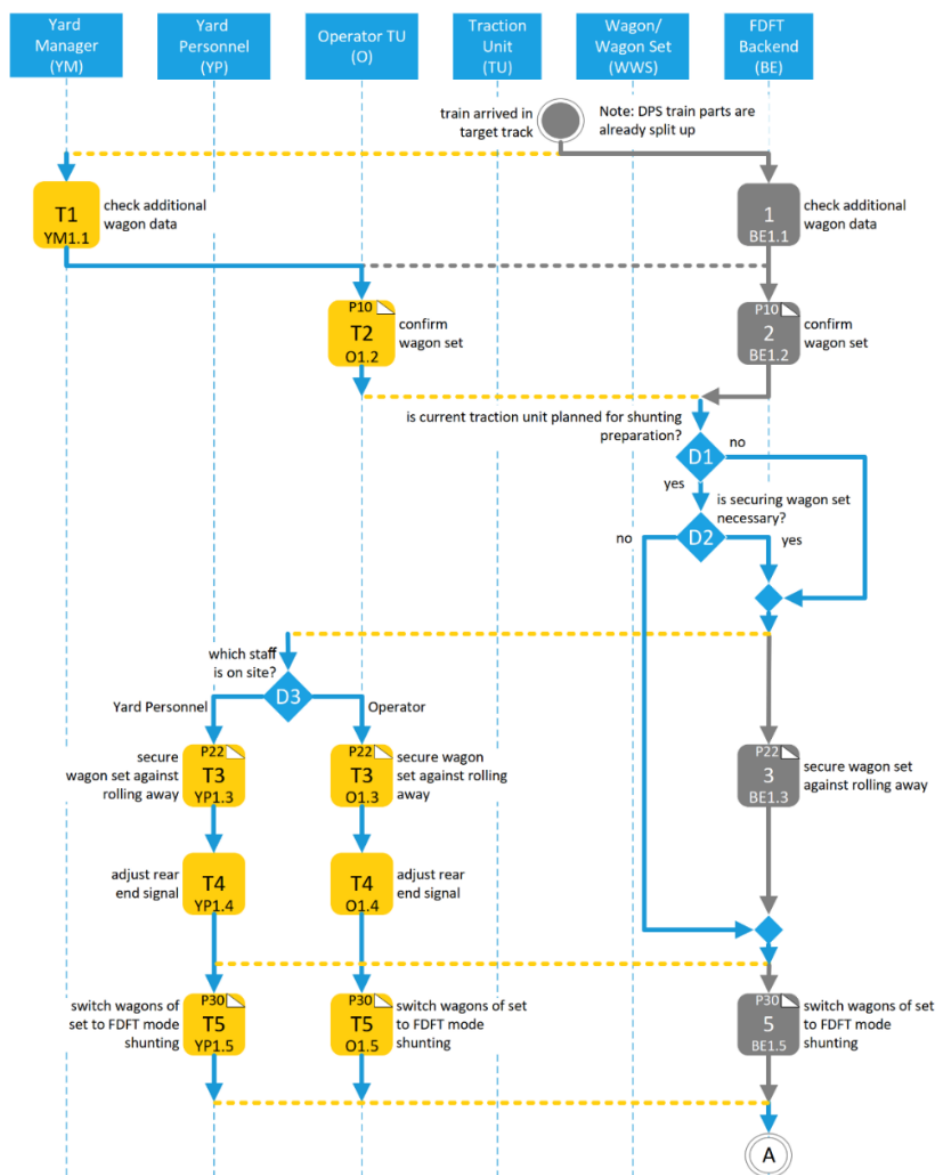
The improvements through the technical enablers and their impact on the KPIs was estimated. In the future, these estimated improvements will be validated via lab tests and the tracking of the KPIs towards the target values will be done by measuring their impact when a new demonstrator (physical or simulation) is available. In addition, KPI 5.6-5.9 will be critically examined and adjusted if necessary. The results will be presented in the project's final KPI report (D1.6) that is due in 2026. The next steps comprise defining a meaningful test requirement specifying which data needs to be measured in the tests as validation of the estimations made in this report. In addition, the assumptions of the project's cost benefit analysis need to be aligned with the approach presented here. An according alignment workshop will be initiated.

10 References

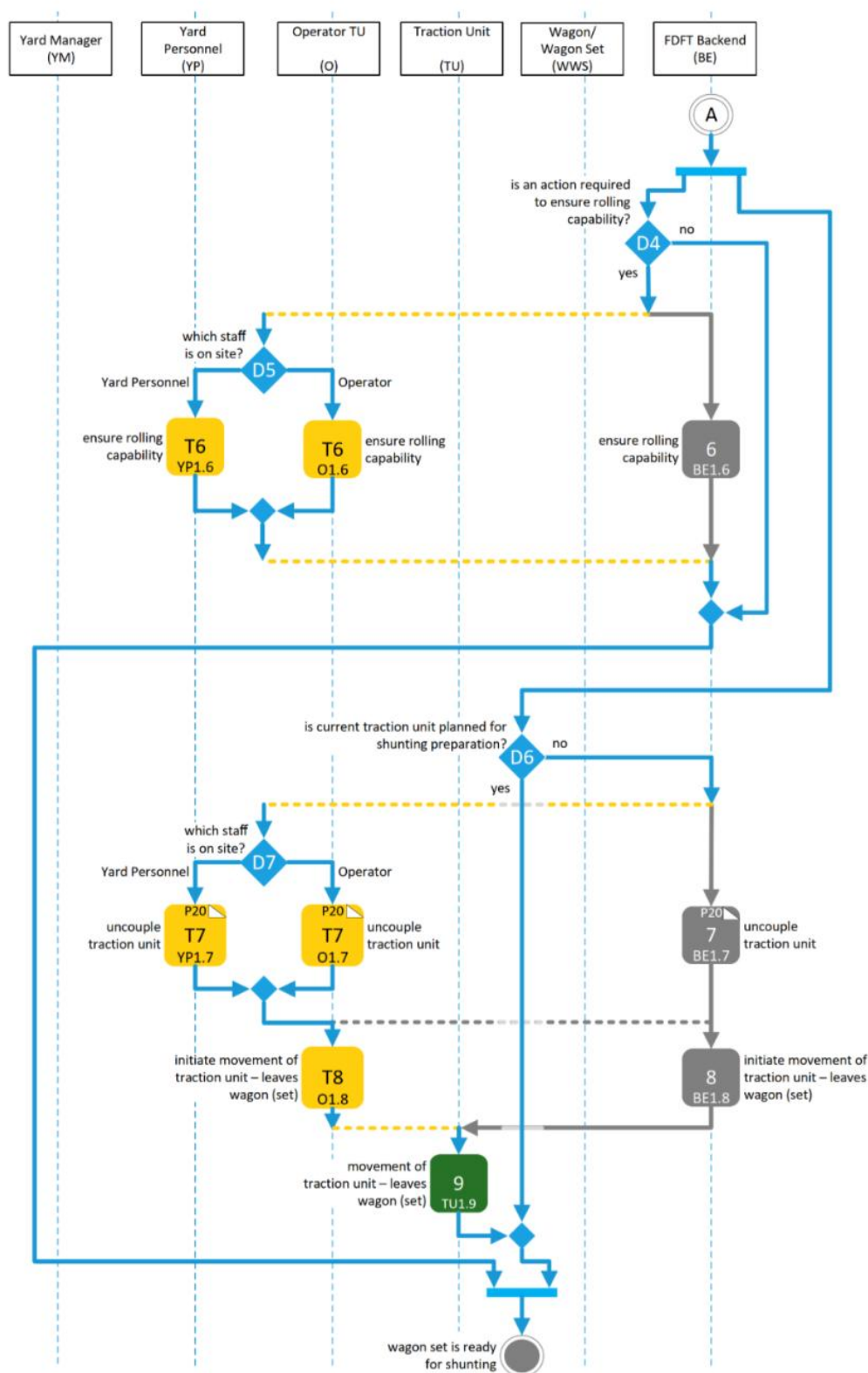
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11 Appendices

11.1 Referenced Operational Procedures

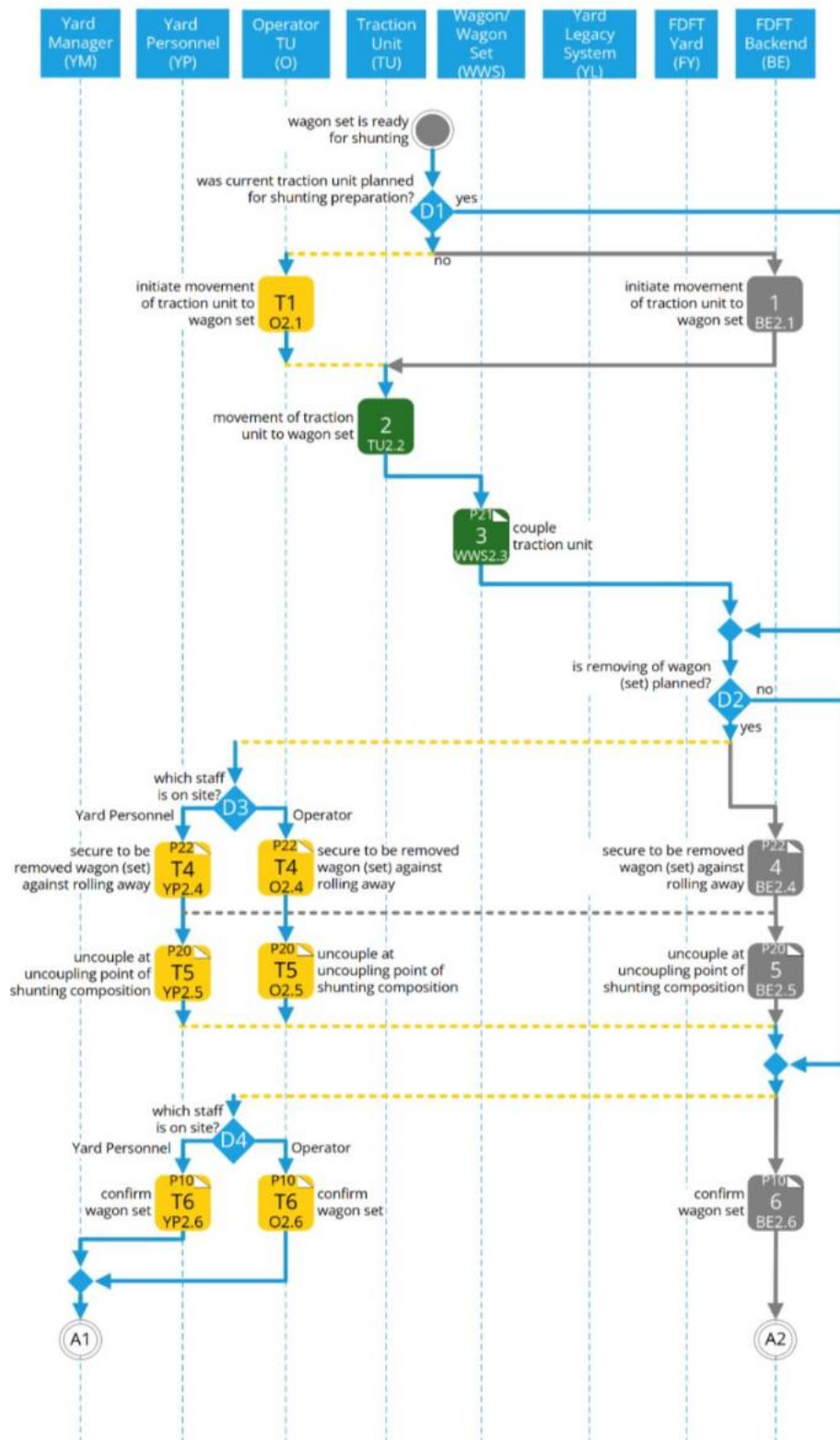


EP01 Shunting Preparation - 1 of 2



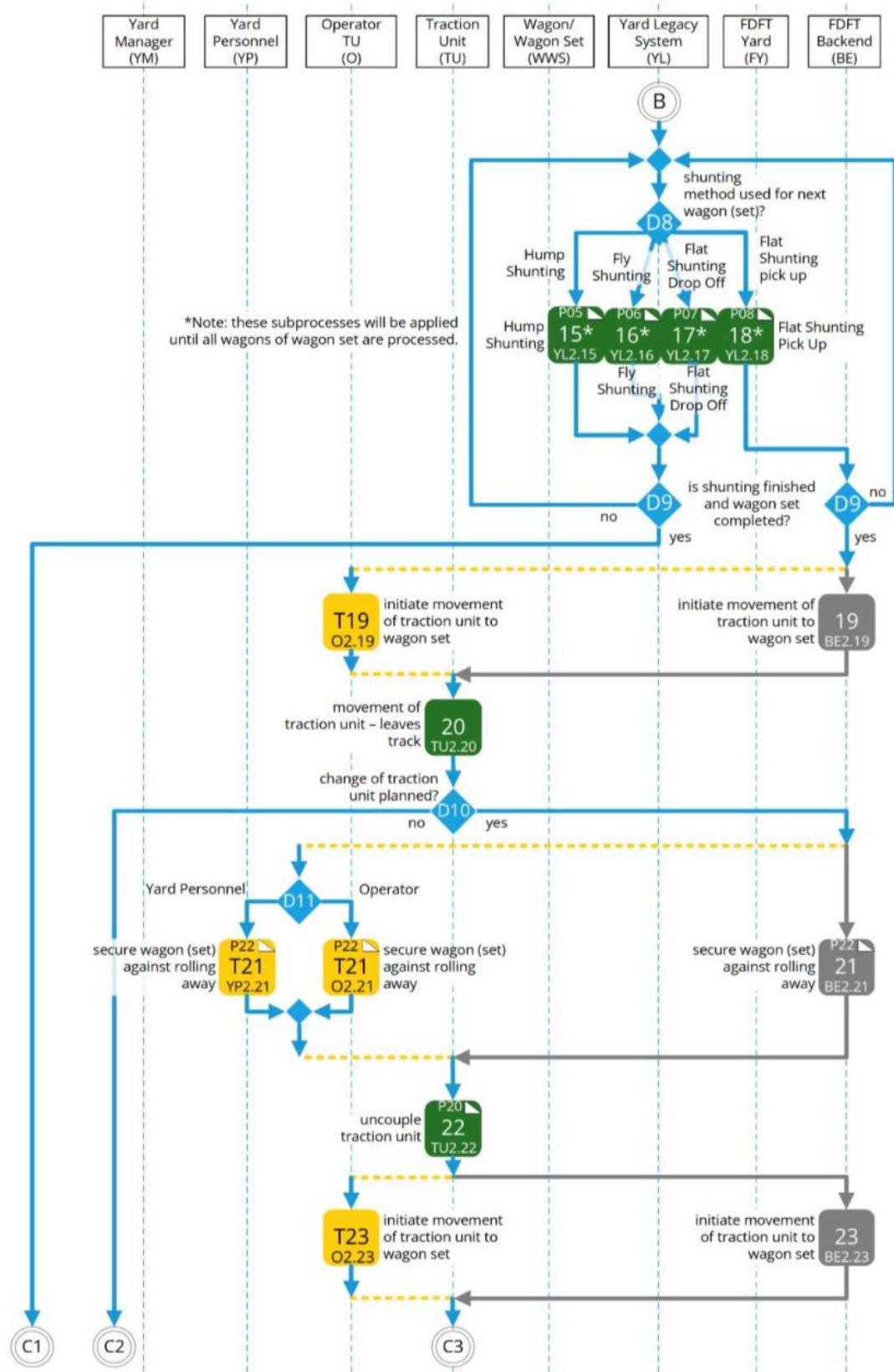
EP01 ERJU Shunting Preparation - Ed. 02P08 13.06.2023

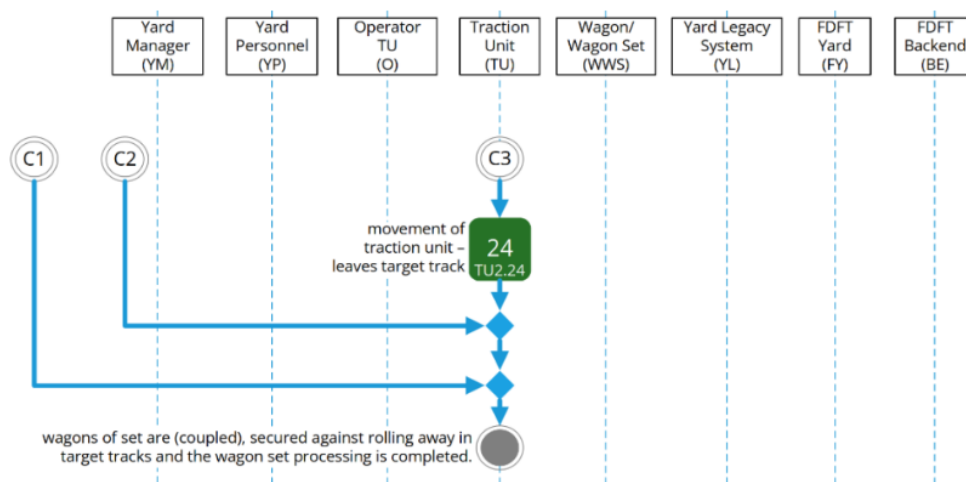
EP01 Shunting Preparation - 2 of 2



EP02 Wagon Processing - 1 of 4







EP02 ERJU Wagon Processing - Ed. 02P12 21.06.2023

EP02 Wagon Processing - 4 of

11.2 KPI assessment for the Seamless cluster

Table 18 KPI assessment for the identified use cases within the Seamless cluster

KPI 5.4: Reduce average transportation time on reference corridor. Time reduced targeting 10-20%					Reference value: Transportation Time at reference corridor: 10:53:11 + (45 min each for service time at Malmö and Alnabru)		
Use-Case	Related EP and TE	Measurement for selected KPI	Reference data	Estimation of improvement	Improvement included in first KPI estimation (only operational procedures are considered in first KPI estimation, not short term and long term planning)	Magnitude of improvement for reference train	Unit
26.4	TE14	The amount of trains that can be planned L/UL within their scheduled time at the terminal	95%	5%	Yes	4.5	Min
26.4	TE14	The planned deviation from desired time for L/UL in the terminal	Not available yet.	Not available yet.	No		
26.4	TE14	The time spent on long-term track assignment planning	3 weeks	20%	No		
26.8	TE14	The time spent on short-term track assignment replanning	1 week	20%	No		
28.2	TE11	Response time for shunting requests.	Not yet but will be gathered	Not yet but will be estimated	No		

28.2	TE11	Number of shunting requests that are successfully carried out (increase capacity at the terminal)	Aprox. 10% of accepted shunting requests are not attended due to lack of capacity	Not yet but will be estimated	No		
29.1	EP10, TE12, TE5	EP10 Confirm wagon set	30 sec/wagon	100%	Yes (Wagon and LU identification)	11	Min
29.2	EP10, TE12, TE5	EP10 Confirm wagon set	30 sec/wagon	100%	Yes (Dangerous goods)		Min
29.3	EP11, TE12, TE5	EP11 Technical wagon inspection	1 min/wagon (arrival), 3.5 min/wagon (full inspection)	50%, 25%	Yes	11	Min
26.2	TE14	Total transport time due to reduction of idle times (average transport time)	8.2 h	10%	Yes	9	
26.2	TE14	Total transport time due to reduction of idle times (cross border point)	3.7 h	50%	Yes	22.5	Min
26.2	TE14	Total transport time due to reduction of idle times (on intersection stops)	93 min	20%	Yes	18.6	Min
27.1	TE10	Precise transport planning with regard to operational slots	2 days	50%			
		Total transport time due to reduction of idle times			No		
27.4	TE10	Total transport time due to connection of local processes to line processes (FA1), selection and assignment of resources to trains, transfer of data to the Short-term MY departure planning system.	2 days	50%	No		

28.4	TE11	Response time on verification and re-assignment of planned resources due to on time process info about deviation	12 h	50%	No		
SUM						76.6	Min
Estimated improvement in %					12%		
KPI 5.5: Reduce operational dwell time at borders and other handover points -					Reference value: 45 min		
Target value: Dwell time reduced targeting 50%					Improvement included in first KPI estimation	Magnitude of improvement for reference train	
Use-Case	Related EP and TE	Measurement for selected KPI	Reference data	Estimation of improvement	No		
26.2	TE14	Precise transport planning with regard to resources plan Idle time of train and resources at handover points	3.7 h	50%	No		
27.1	TE10	Precise transport planning with regard to resources plan	2 days	50%			

		Idle time of train and resources at handover points			No, specifically for intermodal transports		
UC-GTS		Disposition tasks around the loading of an intermodal train	52min	~26min	No, specifically for intermodal transports		
UC-GTS		Reach stacker loading time for an intermodal train	3-4 hours	~60min	No		
27.2	TE10	Number of track conflicts	Not available yet.	5%	Yes	2.25	min
27.2	TE10	Lead times for shift including waiting times for track access	Not available yet.	5%	No, considered in Use case 29.3		
27.7	TE10	Average verification time for incoming train and cargo	1h	90%	No		
28.4	TE11	Response time on verification and re-assignment of planned resources due to on time process info about deviation	12 h	50%	No		
28.1	TE11	Average dwell time at the terminal for trucks awaiting to load/unload containers.	25 min (average reference week from may 27th to may 31th)	Not yet but will be estimated	Yes (Wagon and LU identification)	11	min
29.1	EP10, TE12	EP10 Confirm wagon set	30 sec/wagon	100%	Yes (Dangerous goods)		
29.2	EP10, TE12	EP10 Confirm wagon set	30 sec/wagon	100%	Yes	11	min
29.3	EP11, TE12	EP11 Technical wagon inspection	1 min/wagon (arrival), 3.5 min/wagon (full inspection)	50%, 25%	Yes	11	min
26.4, 26.8	TE14	The planned waiting times to start unloading	Not available yet.	Not available yet.			
26.4, 26.8	TE14	The planned time wagons stand on a L/UL track	Not available yet.	Not available yet.			
Sum						35.25	min
Estimated improvement in %					78%		

KPI 5.6: Reduce the number of additional operational stops.					Reference value: 3-5 stops, 45 min each		
Target :Reduced number of operational stops targeting 20%					Improvement included in first KPI estimation	Magnitude of improvement for reference train	
Use-Case	Related EP and TE	Measurement for selected KPI	Reference data	Estimation of improvement			
27.1	TE10	Precise transport planning with regard to operational slots	2 days	50%	No		
		Total transport time (due to reduction of idle times)			No		
28.4	TE11	Response time on verification and re-assignment of planned resources (due to on time process info about deviation)	12 h	50%	Yes (Wagon and LU identification)	11 min	
29.1	EP10, TE12	EP10 Confirm wagon set	30 sec/wagon	100%	Yes (Dangerous goods)		
29.2	EP10, TE12	EP10 Confirm wagon set	30 sec/wagon	100%	Yes	11 min	
29.3	EP11, TE12	EP11 Technical wagon inspection	1 min/wagon (arrival), 3.5 min/wagon (full inspection)	50%, 25%	Yes	11 min	
Sum						22 min	
Estimated improvement in %					49%		
KPI 5.7: Reduce handling/ response time for ad-hoc cross border path requests					Reference value: 5-7 hours (request for same day), 24-48 hours		

Reduced time by targeting 70%					Improvement included in first KPI estimation	Magnitude of improvement for reference train	
Use-Case	Related EP and TE	Measurement for selected KPI	Reference data	Estimation of improvement			
27.1	TE10	Total transport time due to reduction of idle times	2 days	50%	Yes	3	hours
27.4	TE10	Idle time in handover point due to precise planning	2 days	50%	No		
26.8	TE14	(Note: Not cross-border related) response time for ad-hoc new/updated L/UL requests	1 day	25%	Yes	1.5	hours
Sum						4.5	hours
Estimated improvement in %					75%		
KPI 5.8: Reduce handling/ response time for connected comprehensive multimodal offers					Reference values: 45 - 120 min (contracted assignments), 24-72 h (ad-hoc requests for assignments in non standard trains)		
Target value: reduced time by at least 50%.					Improvement included in first KPI estimation	Magnitude of improvement for reference train	
Use-Case	Related EP and TE	Measurement for selected KPI	Reference data	Estimation of improvement			
31.4	TE10, TE11, TE14	Overlaps of requests on facilities and resources	TBD	TBD			
31.4	TE10, TE11, TE14	Average response time of resources booking	7 days	TBD		41.25	min

GTS-UC		Booking of multiple supplier services	more measurements needed as big spread of data	50%			
Sum						41.25	min
Estimated improvement in %					50%		
KPI 5.9: Reduced energy consumption and reduced footprint					Reference values: 17 967 KWh, 1797 kg CO2		
Target value: reduced by at least 10%.					Improvement included in first KPI estimation	Magnitude of improvement for reference train	
Use-Case	Related EP and TE	Measurement for selected KPI	Reference data	Estimation of improvement			
31.3	TE10, TE11, TE14	Footprint related to freight transportation based on modal shift from road transport to intermodal freight transportation services based on rail. Measure the increase in number of O/D relations and estimate the reduction in CO2 emission based on the TON/Km moved through the new services.	Approx. 42.900.000.000 ton/km in 2026 (Reference year)	It is expected that the New Transport Configurator module will account for 10% of the increase in TON/Km for multimodal services based on rail between 2026 and 2029.	No		
27.1	TE10	Precise transport planning with regard to operational slots Total electric energy due to reduction of stops	2 days	50%	No		
Impact from KPI 5.4		Reduction of transportation time on reference corridor	76.6	12%	Yes	76.6	min

Impact from KPI 5.5		Reduction of service time at nodes	35.25	78%	Yes	35.25	min
Impact from KPI 5.6		Reduction of service time at nodes	22	49%	Yes	22	min
Impact from KPI 5.7			-	-	No		
Impact from KPI 5.8			-	-	No		
Sum						133.85	min
Estimated improvement in %					19%		

11.3 Demogroups within the Seamless cluster

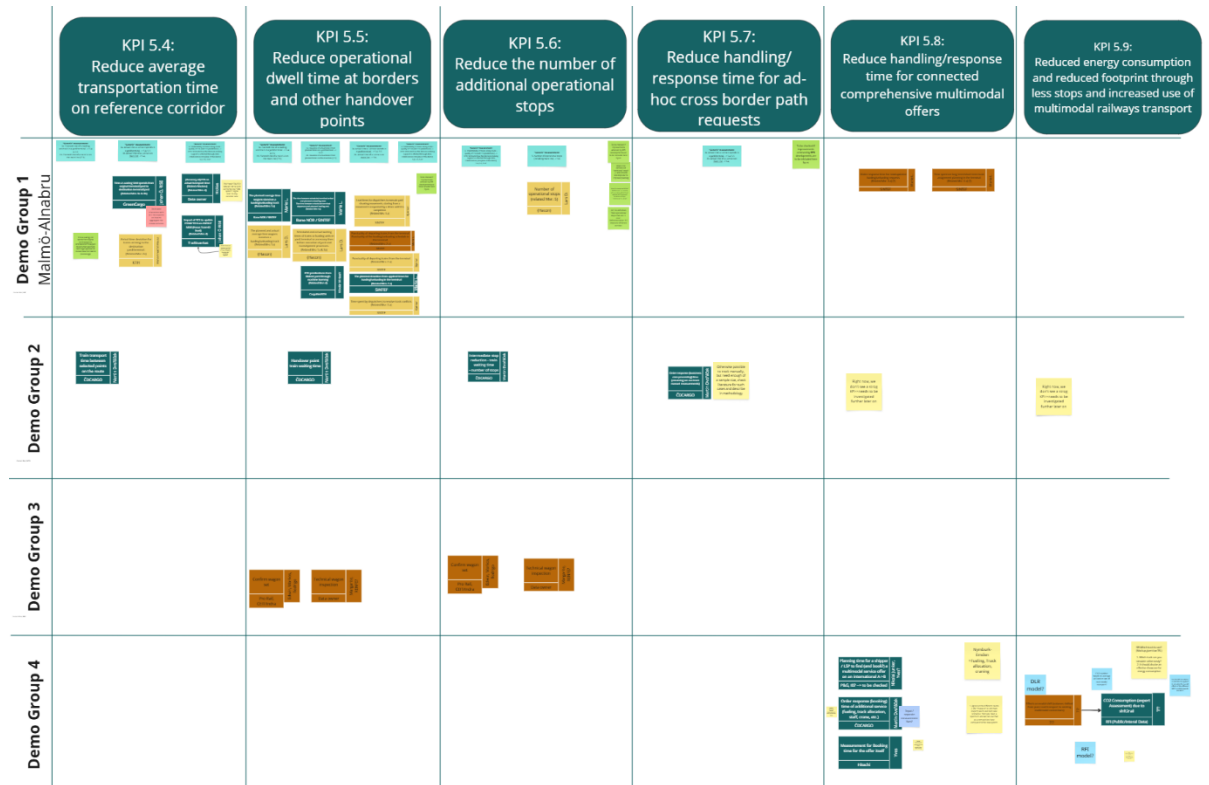


Figure 13. Mapping of the Demogroups of the Seamless cluster towards the KPIs.