Grant Agreement Number: 101101962

Project Acronym: FP6 – FutuRe

Project Title: Flagship Project 6 – Delivering innovative rail services to revitalise capillary lines and regional rail services

DELIVERABLE D3.3

USE CASES AND SCENARIOS FOR TRAFFIC MANAGEMENT SYSTEMS DEMOS ON G1 REGIONAL LINES

Project Acronym:	FP6 – FutuRe
Starting Date:	01/12/2022
Duration (in months):	48
Call (part) Identifier:	Call: EU-RAIL JU Call Proposals 2022-01 (HORIZON-ER-JU-2022-01) Topic HORIZON-ER-JU-2022-FA6-01
Grant Agreement No:	101101962
Grant Amendments:	NA
Due Date of Deliverable:	02-10-2024
Actual Submission Date:	16-10-2024
Coordinator:	Alessandro Mascis, Wabtec
Lead Beneficiary:	ENYSE
Version:	v10
Type:	Report
Sensitivity or Dissemination Level[1]:	PU
Taxonomy/keywords:	Use Cases, TMS, Conflict Resolution, Adhesion Management, Mix Regulation, Mix Planning

[1] PU: Public; SEN: Sensitive, only for members of the consortium (including Commission Services)

This project has received funding from the Europe's Rail Joint Undertaking (JU) under grant agreement 101015423. The JU receives support from the European Union's Horizon Europe research and innovation programme and the Europe's Rail JU members other than the Union.

Document History

Date	Name	Affiliation	Position/Project Role	Action/ Short Description
24/08/2023	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v1 – Creation. CAF's comments inserted into the document, using "track changes".
02/10/2023	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v2 – Update following CAF's comments, using "track changes".
03/10/2023	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v3 – Equal to v2 with all the comments accepted; version shared with internal stakeholders in Task 3.3, to gather their comments, using "track changes".
07/10/2023	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v4 – Equal to v3 with all the comments solved. Version shared within the FP6 as **Milestone in M12**.
12/04/2024	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v5 – ENYSE Uses Cases developed.
15/04/2024	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	V6 – MERMEC contribution Use Cases. Highlighted in yellow (only highlighted in this version V6).
07/05/2024	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v7 – Annex 3 and Annex 6 added. CAF Uses Cases developed.
28/05/2024	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v8 – Section 5 updated. Template updated. Still a few sections pending to complete, highlighted in blue (only highlighted in version V8). Version shared as **Milestone in M18**.
23/09/2024	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v9 – Version that tracks comments for the nominated external reviewers.
02/10/2024	Noelia Medrano	ENYSE	Task Leader (Task 3.3)	v10 – Clean version. Implements the comments from v9.

Date	Name	Affiliation	Position/Project Role	Action/ Short Description
03/10/2024	Fabrizio Burro	FT	WP1 Leader	Quality Check
10/10/2024	Fabrizio Burro	FT	WP1 Leader	Steering Committee Review

Document Contributions

Date	Contributor(s) / Affiliation	Reviewer(s) / Affiliation
v1 – 24/08/2023 v2 – 02/10/2023	Noelia Medrano / ENYSE Jose Antonio Reyes / CAF	None
v3 – 03/10/2023 v4 – 07/10/2023	Noelia Medrano / ENYSE	Miguel López / CEDEX Mariano Martínez / ADIF Jose Antonio Reyes / CAF
v5 – 12/04/2024	Noelia Medrano / ENYSE	None
v6 – 15/04/2024	Francesco Inzirillo / MERMEC	None
v7 – 07/05/2024	Jose Antonio Reyes / CAF	None
v8 – 28/05/2024	Noelia Medrano / ENYSE Jose Antonio Reyes / CAF	None
v9 – 23/09/2024 v10 – 02/10/2024	Noelia Medrano / ENYSE	Jose Antonio Reyes / CAF Anna Beszczyńska/ PKP Matthias Walter / HACON

Disclaimer

The information in this document is provided "as is", and no guarantee or warranty is given that the information is fit for any particular purpose. The content of this document reflects only the author's view – the Europe's Rail Joint Undertaking is not responsible for any use that may be made of the information it contains. The users use the information at their sole risk and liability.

Index

Executive Summary

With the support of EU's key funding program Horizon Europe, the **Europe's Rail Joint Undertaking** (EU-Rail) aims to deliver a high-capacity integrated European railway network by eliminating barriers to interoperability, providing solutions for full integration, and achieving faster uptake and deployment of innovation.

Having an essential function by providing green transport services and connection with other transport systems, **regional railways** play a crucial role in the European network acting as feeder lines for both passenger and freight traffic. However, regional lines are gradually disappearing. Current economic, social, and environmental conditions negatively impact their survival throughout Europe to the extent of being abandoned. In response, EU-Rail **FP6 Project** (**FutuRe**) is born to revitalize them by exploiting leading-edge technologies which lead to a reduction in the Total Cost of Ownership (TCO), while meeting safety standards and improving reliability and availability of the regional railway system.

The expected outcomes of FutuRe shall form the basis for a common European regional rail development management framework characterized by green, digital, safe, and cost-efficient solutions, which is linked to the technical objective of **FutuRe Work Package 3** (WP3):

- Regional rail CCS & operations for Group 1 (G1) regional lines

G1 regional lines are lines or network of lines that are connected to the mainline railway system, forming together the Single European Railway Area (SERA) in accordance with the Directive 2012/34. They are characterized by a regular passenger service operated from/to mainline and/or demonstrated demand for rail freight services. Therefore, G1 lines must be fully compliant with the applicable EU legal framework establishing SERA, primarily with the Directive 2016/797/EU.

In the context of CCS, FutuRe WP3 leads the assessment for the applicability of several solutions covering an integrated control and command system for G1 lines, which shall first be demonstrated in laboratory conditions in **FutuRe Work Package 8** (WP8) targeting the Technology Readiness Level (TRL) 4/5:

- Automatic Train Operation (ATO), up to GoA4
- ERTMS/ETCS level 2, considering both Fixed Virtual Blocks and Moving Block implementations.
- Traffic Management System (TMS)
- Absolute Safe Train Positioning (ASTP)
- Train Integrity and Train Length

FutuRe WP3 builds on specifications, guidelines, and other existing deliverables coming from:

- CCS TSI 2023/1695
- FutuRe Work Package 2 (WP2)
- Flagship Project 1 - Mobility management multimodal environment and digital enablers
- Flagship Project 2 - Rail to Digital automated up to autonomous train operation
- EU-Rail's System Pillar
- Shift2Rail (S2R) projects

As a result of the work performed in WP3, a comprehensive list of unique use cases/scenarios is provided together with a definition of WP8's demonstrator laboratory set-ups.

More concretely, this document represents the deliverable D3.3 entitled "Use Cases and Scenarios for Traffic Management Systems demos on G1 Regional Lines".

This deliverable aims to provide a set of Use Cases and Scenarios that reflect the operational behaviour of a Regional Line, in relation to some Traffic Management System (TMS) functions.

The concept of a Use Case or Scenario is broadly defined in the industry, but in the context of this document it must be understood as a "sequence of steps or actions that defines the interaction between different actors (being those humans or technical systems) in a given situation".

Following that description, this document gathers a list of potential situations that might happen on a regional line in regard to the TMS.

The main actors involved in the scenarios described here are the signaller operator (or any other equivalent role), the train (understood as the on-board systems + rolling stock) and the TMS (or the relevant SW module within), while the main functions under study are the next two: Conflict Resolution and Adhesion Management.

Once this deliverable has been released, its Use Cases and Scenarios shall be played (i.e., executed) in a demonstrator, to be developed under the scope of the FP6 WP8.

This later step shall serve to demonstrate that the technology developed in other Flagship Projects (FP1) is applicable and fits customer needs when it is applied to regional lines, by using the demonstrators created in FP6 (see Figure 1, which illustrates the interaction between FP1 and FP6).

This deliverable is a key element to join both ends, the development of the technology and its application:

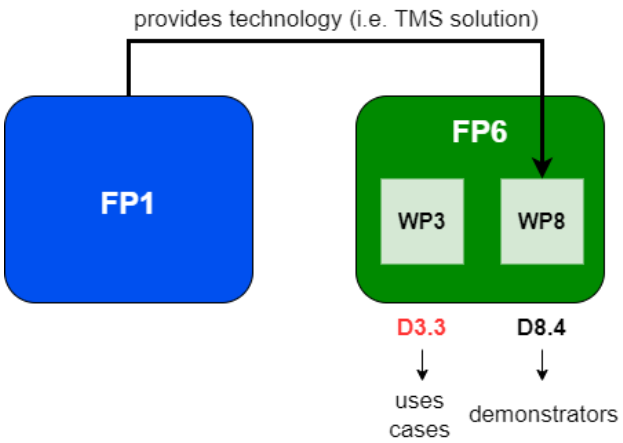


Figure 1. Link between FPs

List of Abbreviations, Acronyms and Definitions

Table 1: Abbreviations, Acronyms and Definitions

AD	Automatic Driving
AI	Artificial Intelligence
ASTP	Absolute Safe Train Positioning
ATO	Automatic Train Operation
ATO-OB	ATO On-board
ATO-TS	ATO Trackside
CCS	Control, Command and Signalling
C-ITS	Cooperative Intelligent Transport Systems
Conflict Resolution	Conflict detection and resolution is a daily task faced by railway signallers and consists of adjusting train schedules whenever disturbances make the timetable infeasible. In the context of the ER-JU initiative, the innovation is brought by the use of Artificial Intelligence to develop algorithms that detect in advance potential conflicts and if not possible to prevent them, then to offer the best alternatives to the signaller for their resolution, minimising the impact in the trains´ schedule. This algorithm shall be installed as a SW module in the TMS.
ETCS	European Train Control System
ETCS OB	ETCS On-board
ERTMS	European Railway Traffic Management System
EU	European Union
IXL	Interlocking
FP1	Flagship Project 1 – MOTIONAL
FP6	Flagship Project 6 – FutuRe
FP6 D3.3	Use Cases and Scenarios for Traffic Management Systems demos on G1 Regional Lines – Collaborative Deliverable
FP6 D8.4	Traffic Management Systems and C-ITS on G1 lines Demonstrator Report
FP6 Task 3.3	Task 3.3 – Preparatory Activities for the Traffic Management Systems demos on G1 Regional Lines
FP6 Task 8.4	Task 8.4 – Development of Individual Demonstrator for Traffic Management Systems on G1 Regional Lines
FP6 WP2	Work Package 2 – Regional Rail System Solutions/Architecture

FP6 WP3	Work Package 3 – Regional Rail CCS & Operations for G1 Requirements & Specifications
FP6 WP8	Regional Rail CCS & Operations for G1 Demonstrations
FutuRe	Future of Regional
G1	Group 1 Regional Lines – those that are connected with the mainline railway system, forming together the Single European Railway Area (SERA) (see GA for further details)
G2	Group 2 Regional Lines – those that are not functionally/operationally connected with the mainline railway network (see GA for further details)
GA	Grant Agreement
GoA	Grade of Automation
KPI	Key Performance Indicator
Mixed Planning	The ability to plan train traffic by timetable and headway considering the train position and the service hour in a mixed way. Plan is the theory, what is expected to happen.
Mixed Regulation	The ability to regulate train traffic by timetable and headway considering the train position and the service hour in a mixed way. Regulation is the set of on-line updates done over the plan.
MoM	Minutes of Meeting
MOTIONAL	MObility managemenT multImodal envirOnment aNd digitAl enabLers
MXX	Month (number) XX
NA	Not Applicable
OB	On-board
RBC	Radio Block Centre
S2R	Shift2Rail
SEO	Socio-Economic Objective(s)
SERA	Single European Railway Area
SW	Software
TCMS	Train Control Management System
TCO	Total Cost of Ownership
TMS	Traffic Management System
TRL	Test Readiness Level

TSI	Technical Specification of Interoperability
TVD	Track Vacancy Detector

List of References

Table 2: References

[Ref.1]	FP6 WP3 Task 3.3 – MoM 1st Job Session, dated on 30th March 2023 20230330_Task33-1stJobSession_MoM.docx
[Ref.2]	FP6 WP3 Task 3.3 – MoM ENYSE&CAF Alignment, dated on 18th July 2023 20230718_Task33-ENYSE&CAFAlignment_MoM.docx
[Ref.3]	FP6 WP2 D2.1 – Regional Lines Architecture Id: FP6-WP02-D-MER-002-01 Version: 2 Due date of deliverable: 31st May 2026 Actual submission date: 16th February 2024
[Ref.4]	FP6 WP2 D2.2 – Regional Lines Operational and Functional Requirements Id: FP6-WP02-D-MER-001-01 Version: 2 Due date of deliverable: 31st May 2026 Actual submission date: 16th February 2024
[Ref.5]	FP1 WP02 D2.3 – Use Cases for Planned Technical Developments of the Project Id: FP1-WP02-D-HAC-010-02 Due date of deliverable: 31st December 2023 Actual submission date: 22nd December 2023
[Ref.6]	FP6 WP2 D2.3 – First Release of KPI Achievement Version: 2.0 Due date of deliverable: 31st Jan 2024 Actual submission date: 21st February 2024

List of Figures

List of Tables

1 INTRODUCTION

The present document constitutes the deliverable D3.3 (Use Cases and Scenarios for Traffic Management Systems demos on G1 Regional Lines – Collaborative Deliverable).

The final version of the document shall be provided in September 2024.

Chapter 1 provides the list of inputs and outputs involved.

Chapter 2 explains the objective of the task 3.3 and of its associated deliverable, D3.3.

Chapter 3 depicts the scope of the content of this deliverable.

Chapter 4 gathers the list of Uses Cases, grouped by functionalities.

Chapter 5 introduces tips and needs to be considered prior to performing the demonstration (during WP8 lifetime).

Chapter 6 closes the document, with the most relevant conclusions.

And last, at the end a series of valuable annexes to help in the complete understanding of this deliverable is provided.

1.1 INPUTS

Different sources have been used to create this deliverable. The next two paragraphs identify the main inputs, both external to this FP and internal to this FP, which have been evaluated.

EXTERNAL: FP1, in particular, the deliverables coming from:

- within work package WP3 (Specifications of demonstrators for improved strategic and tactical planning of the rail network):
  - task 3.2 (High-level Use Cases and demonstrator specifications)
- within work package WP8 (Development - Simulation and operational feedback for improved planning):
  - task 8.1 (Technical preparatory work)
  - task 8.2 (Identify the need for future development of methods and models for capacity simulations and feedback loops between planning and operations)
  - task 8.4 (Develop simulation methods and models for capacity evaluation of ETCS and C-DAS/ATO)
- within work package WP10 (Alignment of specifications):
  - task 10.2 (High-level specification of Use Cases and demonstrators)
- the whole work package 15 (Development - Linking TMS to ATO/C-DAS for optimised operations)
- the whole work package 16 (Demonstration - Linking TMS to ATO/C-DAS for optimised operations)
- within the work package 17 (Development - Automated decisions and decision support for traffic management optimisation):
  - subtask 17.2.2 (Specific Application to Depots and Terminal Stations environments of Algorithms for Automatic Conflict Detection and Resolution using AI)

- within the work package 18 (Demonstration - Automated decisions and decision support for traffic management optimisation):
    - subtask 18.2.1 (Demonstrator for Real Time Conflict Identification & Resolution)
    - subtask 18.2.2 (Demonstrator Specific Application to Depots and Terminal Stations environments of Algorithms for Automatic Conflict Detection and Resolution using AI)

INTERNAL

The main internal provider of inputs to WP3, is FP6 WP2. From this WP, two deliverables are used as reference:

- D2.1 “Regional Lines Architecture” (see [Ref.3]).
  The Annex 1, at the end of this document, describes the traceability between D2.1 and this deliverable D3.3.
- D2.2 “Regional Lines Operational and Functional Requirements” (see [Ref.4]).
  The Annex 1, at the end of this document, describes the traceability between D2.2 and this deliverable D3.3.

Additionally, another task within FP6 WP3, is used as inspiration (concretely for the Uses Cases related to Adhesion Management):

- FP6 WP3 T3.1: Preparatory activities for Automatic Train Operation (ATO) in different Grade of Automation (GoA) on G1 regional lines.

1.2 OUTPUTS

According to the GA, the present deliverable, shall provide:

- Uses Cases and Scenarios (per Company involved);
- Compendium of Use Cases and Scenarios (…) to provide a consolidated and complete list of unique use cases/scenarios, which allow to perform the demonstrators.

The first bullet (that can be understood as an “independent” list of Uses Cases per company involved in the creation of this deliverable) was thought for the situation where two or more contributors were participating in the development of Use Cases for the same scope.

This situation is finally not applicable to this deliverable D3.3, as the scope has been clearly divided between the three contributors (see Chapter 3 to find that split), so it is feasible to directly generate a list with the compendium of Use Cases.

That list of Use Cases is materialised in the Chapter 4.

Complementarily, and in order to satisfy the objectives of the task 3.3 (summarised in the next Chapter), this deliverable also contains information about the future demonstrator setup.

Thus, this deliverable is intended to be used as one of the inputs to support task 8.4 (within WP8), with title “Development of Individual Demonstrator for Traffic Management Systems on G1 Regional Lines”. Additionally, and during the time duration of the task, it has been decided to infer requirements from the Uses Cases created, which may bring value in future deliverables of FP6 WP2.

2 OBJECTIVES

As already introduced in the Executive Summary “the FP6 Project (FutuRe) is born to revitalize the regional lines by exploiting leading-edge technologies which lead to a reduction in the Total Cost of Ownership (TCO), while meeting safety standards and improving reliability and availability of the regional railway system”.

This European project must bring innovation and some novelty to the existing systems; in the case of TMS functions, such innovations are described in FP1, and not in FP6, which aims at demonstrating such novelties.

An example of these innovations is the use of Artificial Intelligence (see FP1 WP17, Development - Automated decisions and decision support for traffic management optimisation) and its application in railway topologies of regional shape (for example in terminal stations and depots).

Additionally, it shall be explored how certain conditions on the track (i.e., low adhesion conditions) affect traffic regulation and planning using FP1’s Mixed Regulation and Mixed Planning functionality (see FP1 D8.1 “Report: The need for future development of methods and models for capacity simulations and feedback loops between planning and operations” and FP1 D15.1 “Requirements for the deployment of TMS linked with ATO/C-DAS”. Considering jointly the main goal of WP3 and the innovation added by the collaborative FP1, and for sure considering what is stated in the GA, it can be extrapolated that the objective of the Task 3.3 is divided into:

- consolidate a unique list and comprehensive list of Use Cases and Scenarios to demonstrate a set of TMS functions, and
- define the most suitable demonstrator setup.

3 TARGET OPERATIONAL ENVIRONMENT

This chapter aims to depict the scope of the content of this deliverable.

The word “content” refers to two topics:

- the TMS functions selected to perform the further demonstration, and
- the type of lines/topology used as inspiration, to describe the Use Cases.

The framework for the Operational Environment is under the umbrella of G1 regional lines.

G2 lines are out of the scope (refer to the GA to find more details about these two line categories).

In regard to the TMS functions, after some discussions between the beneficiaries acting as contributors for this task (see [Ref.1] and [Ref.2]), the next ones have been selected:

- Conflict Resolution, using AI and focus on Depot / Terminal Stations (ENYSE)
- Conflict Resolution in specific situations as for example TMS borders (MERMEC)
- Adhesion Management (CAF)

With reference to the lines/topology, the **Conflict Resolution[2] using AI** Use Cases are described in a way that a generic topology is used. A “generic topology” is one that describes a given set of rules (shape of tracks, number of elements, conditions to place the elements, etc.) independently of the concrete instantiation of elements. Then, the specific “topologies” shall be the ones describing real installations, by applying those applicable rules described in the generic pattern.

In parallel with what is reported in FP6 D3.1 “Use cases and scenarios for ATO in different GoA demos for G1 regional lines” , FP1 D8.1, and FP1 D15.1, in the context of **Mixed Planning**[2] and **Mixed Regulation**[2] functionality, **adhesion conditions management** Use Cases shall be focused on the analysis of how such conditions impact TMS by enabling a more accurate traffic regulation and hence a more efficient traffic management.

It shall be at the moment of developing the demonstrator when one (or several) specific topology must be chosen.

[2] Check “List of Abbreviations, Acronyms and Definitions” for a high-level description.

4 USE CASES

This chapter presents the Uses Cases, grouped by function, as already identified in the Chapter 3:

- Conflict Resolution using AI and focus on Depot / Terminal Stations (ENYSE)
- Conflict Resolution in specific situations as for example TMS borders (MERMEC)
- Adhesion Management (CAF)

The list of Use Cases is fully consolidated – that means that there is no repetition, and each scenario has only one owner. See Table 3, where the complete list is gathered.

Each Use Case has a unique ID, which follows the pattern explained in Figure 2: `UC_01_3_X_Y`, where:

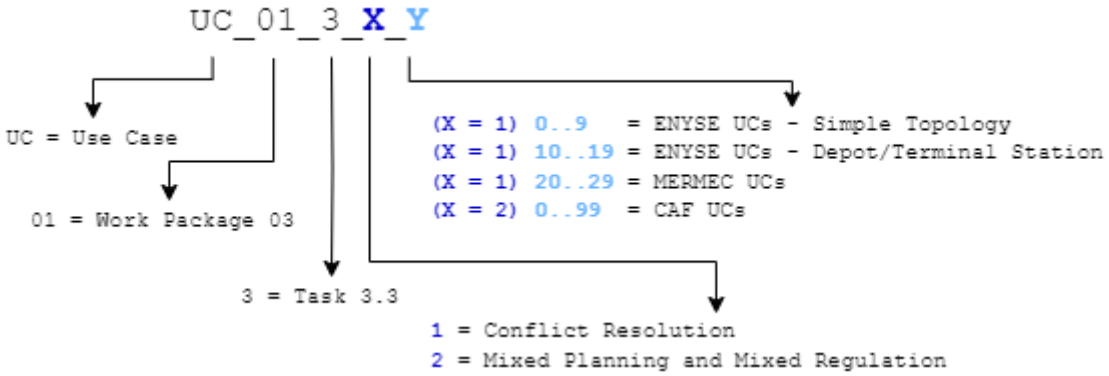


Figure 2. Use Cases ID Pattern

Table 3: Use Cases List

UC ID	Title	Comments
UC_01_3_1_**0**	Configuration about Conflict Resolution algorithm – Simple topology	Applicable to Simple topology - See Annex 2
UC_01_3_1_**1a**	Conflict Resolution – Catch-up – TVD occupied in front	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**1b**	Conflict Resolution – Catch-up – Delay	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**1c**	Conflict Resolution – Catch-up – Delay + Recover	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**2a**	Conflict Resolution – Crossing – Route incompatible	Applicable to Simple topology - See Annex 2
UC_01_3_1_**2b**	Conflict Resolution – Crossing – Cross delay	Applicable to Simple topology - See Annex 2

UC ID	Title	Comments
UC_01_3_1_**3a**	Conflict Resolution – Proximity – TVD occupied at station	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**3b**	Conflict Resolution – Proximity – Route not released	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**3c**	Conflict Resolution – Possible Conflict	Applicable to Simple topology - See Annex 2
UC_01_3_1_**4a**	Conflict Resolution – Others – Front TVD blocked	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**4b**	Conflict Resolution – Others – TVD blocked at station	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**4c**	Conflict Resolution – Others – Front TVD failure	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**4d**	Conflict Resolution – Others – TVD failure at station	Applicable to Simple & Depot topology - See Annex 2
UC_01_3_1_**10**	Configuration of Conflict Resolution Algorithm – Depot/Terminal Station	Applicable to Depot topology - See Annex 2 Traced to UC-FP1-WP10-45 (see [Ref.5])
UC_01_3_1_**11**	Conflict Resolution – Perform a task	Applicable to Depot topology - See Annex 2 Traced to UC-FP1-WP10-45 (see [Ref.5])
UC_01_3_1_**12**	Conflict Resolution – Perform more than one task	Applicable to Depot topology - See Annex 2 Traced to UC-FP1-WP10-45 (see [Ref.5])
UC_01_3_1_**13**	Conflict Resolution – Split	Applicable to Depot topology - See Annex 2 Traced to UC-FP1-WP10-45 (see [Ref.5])
UC_01_3_1_**14**	Conflict Resolution – Join	Applicable to Depot topology - See Annex 2 Traced to UC-FP1-WP10-45 (see [Ref.5])

UC ID	Title	Comments
UC_01_3_1_15	Conflict Resolution – Possible Conflict	Applicable to Depot topology - See Annex 2 Traced to UC-FP1-WP10-45 (see [Ref.5])
UC_01_3_1_20	Cooperative Conflict Resolution (two TMS)	
UC_01_3_1_21	Exchanging Real Time Train Data regarding the Border Stations	
UC_01_3_1_22	Level Crossing Accidents	
UC_01_3_1_23	Conflict Detection and Resolution	
UC_01_3_1_24	Very Short Term Decision	
UC_01_3_1_25	Railway Undertaking requests a New Train Path without Conflict	
UC_01_3_1_26	Railway Undertaking requests a New Train Path with Conflict	
UC_01_3_2_1	Slippery Rail/Non-Slippery Rail conditions are transmitted to TMS	This use case is linked to FP6 D3.1 UC_01_1_8_1
UC_01_3_2_2	Adhesion conditions reported by TCMS/Train are transmitted to TMS	This use case is linked to FP6 D3.1 UC_01_1_8_2
UC_01_3_2_3	TMS reports to ATO-TS on adhesion conditions	This use case is linked to FP6 D3.1 UC_01_1_8_3
UC_01_3_2_4	TMS constructs a Slippery-Rail area when Slippery Rail is reported by the Train Driver of n trains	This use case is linked to FP6 D3.1 UC_01_1_8_4
UC_01_3_2_5	TMS constructs an adhesion area when adhesion is reported by the TCMS/Train of N trains	This use case is linked to FP6 D3.1 UC_01_1_8_5
UC_01_3_2_6	TMS shortens/lengthens an already-defined adhesion area	This use case is linked to FP6 D3.1 UC_01_1_8_6
UC_01_3_2_7	TMS removes an already-defined Slippery Rail area on the basis of Status Reports	This use case is linked to FP6 D3.1 UC_01_1_8_7
UC_01_3_2_8	TMS modifies the adhesion category applied to an existing adhesion area on the basis of the information received from an External Source	This use case is linked to FP6 D3.1 UC_01_1_8_8

UC ID	Title	Comments
UC_01_3_2_**9**	TMS modifies the adhesion category applied to an existing adhesion area on the basis of the information received from the TCMS/Train	This use case is linked to FP6 D3.1 UC_01_1_8_9

4.1 CONFLICT RESOLUTION USING AI USE CASES

Concepts (alphabetical order)

- CATCH-UP: The pursuit train has reached the first one.
- CROSSING: Two trains facing each other.
- PROXIMITY: Two trains running in the same direction, and the pursuit one is approaching the first one (which may be driving slower than planned).

Variables (alphabetical order)

The objective of Table 4 is to collect the variables that may be required to configure the Conflict Resolution algorithm within the TMS software:

Table 4: ENYSE Conflict Resolution Algorithm Variables

Variable	Description	Topology
[AVAILABILITY]	To verify the availability of the necessary resources to perform a task or a movement. Among others: • Track availability. • Route availability. • Driver availability. • Train availability (i.e., train must be "healthy" – it must not have problems).	Simple and Depot
[CAPACITY]	Refers to the number of elements that the different resources may manage: • Track/Track Vacancy Detectors capacity → Number of trains/wagons that can be placed per track/TVD. Note that this capacity may have a different value for different tasks. E.g.: 2 trains can be parked in TVD X, while 3 trains can be moved into the same TVD X to perform a joining. • Train capacity → Number of passengers allowed, number of tones allowed, etc.	Simple and Depot
[EVENT]	Refers to a social event which may require special train services. E.g.: Concert, Sport Match, Demonstration, etc.	Simple and Depot
[ON_BOARD]	Refers to the signalling system that the train is equipped with. E.g.: ATP, LZB, National System, ERTMS, Non-equipped, etc.	Simple and Depot

Variable	Description	Topology
[PRIORITY_DEPOT]	Refers to the criteria to be applied in case of discrepancies about an action to be taken. Priority may be assigned from two different points of view: • Single train: There are some tasks (delayed) for a given train. This is the criterion to decide which task performs first. • Several trains at a time: Whether it becomes necessary to allow entry/exit several trains at the same moment, criteria must be defined. E.g.: By train type, by task, by driver availability, etc. E.g.: Skip actions, for example: it becomes urgently to send a train to rescue passengers from a faulty train, but there is no train available – perhaps one waiting just for cleaning task, could be sent.	Depot
[PRIORITY_MAIN_LINE]	Refers to the criteria to be applied in case of delay of several trains. For example, the most delayed, the passenger trains, etc.	Simple
[STATION]	Each station must be parametrized by defining: • Tracks (tracks ID number, positions, and lengths). • Platforms (positions and lengths). • Stabling areas (positions and lengths). • Crossings (passenger or Staff).	Simple and Depot
[TASK]	Type of activity that a train may perform. Normally, there should be tracks dedicated for each task, i.e., not any task can be performed at any track. E.g.: Parking, Preventive Maintenance, Maintenance (fix of problems), Axle Changing, Cleaning, etc.	Depot
[TASK_DURATION]	Necessary time to perform a given task. E.g.: 1h for Cleaning, 1h – 5h Preventive Maintenance, etc.	Depot
[TASK_ORDER]	Indicates the order established by the working procedures in the depot, to perform the tasks (to be applied in the case that a train needs to perform more than one). E.g.: Maintenance (fix of problems), and then Preventive Maintenance, and then Cleaning.	Depot
[TIMETABLE]	Each timetable must be parametrized by defining: • Operation Capacity: Refers to the load of train trips contained in the timetable (i.e. normal, optimized, above average, concerned, stressed, collapsed, etc.).	Simple and Depot

Variable	Description	Topology
	• Headway: Time between trains. • Validity: Timetable duration and time it is valid for (e.g., 24h, for a given weekday, etc.).	
[TRACK]	Each track must be parametrized by defining: • Track ID number. • Sense of movement (single or double). • Length. • Number of TVDs (positions and lengths). • Buffer stops, if any.	Simple and Depot
[TRAIN_LENGTH]	Refers to the length of a complete train. Next attributes must be evaluated to calculate that length: • Number of Wagons: Whether the train is a unique wagon (not possible to split) or if it is composed by a number of wagons. • Length of each wagon (the value may be different per wagon).	Simple and Depot
[TYPE]	Refers to a type of train in terms of Rolling Stock vehicle. E.g.: Freight, Passenger, Sweeper, Yellow fleet, Auscultatory, etc.	Simple and Depot

Uses Cases Group

- First, the **configuration** of the Conflict Resolution algorithm is considered as prerequisite step to allow using the algorithm within the TMS. The Use Cases are defined using only one criterion: Topology. Therefore, two Use Cases are defined to Main Line and Depot/Terminal Station, respectively.
- Secondly, the Uses Cases related to the **Conflict Resolution** are defined using three main criteria:
  a) Topology (i.e., Main Line or Depot/Terminal)
  b) Main scenarios where a conflict needs to be detected and resolved.
     i. The scenarios in case of Main Line topology are:
        - Crossing
        - Proximity
        - Catch-up
        - Others (e.g. failure, TVD blocked…)
     ii. The scenarios in case of Depot/Terminal Station are:
        - Perform a task
        - Perform more than one task
        - Split
        - Join
        - Possible conflict

c) Specific situations in each scenario to try to resolve the detected conflict.

The next picture presents all the Use Cases identified for Configuration and Conflict Resolution algorithm developed by ENYSE:

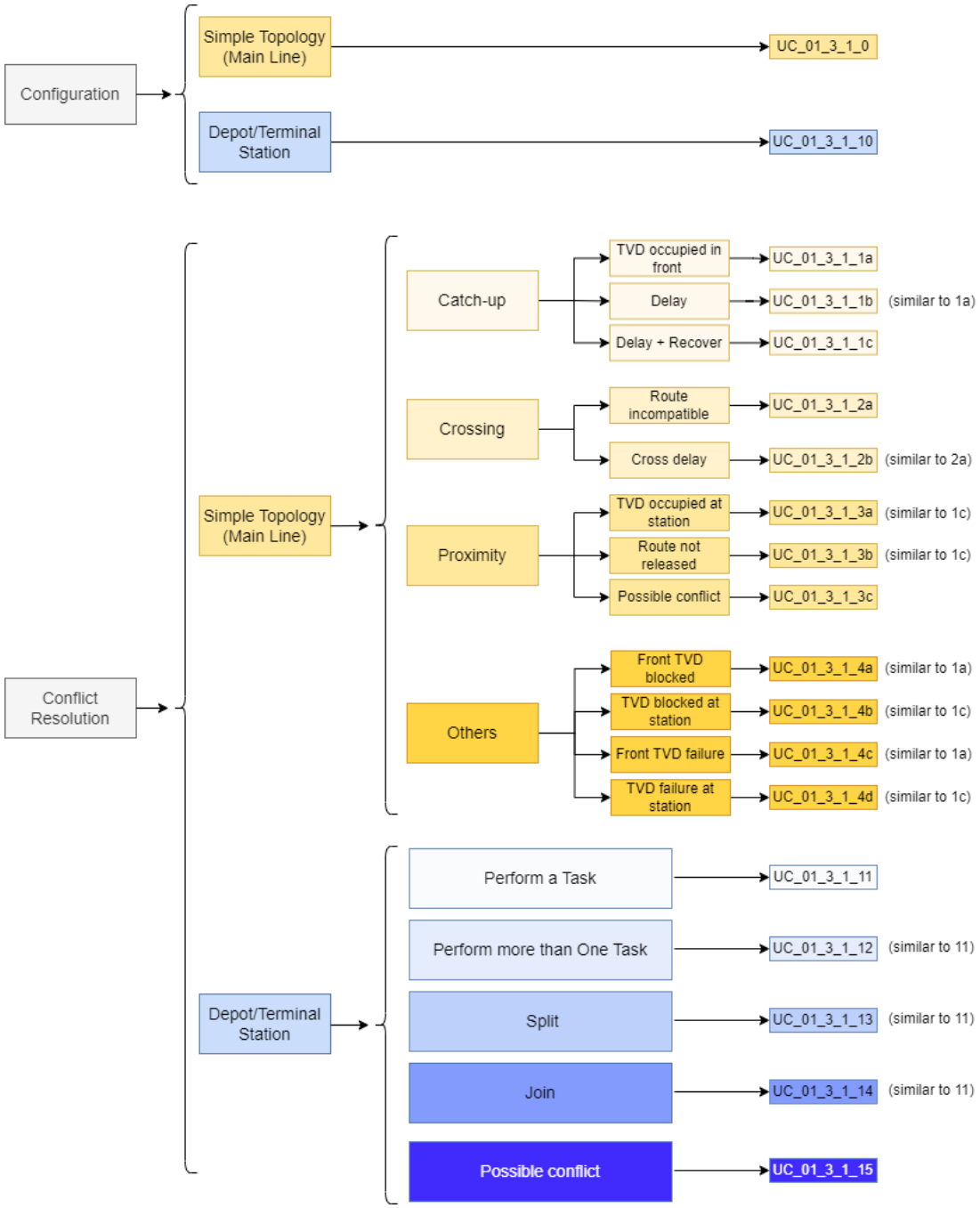
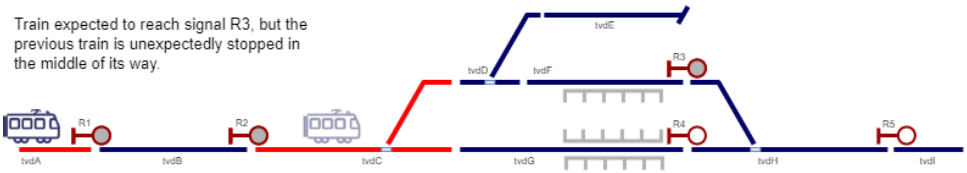


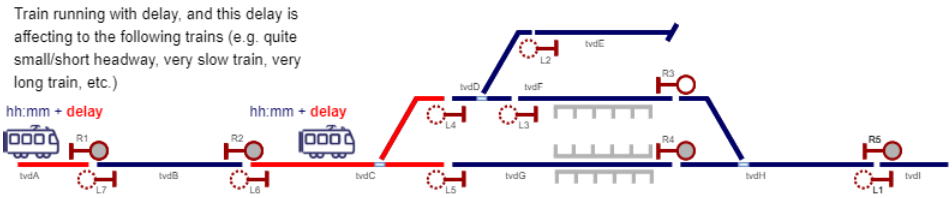
Figure 3. Conflict Resolution using AI Use Cases

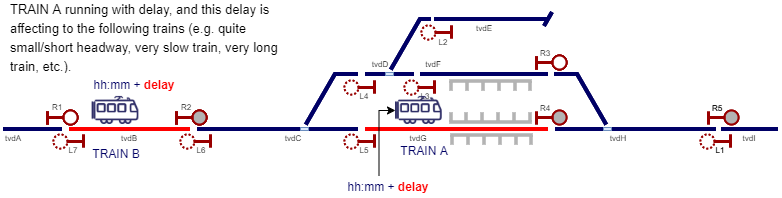
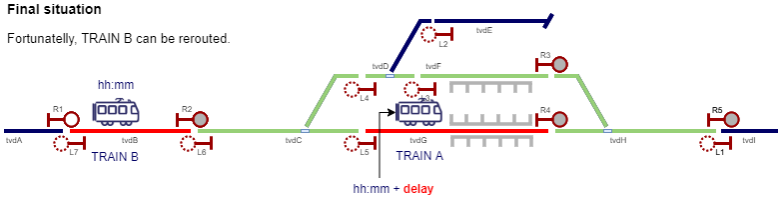
Note: “Similar“ is used to indicate that a UC has the same flow of events. “Similar” does not mean that a UC is the same than other, i.e., it does not mean that the UC is based on similar situations than other UC.

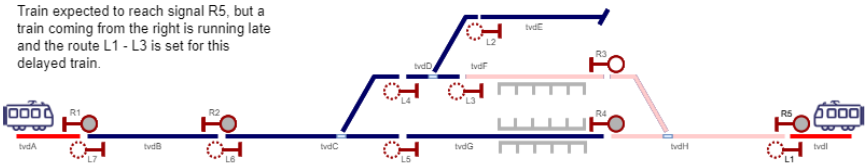
Uses Cases

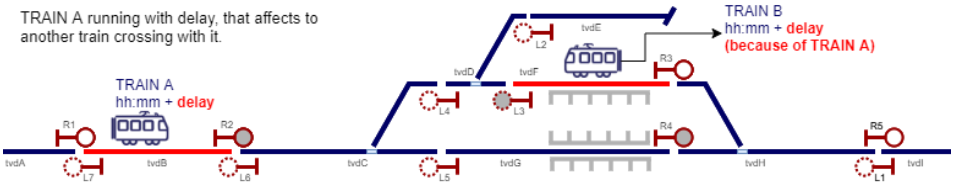
Use Case Group	WP3 – Task 3.3
Use Case	Configuration about Conflict Resolution algorithm – Simple topology.
UC ID	UC_01_3_1_0
Main actor	TMS
Other actors	Staff to configure TMS
Main goal	Configure the Conflict Resolution Algorithm within TMS software.
Assumptions	Simple topology (main line).
Precondition	• TMS equipped with all SW and HW constituents to allow configuring the Conflict Resolution Algorithm. • Specific data configuration is known (i.e., the concrete values for each of the variables). • The staff in charge of the configuration must be properly trained.
Flow of events	1. The staff member must be logged into the TMS, with the proper rights to perform the configuration. 2. The staff member must configure the algorithm with the proper values of the variables. 3. The TMS should confirm that the configuration has been properly introduced.
Postcondition	TMS configured correctly with the Conflict Resolution algorithm.
Safety relation	None.
Open topics / consideration	None.

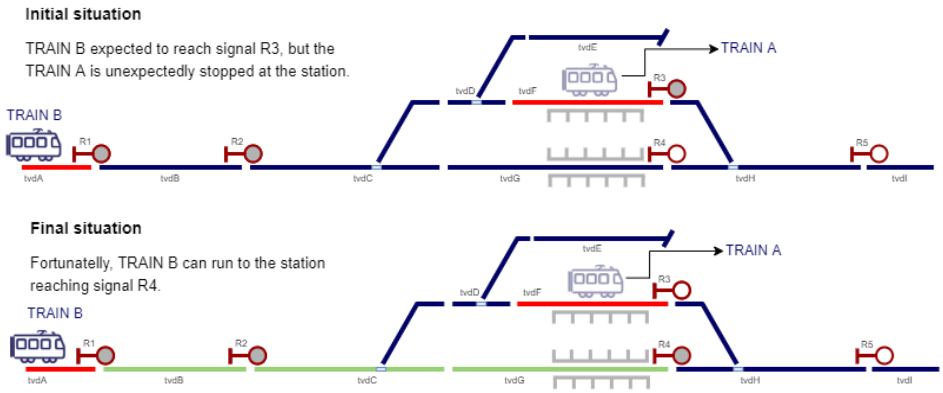
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Catch-up – TVD occupied in front. 
UC ID	UC_01_3_1_1a
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect a conflict and inform to the operator that it is unresolvable.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved – same sense. • The TVD occupied is one in front of the train, which is occupied by a precedent train.
Flow of events	1. The algorithm detects a conflict and warns to the operator. 2. The algorithm tries to calculate alternatives for the resolution. 3. The algorithm cannot identify alternatives and then, informs to the operator. 4. The conflict cannot be resolved.
Postcondition	Conflict cannot be resolved.
Safety relation	None.
Open topics / consideration	None.

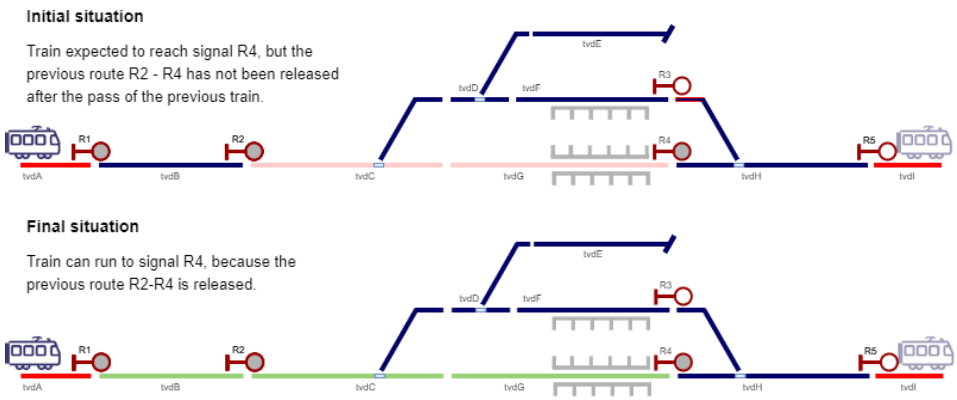
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Catch-up – Delay. 
UC ID	UC_01_3_1_1b
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect a conflict and inform to the operator that it is unresolvable.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved – same sense. • Precedent train is running with delay, which is directly impacting and generating delay for the pursuivant train.
Flow of events	Equal to UC_01_3_1_1a.
Postcondition	Conflict cannot be resolved.
Safety relation	None.
Open topics / consideration	None.

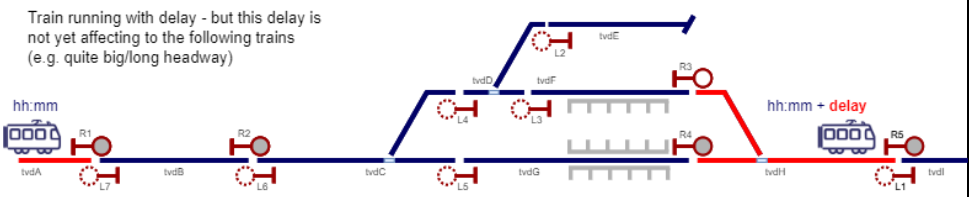
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Catch-up – Delay + Recover. **Initial situation** TRAIN A running with delay, and this delay is affecting to the following trains (e.g. quite small/short headway, very slow train, very long train, etc.).  **Final situation** Fortunatelly, TRAIN B can be rerouted. 
UC ID	UC_01_3_1_1c
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect and resolve a conflict.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved – same sense. • Precedent train is running with delay, which is directly impacting and generating delay for the pursuivant train.
Flow of events	1. The algorithm detects a conflict and warns to the operator. 2. The algorithm calculates alternatives for the resolution. 3. The algorithm presents alternatives in a ranked list and then, advises to the operator to choose one. 4. Once the operator has chosen the alternative, the conflict is resolved. If the operator does not select any alternative after X seconds, the algorithm considers the conflict as unresolved.
Postcondition	Conflict can be resolved.
Safety relation	None.
Open topics / consideration	None.

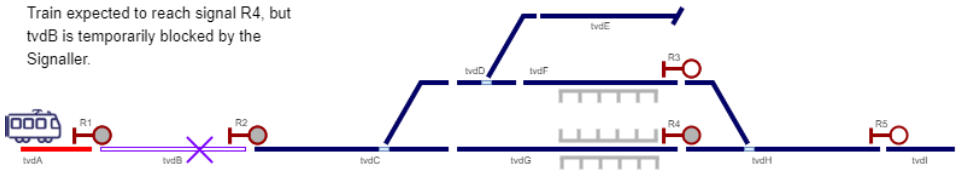
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Crossing – Route incompatible. 
UC ID	UC_01_3_1_2a
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect a conflict and inform to the operator that if it can be resolved or not.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved – facing sense. • One of the trains is delayed, thus generates the conflict between 2 facing trains.
Flow of events	1. The algorithm detects a conflict and warns to the operator. 2. The algorithm tries to calculate alternatives for the resolution. 3. A) The algorithm cannot identify alternatives and then, informs to the operator. B) The algorithm presents alternatives in a ranked list and then, advises to the operator to choose one. 4. A) The conflict cannot be resolved. B) The conflict can be resolved. If the operator does not select any alternative after X seconds, the algorithm considers the conflict as unresolved.
Postcondition	The conflict may be resolved depending on the circumstances (e.g. topology, timetable...).
Safety relation	None.
Open topics / consideration	• As indicated in Postcondition, the conflict shall be resolved depending on the topology. Therefore, one option (A or B) in step 3 shall be chosen. • If the conflict can be resolved, options B in both steps are chosen, but if not, options A in both steps are chosen.

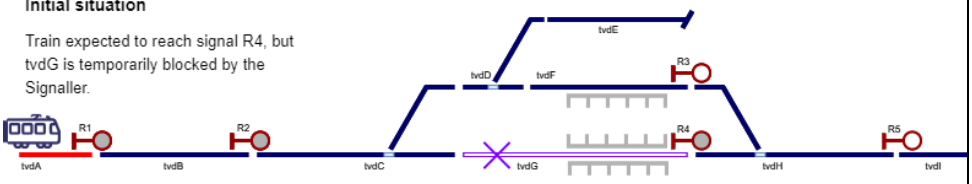
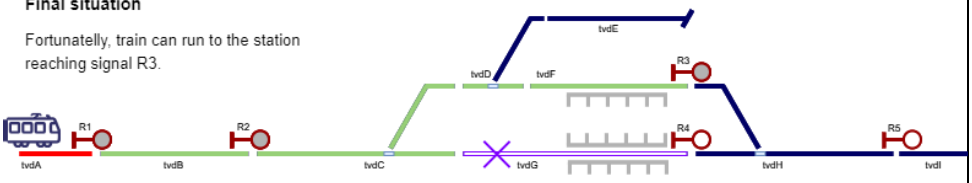
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Crossing – Cross delay. 
UC ID	UC_01_3_1_2b
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect a conflict and inform to the operator that if it can be resolved or not.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved – facing sense. • One of the trains is delayed, thus generates the conflict between 2 facing trains.
Flow of events	Equal to UC_01_3_1_2a.
Postcondition	The conflict may be resolved depending on the circumstances (e.g. topology, timetable...).
Safety relation	None.
Open topics / consideration	• As indicated in Postcondition, the conflict shall be resolved depending on the topology. Therefore, one option (A or B) in step 3 shall be chosen. • If the conflict can be resolved options A in both steps are chosen, but if not, options B in both steps are chosen.

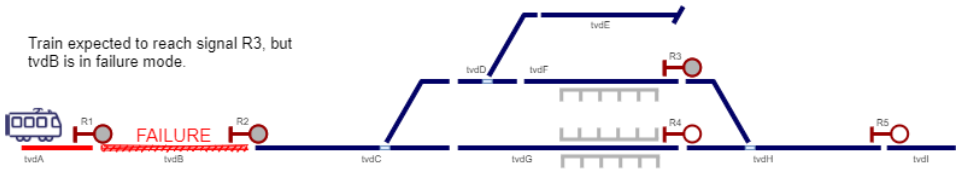
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Proximity – TVD occupied at station. 
UC ID	UC_01_3_1_3a
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect and resolve a conflict.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved – same sense. • The TVD occupied is further enough to allow the conflict resolution. It is occupied by precedent train, placed at a Station.
Flow of events	Equal to UC_01_3_1_1c.
Postcondition	Conflict can be resolved.
Safety relation	None.
Open topics / consideration	None.

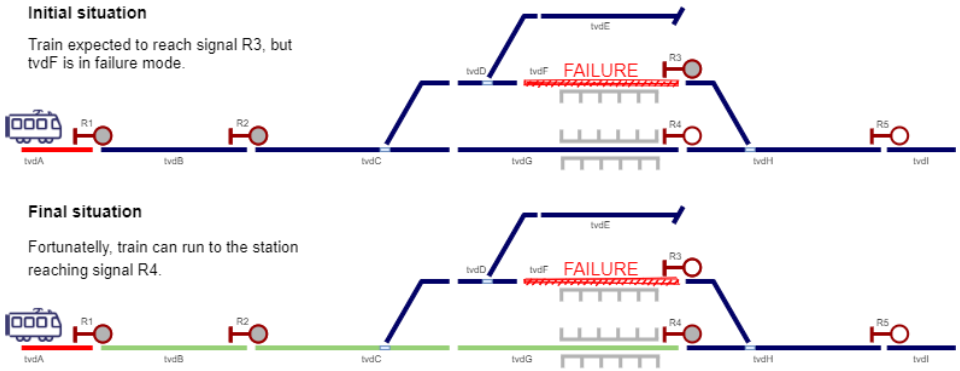
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Proximity – Route not released. 
UC ID	UC_01_3_1_3b
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect and resolve a conflict.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved – same sense. • The precedent train has not released an already run route (because of an error (*)), so this is not available for the coming train.
Flow of events	Equal to UC_01_3_1_1c.
Postcondition	Conflict can be resolved.
Safety relation	None.
Open topics / consideration	(*) There could be an error in the algorithm controlling the release of the routes; for example, in ERTMS Level 2, the release of routes may be triggered by the RBC (towards the IXL) after the reception of a Train Position Report in a given location. It that Train Position Report is not received when expected, the route may remain locked longer than expected.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Proximity – Possible conflict. 
UC ID	UC_01_3_1_3c
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect a possible conflict and inform to the operator that finally, it is not necessary to resolve any conflict.
Assumptions	Simple topology (main line).
Precondition	• 2 trains involved - same sense. • Precedent train is running with delay, but not yet affecting to the pursuivant train.
Flow of events	1. The algorithm detects a possible future conflict and warns to the operator. 2. The algorithm tries to calculate alternatives for the resolution depending on where and when the conflict could occur, e.g.: considering certain factors such as if the delay is incrementing or not, the possibility to take another route, etc. 3. The algorithm presents alternatives in a ranked list taking into account the factors mentioned in the previous point and then, advises to the operator in case that he/she had to choose one. 4. Finally, the algorithm considers that there is not any conflict and then, informs to the operator.
Postcondition	No need to resolve any conflict.
Safety relation	None.
Open topics / consideration	None.

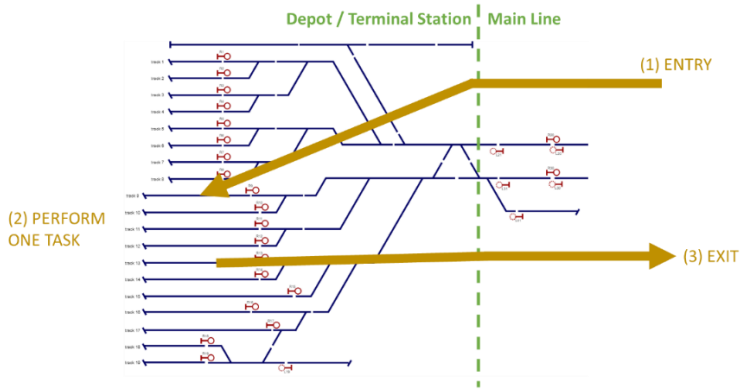
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Others – Front TVD blocked. 
UC ID	UC_01_3_1_4a
Main actor	TMS
Other actors	• Train • Operator
Main goal	Detect a conflict and inform to the operator that it is unresolvable.
Assumptions	Simple topology (main line).
Precondition	• Only 1 train involved. • The TVD blocked is the one just in front of the train.
Flow of events	Equal to UC_01_3_1_1a.
Postcondition	Conflict cannot be resolved.
Safety relation	None.
Open topics / consideration	None.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Others – TVD blocked at station. **Initial situation** Train expected to reach signal R4, but tvdG is temporarily blocked by the Signaller.  **Final situation** Fortunatelly, train can run to the station reaching signal R3. 
UC ID	UC_01_3_1_4b
Main actor	TMS
Other actors	• Train • Operator
Main goal	Detect and resolve a conflict.
Assumptions	Simple topology (main line).
Precondition	• Only 1 train involved. • The TVD blocked is further enough to allow the conflict resolution.
Flow of events	Equal to UC_01_3_1_1c.
Postcondition	Conflict can be resolved.
Safety relation	None.
Open topics / consideration	None.

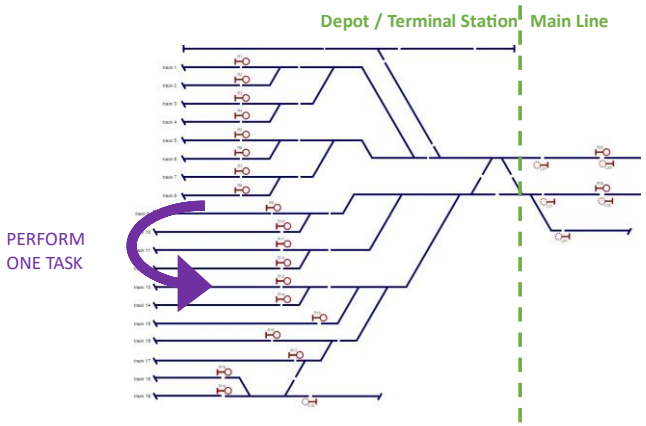
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Others – Front TVD failure. 
UC ID	UC_01_3_1_4c
Main actor	TMS
Other actors	• Train • Source of Error (for example the TVD detector through the IXL/TMS) • Operator
Main goal	Detect a conflict and inform to the operator that it is unresolvable.
Assumptions	Simple topology (main line).
Precondition	• Only 1 train involved • The TVD in failure is the one just in front of the train
Flow of events	Equal to UC_01_3_1_1a
Postcondition	Conflict cannot be resolved.
Safety relation	None.
Open topics / consideration	None.

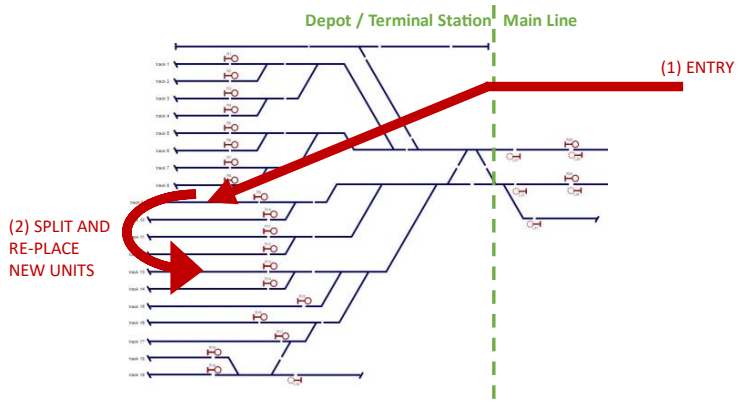
Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Others – TVD failure at station. 
UC ID	UC_01_3_1_4d
Main actor	TMS
Other actors	• Train • Source of Error (for example the TVD detector through the IXL/TMS) • Operator
Main goal	Detect and resolve a conflict.
Assumptions	Simple topology (main line).
Precondition	• Only 1 train involved. • The TVD in failure is further enough to allow the conflict resolution.
Flow of events	Equal to UC_01_3_1_1c.
Postcondition	Conflict can be resolved.
Safety relation	None.
Open topics / consideration	None.

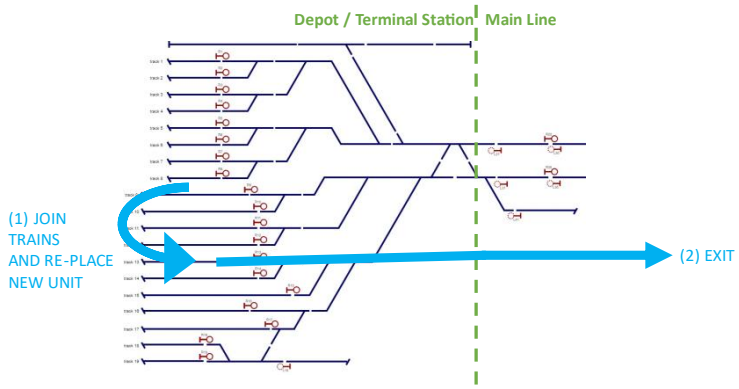
Use Case Group	WP3 – Task 3.3
Use Case	Configuration of Conflict Resolution Algorithm – Depot/Terminal Station.
UC ID	UC_01_3_1_10
Main actor	TMS
Other actors	Staff to configure TMS
Main goal	Configure Conflict Resolution Algorithm within TMS software.
Assumptions	Depot/Terminal station.
Precondition	• TMS equipped with all SW and HW constituents to allow configuring the Conflict Resolution Algorithm. • Specific data configuration is known (i.e., the concrete values for each of the variables). • The staff in charge of the configuration must be properly trained.
Flow of events	1. The staff member must be logged into the TMS, with the proper rights to perform the configuration. 2. The staff member must configure the algorithm with the proper values of the variables. 3. The TMS should confirm that the configuration has been properly introduced.
Postcondition	TMS configured correctly with the Conflict Resolution algorithm.
Safety relation	None.
Open topics / consideration	None.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Perform a task. 
UC ID	UC_01_3_1_11
Main actor	TMS
Other actors	• Train • Operator
Main goal	Train must enter **depot on time,** the task must be performed **correctly**, and train should exit **to the main line either on time or with a minimum delay.**
Assumptions	Depot/Terminal Station.
Precondition	• Only 1 train involved ($*_1$). • There is a disturbance ($*_2$) that prevents to perform the scheduled task.
Flow of events	1. The algorithm detects a conflict and warns to the operator. 2. The algorithm calculates alternatives for the resolution. 3. The algorithm presents alternatives in a ranked list and then, advises to the operator to choose one. 4. Once the operator has chosen the alternative, the conflict is resolved (perhaps with some delay). If the operator does not select any alternative after X seconds, the algorithm considers the conflict as unresolved.
Postcondition	Train exits to the main line either on time or with a minimum delay with the task performed.
Safety relation	None.

Open topics / consideration	• ($*_1$) Variations of the following sentence must be considered in this UC: Train of [TYPE] coming from [TRACK], must arrive at [HH:MM:SS-DD/MM/YY] to perform [TASK] at [TRACK], and then exit to [TRACK] at [HH:MM:SS-DD/MM/YY]. • ($*_2$) Different disturbances must be considered in this UC. For example: The track where the task must be done is occupied because the previous train has suffered a delay, or the track is unavailable for maintenance reasons.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Perform more than one task. 
UC ID	UC_01_3_1_12
Main actor	TMS
Other actors	• Train • Operator
Main goal	New task must be performed **correctly either at the scheduled time or with a minimum delay**.
Assumptions	Depot/Terminal Station
Precondition	• Only 1 train involved ($*_1$). • The train has already performed a task. • There is a disturbance ($*_2$) that prevents to perform the scheduled task.
Flow of events	Equal to UC_01_3_1_11.
Postcondition	Task performed correctly either at the scheduled time or with a minimum delay.
Safety relation	None.
Open topics / consideration	• ($*_1$) Variations of the following sentence must be considered in this UC: Train of [TYPE] already placed in [TRACK] (which have already performed [TASK] (previous)), must move to [TRACK] to perform [TASK] scheduled at [HH:MM:SS-DD/MM/YY]. ($*_2$) Different disturbances must be considered in this UC. For example: The track where the next task must be done is occupied because the previous train has suffered a delay, or the track is unavailable for maintenance reasons.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Split. 
UC ID	UC_01_3_1_13
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Train must enter **depot on time**, the split must be performed, and new trains must be **placed in their corresponding tracks or in the tracks where can perform the following tasks/actions**, e.g.: maintenance task or exit to the main line).
Assumptions	Depot/Terminal Station.
Precondition	• 2 trains involved – same sense, although as precondition both enters like 1 unique train ($*_1$). • There is a disturbance ($*_2$) that prevents to perform the scheduled task.
Flow of events	Equal to UC_01_3_1_11.
Postcondition	Split performed and 2 trains placed in their corresponding tracks or in the tracks where can perform the following tasks/actions.
Safety relation	None.
Open topics / consideration	• ($*_1$) Variations of the following sentence must be considered in this UC: Train of [TYPE] coming from [TRACK], must arrive at [HH:MM:SS-DD/MM/YY] to perform SPLIT at [TRACK], and [N] new trains must be created, and placed in [TRACKs]. • ($*_2$) Different disturbances must be considered in this UC. For example: Some of the tracks where one of the trains must be placed is occupied by another train or the track is unavailable for maintenance reasons.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Join. 
UC ID	UC_01_3_1_14
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Trains must be joined and then, new train must exit to the main line **either on time or with a minimum delay**.
Assumptions	Depot/Terminal Station
Precondition	• 2 trains involved – same sense ($*_1$). • There is a disturbance ($*_2$) that prevents to perform the scheduled task.
Flow of events	Equal to UC_01_3_1_11.
Postcondition	Join performed and 1 train exits to the main line either on time or with a minimum delay.
Safety relation	None.
Open topics / consideration	• ($*_1$) Variations of the following sentence must be considered in this UC: [N] trains of [TYPEs] which are placed in [TRACKs], must move to [TRACK] to perform a JOIN, and then the new train must exit to [TRACK] at [HH:MM:SS-DD/MM/YY]. • ($*_2$) Different disturbances must be considered in this UC. For example: The track where the join must be performed is occupied or unavailable for maintenance reasons.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict Resolution – Possible conflict ($*_1$).
UC ID	UC_01_3_1_15
Main actor	TMS
Other actors	• Train(s) • Operator
Main goal	Detect a possible conflict and inform to the operator that finally, it is not necessary to resolve any conflict.
Assumptions	Depot/Terminal Station.
Precondition	• At least, 2 trains involved ($*_2$). • The task assigned to the precedent train with delay, but not yet affecting to the following train.
Flow of events	1. The algorithm detects a possible future conflict and warns to the operator. 2. The algorithm tries to calculate alternatives for the resolution depending on when the conflict could occur, e.g.: considering certain factors such as if the delay is incrementing or not, the possibility to take another track, etc. 3. The algorithm presents alternatives in a ranked list taking into account the factors mentioned in the previous point and then, advises to the operator in case that he/she had to choose one. 4. Finally, the algorithm considers that there is not any conflict and then, informs to the operator.
Postcondition	No need to resolve any conflict.
Safety relation	None.
Open topics / consideration	• ($*_1$) The present UC has as purpose to **anticipate a possible conflict** taking into account the four following scenarios: perform one task, more than one task, split or join. • ($*_2$) Considering the information in ($*_1$), variations of the sentences mentioned in UC_01_3_1_11, UC_01_3_1_12, UC_01_3_1_13 or UC_01_3_1_14 must be considered in this Use Case.

4.2 CONFLICT RESOLUTION IN SPECIFIC SITUATIONS USE CASES

Use Case Group	WP3 – Task 3.3
Use Case	Cooperative conflict resolution (Two TMSs).
UC ID	UC_01_3_1_20
Main actor	TMS 1
Other actors	• TMS2 • TMS1 Operator • TMS2 Operator
Main goal	A train conflict solution shall consider also the possible choices taken by the TMS behind the border.
Assumptions	• It is working a real-time connection of rail networks managed by at least two TMSs and involved actors. • It is operative a modelling and decision support for cross-border traffic management.
Precondition	Two TMSs, current plans loaded and a conflict in the border common track present.
Flow of events	1. TMS1 Operator chooses a conflict solution. 2. Conflict solution is sent to TMS 2. 3. TMS2 Operator accepts or rejects the proposal solution (and eventually adds a note). 4. When accepted, the conflict is solved in both TMSs.
Postcondition	Conflict is solved and the train can run.
Safety relation	None.
Open topics / consideration	None.

Use Case Group	WP3 – Task 3.3
Use Case	Exchanging real time train data regarding the border stations.
UC ID	UC_01_3_1_21
Main actor	TMS 1
Other actors	TMS 2
Main goal	The TMS shall be able to exchange train characteristic, issues, and forecast information with neighbour TMSs.
Assumptions	• It is working a real-time connection of rail networks managed by at least two TMSs and involved actors. • It is operative a modelling and decision support for cross-border traffic management.
Precondition	Two TMSs, current plans loaded and at least a cross border/area train with delay.
Flow of events	1. A deviation for a cross border/area train is detected by the related module in TMS 1. 2. Forecast is updated for the above train in TMS 1. 3. Train information is sent to the neighbouring TMS 2 by Cooperative module. 4. The neighbouring TMS 2 updates its operational plan accordingly.
Postcondition	The operational plans are harmonized.
Safety relation	None.
Open topics / consideration	None.

Use Case Group	WP3 – Task 3.3
Use Case	Level crossing accidents.
UC ID	UC_01_3_1_22
Main actor	TMS Operator
Other actors	• TMS • Train driver • Emergency/rescue services
Main goal	Accidents at level crossings. Leads to stop in traffic and involves several actors that that need information to receive a shared situation awareness.
Assumptions	The TMS has and interactive HMI based on User Experience.
Precondition	There is a link between the level crossing and TMS.
Flow of events	1. Incoming alarm to the TMS Operator (either from the Train driver or the TMS) about a level crossing accident. 2. The TMS Operator protects the area. 3. The TMS Operator contacts concerned actors. 4. The TMS Operator re-plans the traffic plan. 5. Concerned actors complete their tasks at the scene. 6. The operative personnel in charge (at the scene) contact the TMS Operator. 7. The TMS Operator re-writes the traffic plan.
Postcondition	Problem solved and train can run.
Safety relation	None.
Open topics / consideration	These accidents involve several actors that need information to receive a shared situation awareness.

Use Case Group	WP3 – Task 3.3
Use Case	Conflict detection and resolution.
UC ID	UC_01_3_1_23
Main actor	TMS Operator
Other actors	TMS
Main goal	Providing conflict detection after a train deviation and applying or suggesting conflict solution.
Assumptions	• The TMS can take very short-term train control decisions. • The TMS has a real-time conflict detection & resolution and optimization.
Precondition	Current traffic plan loaded.
Flow of events	1. A deviation for a train is detected by the related module. 2. Forecast is updated for the above train. 3. Conflicts are detected and shown to the TMS Operator (semi-automatic mode). 4. Conflicts are solved and solution is applied in automatic mode or proposed to the TMS Operator in semi-automatic mode. 5. TMS Operator can choose a solution in semi-automatic mode.
Postcondition	The train can run.
Safety relation	None.
Open topics / consideration	None.

Use Case Group	WP3 – Task 3.3
Use Case	Very short term decision.
UC ID	UC_01_3_1_24
Main actor	TMS
Other actors	TMS HMI
Main goal	In automatic and semi-automatic mode in the case in which the operational plan has to be performed within a couple of minutes the system shall actuate it.
Assumptions	• The TMS can take very short-term train control decisions. • The TMS has a real-time conflict detection & resolution and optimization.
Precondition	• Current traffic plan loaded. • A conflict to be solved is present.
Flow of events	1. A conflict with a conflict solution proposal is present on TMS HMI. 2. The conflict should be solved in at most a couple of minutes or it remains unsolved, so the TMS Conflict Resolution module forces the solution that is based on the chosen algorithm. 3. The conflict disappears on TMS HMI.
Postcondition	Conflict solved and the TMS Operator has not made any choice.
Safety relation	None.
Open topics / consideration	None.

Use Case Group	WP3 – Task 3.3
Use Case	Railway Undertaking requests a new train path without conflict
UC ID	UC_01_3_1_25
Main actor	TMS
Other actors	• Railway Undertaking • Passenger Information • Automatic Route Setting
Main goal	Introduce a new train path.
Assumptions	None.
Precondition	The Railway Undertaking requires a new itinerary in the short-term or during the operation, including the following data: • Start Location • End Location • Stopping Locations • Dates/Times for locations • Optional: Composition.

Flow of events	1. The Railway Undertaking requests a new train path through the TMS Capacity Management module. It specifies the Start and End locations and the stopping locations, and optionally the expected train composition. 2. The Capacity Management receives the request, and it requires a Running Simulation and the Forecasted Timetable to study the viability of the Itinerary. The following processes shall be launched in sequence: • If the formation is specified it is taken into account for the calculations, but if it is not specified, a default formation is used according to the Railway Undertaking and the type of train and service required. • The Capacity Management requests to the Running Time Calculation module for Running Simulation of the requested itinerary. • The Capacity Management, with the Running Simulation, requires to Timetable Forecasting module for Forecasted Timetable. 3. The Timetable Forecasting, with the Running Simulation and the Forecasted Timetable, requests to the Conflict Detection module to analyse possible conflicts with the new itinerary. 4. If Conflicts are not detected: The requested itinerary is accepted, and therefore the Train Path is formed. The Capacity Management informs the Railway Undertaking. 5. The Capacity Management sends the New Itinerary to the Timetable Management. 6. Timetable Management sends the new Target Timetable to the Passengers Information System. 7. Timetable Management sends the new Target Timetable to Automatic Route Setting.
Postcondition	New train itinerary is operative.
Safety relation	None.
Open topics / consideration	None.

Use Case Group	WP3 – Task 3.3
Use Case	Railway Undertaking requests a new train path with conflict
UC ID	UC_01_3_1_26
Main actor	TMS
Other actors	• Railway Undertaking • Passenger Information • Automatic Route Setting
Main goal	Introduce a new train path.
Assumptions	None.
Precondition	The Railway Undertaking requires a new itinerary in the short-term or during the operation, including the following data: • Start Location • End Location • Stopping Locations • Dates/Times for locations • Optional: Composition.

Flow of events	1. The Railway Undertaking requests a new train path through the TMS Capacity Management module. It specifies the Start and End locations and the stopping locations, and optionally the expected train composition. 2. The Capacity Management receives the request, and it requires a Running Simulation and the Forecasted Timetable to study the viability of the Itinerary. The following processes shall be launched in sequence: • If the formation is specified it is taken into account for the calculations, but if it is not specified, a default formation is used according to the Railway Undertaking and the type of train and service required. • The Capacity Management requests to the Running Time Calculation module for Running Simulation of the requested itinerary. • The Capacity Management, with the Running Simulation, requires to Timetable Forecasting Module for Forecasted Timetable. 3. The Timetable Forecasting, with the Running Simulation and the Forecasted Timetable, requests to the Conflict Detection module to analyse possible conflicts with the new itinerary. 4. Conflicts are detected. The Conflicts Resolution module takes in charge the conflict and proposes a possible solution. If there is at least one solution, the result is a new Timetable that could be accepted by the Railway Undertaking Operator. 5. If the Operator accepts the new Timetable, the requested itinerary is accepted, and therefore the Train Path is formed. The Capacity Management informs the Railway Undertaking. 6. The Capacity Management sends the New Itinerary and the new timetable to the Timetable Management. 7. Timetable Management sends the new Target Timetable to the Passengers Information System. 8. Timetable Management sends the new Target Timetable to Automatic Route Setting.
Postcondition	New Timetable is operative.
Safety relation	None.
Open topics / consideration	None.

4.3 ADHESION MANAGEMENT USE CASES

The use cases presented in the following subchapters are aimed at assessing how special conditions on the track (adhesion conditions) impact TMS by enabling a more accurate traffic regulation and hence a more efficient traffic management. As stated in previous chapters, a series of input sources have been considered for the development of the use cases:

- FP1 D8.1 - Report: The need for future development of methods and models for capacity simulations and feedback loops between planning and operations
- FP1 D15.1 - Requirements for the deployment of TMS linked with ATO/C-DAS
- FP6 D3.1 - Use cases and scenarios for ATO in different GoA demos for G1 regional lines

FP1 D8.1 and FP1 D15.1 provide the Mixed Planning and Mixed Regulation functionality that shall be the basis for testing the adhesion management use cases:

- FP6 D3.1 addresses the adhesion management use cases in the context of ATO
- FP6 D3.3 addresses the adhesion management use cases in the context of TMS

As stated in FP6 D3.1, during some periods of the year, particularly in the winter and the autumn, special circumstances on the track can affect the wheel-rail friction (e.g., crushed leaves, moisture, extreme weather events), thereby reducing the adhesion level. This can lead to constraining the braking and acceleration rate, and thus the overall performance.

The acceleration and braking performance of trains is thus affected by these conditions causing disruption to the normal operation.

As previously mentioned, specific strategies need to be adopted for disruption minimization. With a view to ensuring a more accurate traffic regulation and a more efficient traffic management, the following subchapters present a series of use cases with innovative solutions for handling low adhesion conditions.

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	Slippery Rail/Non-Slippery Rail conditions are transmitted to TMS.
UC ID	UC_01_3_2_1
Main actor	TMS
Other actors	ETCS-OB, ATO-OB, ATO-TS, Train Driver
Main goal	To describe how Slippery Rail/Non-Slippery Rail conditions are transmitted to TMS when reported by Train Driver in a specific location of the track.
Assumptions	ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. D3.1 UC_01_1_8_1 2. TMS receives and processes adhesion information when reported by Train Driver
Postcondition	TMS manages adhesion information in accordance with the Status Reports received
Safety relation	ATO is supervised by ETCS
Open topics / consideration	Requirements: R_01_3_2_1_1 R_01_3_2_1_2 R_01_3_2_1_3

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	Adhesion conditions reported by TCMS/Train are transmitted to TMS
UC ID	UC_01_3_2_2
Main actor	TMS
Other actors	Traction/Braking system, ATO-OB, ATO-TS, TCMS/Train
Main goal	To describe how different adhesion categories are reported by TCMS/Train.
Assumptions	ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. FP6 D3.1 UC_01_1_8_2 2. TMS receives and process adhesion information when reported by TCMS/Train
Postcondition	TMS manages adhesion information in accordance with the Status Reports received
Safety relation	ATO is supervised by ETCS
Open topics / consideration	

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	TMS reports to ATO-TS on adhesion conditions
UC ID	UC_01_3_2_3
Main actor	TMS
Other actors	External Source, ATO-OB, ATO-TS
Main goal	To describe how information on weather conditions impacting adhesion provided by External Source to TMS leads to an update of the ATO Operational Speed Profile
Assumptions	ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. External Source informs TMS about weather conditions in a specific section of the track. 2. TMS associates the reported weather conditions with one of the following adhesion categories: a) Dry Rail b) Dry Rail (Medium) c) Dry Rail (Low) d) Low Adhesion e) Very Low Adhesion f) Extremely Low Adhesion 3. TMS informs ATO-TS on a specific adhesion category in a specific section of the track. 4. FP6 D3.1 UC_01_1_8_3 (events 2 – 4)
Postcondition	The ATO Operational Speed Profile is adapted by ATO-OB
Safety relation	ATO is supervised by ETCS.
Open topics / consideration	Requirements: R_01_3_2_3_1 R_01_3_2_3_2 R_01_3_2_3_3

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	TMS constructs a Slippery-Rail area when Slippery Rail is reported by the Train Driver of n trains
UC ID	UC_01_3_2_4
Main actor	TMS
Other actors	ATO-TS, ATO-OB, ETCS-OB, Train Driver
Main goal	To describe how a Slippery-Rail area is built by TMS on the basis of the Status Reports with the information “low adhesion reported by driver” sent by ATO-OB of n trains to ATO-TS.
Assumptions	• There does not exist a defined Slippery-Rail area • ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. FP6 D3.1 UC_01_1_8_4 (events 1 – 3) 2. TMS builds the adhesion area characterized by a certain adhesion category (Open topic 1). 3. TMS informs ATO-TS about the creation of the adhesion area. 4. FP6 D3.1 UC_01_1_8_4 (events 5 – 7) 5. TMS updates the adhesion area’s length on the basis of new Status Reports from following trains, ATO-TS sends updated Journey Profiles, and the ATO-OB of following trains adapts the ERTMS/ATO Operational Speed Profile
Postcondition	A low-adhesion area is built and reported to trains through Journey Profiles.
Safety relation	ATO is supervised by ETCS
Open topics / consideration	Open topic 1: When reported by the Train Driver, Slippery-Rail does not provide an adhesion category. It is not defined what adhesion category would be assigned to the adhesion area by the TMS and what adhesion category would be provided to ATO-OB by ATO-TS through the Journey Profile. To be explored whether TCMS/Train could provide such information. Requirements: R_01_3_2_4_1 R_01_3_2_4_2 R_01_3_2_4_3

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	TMS constructs an adhesion area when adhesion is reported by the TCMS/Train of n trains
UC ID	UC_01_3_2_5
Main actor	TMS
Other actors	ATO-TS, ATO-OB, TCMS
Main goal	To describe how an adhesion area is built by TMS on the basis of the information reported by TCMS/Train
Assumptions	• There does not exist a defined Slippery-Rail area • TCMS is able to report adhesion categories to ATO-OB • ATO-OB is able to report adhesion categories to ATO-TS • ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. FP6 D3.1 UC_01_1_8_5 (events 1 – 2) 2. TMS builds the adhesion area based on the information contained in Status Reports. 3. TMS informs ATO-TS about the creation/modification of the adhesion area on a regular basis. 4. FP6 D3.1 UC_01_1_8_5 (events 4 – 5)
Postcondition	The ATO Operational Speed Profile of following trains is constantly updated as a result of a constant adhesion monitoring and reporting. TMS updates the adhesion area's length and adhesion category on the basis of regular Status Reports, ATO-TS sends updated Journey Profiles to trains, and ATO-OB adapts the ATO Operational Speed Profile.
Safety relation	ATO is supervised by ETCS
Open topics / consideration	Consideration 1: UC_01_3_2_4 describes the situation where an adhesion area (Slippery Rail adhesion area) is built as a result of the Train Driver reporting Slippery-Rail by pressing the DMI button n times between 2 locations. Consequently, such area is only built once the Train Driver's input has been received. The ATO Operational Speed Profile is then updated only when reported by the Train Driver. In this use case, the TCMS would constantly report the adhesion level transmitted by the traction/braking system and, consequently, Status Reports sent by the ATO-OB would also constantly report an adhesion level, unlike UC_01_3_2_4. In this way, there would be a constant adhesion area on the track (i.e., the ATO Operational Speed Profile would always be "affected" by adhesion).

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	TMS shortens/lengthens an already-defined adhesion area
UC ID	UC_01_3_2_6
Main actor	TMS
Other actors	External Source, ATO-TS, ATO-OB
Main goal	To describe how the length of an already-defined adhesion area is modified when External Source informs TMS about new wheel/rail adhesion conditions in such area.
Assumptions	• There exists an already-defined adhesion area • ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. External Source recognizes that conditions affecting wheel/rail adhesion have changed in an already-defined adhesion area. 2. TMS shortens/lengthens the already-defined adhesion area and informs ATO-TS about it. 3. FP6 D3.1 UC_01_1_8_6 (events 2 – 4)
Postcondition	The already-defined low-adhesion area is shortened/lengthened
Safety relation	ATO is supervised by ETCS
Open topics / consideration	Requirements: R_01_3_2_6_1

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	TMS removes an already-defined Slippery Rail area on the basis of Status Reports
UC ID	UC_01_3_2_7
Main actor	TMS
Other actors	ATO-TS, ATO-OB
Main goal	To describe how an already-defined Slippery Rail area is removed by TMS on the basis of the information contained in the Status Reports sent by n ATO-OB units as a result of: a) the Train Driver not reporting Slippery Rail b) the TCMS not reporting slip/slide
Assumptions	• There exists an already-defined Slippery Rail area • ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. FP6 D3.1 UC_01_1_8_7 (events 1 – 2) 2. TMS removes the low-adhesion area 3. FP6 D3.1 UC_01_1_8_7 (events 4 – 6)
Postcondition	The already-defined Slippery Rail area is removed
Safety relation	ATO is supervised by ETCS
Open topics / consideration	Requirements: R_01_3_2_7_1 R_01_3_2_7_2

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	TMS modifies the adhesion category applied to an existing adhesion area on the basis of the information received from an External Source
UC ID	UC_01_3_2_8
Main actor	TMS
Other actors	ATO-TS, External Source, ATO-OB.
Main goal	To describe how the adhesion category of an already-defined adhesion area is modified by TMS on the basis of the information received from External Source. Weather conditions affect wheel/rail adhesion (e.g., due to extreme weather events), which has an impact on the ATO Operational Speed Profile. Handling weather information enables TMS to update the adhesion category applied to a defined adhesion area.
Assumptions	• There exists an already-defined adhesion area • ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. External Source recognizes that weather conditions have changed (e.g., due to extreme weather events), which might lead to a modification of the wheel/rail adhesion and informs TMS. 2. TMS updates, if necessary, the adhesion category applied to an already-defined adhesion area. 3. FP6 D3.1 UC_01_1_8_8 (events 2 – 4)
Postcondition	The already-defined adhesion area is characterized by a different adhesion category
Safety relation	ATO is supervised by ETCS
Open topics / consideration	Requirements: R_01_3_2_3_1 R_01_3_2_3_2 R_01_3_2_3_3 R_01_3_2_8_1

Use Case Group	WP3 – Task 3.3 -- Adhesion Management
Use Case	TMS modifies the adhesion category applied to an existing adhesion area on the basis of the information received from the TCMS/Train
UC ID	UC_01_3_2_9
Main actor	TMS
Other actors	TCMS, ATO-TS, ATO-OB
Main goal	To describe how the adhesion category of an already-defined adhesion area is modified by the TMS on the basis of the information received from TCMS. It is assumed that the TCMS is able to report different adhesion categories, as described by UC_01_3_2_2.
Assumptions	• There exists an already-defined adhesion area characterized by a given adhesion category. • The TCMS is able to report different adhesion categories • The ATO-OB is able to report different adhesion categories through the Status Report • ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. FP6 D3.1 UC_01_1_8_9 (events 1 – 2) 2. TMS is informed by ATO-TS and changes the adhesion category of the already-defined adhesion area 3. FP6 D3.1 UC_01_1_8_9 (events 4 – 6)
Postcondition	The already-defined adhesion area is characterized by a different adhesion category
Safety relation	ATO is supervised by ETCS
Open topics / consideration	

5 ABOUT DEMONSTRATION

The present section aims to provide an introduction giving the first flavour about the demonstrators, which are going to be developed by the WP8.

This section is divided into three, because the first step is to consider individual demonstrators for each technology developed:

5.1 CONFLICT RESOLUTION USING AI

TMS demonstration activities, in concrete about the Conflict Resolution using AI algorithms envisaged in WP8 T8.3, shall comprise a selection of Use Cases contained in this deliverable, and then transformed in appropriate tests.

The future demonstrator, built as part of WP8, must allow the execution and analysis of such tests, in a laboratory environment.

At the time of working in the WP3, as the WP8 is not yet started, it is suggested/guessed that the future demonstrator should look like depicted in Figure 4.

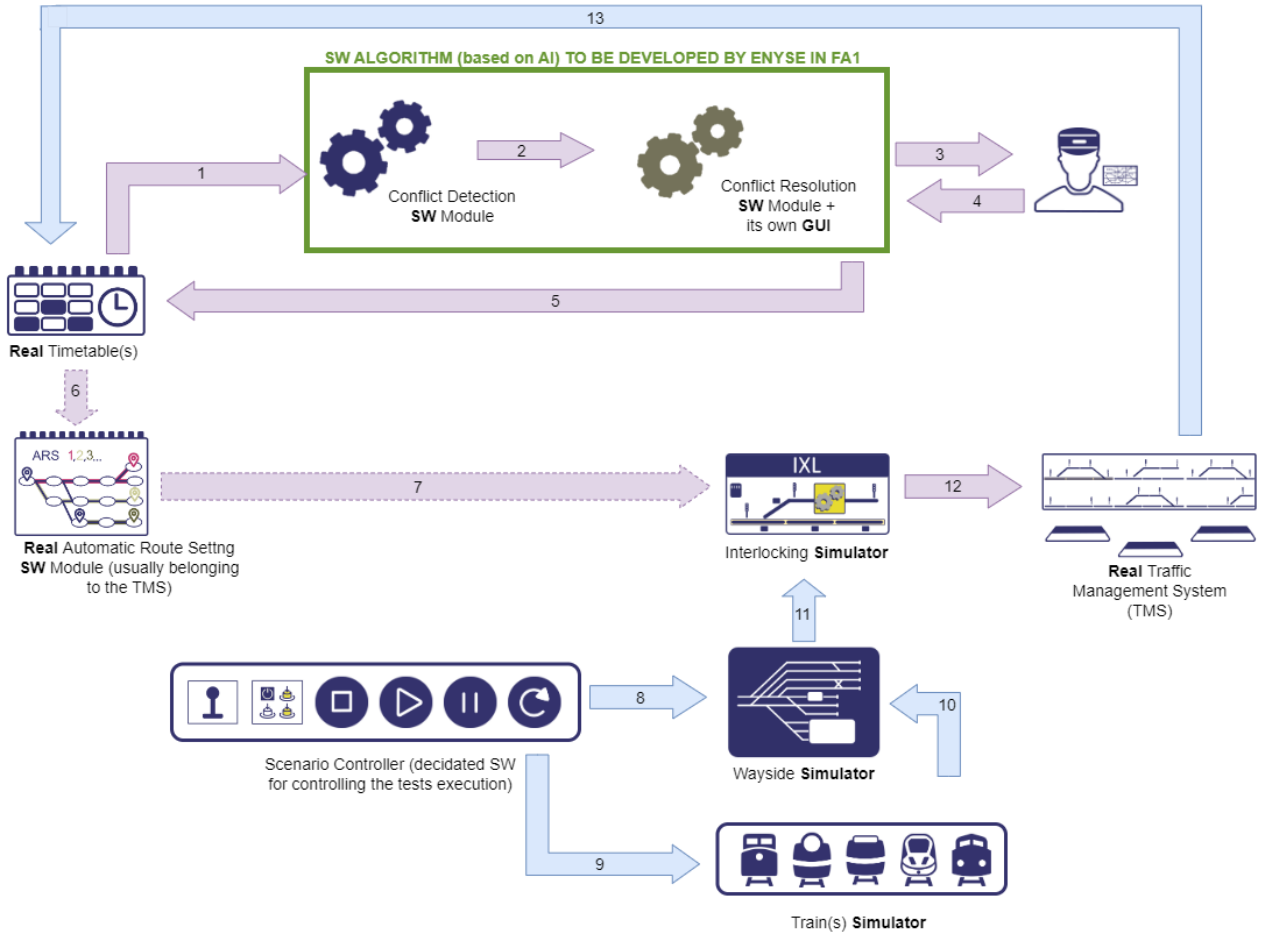


Figure 4. Demonstrator I

To help in the understanding of Figure 4, next considerations are to be considered:

- Each of the pieces is labelled either as a **SW Module**, a **Simulator** or a **Real** element.
- The two SW modules inside the green box are to be provided as part of the FP1 outcomes, used as input in the FP6 demonstrator. The considerations to install and use properly these SW modules shall be concreted during the FP6 WP8 activities.
- The path filled in **purple** is the path to be followed by those scenarios in which an actual conflict has not yet happened, but it can be anticipated (i.e. somehow the Real Timetable(s) are analysed by the Conflict Detection SW Module to forecast any potential conflict, and then to show alternatives to the user through the Conflict Resolution SW Module).
- Dotted line arrows 6 and 7, within the purple path are "*optional*", as the final installation may or may not have Automatic Route Setting module configured.
- The path filled in **blue**, represents the scenarios in which the conflict has already happened; thanks to the Scenario Controller, a disturbance can be introduced (e.g. simulate a train stopped longer than planned, simulate a wayside incident, etc.), then IXL and TMS are informed, and in case the Timetable is affected, the whole process starts again.

5.2 CONFLICT RESOLUTION IN SPECIFIC SITUATIONS

Figure 5 shows the functional architecture of the demonstrator that shall be built by MERMEC. That figure reports the modules and the main interfaces involved in the TMS activities.

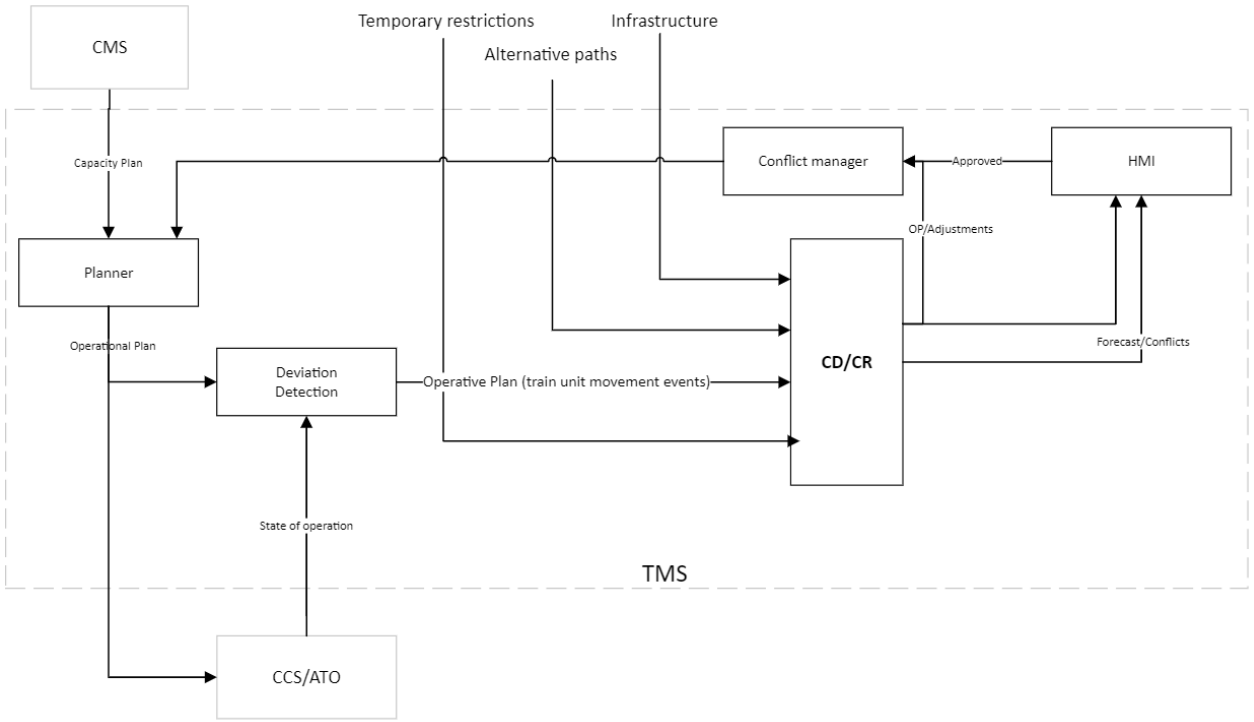


Figure 5. Demonstrator II

5.3 ADHESION MANAGEMENT

FutuRe Consortium Member CAF shall lead one of the TMS demonstrators envisaged in WP8 task 8.4 by means of providing an environment that enables to undertake tests under laboratory conditions. Pending the selection of a range of use cases to be tested, the test campaign shall mainly put the focus on the adhesion management use cases reported in the present document.

The laboratory environment shall comprise the actors illustrated in Figure 6:

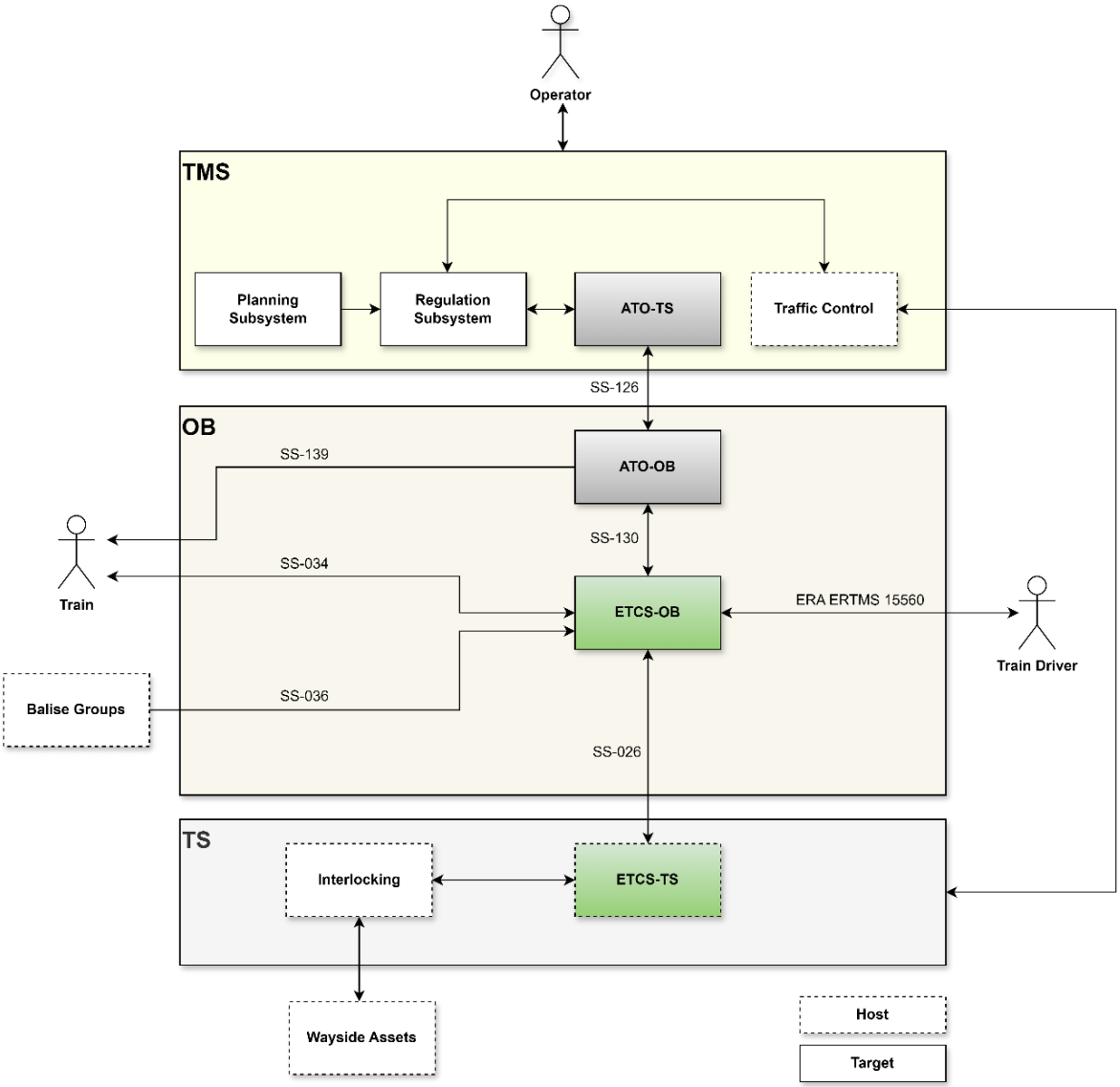


Figure 6. Demonstrator III

6 CONCLUSIONS

As closure for this deliverable, this chapter recaps its key points, in a concise and synthetic manner.

INTRODUCTION

- ✓ This document constitutes deliverable D3.3.
- ✓ It has been built consistently with some inputs coming from externals, as FP1.
- ✓ It can be used as entry point to the definition and deployment of the demonstrator to be delivered by further task 8.4.

OBJECTIVE

- ✓ This deliverable has two main objectives:
  - to provide the definition of the demonstrator setup, and
  - to provide the list of Use Cases to be exercised in that demonstrator.
- ✓ Both mentioned objectives have the final aim to satisfy the overall WP3 goal, which is to "find suitable already existing and interoperable CCS solutions which can be applied for G1 lines, to ensure their long-term viability and decrease their total costs" (as extracted from the GA).

TARGET OPERATIONAL ENVIRONMENT

- ✓ Three contributors: CAF, MERMEC and ENYSE.
- ✓ Three functions to demonstrate: Adhesion Management and Conflict Resolution.
- ✓ Innovation: Use of Artificial Intelligence.
- ✓ Operational Area: G1 regional lines.

USE CASES

- ✓ Compendium of Use Cases and Scenarios, provided in a unique list. These Use Cases shall be used in the WP8 as the seed for creating tests and execute them in the future demonstrators.

ABOUT DEMONSTRATION

This deliverable outlines the draft hypotheses for the future demonstrators' architecture.

OTHERS

- ✓ The main **challenge** found while developing this deliverable has been the late availability of some of the inputs, and occasionally the poor quality of some of them. As mitigations, the fact of having the same companies involved in related tasks and the expertise of some of the stakeholders, has helped to anticipate information and to have a clear understanding of the missing parts.
- ✓ The main relevant **risk** expected for the future is the identification of gaps or issues in the Use Cases (future tests) when they shall be played in the demonstrator. Unfortunately, this is something that may happen (until the Use Cases are not tested, it shall be not possible to ensure their complete maturity). As partial mitigation, the deep review of this deliverable and the expertise of some of the participants, should help to reduce the impact of issues. In case of issues over this deliverable are found after its final release (by M22), it is suggested to track them in the deliverable of task 8.4.
- ✓ With the main aim of supporting WP2, the Use Cases have been evaluated to derive **requirements,** which are gathered in the last Annex of this deliverable.

TRACEABILITY FP6 D2.1

One of the inputs used as a basis to define the list of Use Cases contained in the present document is the “Regional Lines Architecture” definition provided by the FP6 W2 (see [Ref.3]).

From that input, it is extracted the “CCS Wayside Architecture for G1 Lines”, which serves to places where the main actor of the Uses Cases described in this document is located:

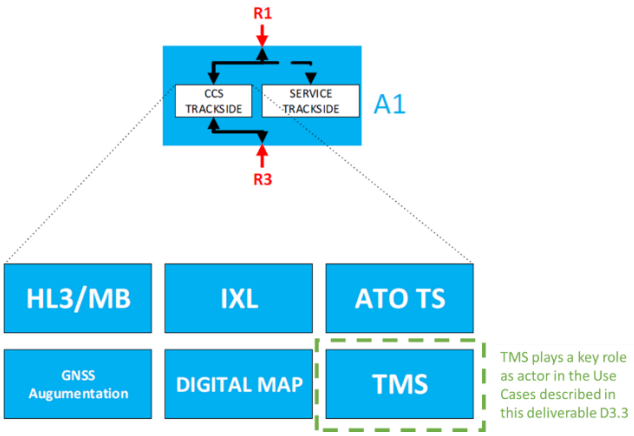


Figure 7. CCS Wayside Architecture for G1 Lines (extracted from [Ref.3])

TRACEABILITY FP6 D2.2

Other input used as a basis to define the list of Use Cases contained in the present document is the “Regional Lines Operational and Functional Requirements” provided by the FP6 W2 (see [Ref.4]).

That input contains two types of requirements (Operational and Functional) that, when applicable are traced to the WP3 requirements, in the Table 5 at the end of this document.

TRACEABILITY TO FP6 D2.3

In the context of FutuRe, an analysis of how some of the key functions provided by the TMS contribute to the expected socio-economic objectives (SEO) as per defined by the task 2.3 “KPI Achievement Monitoring” has been conducted (see [Ref.5]). The two applicable SEO are:

- SEO5 Overall reduction of OPEX and CAPEX by targeting 15%
- SEO7 Optimized punctuality by targeting 15% increase

The improvement and innovation implemented by the TMS in its Conflict Resolution function (for example, by using AI algorithms) shall allow, on the one hand the reduction of human intervention to firstly avoid, and then if not possible, to resolve conflicts in timetables (so less workload in the Signallers and other roles), what has a clear and demonstrable impact on the OPEX. On the

other hand, although with much less impact there could be a benefit in regard to the CAPEX as the use of novelty SW technologies may require less and lighter HW equipment.

The main consequence of including innovations in the Conflict Resolution function (to prevent and to resolve) is for sure, an improvement in the “punctuality”. Because of the nature of the Regional Lines (one or two tracks, big headways, reduced frequencies, etc.) makes a bit complicated to demonstrate benefit with that improvement; this why the focus shall be kept in terminal/depot stations with a higher number of tracks, where the number of conflicts (to park, repair, wash, etc.) seems to be bigger and where optimisation shall have a larger positive impact on punctuality.

SIMPLE / MAIN LINE

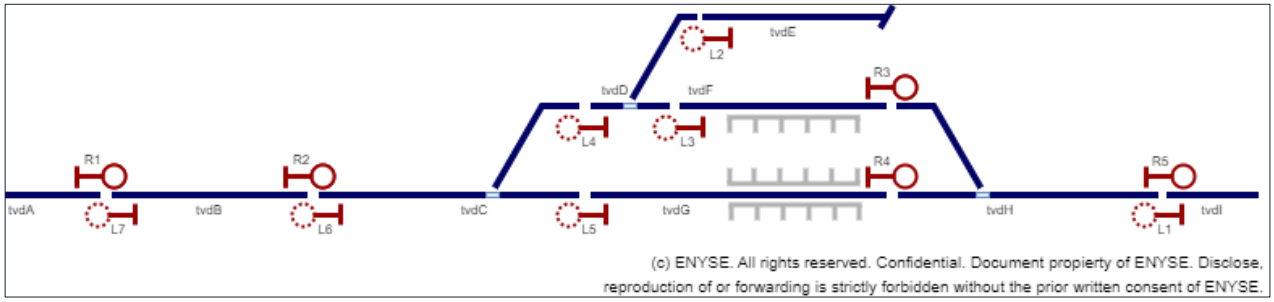


Figure 8. Simple / Main Line Topology Pattern (for ENYSE Use Cases)

DEPOT / TERMINAL STATION

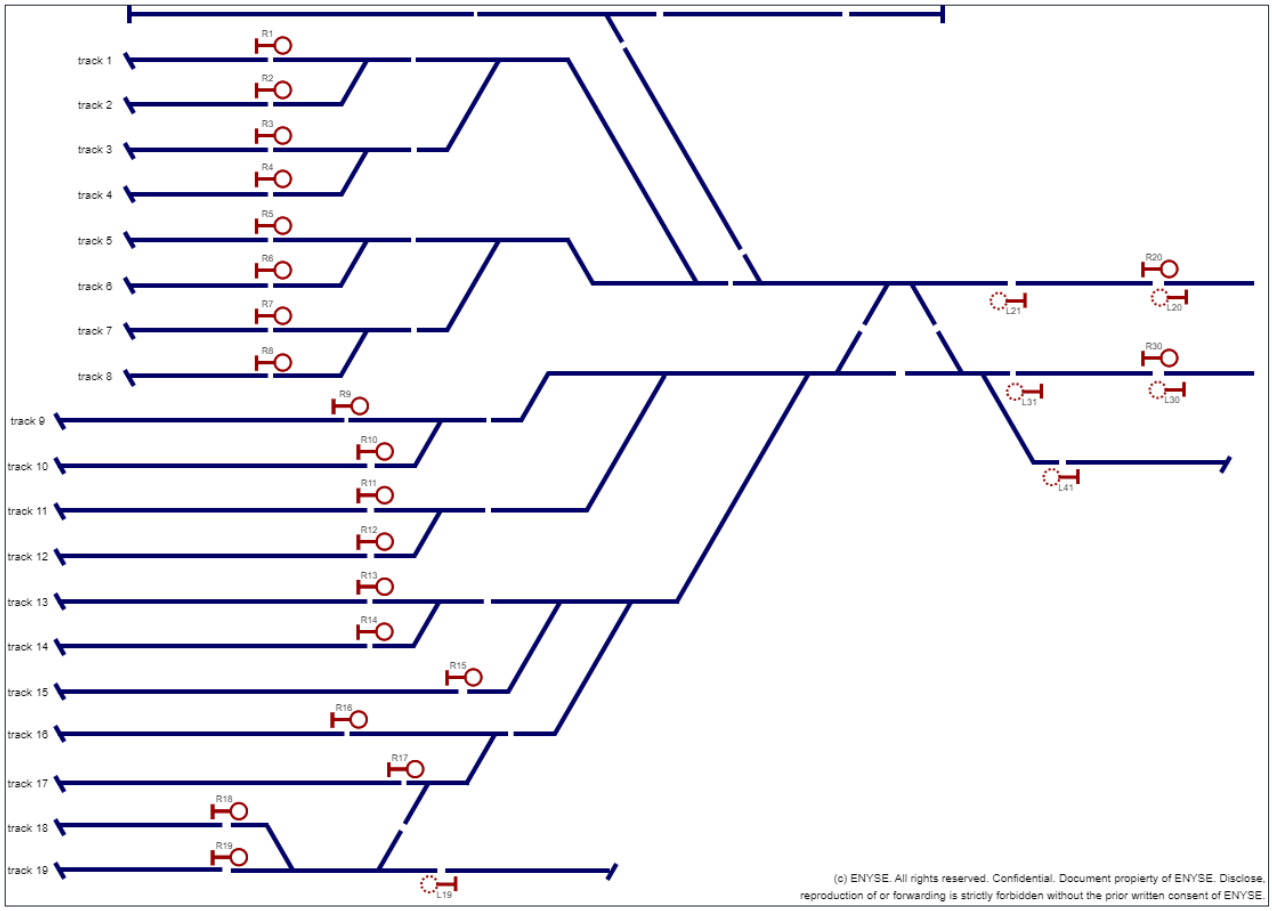


Figure 9. Depot / Terminal Stations Topology Pattern (for ENYSE Use Cases)

ANNEX 3. REQUIREMENTS COLLECTION

Table 5: Requirements

(1) **ArchDes** [Related to a design or architecture matter] /
Assumption [Not a requirement but an assumption needed to satisfy the requirements] /
Configuration [Related to a configuration matter, e.g. concrete values (timers, distances, lengths, etc.)] /
Definition [Not a requirement but a definition needed to understand the requirements] /
Functional [Related to an internal behaviour, describing how the asset/function must behave] /
Operational [Related to an operational condition that the asset/function shall require/provide from/to externals]
(2) **NO / YES**

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_1	CATCH-UP: The pursuit train has reached the first one.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_2	CROSSING: Two trains facing each other.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_3	PROXIMITY: Two trains running in the same direction, and the pursuit one is approaching the first one (which may be driving slower than planned).	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_4	PRIORITY_MAIN_LINE: Refers to the criteria to be applied in case of several trains delay. For example, the most delayed, the passenger trains, etc.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_5	PRIORITY_DEPOT: Refers to the criteria to be applied in case of discrepancies about an action to be taken. Priority may be assigned from two different points of view: • Single train: There are some tasks (delayed) for a given train. This is the criterion to decide which task performs	Definition	NO		

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
		first. • Several trains at a time: Whether it becomes necessary to allow entry/exit several trains at the same moment, criteria must be defined. E.g.: By train type, by task, by driver availability, etc. E.g.: Skip actions, for example: it becomes urgently to send a train to rescue passengers from a faulty train, but there is no train available – one waiting just for cleaning task, could be sent.				
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_6	TASK: Type of activity that a train may perform. Normally, there should be tracks dedicated for each task, i.e., not any task can be performed at any track. E.g.: Parking, Axle Changing, Cleaning, etc.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_7	TASK_DURATION: Necessary time to perform a given task. E.g.: 1h for Cleaning, 1h – 5h Preventive Maintenance, etc.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_8	TASK_ORDER: Indicates the order established by the working procedures in the depot, to perform the tasks (to be applied in the case that a train needs to perform more than one). E.g.: Maintenance (fix of problems), and then Preventive Maintenance, and then Cleaning.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_9	AVAILABILITY: To verify the availability of the necessary resources to perform a task or a movement. Among others: • Track availability. • Route availability. • Driver availability. • Train availability (i.e., train must be "healthy" – it must not have problems).	Definition	NO		

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_10	CAPACITY: Refers to the number of elements that the different resources may manage: • Track/Track Vacancy Detectors capacity → Number of trains/wagons that can be placed per track/TVD. Note that this capacity may have a different value for different tasks. E.g.: 2 trains can be parked in TVD X, while 3 trains can be moved into the same TVD X to perform a joining. • Train capacity → Number of passengers allowed, number of tones allowed, etc.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_11	EVENT: Refers to a social event which may require special train services. E.g.: Concert, Sport Match, Demonstration, etc.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_12	ON-BOARD: Refers to the signalling system that the train is equipped with. E.g.: ATP, LZB, National System, ERTMS, Non-equipped, etc.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_13	STATION: Each station must be parametrized by defining: • Tracks (tracks ID number, positions, and lengths). • Platforms (positions and lengths). • Stabling areas (positions and lengths). • Crossings (passenger or Staff).	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_14	TRACK: Each track must be parametrized by defining: • Track ID number. • Sense of movement (single or double). • Length. • Number of TVDs (positions and lengths). • Buffer stops, if any.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_15	TRAIN_LENGTH: Refers to the length of a complete train. Next attributes must be evaluated to calculate that length:	Definition	NO		

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
		• Number of Wagons: Whether the train is a unique wagon (not possible to split) or if it is composed by a number of wagons. • Length of each wagon (the value may be different per wagon).				
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_16	TIMETABLE: Each timetable must be parametrized by defining: • Operation Capacity: Refers to the load of train trips contained in the timetable (i.e. normal, optimized, above average, concerned, stressed, collapsed, etc.). • Headway: Time between trains. • Validity: Timetable duration and time it is valid for (e.g., 24h, for a given weekday, etc.).	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_17	TYPE: Refers to a type of train in terms of Rolling Stock vehicle. E.g.: Freight, Passenger, Sweeper, Yellow fleet, Auscultatory, etc.	Definition	NO		
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_18	WAYSIDE ISSUES: Refers to the disturbances occurred in the wayside. E.g.: TVD blocked, TVD failure, etc.	Definition	NO		
UC_01_3_1_0; UC_01_3_1_10;	R_01_3_1_1_19	The Conflict Resolution algorithm shall have the capability to be configured within TMS software**.**	Configuration	NO	See UCs.	
UC_01_3_1_0; UC_01_3_1_10;	R_01_3_1_1_20	The Conflict Resolution algorithm shall only allow to be configured in a TMS equipped with the necessary SW and HW constituents.	Configuration	NO	See UCs.	
UC_01_3_1_0; UC_01_3_1_10;	R_01_3_1_1_21	The Conflict Resolution algorithm shall use specific data configuration. Note: “Specific data configuration” means the concrete values for each of the variables.	Configuration	NO	See UCs.	[FP6, WP2, D2.2] ORWS 7;
See sub-requirements.	R_01_3_1_1_22	In Simple topology, the Conflict Resolution algorithm shall require configuring the following variables**:**	Configuration	NO	See sub-requirements.	[FP6, WP2, D2.2] ORWS 7;

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
UC_01_3_1_0	R_01_3_1_1_22a	Priority_Main_Line.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22b	Availability.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22c	Capacity.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22d	Event.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22e	On_board.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22f	Station.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22g	Track.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22h	Train_Length.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22i	Timetable.	Configuration	NO	See UC.	
UC_01_3_1_0	R_01_3_1_1_22j	Type.	Configuration	NO	See UC.	
See sub-requirements.	R_01_3_1_1_23	In Depot/Terminal Station, the Conflict Resolution algorithm shall require configuring the following variables:	Configuration	NO	See sub-requirements.	[FP6, WP2, D2.2] ORWS 7;
UC_01_3_1_10	R_01_3_1_1_23a	Priority_Depot.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23b	Task.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23c	Task_Duration.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23d	Task_Order.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23e	Availability.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23f	Capacity.	Configuration	NO	See UC.	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
UC_01_3_1_10	R_01_3_1_1_23g	Event.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23h	On_board.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23i	Station.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23j	Track.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23k	Train_Length.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23l	Timetable.	Configuration	NO	See UC.	
UC_01_3_1_10	R_01_3_1_1_23m	Type.	Configuration	NO	See UC.	
UC_01_3_1_0; UC_01_3_1_10;	R_01_3_1_1_24	The Conflict Resolution algorithm shall allow to be configured/maintained if the staff responsible is logged with the proper rights into the TMS. Note: The staff responsible for configuring the Conflict Resolution algorithm must be properly trained for this task.	Assumption	NO	See UCs.	[FP6, WP2, D2.2] ORWS 9
UC_01_3_1_0; UC_01_3_1_10;	R_01_3_1_1_25	The Conflict Resolution algorithm shall allow that the TMS notify to the staff member the result of the configuration.	Configuration	NO	See UCs.	
See sub-requirements.	R_01_3_1_1_26	In Simple topology, the Conflict Resolution algorithm shall consider as conflict the following situations:	Functional	NO	See sub-requirements.	[FP6, WP2, D2.2] ORWS 1;
UC_01_3_1_1a; UC_01_3_1_1b; UC_01_3_1_1c;	UC_01_3_1_26a	Catch-up.	Functional	NO	See UCs.	
UC_01_3_1_2a; UC_01_3_1_2b;	UC_01_3_1_26b	Crossing.	Functional	NO	See UCs.	
UC_01_3_1_3a; UC_01_3_1_3b; UC_01_3_1_3c;	UC_01_3_1_26c	Proximity.	Functional	NO	See UCs.	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
UC_01_3_1_4a; UC_01_3_1_4b; UC_01_3_1_4c; UC_01_3_1_4d;	UC_01_3_1_26 d	Wayside issues.	Functional	NO	See UCs.	
See sub-requirements.	R_01_3_1_1_27	In Depot/Terminal Station, the Conflict Resolution algorithm shall consider as conflict any disturbances of the following situations:	Functional	NO	See sub-requirements.	
UC_01_3_1_11; UC_01_3_1_15;	R_01_3_1_1_27 a	Perform a task.	Functional	NO	See UCs.	
UC_01_3_1_12; UC_01_3_1_15;	R_01_3_1_1_27 b	Perform more than one task	Functional	NO	See UCs.	
UC_01_3_1_13; UC_01_3_1_15;	R_01_3_1_1_27 c	Split	Functional	NO	See UCs.	
UC_01_3_1_14; UC_01_3_1_15;	R_01_3_1_1_27 d	Join	Functional	NO	See UCs.	
All UC_01_3_1_0..19 except those about Configuration.	R_01_3_1_1_28	The Conflict Resolution algorithm shall detect the conflict or anticipate the possible conflict.	Functional	NO	See UCs.	
See sub-requirements.	R_01_3_1_1_29	The Conflict Resolution algorithm shall warn to the operator when:	Functional	NO	See sub-requirements.	
All UC_01_3_1_0..19 except those about Configuration, UC_01_3_1_3c and UC_01_3_1_15	R_01_3_1_1_29 a	a conflict is detected or,	Functional	NO	See UCs.	
UC_01_3_1_3c; UC_01_3_1_15;	R_01_3_1_1_29 b	a possible conflict is detected.	Functional	NO	See UCs.	
See sub-requirements.	R_01_3_1_1_30	The Conflict Resolution algorithm shall try to calculate alternatives for the resolution of the conflict:	Functional	NO	See sub-requirements.	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
All UC_01_3_1_0..19 except those about Configuration, UC_01_3_1_3c and UC_01_3_1_15	R_01_3_1_1_30 a	after detecting the conflict or,	Functional	NO	See UCs.	
UC_01_3_1_3c; UC_01_3_1_15;	R_01_3_1_1_30 b	as anticipation of the possible conflict.	Functional	NO	See UCs.	[FP6, WP2, D2.2] ORWS 3
See sub-requirements.	R_01_3_1_1_31	The Conflict Resolution algorithm shall inform to the operator when:	Functional	NO	See sub-requirements.	
UC_01_3_1_1a; UC_01_3_1_1b; UC_01_3_1_2a; UC_01_3_1_2b; UC_01_3_1_4a; UC_01_3_1_4c;	R_01_3_1_1_31 a	the algorithm does not identify alternatives to resolve the conflict or,	Functional	NO	See UCs.	
UC_01_3_1_3c; UC_01_3_1_15;	R_01_3_1_1_31 b	the algorithm considers that, finally, there is not any conflict to resolve.	Functional	NO	See UCs.	
See sub-requirements.	R_01_3_1_1_32	The Conflict Resolution algorithm shall consider the conflict as **unresolvable** when:	Functional	NO	See sub-requirements.	
UC_01_3_1_1a; UC_01_3_1_1b; UC_01_3_1_2a; UC_01_3_1_2b; UC_01_3_1_4a; UC_01_3_1_4c;	R_01_3_1_1_32 a	the algorithm does not identify alternatives to resolve the conflict or,	Functional	NO	See UCs.	
UC_01_3_1_1c; UC_01_3_1_2a; UC_01_3_1_2b; UC_01_3_1_3a; UC_01_3_1_3b; UC_01_3_1_4b; UC_01_3_1_4d;	R_01_3_1_1_32 b	the algorithm identifies and presents alternatives to resolve the conflict, but the operator does not select any alternative after X seconds of their presentation.	Functional	NO	See UCs.	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
UC_01_3_1_11; UC_01_3_1_12; UC_01_3_1_13; UC_01_3_1_14						
UC_01_3_1_1c; UC_01_3_1_2a; UC_01_3_1_2b; UC_01_3_1_3a; UC_01_3_1_3b; UC_01_3_1_3c; UC_01_3_1_4b; UC_01_3_1_4d; UC_01_3_1_11; UC_01_3_1_12; UC_01_3_1_13; UC_01_3_1_14; UC_01_3_1_15;	R_01_3_1_1_33	The Conflict Resolution algorithm shall present the alternatives in a ranked list when the algorithm identifies the alternatives to resolve the conflict or the possible conflict.	Functional	NO	See UCs.	
UC_01_3_1_1c; UC_01_3_1_2a; UC_01_3_1_2b; UC_01_3_1_3a; UC_01_3_1_3b; UC_01_3_1_3c; UC_01_3_1_4b; UC_01_3_1_4d; UC_01_3_1_11; UC_01_3_1_12; UC_01_3_1_13; UC_01_3_1_14; UC_01_3_1_15;	R_01_3_1_1_34	The Conflict Resolution algorithm shall advise to the operator to choose the best alternative presented in the ranked list to resolve the conflict or the possible conflict.	Functional	NO	See UCs.	
UC_01_3_1_1c; UC_01_3_1_2a; UC_01_3_1_2b; UC_01_3_1_3a; UC_01_3_1_3b;	R_01_3_1_1_35	The Conflict Resolution algorithm shall consider the conflict as **resolved** when the operator chooses the alternative presented in the ranked list before X seconds.	Functional	NO	See UCs.	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
UC_01_3_1_4b; UC_01_3_1_4d; UC_01_3_1_11; UC_01_3_1_12; UC_01_3_1_13; UC_01_3_1_14;						
UC_01_3_1_1c; UC_01_3_1_2a; UC_01_3_1_2b; UC_01_3_1_3a; UC_01_3_1_3b; UC_01_3_1_4b; UC_01_3_1_4d; UC_01_3_1_11; UC_01_3_1_12; UC_01_3_1_13; UC_01_3_1_14;	R_01_3_1_1_36	Once the Conflict Resolution algorithm detects the conflict and presents alternatives to resolve it, the timer to choose an alternative shall start when the ranked list is presented.	Functional	NO	See UCs.	
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_37	The Conflict Resolution algorithm shall provide a GUI to ease its use by the final user (e.g. allowing drag and drop commands).	Functional	NO		[FP6, WP2, D2.2] ORWS 6; [FP6, WP2, D2.2] ORWS 8;
From UC_01_3_1_0 to UC_01_3_1_15	R_01_3_1_1_38	The Conflict Resolution algorithm shall be developed using IA.	Functional			[FP6, WP2, D2.2] ORWS 2;
UC_01_3_2_1	R_01_3_2_1_1	The TMS shall be able to receive and process adhesion information provided by ATO-TS.	Functional		Adhesion information management leads to a more precise regulation and thus a more efficient traffic management system.	
UC_01_3_2_1	R_01_3_2_1_2	The TMS shall be able to receive adhesion information reported by the Train Driver from the ATO-TS: a) Slippery Rail reported by the Train Driver b) Non-Slippery Rail reported by the Train Driver			Adhesion information management leads to a more precise regulation and thus a more efficient traffic management system	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
UC_01_3_2_1	R_01_3_2_1_3	The TMS shall be able to discern among adhesion information reported by the Train Driver, adhesion information reported by TCMS/Train, and adhesion information reported by an external system.	Functional		Adhesion information management leads to a more precise regulation and thus a more efficient traffic management system	
UC_01_3_2_3	R_01_3_2_3_1	The TMS shall be able to receive and exploit weather conditions information input from an External Source.	Functional		An input to the TMS in terms of weather conditions, which can impact traffic regulation, leads to a more precise regulation and thus a more efficient traffic management system.	
UC_01_3_2_3	R_01_3_2_3_2	The TMS shall be able to associate weather conditions information received from an External Source with one of the following adhesion categories: • Dry Rail: Conditions where 100% of the brake force of the vehicle can be applied with no axle sliding of more than 2% (adhesion level typically above 0.15μ). • Medium: Conditions where the wheel/rail adhesion is in the range 0.15 – 0.10 (Damp rails with some contamination). • Normal Low: Conditions where the wheel/rail adhesion is in the range 0.10 – 0.08 (Typical autumn mornings due to dew/dampness often combined with light overnight rust). • Low Adhesion: Conditions where the wheel/rail adhesion is in the range 0.08 – 0.05. • Very Low Adhesion: Conditions where the wheel/rail adhesion is in the range 0.05-0.03.	Functional		Dynamic weather conditions information provided by an External Source to the TMS positively impact traffic regulation.	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
		• Extremely Low Adhesion: Conditions where the wheel/rail adhesion is below 0.03.				
UC_01_3_2_3	R_01_3_2_3_3	The TMS shall be able to transmit the following adhesion categories to ATO-TS: • Dry Rail: Conditions where 100% of the brake force of the vehicle can be applied with no axle. sliding of more than 2% (adhesion level typically above 0.15μ). • Medium: Conditions where the wheel/rail adhesion is in the range 0.15 – 0.10 (Damp rails with some contamination). • Normal Low: Conditions where the wheel/rail adhesion is in the range 0.10 – 0.08 (Typical autumn mornings due to dew/dampness often combined with light overnight rust). • Low Adhesion: Conditions where the wheel/rail adhesion is in the range 0.08 – 0.05. • Very Low Adhesion: Conditions where the wheel/rail adhesion is in the range 0.05-0.03. • Extremely Low Adhesion: Conditions where the wheel/rail adhesion is below 0.03.	Functional		Dynamic weather conditions information provided by the TMS to the ATO-TS positively impact traffic regulation.	
UC_01_3_2_4	R_01_3_2_4_1	The TMS shall be able to build an adhesion area based on the Status Reports reported by the ATO-OB.	Functional		The establishment of adhesion areas leads to a more precise regulation and thus a more efficient traffic management system	
UC_01_3_2_4	R_01_3_2_4_2	The TMS shall be able to build an adhesion area when Slippery Rail condition is reported by the Train Driver.	Functional		The establishment of adhesion areas leads to a more precise regulation and	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
					thus a more efficient traffic management system. Slippery Rail condition can be reported by either the Train Driver or the TCMS/Train	
UC_01_3_2_4	R_01_3_2_4_3	The TMS shall be able to inform the ATO-TS about the existence of adhesion areas and their characteristics: • Start location • End location • Segment Profile coverage • Adhesion Category: ○ Dry Rail: Conditions where 100% of the brake force of the vehicle can be applied with no axle sliding of more than 2% (adhesion level typically above 0.15μ). ○ Medium: Conditions where the wheel/rail adhesion is in the range 0.15 – 0.10 (Damp rails with some contamination) ○ Normal Low: Conditions where the wheel/rail adhesion is in the range 0.10 – 0.08 (Typical autumn mornings due to dew/dampness often combined with light overnight rust) ○ Low Adhesion: Conditions where the wheel/rail adhesion is in the range 0.08 – 0.05 ○ Very Low Adhesion: Conditions where the wheel/rail adhesion is in the range 0.05-0.03 ○ Extremely Low Adhesion: Conditions where the wheel/rail adhesion is below 0.03	Functional		The establishment of adhesion areas leads to a more precise regulation and thus a more efficient traffic management system.	
UC_01_3_2_6	R_01_3_2_6_1	The TMS shall be able to modify the length of an adhesion area when new conditions on the track affecting wheel/rail adhesion	Functional		The establishment of adhesion areas leads to a	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
		are transmitted by an External Source.			more precise regulation and thus a more efficient traffic management system.	
UC_01_3_2_7	R_01_3_2_7_1	The TMS shall be able to remove an already-defined Slippery Rail area when a certain number of Status Reports sent by ATO-OB units report: • Low adhesion is not reported by the Train Driver. • Slip/slide is not reported by the TCMS/Train,	Functional		If Slippery Rail conditions are no longer reported by the Train Driver or slip/slide information is not reported by the TCMS/Train in an already-defined Slippery Rail area, the TMS should be able to remove such area in order for following trains' ATO Operational Speed Profile to be updated, which contributes to the achievement of a more precise traffic regulation and a more efficient traffic management system.	
UC_01_3_2_7	R_01_3_2_7_2	The TMS shall be able to inform the ATO-TS about the removal of an already-defined Slippery Rail.	Functional		If Slippery Rail conditions are no longer reported by the Train Driver or slip/slide information is not reported by the TCMS/Train in an already-defined Slippery Rail area, the TMS should be able to remove such area in order for following trains' ATO Operational Speed Profile to be updated, which contributes to the achievement of a more precise traffic regulation and a more efficient traffic management system.	

UC ID Source	Req ID	Req Description	Req Type (1)	Safety? (2)	Rationale	Req ID (from Others WP)
UC_01_3_2_8	R_01_3_2_8_1	The TMS shall be able to update the adhesion category applied to an already-defined adhesion area when weather conditions change (e.g., due to extreme weather events), thereby leading to a modification of the wheel/rail adhesion.	Functional		The modification of the adhesion category of an adhesion area leads to a more precise regulation and thus a more efficient traffic management system.	

Note: Requirements from the “Conflict Resolution in Specific Situations” use cases (see section 4.2) have not been derived.