Co-financed by the Connecting Europe Facility of the European Union

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Feasibility study on Railway Collaborative Decision Making (Rail-CDM)

Executive Summary

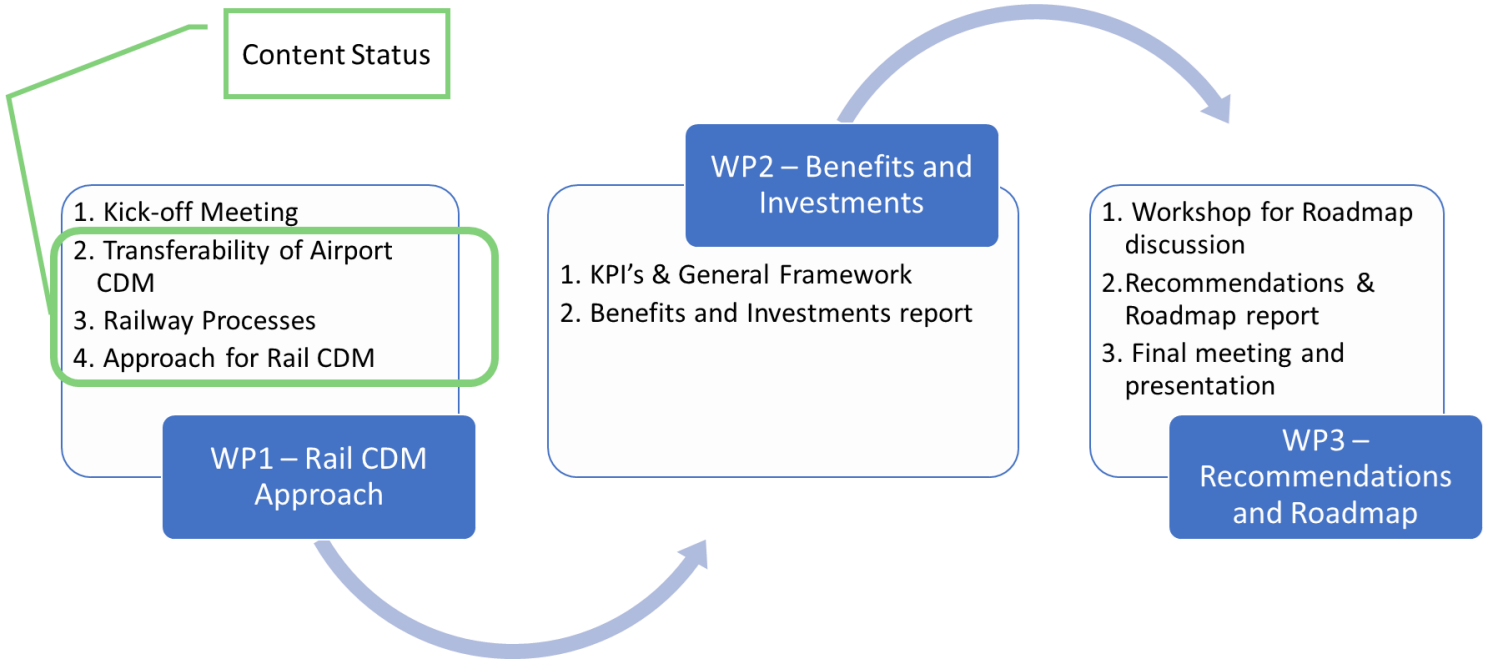
HACON

to70

Status of work

The results of WP 1 are presented:

- **Task 1.1 – Transferability of Airport-CDM**
- **Task 1.2 – Railway Processes**
- **Task 1.3 – Approach for Rail-CDM**



Disclaimer:

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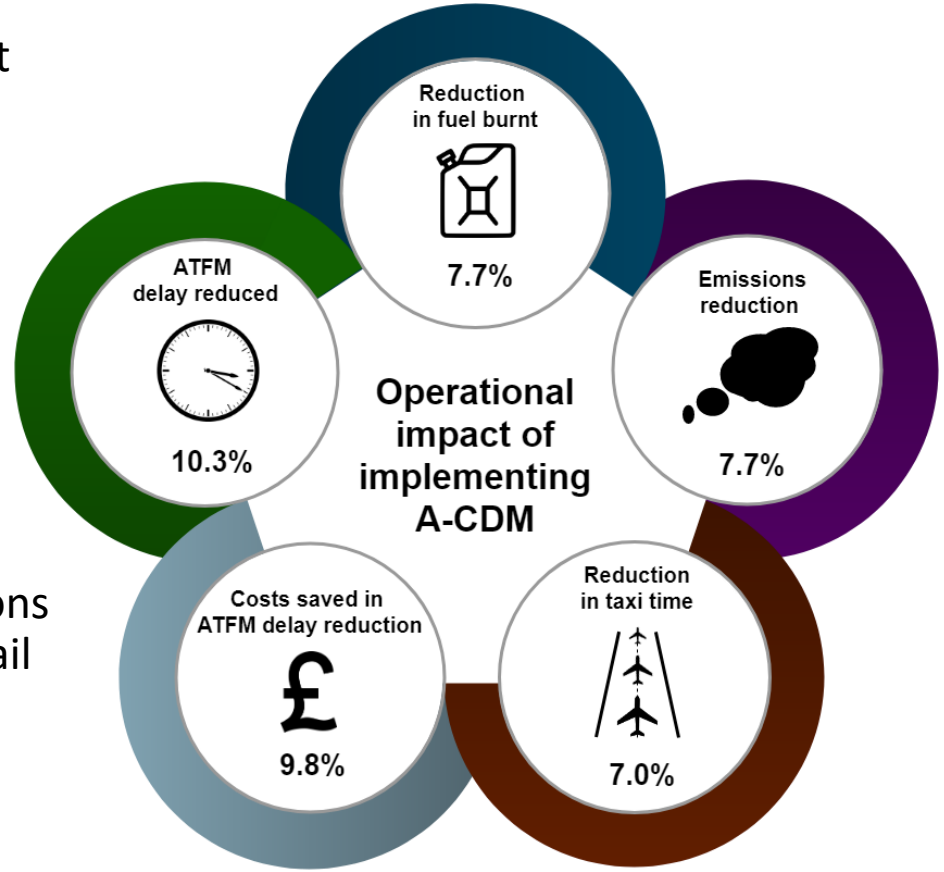
Task 1.1 – Airport-CDM Conclusions

In Task 1.1, the key reasons for the A-CDM development, including key findings and key benefits, are summarised as input for the transferability assessment:

- A-CDM is a concept that is perceived to be transferable to other transport modes, as the concept is focussed on the general challenges of international, multi-actor, multi-interaction and multi-interest business cases;
- Key elements as cultural change, data sharing, predictions, milestones, equality, central coordination and collaborative decision making following agreed rules are introduced;
- The “Steer & Benefit Mechansim” and also the need that benefits are achieved for all stakeholders to ensure acceptance is explained;
- Deliverable D1.1 provides the input for defining the criteria and conclusions for Transferability of A-CDM to Rail. For conclusions of transferability to rail freight, criteria were agreed and met through analysis of rail processes in D1.2.



(Source: A-CDM Impact Assessment 2016, Eurocontrol)

Task 1.2 – Assessment of transferability criteria (1)

No	The following questions have to be answered positive	full	in parts	Comments
C#1	Stakeholders and their operations shall be comparable		✓	Similar transparency and communication needs apply, but differences in operation
C#2	Stakeholder challenges shall be similar to a high extend	✓		
C#3	Freight train processes shall be relatable to that of aircraft		✓	Main differences regarding main line processes / partially comparable in nodes
C#4	Performance areas and indicators shall be comparable or similar		✓	Rail operation on main line from origin to destination and a flight differ significantly but indicators punctuality/predictability are comparable
C#5	A-CDM Concept elements shall each be considered relatable to rail (see next slide)		✓	Rail transport on main line from origin to destination and a flight differ significantly

Task 1.2 – Assessment of transferability criteria (2)

No	A-CDM Concept elements shall be considered relatable to rail, answering positive the following questions:	full	in parts	Comments
CE#1	Is there improvement possible on Situational Awareness?	✓		Stakeholders have to be convinced
CE#2	Can the rail journey be segmented into milestones, similar to a flight?	✓		Milestone concept can be used, but processes themselves are different
CE#3	Is there an uncertainty in the connection between Terminal and IM exit/entry point, also known as last mile?		✓	Resources availability & coordination between different actors
CE#4	Can IMs, similar to ATC, influence the sequence of trains leaving a terminal when they are entering their network (main lines)?		✓	Pre-departure sequencing is possible and necessary but the main motivation is different
CE#5	Is it possible to define special procedures in case of predicted or unpredicted loss of capacity due to adverse conditions?	✓		
CE#6	Is there an ongoing need for integration of European rail sectors and operation?	✓		High dependencies in planning & operation of international trains

Task 1.3 – Approach & Requirements for Basic Rail-CDM

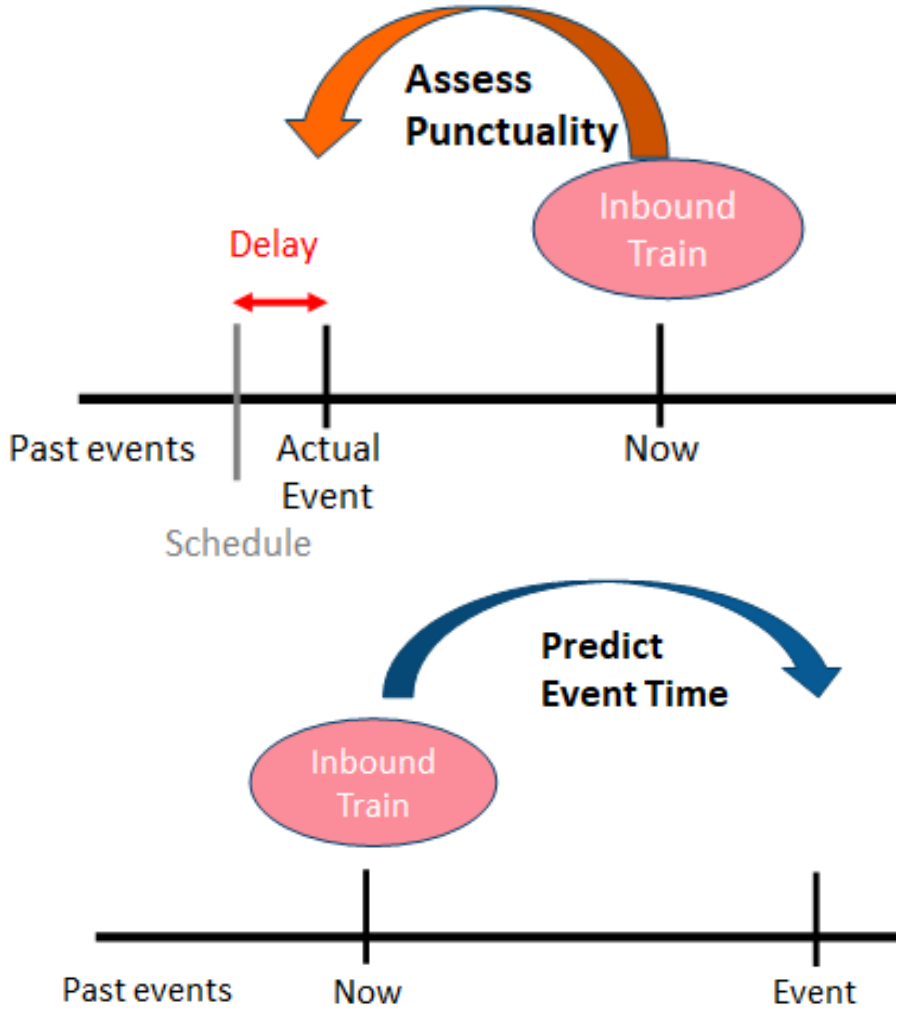
1. **Concept of Predictability**
2. **Concept of Best Planned Best Served**
3. **Concept Elements**
   a) Concept Element #1 – Information Exchange
   b) Concept Element #2 – Milestones Approach
   c) Concept Element #3 – Last Mile Prediction
   d) Concept Element #4 – Pre-Departure Sequencing
   e) Concept Element #5 – Adverse Conditions
   f) Concept Element #6 – International Coordination Support Function
4. **Requirements**

Task 1.3 – Concept of predictability

- **Punctuality**
  - Punctuality adherence to the schedule created by an operator;
  - Punctuality can be assessed Post-Operation: actual versus schedule;
  - Punctuality is a backward assessment on a completed event.

- **Predictability**
  - Predictability is a forward assessment on a future event;
  - Predictability is assessment of potential gain or loss of punctuality;
  - Predictability complements punctuality.

- **Reliability and Accuracy**
  - Reliability is when stakeholders can place confidence in predictions;
  - Accuracy enhances confidence through evaluation of predictions .

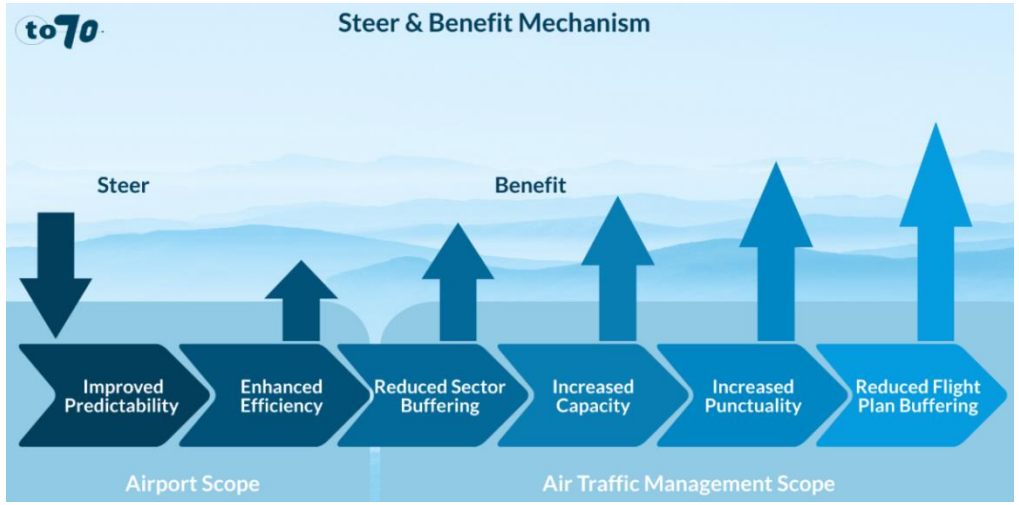


Task 1.3 – Concept of Best Planned Best Served

- **Reactive operations**
  - Reactive operations usually reward few selected stakeholder and distribute delays unequal;
  - Decisions taken by humans naturally include preferences and hinder equal operations;
  - Sub-optimal performance or occasionally contra-productive operations.

- **Proactive operations**
  - Automated process and transparency for information sharing;
  - Agreed decision making rules for all stakeholders, including IMs;
  - Predictability on train ready time and IMs approval time.

- **Incentives for information sharing**
  - Create fair playing field for all stakeholders;
  - Reward those providing accurate predictions;
  - Create trust through performance monitoring and evaluation.



Task 1.3 – Concept Element #1 – Information sharing

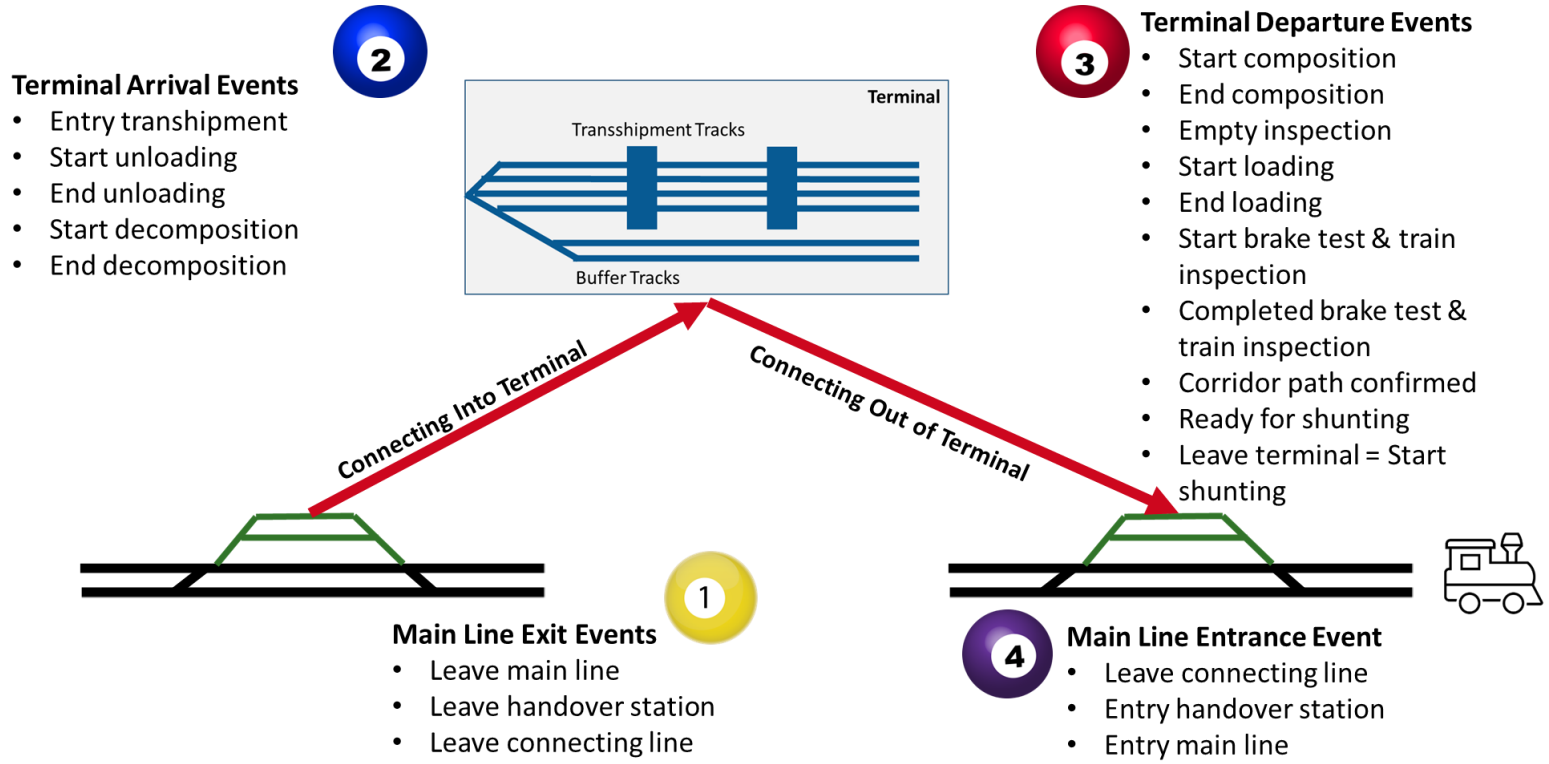
General findings (details have to be discussed in the implementation phase):

- Creating Situational Awareness:
  - **Right information -> right time -> right people -> right decisions**
  - Improve/provide the necessary framework conditions and technologies to improve the situational awareness by sharing data in an appropriate way.
- Change for Stakeholders and Process Ownership:
  - Mentality shift – “joint data sharing is necessary and positive”.
- Requirements to information exchange and data platforms:
  - Real-time sharing of information to other stakeholders through common functional specifications and interfaces;
  - Commonly agreed procedures and access rights;
  - Create new stakeholder data elements focus on prediction;
  - Automated processing of data and generating alerts for discrepancy and stakeholder action for adjustment.
- Rules and Roles:
  - Clear segregation and definition of responsibilities for stakeholders.

Task 1.3 – Concept Element #2 – Milestones (1)

General findings (details have to be discussed in the implementation phase):

- Identify the relevant (common) processes and prepare a list of appropriate milestones. Milestones are a breakdown of common actual rail operation events. Actual events are not planning or estimates; they apply to the actual movement and status of the train;
- En-route events can be related to trains passing nodes, certain signal points or other defined operating points;
- Before entering the last mile and during the transport towards and from terminals operational events occur more rapidly, and granularity of multiple events requires multiple identification points:
  - Arrival phase approaching end of main line and exit of main line;
  - Terminal phase including last mile, exit of main line and shunting handover;
  - Departure phase leaving terminal and approaching main line;
- Milestones are common points in a train journey that can trigger updates of predictions.



Task 1.3 – Concept Element #2 – Milestones (2)

Key train events candidate for milestone definition

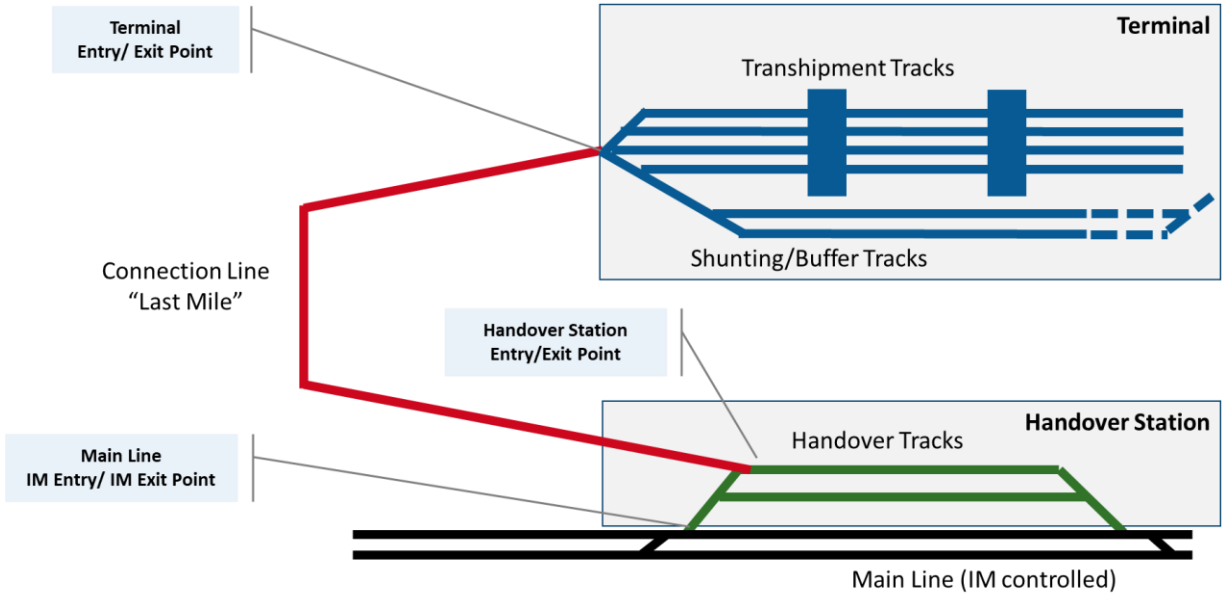
#	Milesstones Descriptions (Key train events)	Related Timestamp to Milestone	Who Inputs	Timestamp Acronym	Aviation Equal	Planned	Estimated	Targeted	Actual
1	Train enters the main line at origin terminal	**Actual Enter Main line Time**	**IM**	**AEMT**	-	**PEMT**	EEMT		**AEMT**
2	Train enters the network of the final IM	Actual Enter Final IM Time	IM	AEFT	-	**PEFT**	**EEFT**		**AEFT**
3	Train leaves the mainline and enters the handover station	**Actual Leave Main line Time**	**IM**	**ALMT**	ALDT	**PLMT**	**ELMT**		**ALMT**
4	Train leaves the handover station and enters the connection line	Actual Leave Handoverstation Time	RU/SO	ALHT	-	PLHT		TLHT	ALHT
5	Train leaves the connection line and enters the transhipment track	**Actual Leave Connection line Time**	**TO**	**ALCT**	AIBT	**PLCT**		TLCT	ALCT
6	All potential checks are done and unloading starts (Bereitstellung)	**Actual Start Unloading Time**	**TO**	**ASUT**	ACGT	**PSUT**	ESUT	TSUT	ASUT
7	The unloading of the train ends	Actual End Unloading Time	TO	AEUT		PEUT			
8	*Start of shunting/decomposition if waggon sets are stored in a siding*	*Actual Start Decomposition Time*	*TO*	*ASDT*					
9	*End of shunting/decomposition if waggon sets are stored in a siding*	*Actual End Decomposition Time*	*TO*	*AEDT*					
10	*Start of shunting/composition if waggon sets were stored in a siding*	*Actual Start Composition Time*	*TO*	*ASCT*					
11	*End of shunting/composition if waggon sets were stored in a siding*	*Actual End Composition Time*	*TO*	*AECT*					
12	The inspection of the empty train is completed	Actual Empty Inspection Time	TO	AEIT					
13	The loading of the train starts	Actual Start Loading Time	TO	ASLT	ASBT	PSLT			
14	The loading of the trains ends (Ladeschluss)	**Actual End Loading Time**	**TO**	**AELT**		**PELT**	EELT	TELT	AELT
15	The brake test & train inspection starts	Actual Start Brake test Time	TO	ASBT		PSBT			ASBT
16	Timestamp when the target time for the "train ready for shunting to handover station" is issued	**Target Ready for Shunting Time**	**RU**	**TRST**	TOBT				
17	The brake test & train inspection ends / is completed without failure	Actual End Brake test Time	TO	AEBT		PEBT		TEBT	AEBT
18	Timestamp when the target time for the "approval of time to enter the main line" is issued	**Target Mainline Approval Time**	**IM**	**TMAT**	TSAT		EMAT	**TMAT**	
19	Timestamp when the target time for the "train ready to enter main line" is issued	**Target Ready for Main line Time**	**RU**	**TRMT**					
20	Train is declared ready for shunting (Terminal exit)	**Actual Ready for Shunting Time**	**TO/SO**	**ARST**	AEGT	PRST		TRST	ARST
21	Train leaves the transhipment tracks and enters the connection line	**Actual Start Shunting Time**	**TO/SO**	**ASST**	AOBT	PSST	ESST	TSST	ASST
22	Train leaves the connecting cine and enters the handover station	Actual Enter Handoverstation Time	SO	AEHT		PEHT		TEHT	AEHT
23	Train is declared ready for main line entry (Train Ready for Dep.)	**Actual Ready for Mainline Time**	**RU**	**ARMT**	ARDT	PRMT		**TRMT**	**ARMT**
24	The IM provides the actual main line approval (Green Light)	**Actual Main line Approval Time**	**IM**	**AMAT**	ASAT				
25	Train enters the main line (actual movement detection by sensor)	**Actual Enter Main line Time**	**IM**	**AEMT**	ATOT	**PEMT**			**AEMT**

- The present table for rail freight transport was drawn up as part of the feasibility study and represents a starting point for later discussion;
- **The list is an initial overview of potential milestones, which might be prioritised and then implemented step-by-step;**
- To discuss, evaluate and agree on the final list of milestones and terminology is a process which is part of the implementation manual.

Task 1.3 – Concept Element #3 – Last Mile Prediction

General findings (details have to be discussed in the implementation phase):

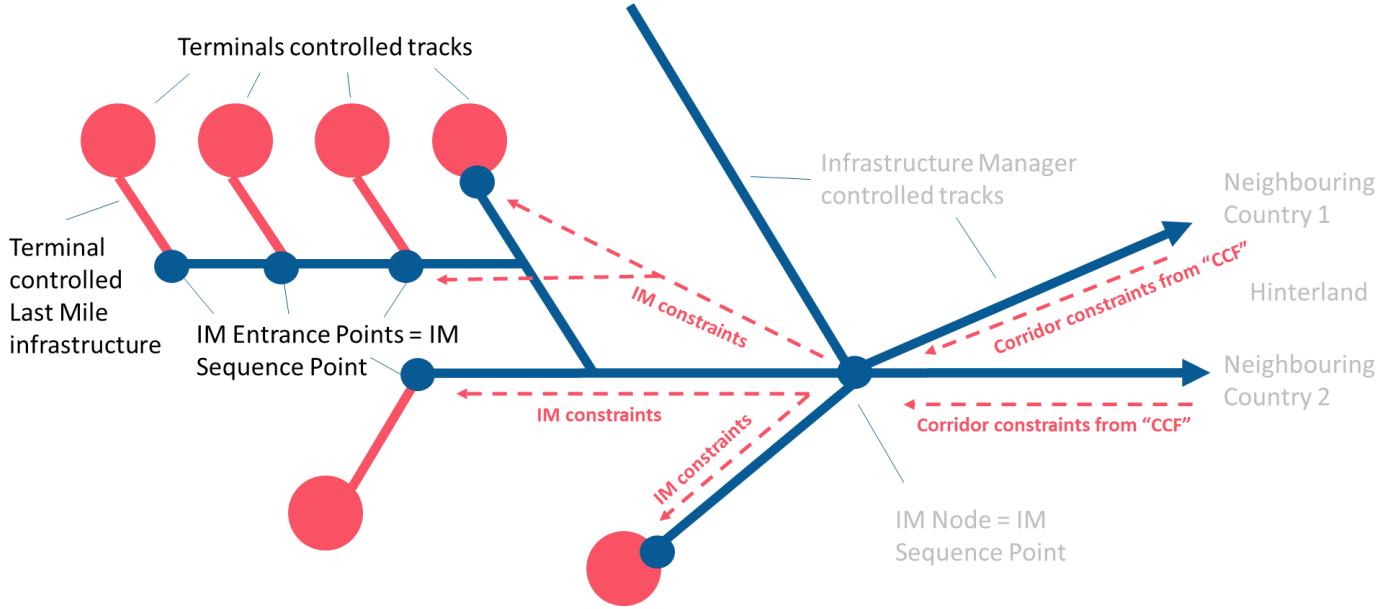
- “Variable taxi time” ⇨ “Last mile prediction”;
- Improvement of the runtime & process time calculation for the last mile processes;
- Additionally improved coordination of the multiple actors in the last mile operation:
  - Coordination of processes (Wagon inspection, Shunting, …);
  - Coordination of resources;
  - Prediction of handover time for the sub-process steps;
  - Deduction of predicted times (ETA) for the key milestones.
- Backwards calculation of the right (latest) departure time from e.g. the transhipment tracks for a timely entry to the main line with optimised utilisation of the intermediate infrastructure & other resources.



Task 1.3 – Concept Element #4 – Pre-departure sequencing

General findings (details have to be discussed in the implementation phase):

- As in aviation also for rail it is important to ensure a fluent operation when entering the main line;
- This should include operation in the last mile area where shunting, connecting and handover-station tracks are optimally used;
- The concept element on pre-departure sequencing has an additional justification in rail transport, as it is of higher importance as in the three-dimensional air space, to enter the main line at the right time and in the right sequence to reduce the need of time, energy and capacity consuming by-passing on the main lines;
- Modern traffic management systems on the network that can assess which train sequence and respective departure time is best based on the current overall operating status and (all) other influencing factors/information.



Task 1.3 – Concept Element #5 – Adverse conditions

General findings (details have to be discussed in the implementation phase):

- As in aviation, the main objective of R-CDM in adverse conditions is to guarantee business continuity and stability of the operations, in order to retain an acceptable level of predictability;
- This is achieved by:
  - Establishing procedures and pre-agreed mitigation scenarios for the different categories of adverse conditions;
  - Creating maximum awareness of those contingency procedures and assigning one coordinator if possible;
  - Stressing on the key aspect of train readiness management under all circumstances, like push-back in aviation.
- The Concept Element #5 is focussed on contingency plans and procedures which are prepared for the different adverse conditions;
- Some of the adverse conditions have also an impact on the capacity on the main or connection line as well as on the corridor and not only on the terminal;
- As there is a natural tendency of the stakeholders to revert to re-active decision-making during disruptions, the R-CDM in adverse conditions should provide a clear procedural framework for robust pro-active operations.

Task 1.3 – Concept Element #6 – International Coordination Support Function

As identified in Task 1.2 and in connection with the concept element #4, the International Coordination Support Function is a requirement for the optimisation of international trains runs and cross border benefits of R-CDM.

General findings (details have to be discussed in the implementation phase):

- The CDM concept is depending on reliable connections between the start and end point of the services;
- The required coordination of capacity and operation needs to be supported by a International Coordination Support Function ;
- To provide the right information for situational awareness it is important to identify any relevant network constraint/conflict;
- Capacity restrictions in the corridor could have impact on trains destined for that restricted area. A International Coordination Support Function could enable as decision support function/system the involved stakeholders to re-sequence (dispatch) trains pre-departure, preparing at terminal site, or trains that could be moved into buffer tracks prior to congested nodes;
- A International Coordination Support Function should process all (international) train information to enable informed capacity-demand balancing and tactical dispatch for congested rail sections on international lines/corridors. Depending on the technological system used, decision support for tactical dispatch can be provided to national IMs, but it is assumed that the final dispatching decisions and the execution remains in their full responsibility;
- An International Coordination Support Function could provide calculated predictions based on the real-time operational situation and shall provide these in the framework of the CDM to the concerned stakeholders.
- How this function could/should be implemented will be point of discussion with the whole sector and the involved institutions in the follow-up process of agreeing on an implementation manual. There are different opinions and factors to be taken into account in a transparent decision making process. Therefore in this feasibility study there is no recommendation in one or the other direction.
- This CE#6 function does not imply the need for a central European Traffic Control for the R-CDM implementation.

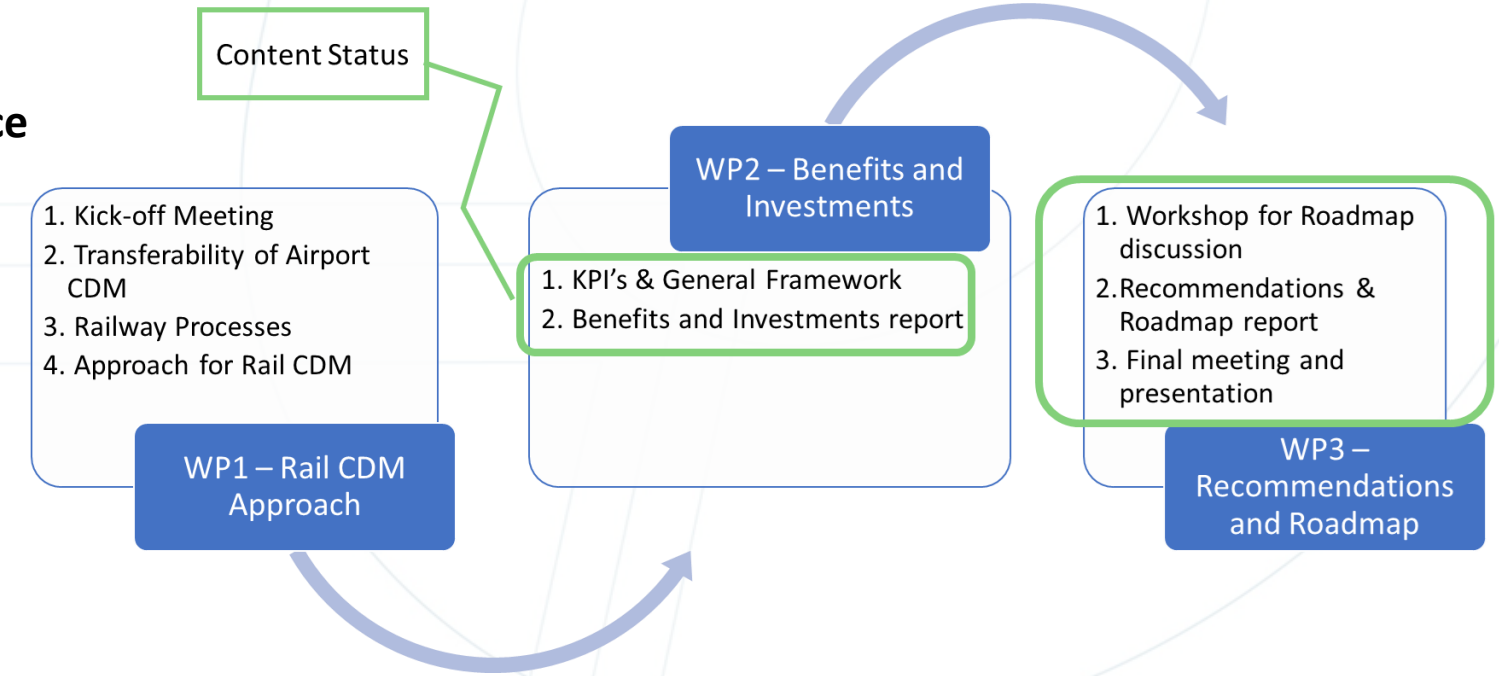
Status of work

The results of WP 2 are presented:

- **Task 2.1 – Expected Benefits and Performance Indicators**
- **Task 2.2 – Existing projects & Benefits for stakeholders**

The results of WP 3 are presented:

- **Task 3.1 – Lessons from Airport CDM & Requirements for Rail**
- **Task 3.2 – Roadmap for Rail CDM**



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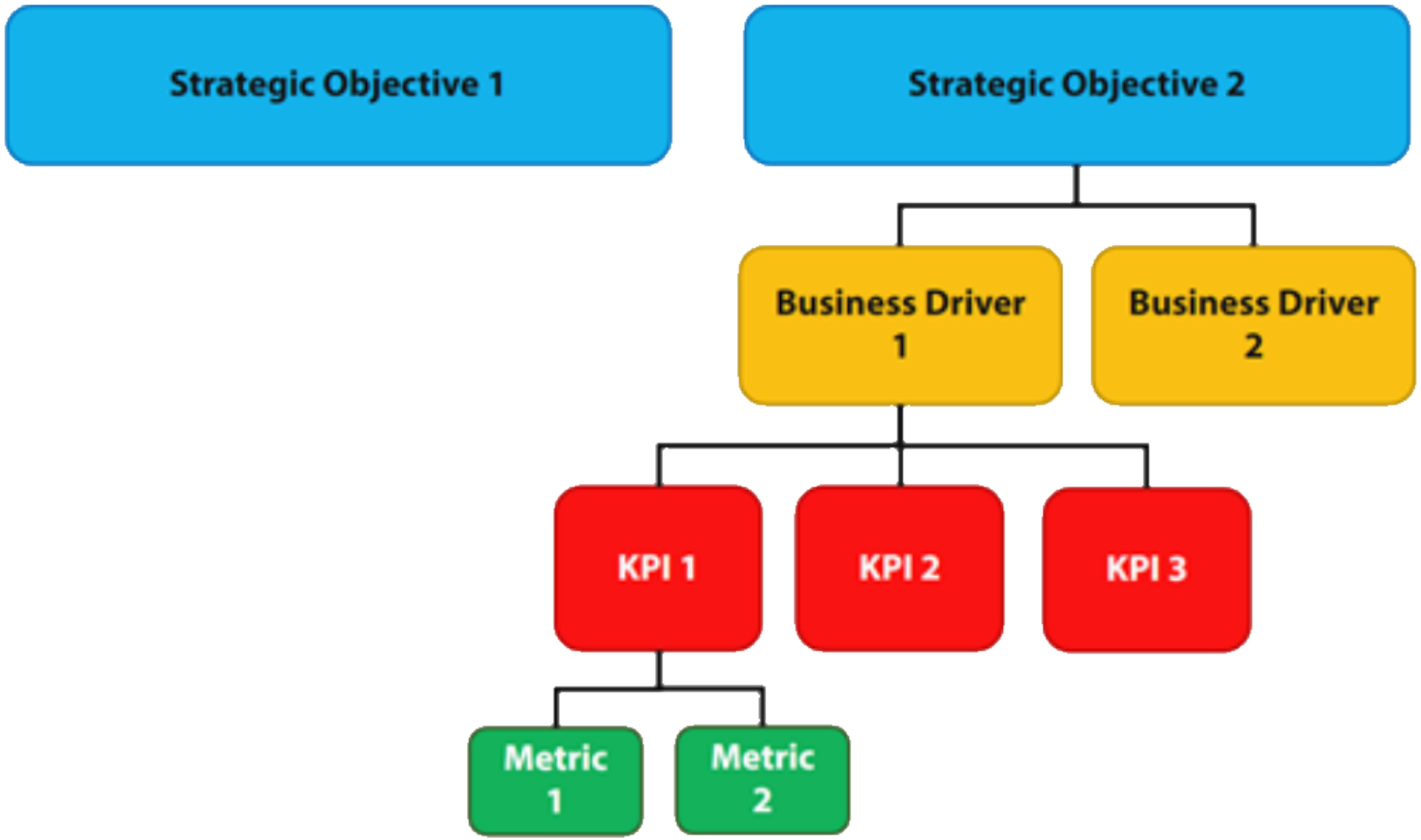
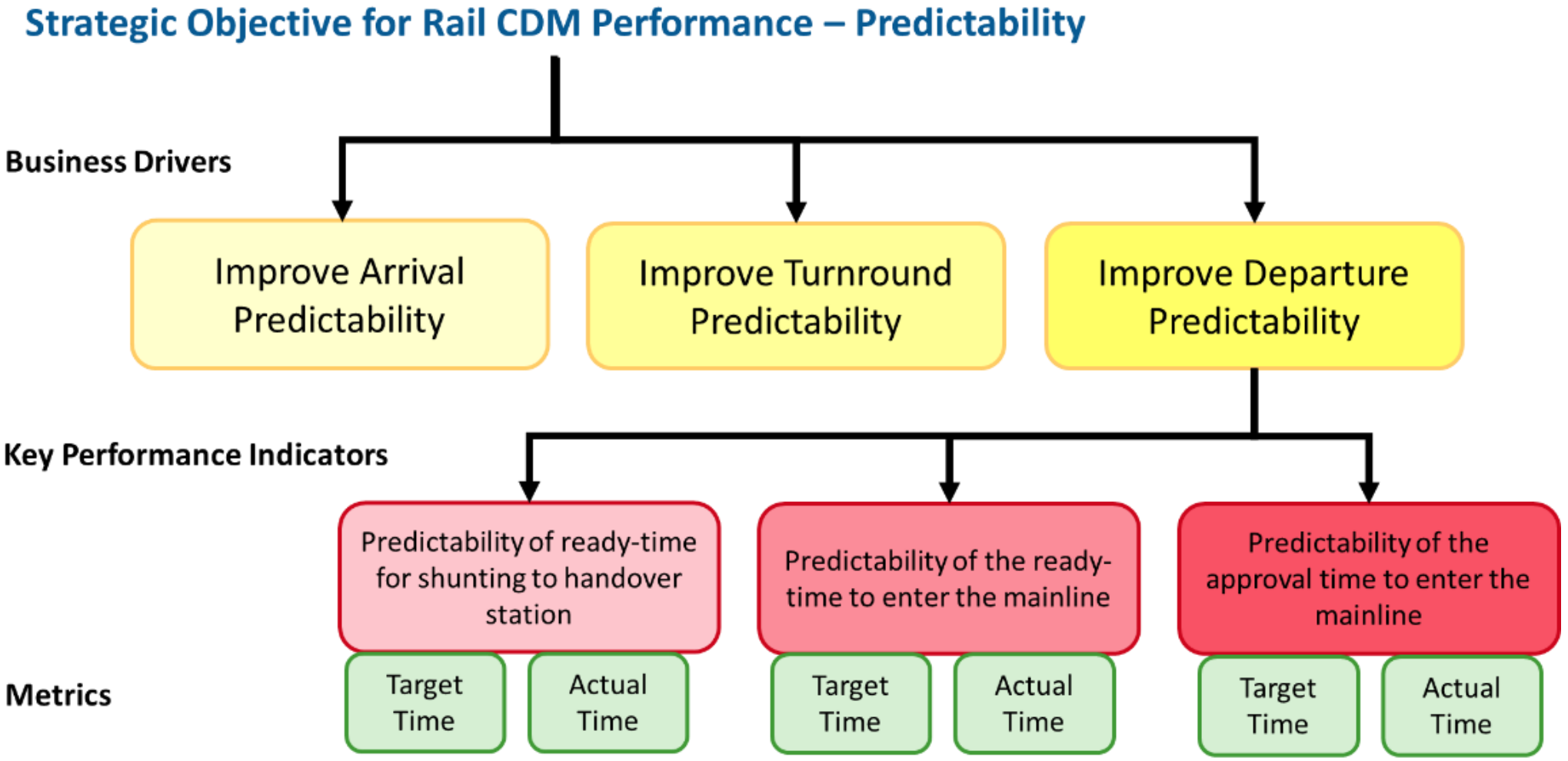
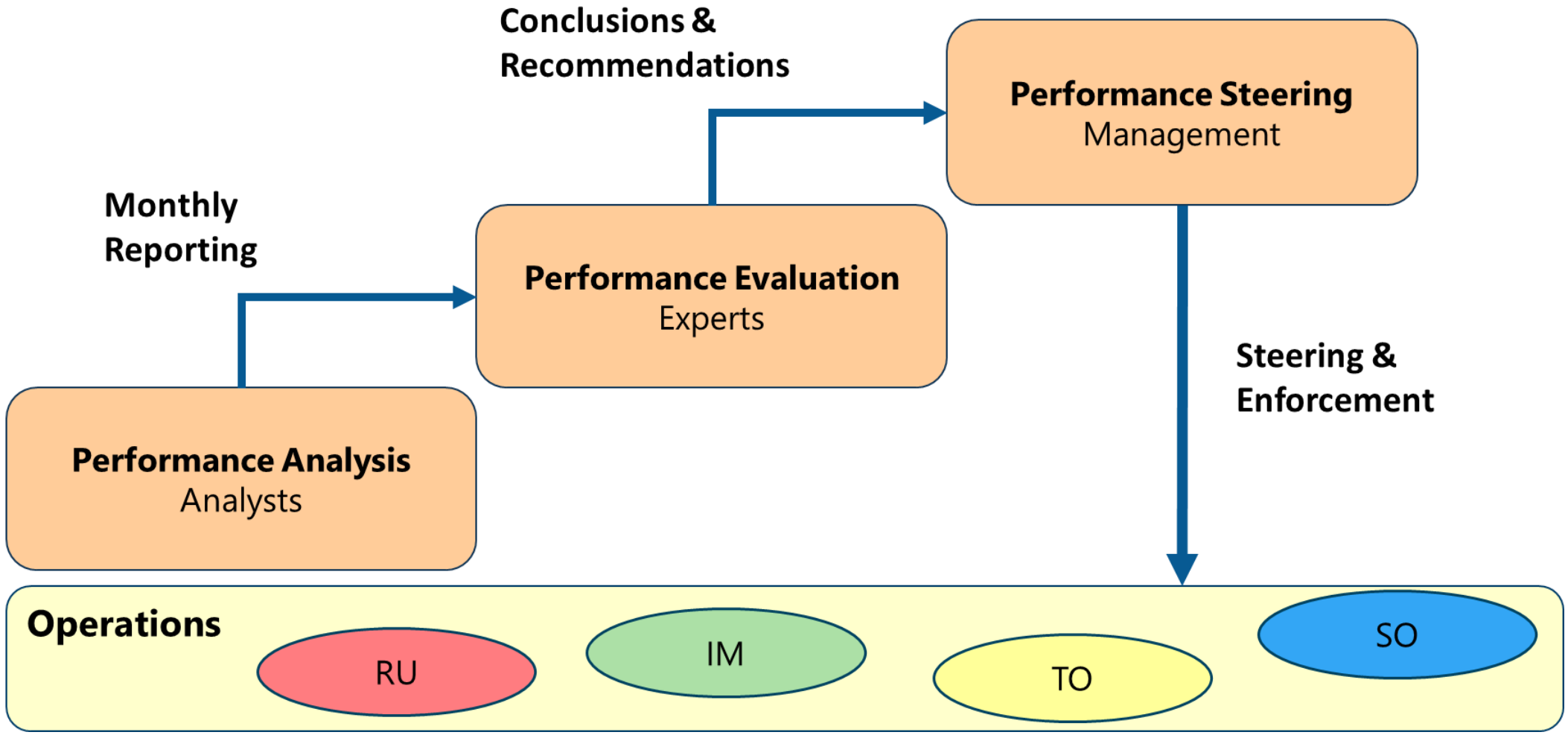
Task 2.1 – Performance Monitoring Methodology



Task 2.1 – Performance Breakdown for Predictability



Task 2.1 – Performance Monitoring Organisation



Task 2.2 – Relation to European Projects (1)

Analysis of ongoing initiatives and their touchpoints with:

- **Rail CDM Concept Elements:**
  - Information Exchange
  - Milestone Approach
  - Last Mile Prediction
  - Pre-Departure Sequencing
  - Adverse Conditions
  - International Coordination Support Function
- **Rail CDM Requirements and supportive functions**:
  - Stakeholder Equity
  - Data Transparency
  - Corridor and Network Operations
  - Conflict detection
  - Conflict solving / prevention
  - Cross-border planning
  - Train monitoring
  - ETA-Rail Prediction
  - Prediction Accuracy Assessment
  - Last mile monitoring / optimisation
  - Stakeholder Communication
  - Mitigation plans
  - Political Pressure and Support

Task 2.2 – Relation to European Projects (2)

Overview of selected Initiatives / Projects / Products (living non-exhausting list)			Concept Elements						Requirements and supportive functions													Comments
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	
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

Task 2.2 – Benefits

Improved environmental performance by reducing emissions even further

More predictable operations

Proactive re-planning

Gain of transparency

Meeting the expectation of customers

Fulfilment of the objectives of the European Green Deal

Regaining trust from stakeholders and clients

Higher safety

Collaborative decision making

More automation

Improved cost efficiency by reduction of energy costs

Improved cost efficiency by improved resource utilisation and shorter resource allocation

- **Improving quality of service by reducing delays**
- **Improving reliability by increasing predictability**
- **Optimising resource utilisation**
- **Optimising infrastructure capacity**
- **Creating situational awareness due to information sharing**

Improved cost efficiency by reduction of energy costs Additional transhipment capacity

Enabling decision-making in collaboration with other stakeholders

Optimisation of interfaces

Simplification of processes

Improved traffic management

Implications on staff deployment

More fluid flow on main lines decreasing delay minutes

Exchange of operational data

Updates on the actual operational situation

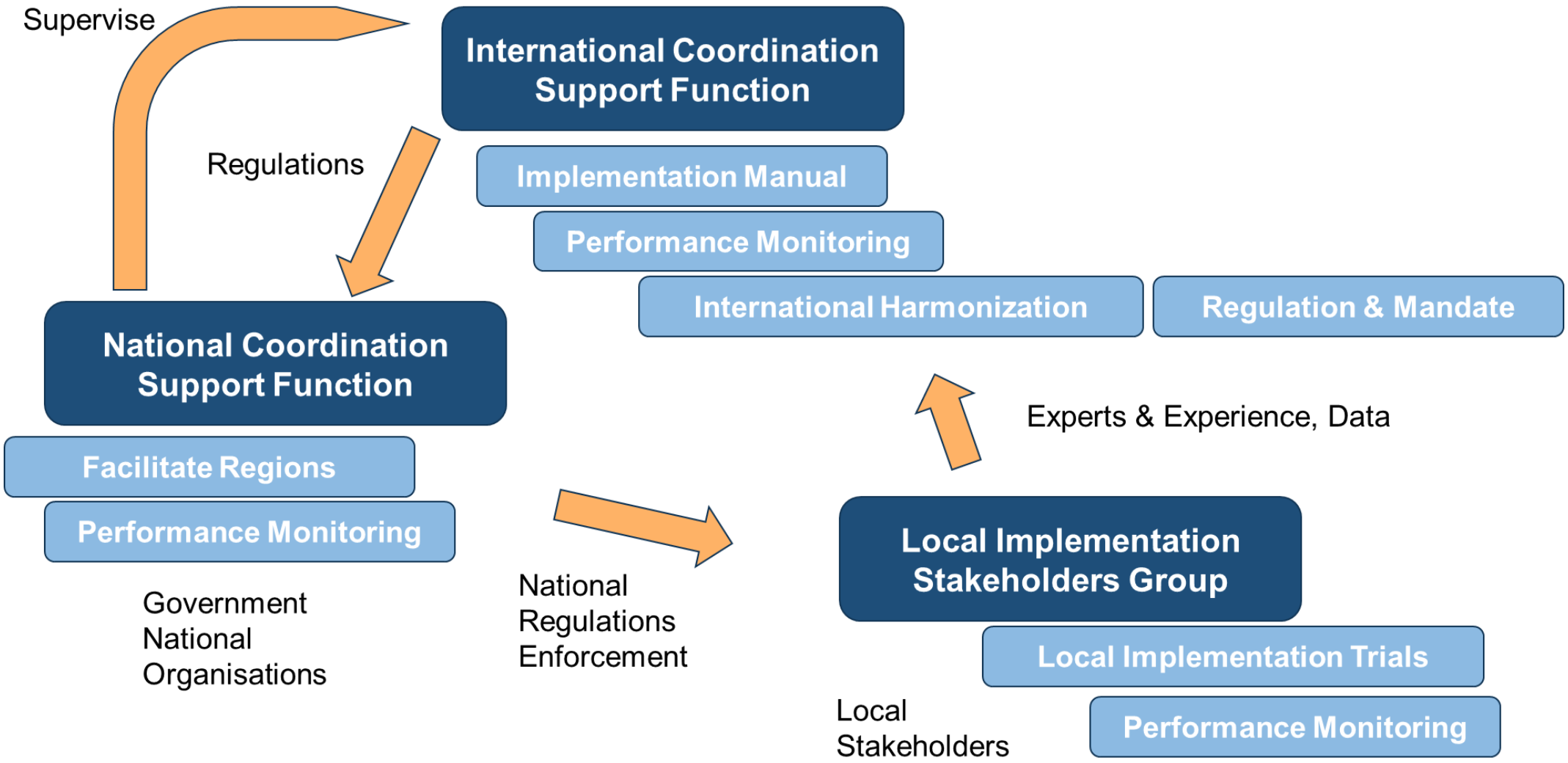
More effective management

Immediate real-time notification of all involved stakeholders

Real-time monitoring

Less reserve capacity

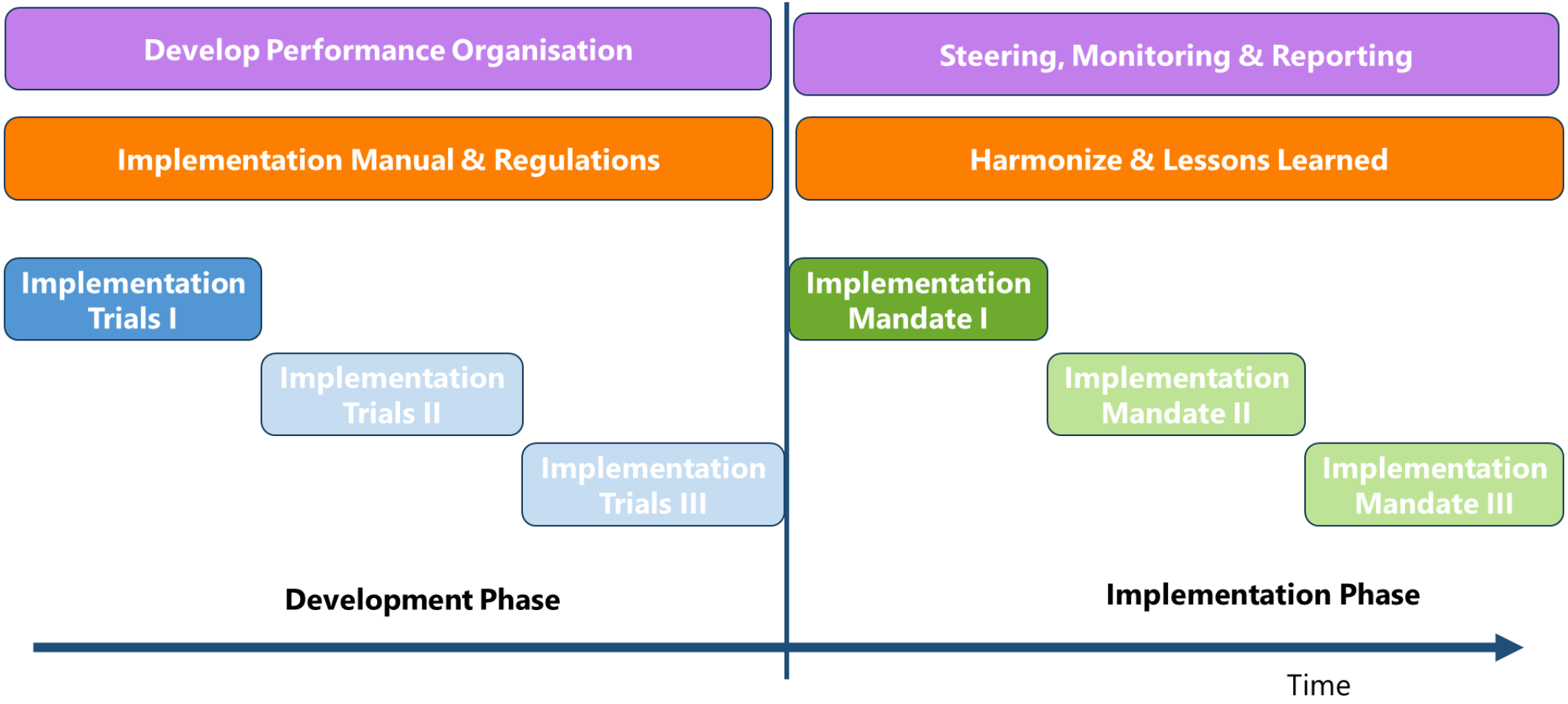
Task 3.1 – Organisation Levels



Task 3.1 – Requirements

1. Develop Rail CDM under International Coordination Support Function
2. Work Together – internationally, nationally, locally with all stakeholders
3. Work Transparent – create environment and start sharing data
4. Create one standard for implementation, basis for regulation, together, lead by International Coordination Support Function
5. Harmonise technical and operational implementation and procedures early
6. Create International, national, and local performance monitoring and reporting.
7. Develop Methodology for Cost benefit Analysis
8. Assess safety and how Rail CDM impacts on safety

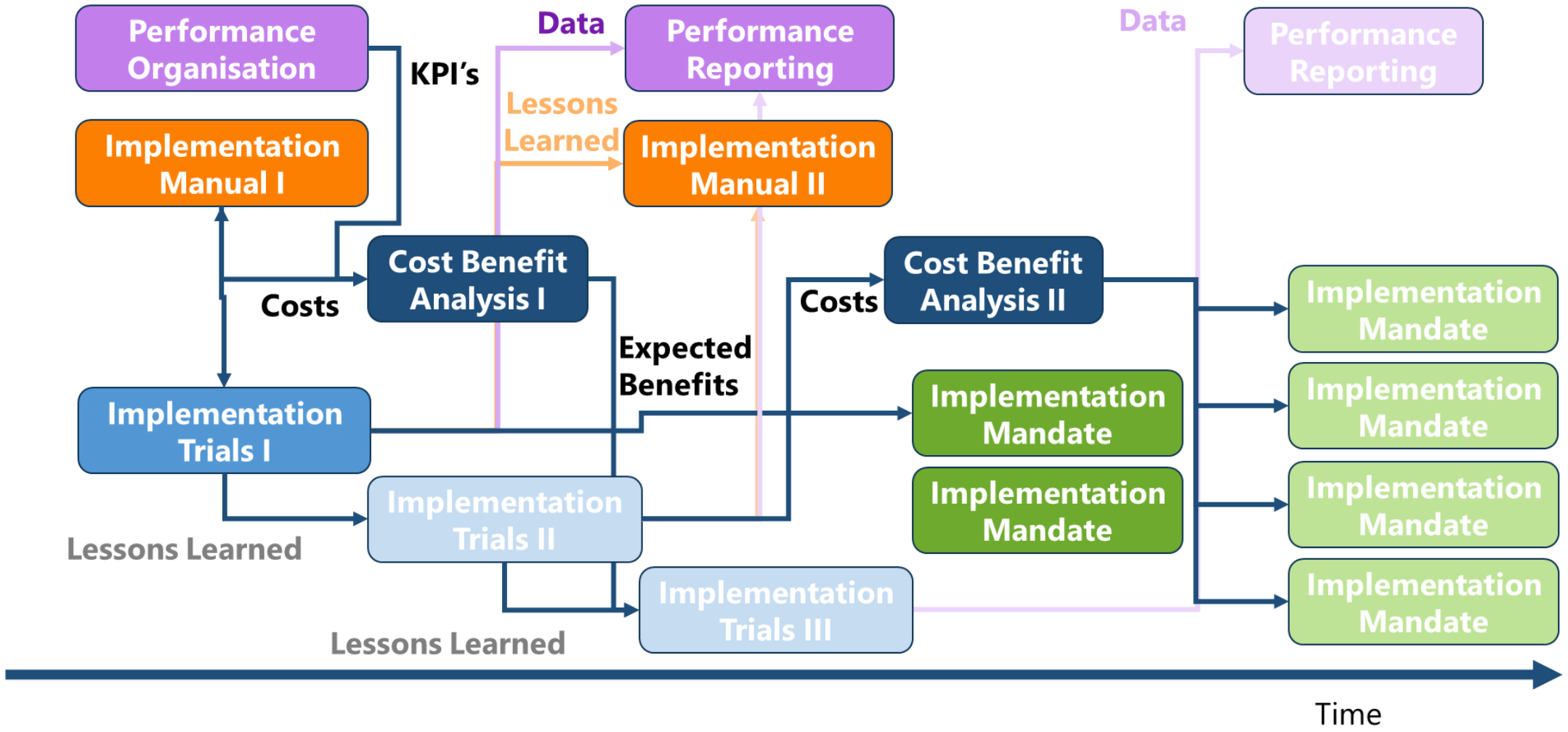
Task 3.1 – Roadmap (1)



Task 3.1 – Roadmap (2)

1. Set-up the International Coordination Support Function, possibly involving Rail Freight Corridors and/or international institutions
2. Develop Implementation Manual by and for the stakeholders
3. Set-up Performance Monitoring Organisation on all levels
4. Initiate Proof-of-Concept Trials locally
5. Develop Cost Benefit Analysis methodology
6. Set-up Development and harmonisation Groups
7. Steering, Monitoring, Reporting on all levels

Task 3.1 – Roadmap (3)



WP2 – Conclusions & Recommendations

- Performance Monitoring is transferrable from aviation to rail.
- Business Drivers related to Predictability of train milestones are the most relevant improvement provided by Rail CDM.
- KPI's require more data to trial validation.
- Benefits are expected for all stakeholders from collaboration, information sharing, and monitoring the performance indicators.

Recommendations

- Performance Monitoring organisation should be set up on each level: international, national and local.
- Methodology for performance monitoring needs to validate expectations on benefits, and costs through a means of Cost Benefit Analysis.
- Performance monitoring requires an initiative to validate expected benefit in multiple regions and corridors.
- More data points may be needed to collect more data for KPI metrics to be measured and quantified.
- Decision makers should decide on trials to learn quickly and develop Rail CDM. RFCs could support this process.

WP3 – Conclusions & Recommendations

- Airport CDM is transferrable
- Stakeholders agreed that Rail CDM may contribute to resolve Rail challenges
- Rail CDM enables efficient national and international rail freight operations

Recommendations

- Start and organise Rail CDM with willing stakeholders; Rail Freight Corridors could support this process as facilitators.
- Make one International Coordination Support Function responsible that enables development efforts, harmonisation, prepares regulation, and supports operations.
- Start at once, agile method:
  - Develop Rail CDM Implementation Manual
  - Initiate and fund local trials on multiple terminals with all stakeholders to learn and collect input
  - Start Cost Benefit Analysis methodology for harmonisation
  - Organise Performance Monitoring

Thanks for your attention!

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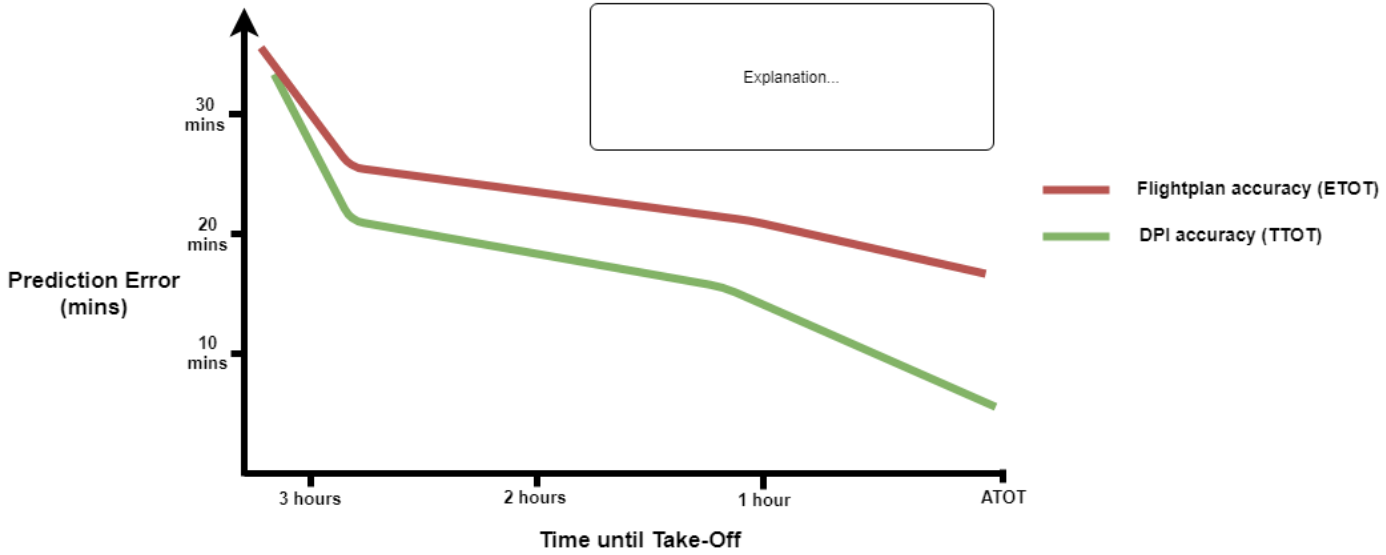
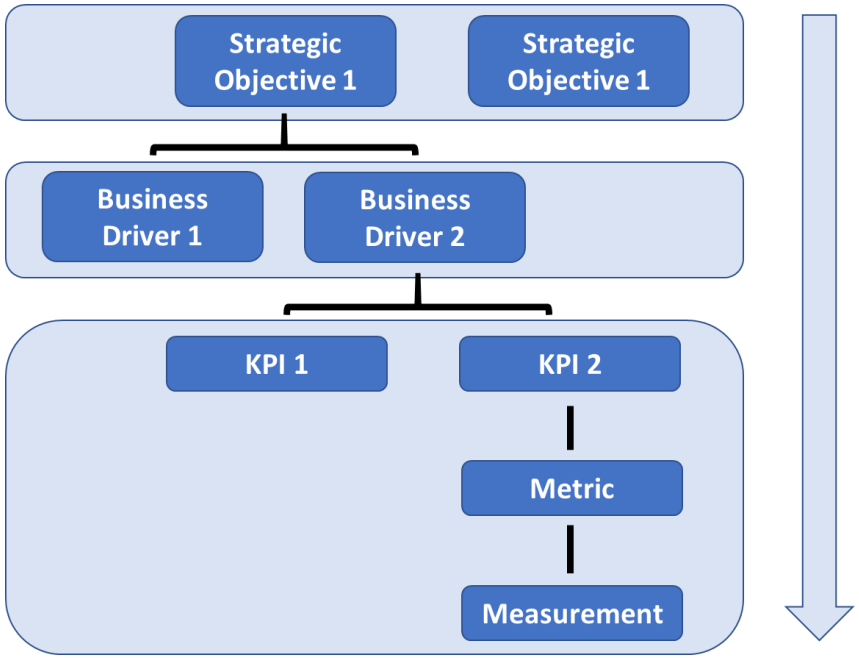
Requirements to enable Rail CDM

- Requirements are determined to promote equality of stakeholders, transparency of information sharing, and define business rules to facilitate performance monitoring and post-operation analysis;
- Introduction of a International Coordination Support Function that serves international capacity demand balancing on corridors and facilitate tactical dispatch in case of planned or unplanned rail capacity restrictions;
- Harmonized performance monitoring on international and national and regional scale, focused on steering, monitoring, managing, and post operation analysis.





Project References

A 1 Project References

1. RFC Rhine Alpine EEIG Contract HACON-To70, Frankfurt, September 2020.
2. Feasibility Study WP1, Rail CDM Approach, HACON-To70, Hanover January 2021
3. Feasibility Study WP2, Rail CDM Performance Organisation & Expected Benefits, HACON-To70, Hanover February 2021

A 2 Aviation References

1. EUROCONTROL Airport CDM Implementation Manual 2017
2. Airport CDM EUROCAE Working Group 69 Airport CDM Standard to Guide Implementation in Europe 2008
3. ETSI Community Specification for European Commission 2010
4. Commission Implementing Regulation (EU) Regulation No 716/2014 of 27 June 2014
5. Airport CDM Impact Assessment, Eurocontrol 2016
6. Airport CDM Cost Benefit Analysis, version 1.4, Eurocontrol 2008
7. Safety Assessment on Airport CDM, version 2.0, EU/Eurocontrol 2016