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DELIVERABLE D3.1
USE CASES AND SCENARIOS FOR ATO IN DIFFERENT GoA DEMOS FOR G1 REGIONAL LINES

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Executive Summary

Regional lines, like main lines, benefit from the introduction of ATO systems. The introduction of the ATO system can effectively reduce operating costs and can contribute to reduce overall infrastructure costs. The solutions explored in the present document are the introduction of ATO Grade of Automation 2 (GoA2) up to Grade of Automation 4 (GoA4) for regional applications.

There are many similarities with what is applied on main lines. Since the same trains can circulate both on main lines and on G1 regional lines, interoperability must be guaranteed.

The use of the ATO over ETCS signalling system is a must that has guided the integration of the solutions in the regional context.

This report covers use cases for G1 regional lines that allow automation of train operation on low-traffic lines with moderate speeds. The ATO functionality developed is using ERTMS/ETCS as a platform. The report specifies several use cases and technical requirements that ATO must meet to improve performance and overall economic sustainability of regional lines.

Subsequently, various grades of automation applicable were analysed. Grade of Automation is studied from GoA2, where a train driver is responsible for starting automatic operation and can intervene and manually drive the train in certain circumstances, to GoA3 which is driverless but with at least one train attendant on board. The on-board staff can handle doors, external and internal communication, facility issues and evacuating passengers if necessary. In GoA4, in which the train operates completely without on-board staff, start, stop, and operation of doors are performed completely without driver and train attendant. However, as a fallback system, the train can be operated by a remote operator (in conformity with GoA3).

The use cases identified are particularly useful for regional lines. The present document constitutes the main outcome of **FP6 WP3 Task 3.1** (**Regional Rail CCS & Operations for G1 Lines Requirements & Specifications**), which forms the basis for the demonstration campaigns to be performed by **FP6 WP8 Task 8.1 (Development of individual demonstrator ATO GoA2 on G1 regional lines)** and **Task 8.2 (Development of individual demonstrator ATO GoA3/4 including perception and remote driving on G1 regional lines)** during the second half of the project.

List of abbreviations, acronyms and definitions

Abbreviation / Acronym	Definition
AC	Alternating Current
AD	Automatic Driving
ADM	Automatic Driving Module
APM	Automatic processing module
ATAF	Automatic track ahead free
ATO	Automatic Train Operation
ATO OB EG	ATO On Board EnGaged
ATO-TS	ATO trackside
ATP	Automatic Train Protection
BG	Balise Group
CAPEX	Capital Expenditure
CCS	Command and Control System
DC	Direct Current
DMI	Driver Machine Interface
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
ETCS L2/L3	European Train Control System Level 2/Level 3
ETCS SR	ETCS Staff Responsible mode
FA	Flagship Area
FP	Flagship Project
FRMCS	Future Radio Mobile Communication System
G1 line	Regional line connected to main network
GOA	Grade of Automation
GPRS	General Packet Radio Service
GSM-R	Global System for Mobile Communications - Railway
JP	Journey Profile
IM	Infrastructure Manager
LTE	Long-Term Evolution (broadband communication standard)
LX	Level Crossing
MA	Movement Authority
OB	On Board
OPEX	Operational Expenditures
OS MA	On Sight Movement Authority
PER	Perception
PIS	Passenger Information System
RBC	Radio Block Center

Abbreviation / Acronym	Definition
SEO	Socio Economic Objective
TCO	Total Cost of Ownership
TMS	Traffic Management System
TOC	Total Cost of Ownership
TRL	Technology Readiness Level
TSI	Technical Specifications for Interoperability
TSR	Temporary Speed Restriction

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1. INTRODUCTION

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 (FP6-FutuRe)** is born to revitalize them by exploiting leading-edge technologies which reduce the Total Cost of Ownership (TCO), while meeting safety standards and improving reliability and availability of the regional railway system.

The expected outcomes of FP6-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 **FP6-FutuRe Work Package 3 (WP3)**:

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

Regional G1 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, FP6-FutuRe WP3 leads the assessment of the applicability of several solutions covering an integrated control and command system for G1 lines, which will first be demonstrated under laboratory conditions in **FP6-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.

FP6-FutuRe WP3 builds on specifications, guidelines, and other existing deliverables coming from:

- CCS TSI 2023/1695
- FP6-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 Task 3.1, a comprehensive list of ATO use cases is elicited, together with a definition of demonstrator laboratory set-ups and a set of requirements derived from these use cases.

2. DEVELOPMENT METHODOLOGY

In this section, the methodology on how this deliverable was developed is described. The methodology section is divided into four sections:

i) Deliverable Objectives

ii) Process Overview

iii) Existing and Relevant Documents

iv) Methodology for Deliverable Development.

2.1 DELIVERABLE OBJECTIVES

The goal of FP6 Task 3.1 is to:

- Develop use cases.
- Derive requirements from the developed use cases that can potentially enrich the regional G1 lines requirement specification elicited in FP6 WP2 (D2.2 - Regional lines operational and functional requirements).
- Define demonstrator setups.

Tests and evaluation of use cases shall take place during the second phase of the projects in WP8.

FP6 Task 3.1 outcomes shall also be used as an input to FP6 WP7 for a preparation of the integrated demonstrators in the follow-up project.

2.2 PROCESS OVERVIEW

The Figure 1 below schematically shows the work process in Task 3.1. The work started by defining use cases. Requirement specifications were derived from them. Description of suitable locations for testing of the use cases were also done. Task 3.1 is also providing WP7 preparatory plans for the integrated demonstrators that will be the topic for the follow up project (second EU Rail call). There is an additional dimension of an interaction with the WP2 of FP6, which collects the requirements of all WPs.

The alignment between R2DATO and FP6-FutuRe has been continuous. Several of the companies in T3.1 also worked with ATO in R2DATO, which ensures that duplication of work does not occur and that the work complements each other. The focus of the report is the specification of use cases together with their functional and operational requirements. They form the basis for the tests of the use case groups to be carried out in the second part of the project and that shall be described in:

- D8.1 - ATO over ETCS GoA2 applied on G1 lines Demonstrator report
- D8.2 - ATO GoA3/4 including perception and remote driving on G1 regional lines

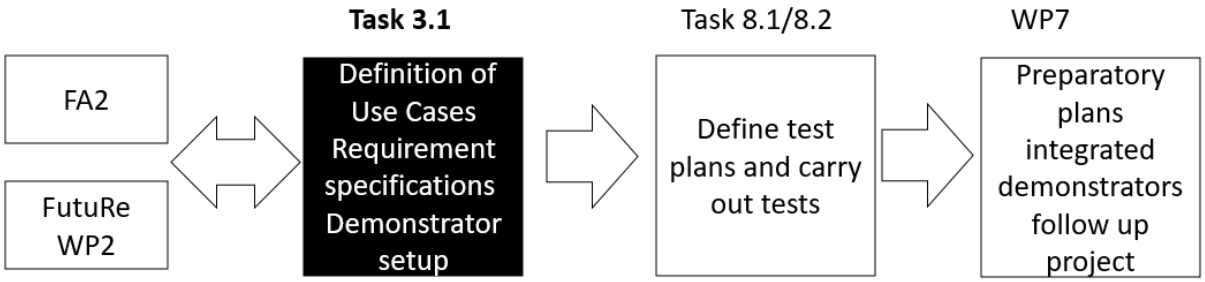

Figure 1: Process overview

2.3 EXISTING AND RELEVANT DOCUMENTS

General governing documents include the FP6-FutuRe Grant Agreement, Consortium agreement and Europe`s Rail Multi-Annual Work Plan.

The work builds on many previous development efforts carried out in the S2R program and elsewhere.

In the area of the absolute train positioning as one of the preconditions for a cost efficient ATO there have been numerous projects like RHINOS, GRAIL, STARS, ERSAT, HELMET or RAILGAP in the last two decades. These projects aimed at demonstrating that the GNSS performance could meet the criteria required for the vital train localisation.

Two projects should be noted specifically:

GaLoROI – the project with an objective to develop certifiable safety relevant onboard satellite-based localisation unit for low-density lines

CLUG and CLUG2.0 - projects with the main objective of demonstrating and complement the existing European Train Control System (ETCS) odometry system through an on-board GNSS+EGNOS-based multi-sensor fusion architecture enabling absolute safe train positioning and navigation whilst also transforming the way train localisation is done today.

A progress in developing ATO technologies has been reflected in the corresponding regulation, namely CCS TSI (COMMISSION IMPLEMENTING REGULATION (EU) 2023/1695) where there are numerous references to the ATO functionality up to GoA2 (not exhaustive list):

Article 6 Availability of ETCS, ATO and FRMCS on-board products

1. The Agency shall prepare by 1 January 2025 a report to the Commission on

(b) the availability of ATO on-board products compliant with ATO Baseline 1 specifications;

4.2.4.3.2. Data communication for ATO

4.2.5. RMR, ETCS and ATO air gap interfaces

4.2.6.4. Interface between ATO and ETCS

4.2.18. On-Board ATO functionality

This basic parameter describes the ATO on-board functionality needed to operate a train up to Grade of Automation 2 with ETCS providing the automatic train protection functionality to enable it.

4.2.19. Trackside ATO functionality

This basic parameter describes the ATO trackside functionality needed to operate a train up to Grade of Automation 2 with ETCS providing the automatic train protection functionality to enable it

The interface and functions are specified by https://www.era.europa.eu/era-folder/1-ccs-tsi-appendix-mandatory-specifications-etcs-b4-r1-rmr-gsm-r-b1-mr1-frmcs-b0-ato-b1, namely:

084	SUBSET-125	ERTMS/ATO System Requirement Specification	1.0.0	-
085	SUBSET-126	ATO-OB / ATO-TS FFFIS Application Layer	1.0.0	-
086	SUBSET-148	ATO-OB / ATO-TS FFFIS Transport and Security Layers	1.0.0	-
087	SUBSET-130	ATO-OB / ETCS-OB FFFIS Application Layer	1.0.0	-
088	SUBSET-139	ATO OB / Rolling Stock FFFIS Application Layer	1.0.0	-

2.4 METHODOLOGY FOR DELIVERABLE DEVELOPMENT

The work has been based on previous work carried out in S2R. The companies participating in the task have identified use cases which have been divided into use case groups. The groups have also been sorted by work streams: GoA2, GoA3/4 and remote driving. The idea is that each use case group should be a platform for the tests to be carried out during the second half of the project. From the use cases, requirement specifications have been derived both at the system level and the operational level.

ATO is an essential instrument for a future efficient railway operation. To be able to assess its contribution in various Grades of Automation there is a need to define the basic parameters to be evaluated:

- Punctuality increase
- Reduction of Energy consumption
- Reduction of CAPEX
- Reduction of OPEX

The baseline against the achievements can be measured is the so called “manual driving” (Table 1), i.e. the mode of operation when the driver is supervised by an ATP (ETCS) but fully responsible for driving the train in accordance with the schedule and stopping at predefined points for passenger embarkation and disembarkation.

Table 1: Baseline scenario - manual driving

1	**Manual Driving**
1.1	**Manual traction/braking control**
1.1.1	Reduced implementation of energy-efficient driving techniques
1.1.2	Manual establishment of speed
1.1.3	Driver-dependent tractive/braking efforts
1.1.3.1	*Unnecessary braking commands due to driver's driving skills*
1.1.3.2	*Unnecessary acceleration commands due to driver's driving skills*
1.2	**Manual establishment of maximum speed within ETCS limits**
1.3	**Driver-dependent stopping accuracy**
1.4	**Manual door opening and closing**
1.5	**Timetable adherence dependent on driver's driving skills**
1.6	**Driver-dependent passenger comfort**
1.7	**Maintenance**
1.7.1	Induced rolling stock wear as a consequence of driver's driving skills
1.7.2	Induced infrastructure wear as a consequence of driver's driving skills
1.8	**Driver-related costs on manual driving lines**

In the individual chapters below, describing the GoA performances, tables 2, 3 and 4 provide a qualitative assessment of the basic parameters for each aspect of the various GoA scenarios, compared to the manual driving scenario reported in Table 1.

3.1 ATO GoA2 Workstream

Defined as an interoperability constituent for both the on-board and trackside subsystems in the published CCS TSI 2023/1695, ATO GoA2 implementation is an additional asset in the search for capacity improvement, punctuality increase, and energy efficiency in the European railway network.

Being complemented by the European Train Control System (ETCS), ATO provides speed control, higher comfort and ergonomics for passengers, accurate stopping, door opening and closing, and driver-related functions while ETCS ensures safety by supervising speed and distance limits. [1]

In comparison with non-automated train operation, a ATO GoA2 over ETCS boosts a reduction in energy consumption, which is one of FP6-FutuRe's key Socio-Economic Objectives (SEO) where ATO plays a crucial role:

- SEO5: Overall reduction of OPEX and CAPEX by targeting 15%
- SEO6: Energy consumption optimization by targeting a 10% reduction
- SEO7: Optimized punctuality by targeting a 15% increase

In the context of FP6-FutuRe, a qualitative analysis of how ATO GoA2 contributes to fulfilling the SEO was conducted in close collaboration with Task 2.3 "KPI achievement monitoring" and FP6-FutuRe's deliverable D2.3 First release of KPI achievement. Based on a baseline reference scenario (manual driving – see table 1 above), FP6-FutuRe ATO GoA2 scenario (table 2) focuses on the aspects that positively impact the fulfilment of punctuality increase, energy consumption reduction, and OPEX reduction.

Table 2: ATO GoA2 scenario

		GoA2	Increase in Punctuality	Reduction in Energy Consumption	Decrease in CAPEX	Decrease in OPEX
1	Automatic driving	X	X	X		X
1.1	Automatic traction/braking control	X	X	X		X
1.1.1	Introduction of train traction energy saving functions (e.g., coasting)	X		X		X
1.1.2	Automatic establishment of the optimum speed in the most energy efficient way	X		X		X
1.1.3	Optimization of tractive/braking effort	X		X		X
1.1.3.1	Reduction in unnecessary braking	X		X		X
1.1.3.2	Reduction in unnecessary acceleration	X		X		X
1.2	Automatic establishment of the maximum speed the train can run without interfering with ETCS speed limits	X				
1.3	Accurate stopping	X	X	X		
1.4	Automatic door opening and closing	X	X	X		
1.5	Improved timetable adherence	X	X			
1.6	Improved passenger comfort	X				
1.7	Maintenance	X				
1.7.1	Reduction in Rolling Stock maintenance (e.g., reduction in maintenance activities due to reduced wheel wear) (Driver's driving skills impact rolling stock wear)	X				X
1.7.2	Reduction in infrastructure maintenance (e.g., reduction in maintenance activities due to reduced rail wear, reduced ballast displacement) (Driver's driving skills impact infrastructure wear)	X				X
1.8	Human Resources: Reduction in driver-related costs Costs related to: ▪ Train driver training ▪ Train attendant training GoA2: The need for a train driver in the cab might not lead to a reduction in driver-related costs. Such driver should also be trained for ATO aspects, which does increase costs.					

3.2 ATO GoA3/4 Workstream

One of the major foreseeable risks for the future regional train service is the lack of qualified workforce (such as train drivers) that may lead to reduced regional mobility services or even the closure of specific regional lines. Similarly to high-speed, mass transit or mainline train operations, driverless train operation (ATO GoA 3/4) on lower-density lines will seek higher technical performance and optimisations of available workforce.

The main preconditions for the developed use cases for driverless train operation in the framework of FP6-FutuRe within WP3 are the following:

- Proposed demonstrations should build on already achieved results, achievements and as much as possible aligned with ATO GoA3/4 draft specifications developed in Shift2Rail (e.g. X2Rail-4 project) with further refinements in Europe`s Rail parallel activities (e.g. System pillar and R2DATO project).
- ATO GoA3/4 is designed to work with interoperable ATP (ETCS).

Proposed use cases or requirements should support finalisation of specifications for future CCS TSI within Europe`s Rail program to better support regional lines specifics, especially considering practical operational perspective.

Technically, the ATO GoA3/4 solution is further developing its functionalities based on already mature ATO over ETCS GoA2 solution, which is ready for deployment and fully specified in CCS TSI 2023/1695. Several new technical components need to be added to fulfil the goal of driverless train operations. Among the most significant ones belong:

- Perception
- Automated Driving Module
- Automatic Processing Module
- Repository (on-board and trackside)
- Localisation
- Digital Map

In comparison to ATO over ETCS GoA2 (covered in the previous chapter), the higher level of automation provides further reduction in energy consumption by covering all the automation modes for train driving. It is thus expected further reduction of OPEX and CAPEX, while slightly increasing punctuality parameters by further elimination of some human limitations. In conclusion, ATO GoA34 contributes to the overall SEO targets:

SEO5: Overall reduction of OPEX and CAPEX by targeting 15%:

SEO6: Energy consumption optimization by targeting a 10% reduction

SEO7: Optimized punctuality by targeting a 15% increase

Following the preliminary evaluation KPIs (confidence that KPI can be achieved by the fully developed solution and relevant justifications) from FP6-FutuRE Deliverable D3.2, the ATO in GoA3 or 4 contributes to :

SEO 5 (CAPEX/OPEX): ATO GoA 3 reduces the demand for skilled personnel (trained drivers) and thus brings essential cost savings; ATO GoA4 contributes to further savings of the onboard personnel and consequently cost reduction.

SEO 6 (energy saving) and SEO7 (punctuality): In both ATO GoA3 and ATO GoA4, during normal operation, the human intervention for driving the train are no longer required. Operations that in lower GoA levels require interactions with the train driver are here fully automatised, freeing up resources (especially time) for driving optimisations. This leads to overall better energy consumption figures, while maintaining the timetable as close to the plan as operationally feasible (punctuality). Note: The system can be optimised for the right balance between punctuality and energy consumption based on customer needs.

In the context of FP6-FutuRe, a qualitative analysis of how ATO GoA3/4 contributes to fulfilling the SEO was conducted in close collaboration with Task 2.3 “KPI achievement monitoring”. Based on the baseline reference scenario (manual driving – see table 1 above), FP6-FutuRe ATO GoA3 scenario (table 3) and ATO GoA4 scenario (table 4) focuses on the aspects that positively impact the fulfilment of punctuality increase, energy consumption reduction, and OPEX reduction.

Table 3: ATO GoA3 scenario

		GoA3	Increase in Punctuality	Reduction in Energy Consumption	Decrease in CAPEX	Decrease in OPEX
1	Automatic driving	X	X	X		X
1.1	Automatic traction/braking control	X	X	X		X
1.1.1	Introduction of train traction energy saving functions (e.g., coasting)	X		X		X
1.1.2	Automatic establishment of the optimum speed in the most energy efficient way	X		X		X
1.1.3	Optimization of tractive/braking effort	X		X		X
1.1.3.1	Reduction in unnecessary braking	X		X		X
1.1.3.2	Reduction in unnecessary acceleration	X		X		X
1.2	Automatic establishment of the maximum speed the train can run without interfering with ETCS speed limits	X				
1.3	Accurate stopping	X	X	X		
1.4	Automatic door opening and closing	X	X	X		
1.5	Improved timetable adherence	X	X			
1.6	Improved passenger comfort	X				
1.7	Maintenance					
1.7.1	Reduction in Rolling Stock maintenance (e.g., reduction in maintenance activities due to reduced wheel wear) (Driver's driving skills impact rolling stock wear)	X				X
1.7.2	Reduction in infrastructure maintenance (e.g., reduction in maintenance activities due to reduced rail wear, reduced ballast displacement) (Driver's driving skills impact infrastructure wear)	X				X
1.8	Human Resources: Reduction in driver-related costs Costs related to: ▪ Train driver training ▪ Train attendant training GoA3: The need for a train attendant on board the train might not lead to a reduction in driver-related costs. Such train attendant should also be trained for ATO aspects, which does increase costs.					

Table 4: ATO GoA4 scenario

		GoA4	Increase in Punctuality	Reduction in Energy Consumption	Decrease in CAPEX	Decrease in OPEX
1	Automatic driving	X	X	X		X
1.1	Automatic traction/braking control	X	X	X		X
1.1.1	Introduction of train traction energy saving functions (e.g., coasting)	X		X		X
1.1.2	Automatic establishment of the optimum speed in the most energy efficient way	X		X		X
1.1.3	Optimization of tractive/braking effort	X		X		X
1.1.3.1	Reduction in unnecessary braking	X		X		X
1.1.3.2	Reduction in unnecessary acceleration	X		X		X
1.2	Automatic establishment of the maximum speed the train can run without interfering with ETCS speed limits	X				
1.3	Accurate stopping	X	X	X		
1.4	Automatic door opening and closing	X	X	X		
1.5	Improved timetable adherence	X	X			
1.6	Improved passenger comfort	X				
1.7	Maintenance					
1.7.1	Reduction in Rolling Stock maintenance (e.g., reduction in maintenance activities due to reduced wheel wear) (Driver's driving skills impact rolling stock wear)	X				X
1.7.2	Reduction in infrastructure maintenance (e.g., reduction in maintenance activities due to reduced rail wear, reduced ballast displacement) (Driver's driving skills impact infrastructure wear)	X				X
1.8	Human Resources: Reduction in driver-related costs Costs related to: ▪ Train driver training ▪ Train attendant training GoA4: No staff on-board competent to operate the train leads to a reduction in driver-related costs.				X	X

3.3 REMOTE DRIVING WORK STREAM

There are two basic needs to deploy remote driving:

1) As an intermediate stage prior to the full implementation of ATO

Before fully deploying ATO-controlled trains on regional lines, remote driving can serve as a crucial intermediary stage, involving human operators in the train control loop. Remote driving requires two-way communication between the train and the driver at the remote Control Center. In such a system, while the train automates all the operations, staff might still be present for roles unrelated to driving or handling the train in the event of disruption. This setup entails the use of public networks for communication between the control center and the train on site. Additionally, the camera installed on the train facilitates the transmission of live video feeds for control purposes.

2) As a backup / emergency option to drive the train in case of ATO failure

In ATO GoA3/4, the ATO function typically operates upon ERTMS, but other types of operation are also being evaluated. If a degradation of system levels occurs, the remote operation works as a backup system. In the scenarios and use-cases described in this document both the ATO and ERTMS subsystems are malfunctioning, leaving the train control to remote operation. A prerequisite is that radio coverage for packet switched video and control signalling exist. This could be a rail dedicated or a public network.

Use of public networks has benefits related to cost efficiency and system capacity. However, the possible use of public networks for communication brings a set of challenges, including concerns about cyber-security and reliability. More specifically:

- Encrypted and secure communication is essential to avoid potential cyber threats.
- It is expected that the system needs redundant communication paths to ensure uninterrupted connectivity.
- Real-time video streaming with acceptable latency from the field shall be displayed in the remote-control monitor for control purposes while the control commands shall be relayed back to the train through a customized control system.

4 USE CASE GROUPS

This chapter contains the complete list of use cases (Table 6) developed by FP6-FutuRe T3.1 Consortium and that are reported in Annex 1. Bearing in mind their nature and with a view to facilitate the reader's comprehension, the following 10 use case groups were established:

- Discretional Stops
- Operation Under High Odometry Error
- Temporary Speed Restriction
- Level Crossings
- Radio Hole
- Prove Clear Ahead
- Object on the Track
- Adhesion Management
- Remote Driving
- Regional G1 Lines – Main Line Interoperability

The use cases reported in Annex 1 report the following aspects:

- Use case group to which the use case belongs
- Use case title
- Use case identification
- Main and other actors
- Assumptions and preconditions
- Flow of events
- Postconditions
- Safety relation
- Open Topics
- Consideration
- Derived requirements

The use case identification follows the pattern adopted in FP6-FutuRe WP3 (Table 5).

Table 5: Use case and requirement identification in FP6-FutuRe WP3

FP6-FutuRe WP3's approach to use case and requirement identification (requirements are listed in annex 2)			
Task – ID	**Task – Description**	**Use Case identification**	**Requirement identification**
T3.1	Preparatory activities for ATO in different GoA on G1 regional lines	UC_01_1_X_Y	R_01_1_X_Y_Z
T3.2	Preparatory activities for the ETCS L3 demos on G1 regional lines	UC_01_2_X_Y	R_01_2_X_Y_Z
T3.3	Preparatory activities for the Traffic Management System demos on G1 regional lines	UC_01_3_X_Y	R_01_3_X_Y_Z
T3.4	Preparatory activities for the Cost-effective fail-safe highly accurate train positioning on G1 lines	UC_01_4_X_Y	R_01_4_X_Y_Z
T3.5	Preparatory activities for the Cost-effective fail-safe on-board train integrity & train length on G1 lines	UC_01_5_X_Y	R_01_5_X_Y_Z
UC: Use Case 01: FP6-FutuRe Work Package 3 X: Use case group Y: Counter of the UC within the same Use Case group Z: Requirement counter			

Table 6: Use Case classification

Use Case Group	Applicable GoA for testing	Use Case – ID	Use Case – Description
Discretional Stops	GoA2, GoA3 & GoA4	UC_01_1_1_1	Passengers on station with enough leeway
	GoA2, GoA3 & GoA4	UC_01_1_1_2	Passengers on station without enough leeway
	GoA2, GoA3 & GoA4	UC_01_1_1_3	Passengers on-board with enough leeway
	GoA2, GoA3 & GoA4	UC_01_1_1_4	Passengers on-board without enough leeway
Operation Under High Odometry Error	GoA2	UC_01_1_2_1	Operation under high odometry error
	GoA2	UC_01_1_2_2	Operation under high odometry error with Virtual Balise Groups
Temporary Speed Restriction	GoA2	UC_01_1_3_1	Temporary Speed Restriction
Level Crossings	GoA2, GoA3 & GoA4	UC_01_1_4_1	The train cross an automatic level crossing working in nominal conditions
	GoA2	UC_01_1_4_2	The train cross an automatic level crossing reporting non protected status
	GoA2	UC_01_1_4_3	The train cross a non-protected level crossing
	GoA2	UC:01_1_4_4	The train cross a group of automatic level crossings reporting non protected status
Radio Hole	GoA2, GoA3 & GoA4	UC_01_1_5_1	Radio Hole
		UC_01_1_5_2	ATO Radio Hole
Prove Clear Ahead	GoA3 & GoA4	UC_01_1_6_Y	Prove Clear Ahead

Use Case Group	Applicable GoA for testing	Use Case – ID	Use Case – Description
Object on the Track	GoA3 & GoA4	UC_01_1_7_1	Object in the track
	GoA3 & GoA4	UC_01_1_7_2	Unprotected Level Crossing
	GoA3 & GoA4	UC_01_1_7_3	Animals near the track
	GoA3 & GoA4	UC_01_1_7_4	Fire near the track
	GoA3 & GoA4	UC_01_1_7_5	Parking lot near the track
Adhesion Management	GoA2	UC_01_1_8_1	Train Driver reports Slippery Rail/Non-Slippery Rail
	GoA2, GoA3 & GoA4	UC_01_1_8_2	Adhesion is reported by TCMS/Train
	GoA2, GoA3 & GoA4	UC_01_1_8_3	ATO-TS reports adhesion conditions on the basis of the information received from TMS
	GoA2	UC_01_1_8_4	Construction of a Slippery-Rail area when reported by Train Driver of multiple trains
	GoA2, GoA3 & GoA4	UC_01_1_8_5	Construction of an adhesion area when adhesion is reported by the TCMS of multiple trains
	GoA2, GoA3 & GoA4	UC_01_1_8_6	An already-defined adhesion area is shortened/lengthened by TMS
	GoA2, GoA3 & GoA4	UC_01_1_8_7	An already-defined Slippery Rail area is removed by the TMS on the basis of Status Reports
	GoA2, GoA3 &	UC_01_1_8_8	The adhesion category applied to an existing adhesion area is

Use Case Group	Applicable GoA for testing	Use Case – ID	Use Case – Description
	GoA4		modified by TMS
	GoA2, GoA3 & GoA4	UC_01_1_8_9	The adhesion category applied to an existing adhesion area is modified by the TMS on the basis of the information received from the TCMS/Train
Remote Driving	N/AFallback for GoA 3/4	UC_01_1_9_1	Remote on-sight driving within ETCS failure
	N/A	UC_01_1_9_2	Transmission quality of video streaming
	N/A	UC_01_1_9_3	User perspective on video streaming
	N/A	UC_01_1_9_4	Remote driving by controlling vehicle engine and brakes
	N/A	UC_01_1_9_5	Stop the train after experiencing a network outage
	N/A	UC_01_1_9_6	Onboard Manual Override
	N/A	UC_01_1_9_7	Remote obstacle detection and reaction
	N/A	UC_01_1_9_8	Passing on the level crossing
Regional G1 Lines – Main Line Interoperability	GoA2	UC_01_1_10_1	Starting Journey
	GoA2	UC_01_1_10_2	De-energising ATO on-board
	GoA2	UC_01_1_10_3	Planned GoA1 to GoA2 transition on the move
	GoA2	UC_01_1_10_4	Driver-initiated GoA2 to GoA1 transition
	GoA2	UC_01_1_10_5	Automatic GoA2 to GoA1 transition on the move
	GoA2	UC_01_1_10_6	ATO inhibition
	GoA2	UC_01_1_10_7	C-DAS inhibition
	GoA2	UC_01_1_10_8	Train stops at a Stopping Point
	GoA2	UC_01_1_10_9	Train stopped by signalling
	GoA2	UC_01_1_10_10	Train stops short of a Stopping Point
	GoA2	UC_01_1_10_11	Train overshoots Stopping Point

Use Case Group	Applicable GoA for testing	Use Case – ID	Use Case – Description
	GoA2	UC_01_1_10_12	Train departs from a Stopping Point (1)
	GoA2	UC_01_1_10_13	Train departs from a Stopping Point (2)
	GoA2	UC_01_1_10_14	Rerouting
	GoA2	UC_01_1_10_15	Trackside initiated 'Stopping Point Skip'
	GoA2	UC_01_1_10_16	Driver initiated 'Stopping Point Skip'
	GoA2	UC_01_1_10_17	Hold train at the next Stopping Point
	GoA2	UC_01_1_10_18	Emergency brake application commanded by ETCS
	GoA2	UC_01_1_10_19	Neutral/Powerless Sections
	GoA2	UC_01_1_10_20	Unprotected Level Crossings
	GoA2	UC_01_1_10_21	Change of Train Running Number
	GoA2	UC_01_1_10_22	Transition from Class B area
	GoA2	UC_01_1_10_23	Transition to Class B area

4.1 DISCRETIONAL STOPS

When considering the concept of regional lines, as opposed to main lines, one of the main characteristics to be highlighted is there is no periodic passenger demand to commercially stop the train on certain stations. On main lines, there is usually the need of passenger's exchange in every train stop by default However, this behaviour is not as common in a regional context with low-density traffic.

Therefore, a functionality that allows to be aware of the needs of the passengers could be very useful. This capability has already been proven in other transport systems such as urban buses.

To practically implement discretional stops functionality, two approaches are possible:

1) Using the current release of ERTMS/ATO specifications.

2) Using an adjustment of future specifications, applicable for GoA3-4 and backward compatible with GoA2.

Both approaches are fully valid since the first approach demonstrate that functionality for regional lines is applicable already today with some reservations, while the second approach

brings adjustments to the functionality, improving compatibility, interoperability and efficiency of the overall solution. FP6-FutuRE as a research project will explore both options.

Solution focused on using current release of ERTMS/ATO specifications

The functionality could be operationally implemented for a GoA1 by means of the driver, but it could also be automatized. In this regard, while it could be conceived for even GoA3/4, as it has been proposed in Flagship Project 2, with the existing specifications it could only be performed for ATO GoA2.

The key elements of the functionality are:

Passengers stop input: the generation of an input regarding a specific station at which a passenger wants to get on or off. This input could be generated in various ways, or even combinations of them.

The decision to stop: once the input is generated, it should be evaluated whether the train has enough leeway to perform the stop. One possibility would be that the decision is made on board, although the specifications for the ATO-OB/ATO-TS (SS126) communication do not enable the ATO-OB to transmit the above-mentioned input, which could lead to issues with the traffic management system such as traffic disturbances. Furthermore, in order to harmonise the behaviour among different trains, the decision should be transferred to the TMS/ATO-TS, which can decide whether or not the train can make a stop at a station.

As a result, even if the input is generated by passengers on board or at a station, the TMS/ATO-TS should be able to receive the information.

Once the input is generated, and it is concluded that the train is able to perform the stop, the ATO-TS can send a new JP or update the previous one. The functionality could then result in an improvement in punctuality, but also in an optimization of the braking curves that can be translated into a reduction in energy consumption.

Solution focused on using adjustment of future specifications, applicable for GoA3-4 and backward compatible with GoA2.

This solution uses spare values in already existing communication between ATO-OB and ATO-TS (SS-126). It does not define new packets, does not need adding new variables into existing packets and does not need to introduce new communication channel.

The key elements of the functionality are:

ATO-OB controls the train in the same way as if stopping is mandatory (which prevents the train to pass the stopping point too early). If there is no passenger request to stop, target braking to stopping point is cancelled in specified point (this point can be defined separately for each stopping point). The passengers stop input can be generated in various ways, or even using combinations of them.

The decision to stop: as the train is following the braking curve to stopping point, each passenger's input is "in time", until passengers are informed about last possibility to request the stop. If there are no requests neither from train nor from platform, ATO-TS sends a command to pass the station (and thus, any disruption in communication between ATO-OB and ATO-TS (and vice versa) cannot cause that the passenger request is rejected, in worst case, the communication failure leads to stopping without any request).

The train is following the braking curve to stopping point (but the current real train speed can be lower than braking curve speed, e.g. due to energy-saving coasting).

The ATO-OB decides on the position of the “last possible point” (the parameters can be user-defined for each stopping point separately). If there is no passenger request from train in this “last possible point”, ATO-OB informs ATO-TS about no request. In opposite case, ATO-OB does not send any information to ATO-TS.

When ATO-TS receives the information from ATO-OB about no request from train, it checks if there is any request from platform. If there is no request from platform (i.e., no request from train and also from platform), ATO-TS sends to ATO-OB the command to pass the station - the train releases the brakes and continues in running. If ATO-TS does not receive the information from the train or if it receives this information, but there is a request from platform, ATO-TS does NOT send any information to ATO-OB and train continues in braking to stopping point.

As ATO-OB calculates the speed profile with respect to possible stopping, there is no risk of passing the stop earlier than prescribed in timetable.

ATO-OB, according to current specifications, has no knowledge which stops are on-request. For labelling the station as “on-request”, spare value is used in variable Q_Stop_Skip_Pass (included in Journey Profile packet). No new wireless communication between on-board and trackside is needed.

The “last possible point” for requesting the stop is computed on-board and can be parametrized for each stopping point (in distance, speed or time to arrival). As ATO-OB standardly executes such computations e.g. for estimation of arrival / passing time, the implementation of this function will be easy, especially as all necessary data (including the dynamic ones) are available on-board.

The “last possible point” can be specified at the point where braking curve crosses the track speed limit, in this case, the train will not start the braking if there is no request to stop (the same situation as in case of “using the existing specifications”). But the same result - no starting to brake - can be achieved when the “last possible point” is (dynamically) set to the point where braking curve crosses the current speed - this is closer to stopping point, it means, later in time, so passengers have more time for requesting the stop.

Delays and disturbances in communications network may lead only to “unrequested” stopping, but from the principle - the active command is sent to pass the station, not to stop there - these failures cannot cause the unwanted passing.

In a summary, this approach has the following characteristics:

Defined and interoperable communication channel between on-board and trackside (for transferring on-board passenger stop request).

For the case when ATO-OB calculates the speed without in-advanced defined intermediate stopping or timing points, the energy efficient speed profile is computed for no stopping in between and may calculate it with acceleration to line speed, running at this speed and long coasting at the end. Therefore, there is no certainty for the passenger when the train may pass on-request stations.

ATO-OB receives a priory information which stops are on-request (not supported by current specifications).

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Since all the on-request stations are defined in-advance and transferred to on-board, delays and disturbances in communications network will not lead to the situation that stop on request could be missed.

4.2 Operation Under High Odometry Error

It should be considered that a possible measure to ensure the long-term viability of regional lines by means of reducing the TCO is to minimize the cost related to positioning. One way of achieving it is by reducing the number of repositioning balise groups, which are used to reset the odometry error once they are read. As a consequence of having a reduced number of balises, the odometry error of the train would reach higher values than what is expected for normal operation on main lines.

Another consideration is that SS125 allows ATO to be interfaced with odometer sensors. While these could indeed improve the positioning of the train, it could also occur an error or have a lower performance than the expected. As a result, there could also be a higher odometry error and as such, operation could be affected.

4.3 Temporary Speed Restriction

In the context of regional lines, where cost considerations may lead to not fully equipped communication systems, the use of radio hole functionality becomes necessary. Furthermore, these regional lines could have a design that does consider areas with unreliable communication.

Under these scenarios, there may be situations requiring immediate action, that ATO is not able to manage as it has not received the information. For example, under high-speed lateral wind, the train should operate under reduced speed, but if has not received this limitation the driver should act.

Moreover, the interaction between the ATO system and human operators is a key aspect. The need for ATO to appropriately respond to driver interventions underscores the importance of comprehensive testing and validation of system behaviour under varying operational conditions. This includes scenarios where the ATO seamlessly transitions between automated and manual modes, ensuring a harmonious and safe operational environment.

4.4 Level Crossings

Railway level crossings are crucial locations where road and rail networks intersect, requiring careful management to ensure the safety of both road and rail users. The design and management of level crossings are critical to prevent accidents and ensure the efficient flow of both road and rail traffic.

One of the key considerations in managing railway level crossings is that, depending on the type, there would be different safety measures, that could range from the installation of warning signs, lights, and barriers to alert road users of approaching trains, etc. Additionally, advanced warning systems, such as flashing lights and audible alarms, are often employed to provide ample notice to drivers of an approaching train.

While these intersections are very limited or even non-existent on main lines, they are very common on regional lines, with several types of level crossing even on the same line.

At this moment, the level crossing types that have been considered are:

- Automatic level crossing: depending on the state of the level crossing, they can be protected or unprotected when the train approaches.
- Non-protected level crossing: this category comprises those level crossings without any means of warning or protection that indicate that it is not safe for the user to cross the level crossing.
- Interlocked Level crossing: while this type has been considered, it has been concluded that the testing of this type would not provide further information.

Regarding the rules upon which the level crossing operates, these do vary greatly. Consequently, a train approaching the LX can be imposed no specific restriction, up to having speed restrictions and/or requiring stopping in the rear of the LX. Furthermore, since i the conditions depend on national technical rules and/or line parameters, the ATO and n the corresponding Use cases, should allow to adapt to the different scenarios.

4.5 Radio Hole

One of the main characteristics when defining regional lines is the presence of a numerous o areas where radio coverage is significantly low or even non-existent. Additionally, the desire of reducing costs by means of not including all the possible equipment on the lines means that not all the equipment required to solve the above mentioned radio coverage problem will be installed.

It follows then that the existing Radio Hole track condition function becomes particularly important when discussing regional lines. The related track condition information transmitted from TS ETCS informs the on-board ETCS that it is going to enter an area that is not likely to have radio coverage and that therefore, it will be not reasonable to continue monitoring the safety connection to the RBC as it will cause undesirable break application stopping the train where the RBC is not going to be able to send a new MA due to the lack of communication.

Nevertheless, when considering this functionality, it must be considered that there are certain singularities on the track that cannot be overlooked. Therefore, even if initially there is an intention of reducing all the possible equipment, there will be special areas with poor radio connection that will have to be equipped with the necessary elements to allow a correct radio communication between the on-board system and the RBC.

4.6 Prove Clear Ahead

In addition to the above-mentioned features of regional lines, another relevant aspect that characterizes such line typology is the long block sections existing between signalling information points (traditionally wayside signals), even single ones between stations. This, together with the absence of track signalling assets due to less deployment costs, increases the importance on managing potential degraded conditions when the train, occupying the whole length of this block section, must recover the mission due to any circumstance leading to a train stop.

The introduction of ATO performances on this kind of events, where traditionally the responsibility until the onboard recovers the full supervised condition relies entirely on the driver, requires some new performances and functionalities, as well as some safety conditions to be adopted by the automatic train operation, mainly on higher grades of automation (GoA 3/4 levels).

On one hand, assuming the trackside is not able to grant a track free ahead of the train until this last reaches some location in the proximity of a signal where ATAF process is possible, some obstacle detection on-board capability, should be required (for further details, see next section 5.7). The related information provided by means of any adequate perception system should be managed by the ATO – OB in this autonomous process. It also must guarantee at least the same safety integrity level than that one provided by the human factor when the driver assumes this responsibility once the trackside has sent an ETCS SR authorization or OS MA.

Thus, similarly as when the ATO-OB can engage an Automatic driving (AD) from an ETCS full supervised (FS), a dedicated (set of) safety relevant ATO mode(s) should be available for OS and other ETCS and, consequently, added to the specifications.

4.7 Object on the Track

Higher grades of automation will gradually enter technological solutions for regional lines. It`s main purpose will not be only to optimise operations from the performance or energy consumption point of view but as well to optimise the use of qualified workforce needed to operate that specific regional line. This may come as necessary precondition since qualified workforce is less and less available on labour market and its current use seem not to be utilised in the most efficient way (long and unproductive waiting times, need to transfer the workforce on specific places, etc.). A list of use cases in main line environment is found in R2DATO D5.2 Documentation of Use Cases for remote driving.

The main challenge for driverless train operation or advanced remote control (with obstacle detection) is to replace or complement human perception and operational awareness by advanced technical means. This task includes the deployment of a number of sensors of sensors (onboard but possibly also trackside), reliable data processing and then highly dependent decision mechanism regarding the system action needed for e.g. to prevent an accident. The chain of processing and actions needed for correct evaluation of critical operational situations is dependent on the specific line characteristics (e.g the way how the line is constructed and operated), environmental and geographical conditions. While the main/high-speed lines are slowly converging towards more unified characteristics, the regional lines are and will be much more diverse.

In order to capture and evaluate these specificities and making sure that they will be part of the future interoperable and standardised solutions, several typical operational scenarios for regional lines have been highlighted and will be further investigated as part of this project.

Following, here are couple of examples of typical regional line environmental and operational situations that need to be correctly captured and evaluated by potential driverless operations:

- Unprotected Level Crossing: In some regional lines, there may be a significant number of unprotected level crossings. When driving the train in ATO GoA3/4 mode, the

obstacle detection system must be aware of these areas and process the risk of a higher probability of potential objects using the crossing path.

- Animals near the track: From the obstacle detection perspective, each train operational environment has unique characteristics that must be considered. In many regional lines, domestic or wild commonly moving around the track and may represent a higher risk of accident when crossing the route of moving train. Similarly, system should accept presence of animals if they are on the safe distance in respect to the train and avoid unnecessary train stops.
- Fire near the track: In certain periods of the year, especially in autumn, people burn fallen leaves or other parts of maintained gardens as part of their cleaning routine. Driverless system shall know the areas in close vicinity to the line, where the smoke is likely to be present and therefore train shall avoid unnecessary braking or stops on these locations and thus being more energy efficient and provide more fluid service.
- Parking lot near the track: In some regional lines in contrast to other types of lines, it is quite common that parking lots are in very close vicinity of that line. Driverless system shall know the areas in close vicinity to the line, where the cars are likely to be present, but very unlikely to enter the line. In these cases, the risk of potential collision with the car is negligible and therefore train shall avoid unnecessary braking or stops on these locations and thus being more energy efficient and provide more fluid service.

4.8 Adhesion Management

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. Therefore, specific strategies need to be adopted to maximise the safety and quality of the service.

Although this is not an exhaustive list, low adhesion is frequently attributed to:

- Moisture
- Snow
- Light rain after a dry period
- Heavy rain
- Contaminants (e.g., rail wear debris)
- Dust
- Airborne diesel fuel from diesel trains
- Lubricating oil droplets from diesel trains
- Leaking hydraulic fluid from track machines
- Defective lubrication
- Others

The acceleration and braking performance of trains is thus affected by these conditions causing disruption to the normal operation on account of, for instance:

- Platform overruns
- Signals passed at danger
- Collisions

Rail Delivery Group, a membership organization that works on behalf of the British rail industry with the support of train operating companies, elaborated the Adhesion Working Group's low adhesion manual as the repository for their corporate knowledge on understanding and managing low adhesion. As a result of investigations and R&D activities, this manual establishes key insights for Infrastructure Managers, Railway Undertakings, and the railway industry to help them enhance safety and performance, thereby improving customer experience. The following conclusions arise from them:

- Conditions vary along the line because of microclimates.
- The implementation of measures across each part of the railway (e.g., operations, infrastructure, and rolling stock) is essential for minimizing disruption.
- Defensive driving is an important means of mitigating low adhesion in conjunction with experience and training.
- Shorter trains are more prone to being affected than longer ones.
- Both wheel and railhead contamination have an impact.
- Low levels of moisture at the wheel/rail interface cause poor adhesion conditions (dew, very light rain, misty conditions, and the transition between dry and wet rails at the onset of rain).

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, Annex 3 describes the existing measures to address adhesion management from the point of view of both ETCS and ATO, and Annex 1 contains a series of use cases with innovative solutions for handling low adhesion conditions.

4.9 Remote Driving

The remote driving UCs defined and described in this document enables basic functions and requirements for a remote-controlled operation. It is a range from basic remote on-sight driving by controlling engine and brakes to quantification of requirements for the video streaming. A couple of error UCs have been designed to secure vehicle behaviour during network outage, and one UC to secure safe passes of level-crossings. In this UC lineside signals guides the remote driver. The remote control use cases are focused on cost efficient solutions utilizing public mobile networks and standard equipment. A list of use cases in main line environment is found in R2DATO D5.4 Documentation of Use Cases for remote driving.

Remote control of trains falls under the category of GoA 3, as there is no driver onboard, but there is still an attendant who can control the train from a remote location if needed. Remote control of trains can be a step toward achieving GoA 4 or used as a layer of resilience to a self-driven train as a fallback system. Human insight can be beneficial in extraordinary situations, as a human's problem-solving skills and flexibility can be better than an automatic system. In complex situations where the automatic systems are not sufficient to handle, using remote control in GoA 3 can increase the flexibility and robustness of the train operation, and accelerate the implementation of automatic systems.

Remote train systems can serve as a backup system for ATO, and as an initial phase of achieving ATO controlled trains for regional lines operation. Furthermore, adopting remote control technology can offer various benefits, such as increased efficiency and capacity usage.

Remote driving thus does not only act as a step towards full automation but also serves as a valuable tool for backup, improving the safety and efficiency of train operations. This is achieved by ensuring the efficiency of the automated system while still having the safety of human intervention for decision-making and control in the event of a system failure.

Various test sites and parameters have been incorporated in the demo UC to align this project's scope with the FP6-FutuRe project's overarching objectives.

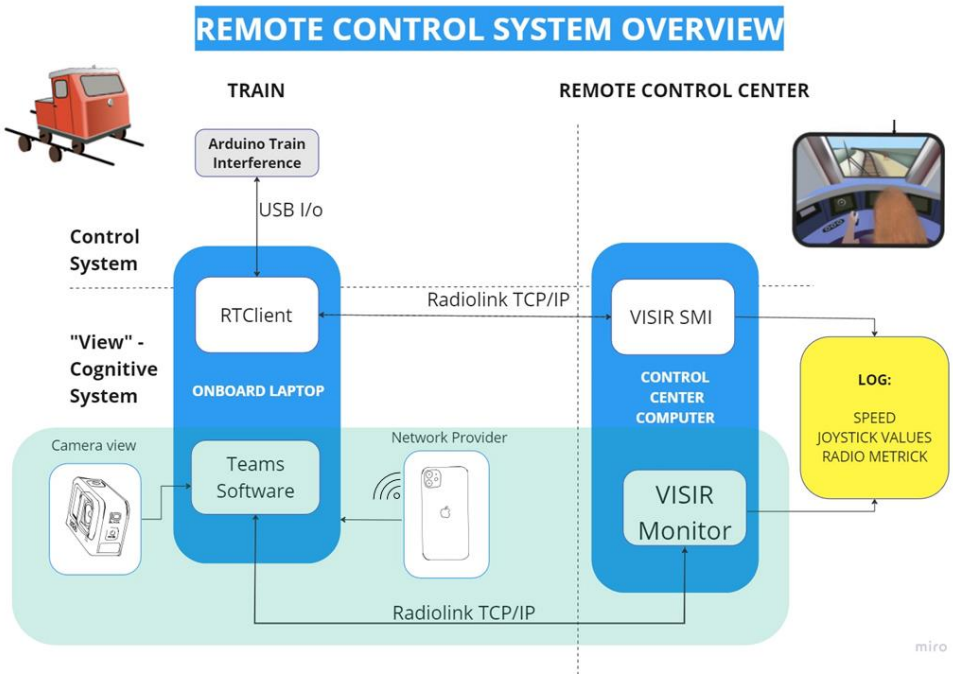


Figure 2: System overview demo tests

Figure 2 provides a system overview of the planned demo tests. This setup encompasses two vital communication aspects essential for remote control operations. Firstly, it addresses the link between the operator system and the vehicle, which manages the control aspects of the system. Secondly, the connection between the onboard camera and computer, facilitates real-time video feed transmission to the control center, as depicted in Figure 2.

One focus of the demo is to investigate the communication aspect, specifically focusing on the video transmission component. This involves evaluating technology requirements and executing a test configuration that integrates a camera with real-time video transmission technology.

While the FP6-FutuRe project aims to renew regional railways through a comprehensive approach involving digitalization, automation, and the integration of new technologies our demo specifically focuses on using standard, cost effective and reliable technology to innovate remote control solutions. This focus is seen as a crucial step toward achieving a larger vision of creating economically, socially, and environmentally sustainable regional railways across Europe. Given the critical nature of real-time communication in remote control operations, the

exploration of options for real-time video transmission setup with high performance is crucial. The intended setup includes a camera system compatible with video sharing technology to function as the communication perspective for remote control. 7. .8 Regional G1 Lines – Main Line Interoperability

4.10 REGIONAL G1 LINES – MAIN LINE INTEROPERABILITY

As stated in previous chapters, regional G1 lines are lines or networks of lines that are connected to the mainline railway system, so they must be fully compliant with the applicable EU Regulations. Interoperability must therefore be ensured for passenger and freight services between G1 lines and main lines and more specifically, with respect to ATO, the interface between ATO-OB subsystem and ATO-TS subsystem must be technically interoperable. In the context of FP6-FutuRe, SUBSET-151 (ERTMS/ATO Test Specification) arises as a reference for Task 3.1 to check such interoperability by leveraging the already-defined operational test scenarios relevant for GoA2 operation:

- Starting Journey
- De-energising ATO on-board
- Planned GoA1 to GoA2 transition on the move
- Driver-initiated GoA2 to GoA1 transition
- Automatic GoA2 to GoA1 transition on the move
- ATO inhibition
- C-DAS inhibition
- Train stops at a Stopping Point
- Train stopped by signalling
- Train stops short of a Stopping Point
- Train overshoots Stopping Point
- Train departs from a Stopping Point
- Rerouting
- Trackside initiated ‘Stopping Point Skip’
- Driver initiated ‘Stopping Point Skip’
- Hold train at next Stopping Point
- Emergency brake application commanded by ETCS or other safety system
- Neutral/Powerless Sections
- Unprotected level crossings
- ATO adhesion management
- Change of Train Running Number
- Transition from Class B area
- Transition to Class B area

A number of these operational scenarios shall be selected for testing in future stages of the project where demonstration activities are performed (WP8 T8.1). Additionally, with the objective of complementing the ATO adhesion management operational scenario listed above, Annex 3 contains a detailed analysis of how adhesion management is currently handled by both ETCS and ATO in accordance with the existing regulatory framework defined by CCS TSI 2023/1695. As a result of such analysis, the complementary use cases presented in Annex 1 provide some insights that might lead to an improvement in the process of addressing low adhesion conditions, which has an impact on the operation of regional lines.

5.1 ATO GoA2 Demonstrator Set-Up – CAF

As stated in previous chapters, ATO GoA2 demonstration activities envisaged in WP8 T8.1 shall comprise the selection of use cases to be tested as well as the development, test, and validation of the ATO GoA2 demonstrator, among others.

FP6-FutuRe Consortium Member CAF shall lead one of the ATO GoA2 demonstrators envisaged in T8.1 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 SUBSET-151 (ERTMS/ATO Test Specification) and adhesion management use cases.

The ATO GoA2 simulated environment shall consist of a **Test Execution Tool** that enables to send/receive orders to/from the following key actors:

- **Subset 130 Simulator**: Simulation of the interface between ATO-OB subsystem and ETCS-OB subsystem
- **Subset 126 Simulator**: Simulation of the interface between ATO-OB subsystem and ATO-TS subsystem
- **Subset 139 Simulator**: Simulation of the interface between ATO-OB subsystem and TCMS
- **ATO-OB:** Target/host ATO-OB subsystem

The Test Execution Tool, together with the **Train Dynamics Simulator**, which simulates Rolling Stock dynamics, enables the interaction with the abovementioned key ATO GoA2 actors by providing and receiving input/output to/from the simulation environment. The Demonstrator Set-up illustrated in Figure 3 shall be the basis for the T8.1 test campaign.

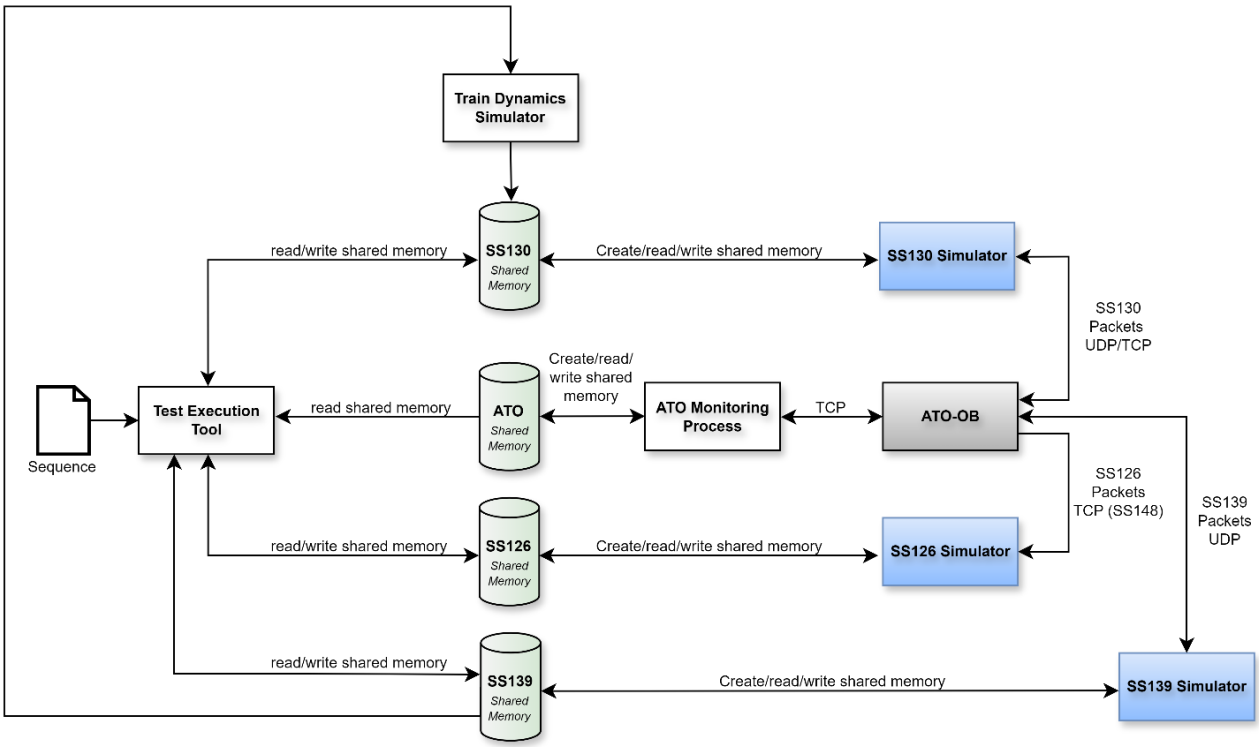


Figure 3: ATO GoA2 demonstrator set-up

5.2 ATO GoA2 Demonstrator Set-Up – MERMEC

The scope of the demonstrator prepared by the FP6-FutuRe Consortium member MERMEC, is to select test cases defined in the current specification which are applicable to the operation of the ERTMS/ATO in the regional lines. The device under test will be the ATO on-board GoA 2 operated in ATO SV 1.0 (according to the TSI CCS annex A, as per Regulation (EU) 2023/1695).

The scope of the testing will be to demonstrate how the ATO technology can be effective for railway operation on regional lines.

The test activities will be held on a laboratory environment using, if possible, trackside data provided by IM members of the Consortium, or in alternative, derived by one of the MERMEC projects in regional lines in Italy.

The lab test environment for GoA 2 ERTMS/ATO on-board shall be based on the standard architecture for the Interoperability Test Environment being defined in Subset-111 and shall consist of Test Control Unit (TCL), simulators (for train dynamic and TCMS, ATO-TS and ETCS-OB) and an adapter to the DUT (Device Under test) that is the ATO-OB target.

The TCL, equipped with a Graphical User Interface, will be responsible to receive in input the test sequence and manage transmission/reception of messages to/from the following simulators:

- **ETCS-OB**: simulation of the interface (application layer Subset-130) between ATO-OB and ETCS-OB.

- **ATO-TS**: simulation of the interface (application layer Subset-126) between ATO-OB and ATO-TS.
- **Train Simulator**: simulation of the train dynamic and of the interface (application layer Subset-139) between ATO-OB and TCMS.

and the ATO-OB adapter whose scope is to allow the exchange of data from/to subsystem out of the scope of the test, in accordance with the ATO-OB FFFIS interfaces.

The Lab testing environment will host the target system ERTMS/ATO on-board subsystem.

The Demonstrator Set-up concept presented in Figure 4 shall be used for the T8.1 test campaign in a local configuration.

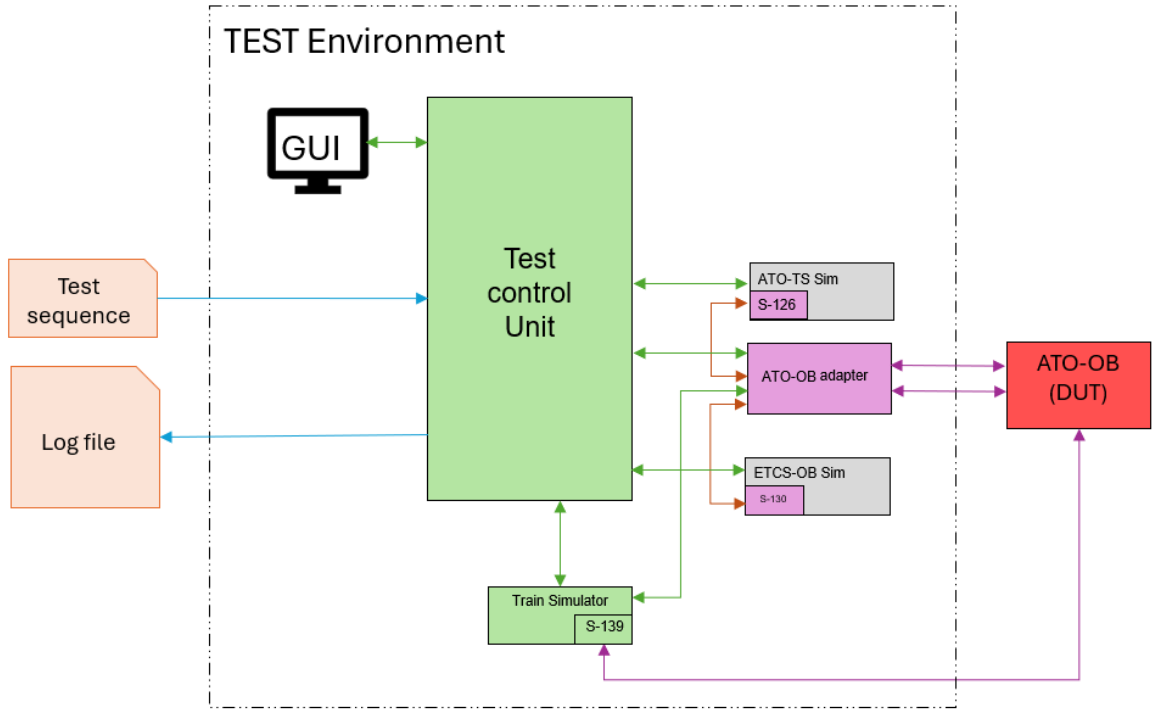


Figure 4: ATO GoA2 demonstrator set-up (Mermec)

5.3 Remote Driving Demonstrator Set-Up – TRV & NRD

A simplified piece of rolling stock is produced for the demo purpose. The vehicle will serve as a platform for sensors and communication equipment. It is designed to accommodate test crew on board, as backup and to oversee data collection.

Figure 5: VTI test vehicle

A remote control environment is established based on a train driving simulator environment. Simulated visualization of train driving is replaced with real time video streaming. In demo mode, speed and breaking on the demo vehicle is controlled from the equipment that usually only provide input to the simulation. Input from other sensors than video camera may be displayed on the screen or in other ways.

Figure 6: VTI train driving simulator

Public mobile networks are used for communication between the remote control center and the vehicle. This is interesting both as backup, and as main communication channel for video streaming even in normal operations.

Regarding the use of public network, several factors considered such as network coverage, bandwidth, comparing the expenses of using a public network versus dedicated systems. The choice to use public networks for communication brings its set of challenges. Security is crucial; encrypted and secure communication is essential to avoid potential cyber threats. Reliability is another concern; the system has redundant communication paths to ensure uninterrupted connectivity. Furthermore, the real-time video streaming with minimal latency from the field will be displayed in the remote-control monitor for control purposes.

In accordance with the FP6-FutuRe objective of cost effectiveness, a key element of the demo is to utilise standard and easily available equipment, such as commonly used camera, video streaming system and system control equipment.

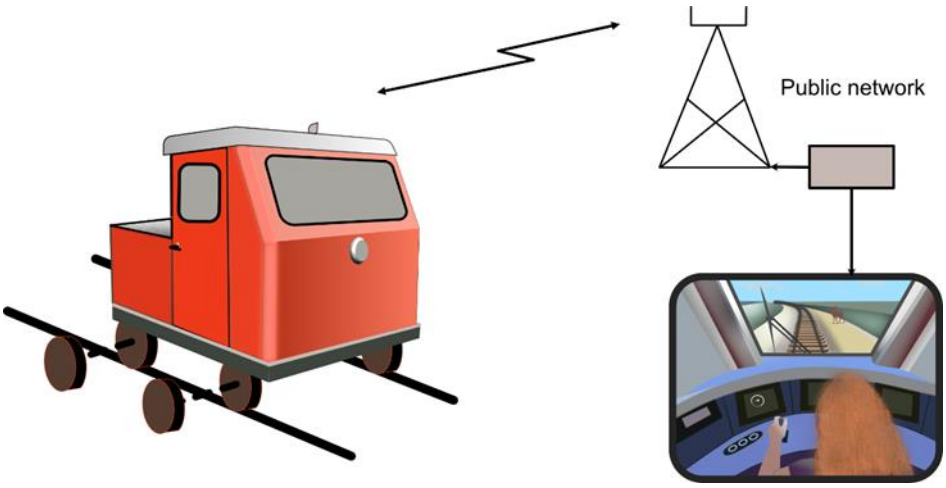


Figure 7: Remote driving demonstrator set-up

Possible test locations in Sweden

Initial testing is carried out at The Wadstena Fogelsta Railway in Sweden. The line is 9.6 km long, going between Vadstena and Fågelsta. It is narrow gauge, 891 mm. The prototype train is prepared for this gauge. The line is owned by Vadstena municipality and the Wadstena Fogelsta Järnväg museum association leases it.

More information here:

The Wadstena Fogelsta Railway museum association – Wadstena Fogelsta Railway (wfj.se)

Following testing on other locations is planned. One possible test site in Sweden is the Dellen line, going between Ljusdal and Hudiksvall. It is 62 km standard gauge, 1435 mm. The prototype train is prepared for this gauge.

More information here (in Swedish):

Banguide - Dellenbanan Ljusdal-Hudiksvall - järnväg.net (jarnvag.net)

Hem | Dellenbanan

Following tests in Sweden, the intention is to do tests outside Sweden. Preparations has begun for tests in Norway.

Test locations in Norway

Main alternative location is Namsos line, in central Norway.

Namsos line was the 52 km railway line connecting Grong and Namsos. Standard gauge, 1435 mm. The commercial traffic stopped in 1978 and in 2005 the bridge right after Skogmo station was removed, effectively splitting the line in two parts (Bjerke et al., 2013). The track is owned by Bane NOR. Today, there is no railway activity on either side of the line. Ownership is transferred from the traffic part of Bane NOR to the real estate division. It is possible to rent draisines for a 6-kilometer stretch on the western side between Namsos and Grytøya. Namsos Camping rents out the draisines, from early May until the end of August. The track terrain is very flat. The network coverage is solid 4G/4G+ throughout most of the 6 kilometers, but with a potential blind spot of only 2G coverage near the eastern end at Grytøya.

Figure 8: Namsos banen test track

More information here:
Namsosbanen (Trafikkstrekninger) - DigitaltMuseum

An alternative, especially for follow up demos is the Muruvik sideline.
The Hell-Muruvik option is, to a large degree, an unused sidetrack for the route between Hell and Trondheim. While the new main line, completed in 2011, runs through Gevingåsen tunnel, the sidetrack is routed mostly alongside the water. In Bane NOR's capacity strategy they outline how sidetracks can be utilized for loading, unloading, and other logistical tasks. As per of 2016, there was some transport of gas on the line (Jernbaneverket, 2016), but there is limited information on the activity as of 2023. Standard gauge, 1435 mm. There is a solid 5G-coverage through most of the line, with some sporadic occurrences of 4G/4G+. The short tunnel of about 55 meters is a potential blind spot for the communication.
More information here:
Norge -> Jernbanestrekninger i Norge -> #33 Meråkerbanen (Nedlagt strekning Hommelvik - Hell) | Jernbane.net

5.4 ATO GoA3/4 Demonstrator Set-Up – AZD

In the Czech Republic, there is a suitable testing line dedicated for testing of new technologies.

This is a Kopidlno - Dolní Bousov line (23 km) in Central - East Bohemia.

Standard gauge (1435 mm), non-electrified, max. speed 60 km/h. The commercial traffic stopped in 2010. In 2016, this line has been acquired and now, this line is being converted to line for testing the new railway technologies, especially focusing on automatic train operations. The line is now being equipped with the following technologies:

- ETCS L2 (L3)
- Radio communications: 5G (first of this kind on railway line in Czechia possible future FRMS testing)/ LTE / GPRS / GSM-R
- Fully electronic interlocking (AŽD ESA 55)
- Automatic traffic management in station with automatic route setting (fully interlinked to national central traffic management

- For testing purposes, the line can be operationally isolated from other rail network in Czechia for minimising the barriers for specific testing that would be otherwise not possible or difficult on fully operational commercial lines
- Electronic level crossing systems

In the past (end of 2023), this line was used for Shift2Rail X2Rail-4 tests of ATO over ETCS GoA4 with simulated ETCS (due to legislative reasons - "live" ETCS cannot be technically changed for cooperation with GoA4 components). This line is as well part of Regional line demonstrator within FP2 R2DATO (WP46).

AŽD Praha is owner of both, the line and the suitable testing vehicle, providing certain level of flexibility for testing, while other operational disturbances could be limited.

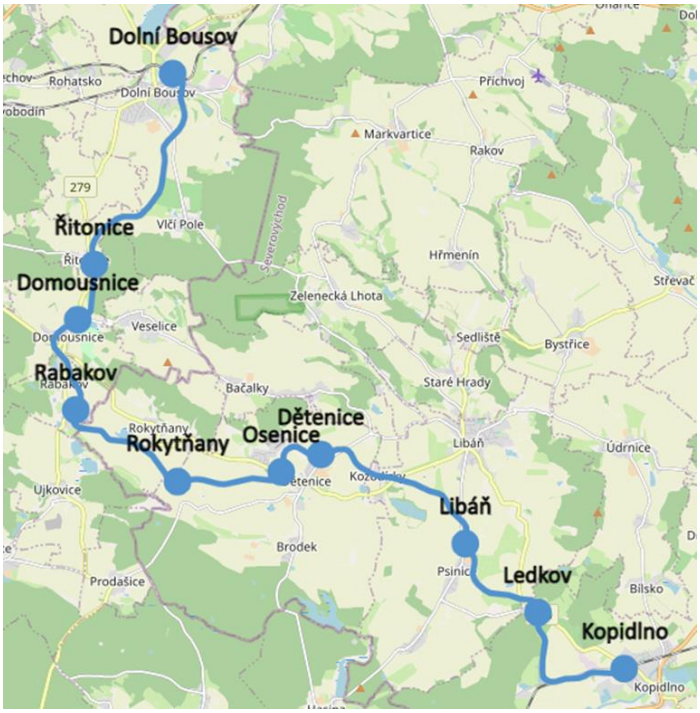


Figure 9: Kopidlno-Dolni Bousov line

For testing purposes, AZD will utilise its experimental train (EDITA), which was specifically developed for practical testing of technologies needed for driverless train operation. The main features of the vehicle can be summarised as follows:

- Independent traction, diesel engine 242kW
- Modern train control (TCMS AVV) with electric braking
- ETCS on-board with ATO GoA2 (TSI compliant)
- Fully integrated Perception system to the vehicle body
- Modular system for several roof antenna installations
- Modular space inside the train accessible for developers for new technologies installations, with available 230V AC, 24V DC and already built-in ethernet networking

Figure 10: Interior AZD test train EDITA

Figure 11: AZD test train EDITA

6. CONCLUSIONS

As a result of the work performed in WP3 Task 3.1 the report addresses use cases applicable to regional G1 lines to allow automation of train operations on regional G1 lines with low traffic and moderate speeds. The report specifies a number of use cases and technical requirements that ATO must meet to improve regional lines performance and overall economic sustainability.

A comprehensive list of ATO use cases is provided along with a definition of demonstrator laboratory set-ups and requirements derived from the use cases.

The solutions explored in the document are the introduction of ATO Grade of Automation 2 (GoA2) up to Grade of Automation 4 (GoA4) for regional applications. The use cases identified establish that:

- There are many similarities with the cases applied on main lines.
- Since the same train can circulate both on main lines and on regional G1 lines, interoperability must be guaranteed.

The use of the ATO over ETCS signalling system is therefore a necessity that has guided the integration of the solutions in the regional context. The ATO functionality developed is thus using ERTMS/ETCS as a platform.

In addition to the standard Grades of Automation, use cases where the train is operated by a remote operator have been specified as a transition and/or fallback system,

The report constitutes the main outcome of FP6 WP3 Task 3.1 (Regional Rail CCS & Operations for G1 Lines Requirements & Specifications), which forms the basis for the demonstration campaigns to be performed by FP6 WP8 Task 8.1 (Development of individual demonstrator ATO GoA2 on G1 regional lines) and Task 8.2 (Development of individual demonstrator ATO GoA3/4 including perception and remote driving on G1 regional lines).

The solutions will first be demonstrated under laboratory conditions in FP6 WP8 targeting the Technology Readiness Level 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

7. REFERENCES

CCS TSI 2023/1695

CLUG: Certifiable Localisation Unit with GNSS, HE funded project, 2019-2022

CLUG2.0: Certifiable Localisation Unit with GNSS 2.0, HE funded project, 2023-2025

ERSAT: Ertms + SATellite, program started in 2012 by RFI in collaboration with Ansaldo STS about integration of satellite technologies on the ERTMS platform

GaLoROI: Galileo Localization for Railway Operation Innovation, FP7 funded project, 2012-2014

GRAIL-2: GNSS-based ATP System for Railway Low Density Lines, FP7 funded project 2010-2013

HELMET: High integrity EGNSS Layer for Multimodal Eco-friendly Transportation, H2020 funded project, 2020-2023

R2DATO: Rail to Digital automated up to autonomous train operation, EU-Rail funded project, 2022-2026

RAILGAP: RAILway Ground truth and digital mAP, HE funded project, 2021-2024

RHINOS: Railway High Integrity Navigation Overlay System will define a GNSS-based system to support the localization of trains respecting the challenging requirements of the railway safety standards, H2020 funded project, 2016-2017

STARS: Satellite Technology for Advanced Railway Signalling, H2020 funded project, 2016-2018

X2RAIL-4: Advanced signalling and automation system - Completion of activities for enhanced automation systems, train integrity, traffic management evolution and smart object controllers, H2020/Shift2Rail funded project, 2019-2023

8.1 ANNEX 1. USE CASES

1. UC_01_1_1_1: Passengers on station with enough leeway

Use Case Group	Discretional stops
Use Case	Passengers on station with enough leeway
UC ID	UC_01_1_1_1
Main actor	ATO-OB GoA2, GoA3 & GoA4
Other actors	ETCS-OB, ATO-TS, TMS.
Main goal	To describe how to perform stops on request, once the passengers on the station have requested the stop with enough leeway to perform the stop.
Assumptions	• **Using current release of ERTMS/ATO specifications** • The Trackside has in advance information regarding any passenger (on station) requesting the train to stop on a station • TMS and ATO-TS are able to obtain the information about any request of stop.
Precondition	• The ATO-OB is engaged. • The stations to be requested on stop is planned for the operation of specific lines.
Flow of events	1. The passenger of the station requests a discretional stop on a specific station. The request is performed with enough time to make a commercial stop. 2. ATO-TS receives information regarding a commercial stop in a specific station. 3. ATO-TS sends to the ATO-OB a JP, whether it is an update of a previous one, or a new one. 4. The JP indicates that the specific station is a Stopping point. The ATO-OB should receive the JP with enough distance to perform the commercial stop. 5. The train reaches the station at a speed according to the station and stops at the station, allowing the passengers to get on and get off the train.

	6. Once the conditions for ATO-OB EG are achieved, the train departs.
Postcondition	The ATO has successfully stop as requested by the passenger on the platform and continues the travel.
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	The means of obtaining the request of stop could vary, whether is by tickets sold or even station interactive panels. This UC is considered as Regional specific because discretional stops are possible only on regional lines, i.e. they not expected in main lines. Requirements: R_01_1_1_1 R_01_1_1_2 Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

2. UC_01_1_1_2: Passengers on station without enough leeway

Use Case Group	Discretional stops
Use Case	Passengers on station without enough leeway
UC ID	UC_01_1_1_2
Main actor	ATO-OB GoA2, GoA3 & GoA4
Other actors	ETCS-OB, ATO-TS, TMS.
Main goal	To describe the situation when the passengers on the station have requested the stop but there is not enough leeway to perform the stop.
Assumptions	• **<u>Using current release of ERTMS/ATO specifications</u>** • The Trackside does not have in advance information regarding any passenger (on station) requesting the train to stop on a station. • • TMS and ATO-TS are able to obtain the information about any request of stop.
Precondition	• The ATO.OB is engaged. • The stations to be requested on stop is planned for the operation of specific lines.
Flow of events	1. The passenger of the station requests a discretional stop on a specific station. The request is performed without enough time to make a commercial stop. 2. ATO-TS does not send to the ATO-OB a JP with a new stopping point at the specific station. 3. The train reaches the station at a speed according to the station and path through the station without a commercial stop.
Postcondition	The ATO-OB was not able to stop on the station and continues the travel.
Safety relation	None (ATO is supervised by ETCS)

Open topics / consideration	The means of obtaining the request of stop could vary, whether is by tickets sold or even station interactive panels. This UC is considered as Regional specific because discretional stops are possible only on regional lines, i.e., they not expected in main lines. <u>Requirements:</u> R_01_1_1_1 R_01_1_1_2 Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

3. UC_01_1_1_3: Passengers on-board with enough leeway

Use Case Group	Discretional stops
Use Case	Passengers on-board with enough leeway
UC ID	UC_01_1_1_3
Main actor	ATO-OB GoA2, GoA3 & GoA4
Other actors	ETCS-OB, ATO-TS, TMS.
Main goal	To describe how to perform stops on request, once the passengers on-board have requested the stop with enough leeway to perform the stop.
Assumptions	• **<u>Using current release of ERTMS/ATO specifications</u>** • The train is equipped with a system that allows the passengers (on-board) to request the next stop • TMS and ATO-TS are able to obtain the information about any request of stop.
Precondition	• The ATO-OB is engaged. • The stations to be requested on stop is planned for the operation of specific lines.
Flow of events	1. The passenger of the train requests a discretional stop on a specific station. The request is performed with enough time to make a commercial stop. 2. ATO-TS receives information regarding a commercial stop in a specific station. 3. ATO-TS sends to the ATO-OB a JP, whether it is an update of a previous one, or a new one. The JP indicates that the specific station is a Stopping point. The ATO-OB should receive the JP with enough distance to perform the commercial stop. 4. The train reaches the station at a speed according to the station and stops at the station, allowing the passengers to get on and get off the train. 5. Once the conditions for ATO-OB EG are achieved, the train departs.
Postcondition	The ATO-OB has successfully stop as requested by the passenger on-board, and continues the travel.

Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	The means of obtaining the request of stop could vary, whether is by tickets sold or even train interactive panels. This UC is considered as Regional specific because discretional stops are possible only on regional lines, i.e., they not expected in main lines.[Requirement]: TMS shall be able to receive information about a request for stop on a station, and as such, the TMS should communicate with the ATO-TS regarding the stop. Requirements: R_01_1_1_1 R_01_1_1_2 Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

4. UC_01_1_1_4: Passengers on-board without enough leeway

Use Case Group	Discretional stops
Use Case	Passengers on-board without enough leeway
UC ID	UC_01_1_1_4
Main actor	ATO-OB GoA2, GoA3 & GoA4
Other actors	ETCS-OB, ATO-TS, TMS.
Main goal	To describe the situation when the passengers on-board have requested the stop but there is not enough leeway to perform the stop.
Assumptions	• **<u>Using current release of ERTMS/ATO specifications</u>** • The train is equipped with a system that allows the passengers (on-board) to request the next stop • • TMS and ATO-TS are able to obtain the information about any request of stop.
Precondition	• The ATO is engaged. • The stations to be requested on stop is planned for the operation of specific lines.
Flow of events	1. The passenger of the train requests a discretional stop on a specific station. 2. The request is performed without enough time to make a commercial stop. 3. ATO-TS does not send to the ATO-OB a JP with a new stopping point at the specific station. 4. The train reaches the station at a speed according to the station and path through the station without a commercial stop.
Postcondition	The ATO-OB was not able to stop on the station and continues the travel.
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	The means of obtaining the request of stop could vary, whether is by tickets sold or even train interactive panels. This UC is considered as Regional specific because discretional stops are possible only on regional lines, i.e., they are not expected in main lines.

	Requirements: R_01_1_1_1 R_01_1_1_2 Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

5. **UC_01_1_1_5: Stop-on-request, no request from train or platform**

Use Case Group	Stop-on-request
Use Case	No request from train or platform
UC ID	
Main actor	ATO-OB GoA2/3/4
Other actors	ATO-TS, TMS, PIS (in the vehicle), PIS (on the platform).
Main goal	To describe how to perform stop on request, when there is no request from train or platform
Assumptions	• **<u>Using adjustment of future specifications, applicable for GoA3-4 and backward compatible with GoA2</u>** • The train is equipped with a system (PIS) that allows the passengers on-board to request the stop and (this system) can forward this information to ATO-OB. • TMS and ATO-TS are able to obtain the information about the request to stop, given by passengers on the platform.
Precondition	• The ATO-OB is engaged. • The station to be requested to stop is planned for the on-request stopping (“on-request” flag in the station data).
Flow of events	Based on on-request flag in the station data: PIS (vehicle) informs passengers that upcoming stop is „on request“. PIS (platform) informs passengers that next train stops only „on request“ ATO-OB calculates the braking curve to possible stopping point and follows it. The passengers on the platform do not request a train to stop in this station (they do not push the „request button“). The passengers inside the train do not request a train to stop in upcoming station (they do not push the „request button“). (optional) At specific distance D_LC before the stopping point, PIS (vehicle) informs passengers about “last call to request the stopping” (“last call”). At specific distance D_DL (“deadline”) before the stopping point, ATO-OB sends message “Train can pass” to ATO-TS. ATO-OB informs PIS (vehicle) about passed deadline, PIS (vehicle) erases the displays. After receiving the message “Train can pass”, ATO-TS sends to ATO-OB JP update in which the upcoming stop is marked as “stopping point to be passed” (“passing” flag). *) PIS (platform) erases the display / displays next train. After receiving the JP update with upcoming stopping point marked as “to be passed”, ATO-OB cancels the braking to stopping point, recalculates the operational speed

	profile to next station and continues in running. PIS (vehicle) displays next station.
Postcondition	The train passed the stop.
Safety relation	No
Open topics / consideration	To consider whether to use value 1 (“Stopping Point to be skipped”) or value 2 (“Passing point”) of Q_Stop_Skip_Pass variable for skipping the station. Value 2 seems to be better, keeping value 1 for forced skipping ordered by dispatcher. In these Test cases, value 1 is used.[Requirement]: IM and RU shall determine the minimum time / distance the request for stop on a station shall be made to be accepted and send to the ATO-TS Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

6. **UC_01_1_1_6: Stop-on-request, request from the train, in-time.**

Use Case Group	Stop-on-request
Use Case	Passenger's request from the train, the request is given in-time.
UC ID	
Main actor	ATO-OB GoA2/3/4
Other actors	ATO-TS, TMS, PIS (in the vehicle), PIS (on the platform).
Main goal	To describe how to perform stops on request, once the passengers on-board have requested the stop and the request was given sufficiently in time.
Assumptions	• **Using adjustment of future specifications, applicable for GoA3-4 and backward compatible with GoA2** • The train is equipped with a system (PIS) that allows the passengers on-board to request the stop and (this system) can forward this information to ATO-OB. • TMS and ATO-TS are able to obtain the information about the request to stop, given by passengers on the platform.
Precondition	• The ATO-OB is engaged. • The station to be requested to stop is planned for the on-request stopping ("on-request" flag in the station data).
Flow of events	Based on on-request flag in the station data: PIS (vehicle) informs passengers that upcoming stop is „on request". PIS (platform) informs passengers that next train stops only „on request". ATO-OB calculates the braking curve to possible stopping point and follows it. The passenger in the train requests the train to stop (by pushing the request button), the request is done before the deadline has passed (i.e., at last when "last call" is given). PIS (vehicle) displays "The train shall stop". (optional) ATO-OB sends to ATO-TS information "Train shall stop". When ATO-TS receives this information, it asks PIS (platform) to display "The train shall stop". ATO-OB continues in braking to stopping point and finally it stops in given place. Once the conditions for ATO-OB EG are achieved, the train departs.
Postcondition	The ATO-OB has successfully stop as requested by the passenger on-board, and continues the travel.
Safety relation	No
Open topics / consideration	[Requirement]: IM and RU shall determine the minimum time the request for stop on a station shall be made to be accepted and send to the ATO-TS Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases**

	UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

7. **UC_01_1_1_7: Stop-on-request, request from the train, too late.**

Use Case Group	Stop-on-request
Use Case	Passenger's request from the train, the request is given too late.
UC ID	
Main actor	ATO-OB GoA2/3/4
Other actors	ATO-TS, TMS, PIS (in the vehicle), PIS (on the platform).
Main goal	To describe how to perform stops on request, once the passengers on-board have requested the stop but the request was given too late.
Assumptions	• **<u>Using adjustment of future specifications, applicable for GoA3-4 and backward compatible with GoA2</u>** • The train is equipped with a system (PIS) that allows the passengers on-board to request the stop and (this system) can forward this information to ATO-OB. • TMS and ATO-TS are able to obtain the information about the request to stop, given by passengers on the platform.
Precondition	• The ATO-OB is engaged. • The station to be requested to stop is planned for the on-request stopping ("on-request" flag in the station data).
Flow of events	• Based on on-request flag in the station data: PIS (vehicle) informs passengers that upcoming stop is „on request". PIS (platform) informs passengers that next train stops only „on request". • ATO-OB calculates the braking curve to possible stopping point and follows it. • (optional) At specific distance D_LC before the stopping point, PIS (vehicle) informs passengers about "last call to request the stopping" ("last call"). • At specific distance D_DL ("deadline") before the stopping point, ATO-OB sends message "Train can pass" to ATO-TS. ATO-OB informs PIS (vehicle) about passed deadline, PIS (vehicle) erases the displays. • Now, the passenger in the train requests the train to stop, but the request is done too late, as the deadline has already passed. Due to this, ATO-OB rejects this request. • After receiving the message "Train can pass", ATO-TS sends to ATO-OB JP update in which the upcoming stop is marked as "stopping point to be passed" ("passing" flag). PIS (platform) erases the display / displays next train. • After receiving the JP update with upcoming stopping point marked as "to be passed", ATO-OB cancels the braking to stopping point, recalculates the operational speed profile to next station and continues in running. PIS (vehicle) displays next station.
Postcondition	The train passed the stop.
Safety relation	No

Open topics / consideration	[Requirement]: IM and RU shall determine the minimum time the request for stop on a station shall be made to be accepted and send to the ATO-TS Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

8. **UC_01_1_1_8: Stop-on-request, request from the platform, in-time.**

Use Case Group	Stop-on-request
Use Case	Passenger's request from the platform, the request is given in-time.
UC ID	
Main actor	ATO-OB GoA2/3/4
Other actors	ATO-TS, TMS, PIS (in the vehicle), PIS (on the platform).
Main goal	To describe how to perform stops on request, once the passengers on the platform have requested the stop and the request was given sufficiently in time.
Assumptions	• **<u>Using adjustment of future specifications, applicable for GoA3-4 and backward compatible with GoA2</u>** • The train is equipped with a system (PIS) that allows the passengers on-board to request the stop and (this system) can forward this information to ATO-OB. • TMS and ATO-TS are able to obtain the information about the request to stop, given by passengers on the platform.
Precondition	• The ATO-OB is engaged. • The station to be requested to stop is planned for the on-request stopping ("on-request" flag in the station data).
Flow of events	Based on on-request flag in the station data: PIS (vehicle) informs passengers that upcoming stop is „on request". PIS (platform) informs passengers that next train stops only „on request". ATO-OB calculates the braking curve to possible stopping point and follows it. The passenger on the platform requests the train to stop, the request is done sufficiently in time, i.e. before ATO-OB sends the information "The train can pass" to ATO-TS. PIS (platform) displays "The train shall stop". (optional) ATO-TS sends to ATO-OB JP update in which the upcoming stop is marked as "stopping point" ("stopping" flag). PIS (vehicle) displays "The train shall stop". ATO-OB continues in braking to stopping point and finally it stops in given place. Once the conditions for ATO-OB EG are achieved, the train departs.
Postcondition	The ATO-OB has successfully stop as requested by the passenger on the platform, and continues the travel.
Safety relation	No
Open topics / consideration	The request to stop can be derived also from other channels, e.g. by tickets sold or specific mobile application. [Requirement]: IM and RU shall determine the minimum time the request for stop on a station shall be made to be accepted and send to the ATO-TS

	Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

9. **UC_01_1_1_9: Stop-on-request, request from the platform, too late.**

Use Case Group	Stop-on-request
Use Case	Passenger's request from the platform, the request is given too late.
UC ID	UC_01_1_1_9
Main actor	ATO-OB GoA2/3/4
Other actors	ATO-TS, TMS, PIS (in the vehicle), PIS (on the platform).
Main goal	To describe how to perform stops on request, once the passengers on the platform have requested the stop but the request was given too late.
Assumptions	• **<u>Using adjustment of future specifications, applicable for GoA3-4 and backward compatible with GoA2</u>** • The train is equipped with a system (PIS) that allows the passengers on-board to request the stop and (this system) can forward this information to ATO-OB. • TMS and ATO-TS are able to obtain the information about the request to stop, given by passengers on the platform.
Precondition	• The ATO-OB is engaged. • The station to be requested to stop is planned for the on-request stopping ("on-request" flag in the station data).
Flow of events	• Based on on-request flag in the station data: PIS (vehicle) informs passengers that upcoming stop is "on request". PIS (platform) informs passengers that next train stops only "on request". • ATO-OB calculates the braking curve to possible stopping point and follows it. • (optional) At specific distance D_LC before the stopping point, PIS (vehicle) informs passengers about "last call to request the stopping" ("last call"). • At specific distance D_DL ("deadline") before the stopping point, ATO-OB sends message "Train can pass" to ATO-TS. ATO-OB informs PIS (vehicle) about passed deadline, PIS (vehicle) erases the displays. After receiving the message "Train can pass", ATO-TS sends to ATO-OB JP update in which the upcoming stop is marked as "stopping point to be passed" ("passing" flag). PIS (platform) erases the display / displays next train. Now, the passenger on the platform requests the train to stop, but the request is done too late, as the deadline has already passed. Due to this, ATO-TS rejects this request and does no other JP update. After receiving the JP update with upcoming stopping point marked as "to be passed", ATO-OB cancels the braking to stopping point, recalculates the operational speed profile to next station and continues in running. PIS (vehicle) displays next station.
Postcondition	The train passed the stop.

Safety relation	No
Open topics / consideration	The request to stop can be derived also from other channels, e.g. by tickets sold or specific mobile application. [Requirement]: IM and RU shall determine the minimum time the request for stop on a station shall be made to be accepted and send to the ATO-TS Relevant Use Cases and Operational Scenarios Developed in previous projects: **R2DATO WP5 Use Cases** UC5.1-016 Implementing discretional stops by regional services **X2R4 Operational Scenarios** R6 React to journey update **X2R4 SRS Use Cases** 13.4.7 Determine stopping point for a freight or passenger train 13.6.1 Manage passenger information systems 13.8.1 React after misrouting.

10. UC_01_1_2_1: Operation under high odometry error

Use Case Group	Operation under high odometry error
Use Case	Operation under high odometry error
UC ID	UC_01_1_2_1
Main actor	ATO-OB GoA2
Other actors	ETCS-OB, ATO-TS.
Main goal	Evaluate the interaction and behaviour of the ATO under situations of high odometry error (i.e. loss of GNSS, long distance between balises…).
Assumptions	• The ATO-OB may be directly interfaced to odometer sensors
Precondition	• The ATO-OB is engaged.
Flow of events	1. The train is running with a high odometry error. 2. The ATO-OB is operating the train without ETCS brake intervention. 3. The ATO-OB performs a stop at a Stopping point within the position margin for the Stopping point (i.e. the tolerance configured in the Segment Profile for this stopping point). 4. Once the conditions for ATO-OB EG are achieved, the train departs.
Postcondition	The ATO operates as efficient as possible under the ETCS limits.
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	The ATO-OB is able to be interfaced with odometer sensors. To be discussed the application of its instalment and the relation with the ETCS odometry. This UC is considered as Regional specific because regional lines have lower deployment costs (e.g., long distance between balises) and lower maintenance works, (e.g., more time to replace a failure balise) than main lines.

11. UC_01_1_2_2: Operation under high odometry error with Virtual Balise Group functionality implemented

Use Case Group	Operation under high odometry error
Use Case	Operation under high odometry error with virtual BG function implemented
UC ID	UC_01_1_2_2
Main actor	ATO-OB GoA2
Other actors	ETCS-OB
Main goal	Evaluate the stopping accuracy of the ATO-OB in situations of high odometry error of the ETCS-OB (i.e. loss of GNSS, long distance between balises…) when a Virtual Balise Group has been configured in rear of the stopping point.
Assumptions	• The ATO-OB relies only on ETCS-OB odometry (no specific ATO sensors installed on the vehicle) • The ETCS-OB is supported by an enhanced odometry system
Precondition	• The ATO-OB is engaged • Virtual Balise Group (enhanced odometry) has been configured in rear of the stopping point.
Flow of events	The train is running with a high odometry error (e.g. the ETCS-OB confidence interval is not relocated by physical BGs in the last 2000m in rear of the stopping point). The ATO-OB is operating the train without ETCS brake intervention. While approaching the stopping point a Virtual Balise Group is received by the ETCS-OB that performs the relocation resetting the confidence interval The ATO-OB stops the train at a Stopping point within the tolerance for the Stopping point position. Once the conditions for ATO-OB EG are achieved, the train departs.
Postcondition	The ATO-OB operates as efficient as possible under the ETCS limits.
Safety relation	No

Open topics / consideration	The presence of the Virtual Balise Group or of a physical Balise Group is irrelevant for the lab testing of this UC (the scope of this UC is to check the degraded odometry when no specific ATO on-board sensors are installed as an alternative to the UC_01_1_2). This UC is considered as Regional specific because regional lines have lower deployment costs (e.g., long distance between balises) and lower maintenance works, (e.g., more time to replace a failure balise) than main lines.

12. UC_01_1_3_1: Temporary Speed Restriction

Use Case Group	Temporary Speed Restriction
Use Case	Temporary Speed Restriction
UC ID	UC_01_1_3_1
Main actor	ATO-OB GoA2
Other actors	ETCS-OB, ETCS-TS, ATO-TS, Train Driver, TMS.
Main goal	The driver detects a situation where a TSR would be required (i.e. due to high-speed lateral wind) but there is no TSR available on-board.
Assumptions	The TSR was not received due to a lack of communication with the on-board because of a radio hole.
Precondition	The ATO is engaged. A condition for a TSR has occurred
Flow of events	The train does not receive a TSR. The Train Driver detects that a TSR should be applied but it is not being considered by the ATO. The Train Driver disengaged ATO and runs manually the train. Once the Train Driver detects that the permitted speed is the correct, the Train Driver engages the ATO.
Postcondition	The train has exited the radio hole area and ATO is engaged again.
Safety relation	Safety relevant.
Open topics / consideration	The specific situations to be discussed. This UC is considered as Regional specific because regional lines have lower deployment costs (e.g., there are more radio holes and cheaper engineering that do not mitigate the case that a TSR should be sent to the OBU when the OBU is in a radio-hole) than main lines. To be discus how to advise the Train Driver that is possible to have a non-announcement TSR inside a Radio Hole.

13. UC_01_1_4_1: The train cross an automatic level crossing working in nominal conditions

Use Case Group	Level Crossing
Use Case	The train cross an automatic level crossing working in nominal conditions
UC ID	UC_01_1_4_1
Main actor	ATO-OB GoA2, GoA3 & GoA4
Other actors	ETCS-OB, ATO-TS, Train Driver, TMS
Main goal	The ETCS-OB received the information about an automatic level crossing that is working properly and report that is protected and cross the LX.
Assumptions	The on-board has knowledge of the information regarding LX. Fail safe level crossing working in nominal conditions
Precondition	The ATO-OB is engaged and the MA cover the level crossing
Flow of events	The train reaches the trigger point where the protection of the LX is activated. The automatic LX perform the protection measures correctly. The LX is protected. The train passes in AD mode the LX without any additional measures or driver intervention.
Postcondition	The level crossing is pass with ATO-OB engaged, no train driver actions required
Safety relation	Safety relevant.
Open topics / consideration	This UC is considered as Regional specific because LX are more common in regional lines than in main lines.

14. UC_01_1_4_2: The train cross an automatic level crossing reporting non protected status

Use Case Group	Level Crossing
Use Case	The train cross an automatic level crossing reporting non protected status
UC ID	UC_01_1_4_2
Main actor	ATO-OB GoA2
Other actors	ETCS-OB, ATO-TS, Train Driver, TMS
Main goal	The train received the information about an automatic level crossing reporting that is not protected and cross the LX.
Assumptions	The on-board has knowledge of the information regarding LX. Fail safe level crossing
Precondition	The ATO-OB is engaged, and the MA cover the level crossing
Flow of events	The train reaches the trigger point where the protection of the LX is activated. The automatic LX do not perform the protection measures correctly. The LX is not protected. The ETCS-TS sends a packet 88 with Q_LXSTATUS=1. The Train Driver is informed that the LX is not protected thus the ETCS-OB leaves the AD mode and the ATO-OB disengages. The Train Driver is responsible for proceeding towards the unprotected LX. Once the Train Driver has verified that it is safe to pass the level crossing, and the operational conditions still apply, the ATO-OB is re-engaged. The train passes in AD mode the LX following the limitations of packet 88.
Postcondition	The level crossing is passed and ATO-OB is engaged
Safety relation	Safety relevant.

Open topics / consideration	The values of the variables of packet 88 (limitations of packet 88) can vary depending on the trackside. This UC is considered as Regional specific because LX are more common in regional lines than in main lines. For an adaptation to GoA3 & GoA4, it should be considered that the actual Subset-026 4.0.0 stablish that ATO mode (AD) is lost when the Train Driver is informed that the LX is not protected.

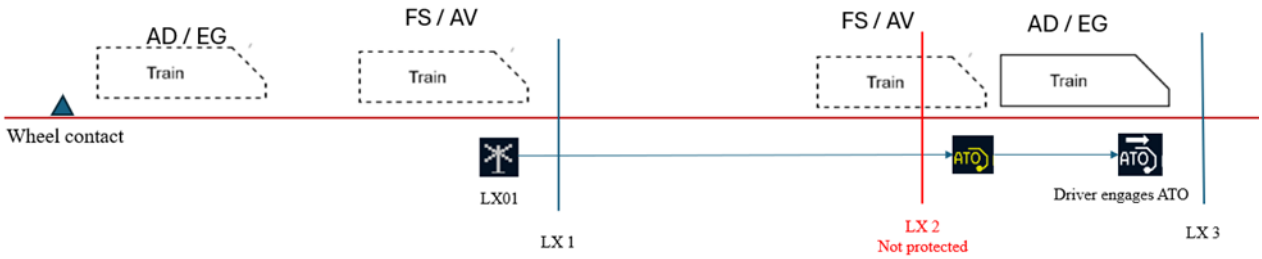
15. UC_01_1_4_3: The train cross a non-protected level crossing

Use Case Group	Level Crossing
Use Case	The train cross a non-protected level crossing
UC ID	UC_01_1_4_3
Main actor	ATO-OB GoA2
Other actors	ETCS-OB, ATO-TS, Train Driver, TMS
Main goal	The train crosses a level crossing which is not protected.
Assumptions	• The on-board has knowledge of the information regarding LX. • Non-protected level crossing
Precondition	• The ATO-OB is engaged, and the MA cover the level crossing
Flow of events	1. The Train Driver is informed that the LX is not protected. 2. The driver performs the necessary operational procedures. 3. The LX is crossed following the required limitations.
Postcondition	The level crossing is passed and ATO-OB is engaged
Safety relation	Safety relevant.
Open topics / consideration	To be considered that these LX are different from the UC_01_1_4_2 because this type of LX doesn't have installed protection that indicates when it is safe to cross it. In contrast, the other use case refers to a protected level crossing that for any reason has an unprotected state The values of the variables of packet 88 (if it is used) can vary depending on the trackside. This UC is considered as Regional specific because LX are more common in regional lines than in main lines. For an adaptation to GoA3 & GoA4, it should be considered that the actual Subset-026 4.0.0 stablish that ATO mode (AD) is lost when the Train Driver is informed that the LX is not protected.

16. UC_01_1_4_4: The train cross a group of automatic level crossings reporting non protected status

Use Case Group	Level Crossing
Use Case	The train cross a group of automatic level crossings reporting non protected status
UC ID	UC_01_1_4_4
Main actor	ATO-OB GoA2
Other actors	ETCS-OB, ATO-TS, Train Driver
Main goal	The train received the information about an automatic level crossing reporting that is not protected.
Assumptions	• A group of LX (up to 3) is managed by the same automatic system (e.g. one activation point for all the three LXs) • The ETCS-OB has knowledge of the information regarding LX and ETCS-TS is configured for request a stop in rear of the non-protected LX. • Fail safe level crossing
Precondition	• The ATO-OB is engaged, and the MA covers the group of level crossings (up to 3 LXs)
Flow of events	1. The train reaches the trigger point where the protection of the LX group is activated. 2. The automatic LX does not perform the protection measures correctly (the second LX of a group of three has a technical issue and it is not protected). 3. The ETCS-TS sends a packet 88 with Q_LXSTATUS=1 (for the LX that is not protected). 4. As soon as the driver is informed that the LX is not protected (icon LX01 displayed on ETCS-OB DMI) the ETCS-OB leaves the AD mode and the ATO-OB disengages. 5. The driver takes the manual control and stops the train in rear of the failed LX (the first LX is passed without stopping). 6. The driver restarts running the train if the conditions of the LX allows to do so 7. The driver re-engages the ATO-OB when the second LX is passed by the train
Postcondition	The third level crossing is passed, ATO-OB is engaged

Safety relation	Safety relevant.
Open topics / consideration	The values of the variables of packet 88 (limitations of Packet 88) can vary depending on the trackside (e.g. stopping requested or not). An Obstacle detection could be used to prove that the LX area is clear (i.e. MA is not shortened but the P88 is used to stop the train) Different operational choices can be applied by the railways for passing with ATO GoA2 an unprotected LX (e.g. ATO-OB could be re-engaged by the driver when crossing an unprotected LX). This UC is considered as Regional specific because LX are more common in regional lines than in main lines (often grouped to minimize trackside assets, e.g. activation points).



17. UC_01_1_5_1: Radio Hole

Use Case Group	Radio Hole
Use Case	Radio Hole
UC ID	UC_01_1_5_1
Main actor	ATO-OB GoA2, GoA3 & GoA4, ETCS-OB
Other actors	ATO-TS, Train Driver, TMS
Main goal	The train received the information about a radio hole and continue in AD mode during the radio hole.
Assumptions	• Radio hole is known and announced by ETCS-TS
Precondition	• The ATO is engaged, and the MA cover the radio hole
Flow of events	1. The ETCS-TS sends a Radio hole announcement. 2. The ATO-OB enters the radio hole area. 3. The ATO-OB runs inside the radio hole area without any issues. 4. The ATO-OB exits the radio hole still in EG state (ETCS-OB is in AD mode).
Postcondition	The radio hole is passed, ATO is engaged, and radio communication is active
Safety relation	Safety relevant.
Open topics / consideration	A radio hole for ETCS-OB not necessary implies a lack of communication for ATO. This UC is considered as Regional specific because regional lines have lower deployment costs, e.g., radio hole are more often than in main lines. <u>Requirements:</u> R_01_1_5_1

18. UC_01_1_5_2: ATO Radio Hole

Use Case Group	Radio Hole
Use Case	ATO Radio Hole
UC ID	UC_01_1_5_2
Main actor	ATO-OB GoA2, ETCS-OB
Other actors	ATO-TS, Train Driver
Main goal	When the train enters a radio hole where the ATO-OB / ATO-TS communication is lost, ATO-OB remains in EG state during the ATO radio hole and requests an update of JP as soon as the communication with ATO-TS is re-established.
Assumptions	• If Radio holes affect ETCS, they are known and announced by ETCS-TS, • the ATO is using a radio system different from ETCS-OB
Precondition	• The ATO-OB is engaged, the MA covers the radio hole, the next timing point in the JP covers the radio hole.
Flow of events	1. The ATO-OB enters the radio hole area. 2. The ATO-OB runs inside the radio hole area without any issues. 3. When the ATO-OB exits the radio hole it is still in EG state, it reestablish the connection with ATO-TS and receives a JP update. 4. The ATO-OB recalculates the optimum speed profile and sends a Status Report remaining in EG state (ETCS-OB in AD mode)
Postcondition	The radio hole is passed, ATO-OB is engaged with the radio communication active
Safety relation	No
Open topics / consideration	This UC is considered as Regional specific because regional lines have lower deployment costs, e.g., the UC is applicable to applications where the ATO uses a different radio system (e.g. it is not economically affordable to migrate the radio system to GSM-R Packet Switching, considering also the further migration to FRMCS. [Requirement]: The information (Segment Profiles and Journey Profiles) required to operate ATO should cover the full length of the radio hole area.

19. UC_01_1_6_1: Prove Clear Ahead

Use Case Group	Prove Clear Ahead
Use Case	Prove Clear Ahead
UC ID	UC_01_1_6_1
Main actor	ATO-OB GoA3/4, ETCS-OB
Other actors	ETCS-TS, ATO-TS, TMS, Track ahead detector.
Main goal	In cases where the train is stopped and requires a SoM in plain line, the ETCS-OB could perform a PCA using ATO.
Assumptions	• The ATO is capable of detecting obstacles on the track.
Precondition	• The train stop in plain line and the trackside is not able to determinate that the track ahead is free.
Flow of events	1. The train receive an OS MA until the next signal with a reduced speed. 2. The ATO-OB runs in a ATO GoA3/4 mode at reduced speed using obstacle detection systems as the track could be already occupied by another train, or obstructed by any kind of obstacle. 3. The train reaches the PCA area, and receive a new MA with nominal speed (ATAF), continuing in AD mode.
Postcondition	The ATO is engaged and running at nominal speed.
Safety relation	Safety relevant.
Open topics / consideration	To be discussed the ability of the ATO to detect objects. This UC is considered as Regional specific because regional lines have lower deployment costs, e.g., less balises, therefore more distance until the next PCA area. New ATO mode different from AD (only valid when the on-board could be in FS) for MA OS and other ETCS mode shall be added to the specifications. This could be one mode or different ATO modes, to be discussed. <u>Requirements:</u> R_01_1_6_1

20. UC_01_1_7_1: Object in the track

Use Case Group	Object in the track
Use Case	Object in the track
UC ID	UC_01_1_7_1
Main actor	ATO-OB GoA3/4
Other actors	ETCS-OB, ATO-TS, TMS, Track ahead detector.
Main goal	The Onboard detects an obstacle on the track and applies brake.
Assumptions	• The Onboard is capable of detecting obstacles on the track.
Precondition	• The train is moving • The ATO is engaged.
Flow of events	1. The ATO-OB approaches an obstacle. 2. The obstacle detection systems detect an obstacle. 3. The ATO-OB commands brake. 4. The train reaches standstill. 5. The ATO-OB warns that it has stopped due to an obstacle. 6. The ATO disengaged itself.
Postcondition	The train is stopped and ATO is not engaged.
Safety relation	Safety relevant.
Open topics / consideration	To be discussed the ability of the ATO to detect objects. This UC is considered as Regional specific because regional lines have lower deployment costs (e.g., there could be no fence protecting the track from external objects) and lower maintenance works, (e.g., the track is not reviewed to detect external objects) than main lines. To be discussed how the ATO-OB is able to communicate the reason for the application of the brake. <u>Requirements:</u> R_01_1_6_1 R_01_1_7_1

21. UC_01_1_7_2: Unprotected Level Crossing

Use Case Group	Object in the track
Use Case	Object in the tracks – Unprotected Level Crossing
UC ID	UC_01_1_7_2
Main actor	Perception
Other actors	APM, ADM, Repository
Main goal	System can reliably evaluate the presence of potential crossing objects on unprotected level crossings by incorporating the right train driving strategy as well as fine tuning the mechanism for detecting potential obstacles on the identified spots.
Assumptions	• Perception module can detect obstacles on the track. • The information about unprotected LXs is in repository (Perception system receives a-priory information regarding the location and characteristics of unprotected level crossing).
Precondition	• Train has valid MA from ETCS • The onboard repository/register contains up-to-date information regarding journey and segment profile • The onboard repository contains information about unprotected level crossing • The ATO is engaged. The ATO is active and in GoA3/4 mode • For the sake of testing, there will be a static obstacle positioned in the level crossing area.
Flow of events	1. Train automatically approaches an unprotected level crossing area, according to valid journey profile 2. REP informs APM about approaching unprotected LX 3. PER informs APM about actual visibility range 4. APM sends a temporary speed limit to PAL due to unprotected LX 5. PAL sends new MA to the end of PER visibility 6. PAL informs ATO-OB about speed restriction 7. ATO-OB adjusts train speed 8. PER detects an object in area of interest 9. PER sends information about object to APM 10. APM evaluate object as an obstacle 11. (Optional) The train activates horn. 12. APM sends information about obstacle to PAL 13. PAL sets new MA in front of the obstacle 14. The ATO-OB commands brake. 15. The train stops in front of the obstacle 16. The ATO disengaged itself. 17. APM inform IM about train stop

Postcondition	The train is stopped, and system is ready to receive commands regarding continuation of the journey.
Safety relation	Safety relevant.
Open topics / consideration	In some regional lines, there may be significant high number of unprotected level crossings. Driving the train in ATO GoA3/4 mode, it means that obstacle detection system shall be aware about those areas and process the risk of higher probability of potential presence of objects using the crossing path. Potential variants of the use case: The obstacle is removed from LX area before the train approaches (and no stop is necessary). Obstacle detection may recognise various types of objects and adjust driving the train accordingly. [Requirement]: ATO trackside shall provide on-board in advance with the location and characteristics (relevant for perception system) of unprotected level crossings ahead the train.

22. UC_01_1_7_3: Animals near the track

Use Case Group	Object in the track
Use Case	Object in the tracks – Animals near the track
UC ID	UC_01_1_7_3
Main actor	Perception
Other actors	APM, ADM, Repository
Main goal	By evaluating the surroundings of the line from the perspective of potential animal presence, obstacle detection system should efficiently evaluate whether the animal in close area around the line represent the acceptable risk for the train or whether the train should initiate the stop to avoid potential accident or damage.
Assumptions	• The ATO Perception module can detect obstacles on the track. The areas with higher risk of animal presence may be indicated in onboard repository/register. • Train drive may be alternatively simulated with injected perception data or within real environment with scale model of an animal.
Precondition	• Train receives MA from ETCS. • The ATO is engaged. • The ATO is active and in GoA3/4 mode. • The onboard repository/register contains up-to-date information regarding journey and segment profile
Flow of events	1. Train automatically approaches an area with higher risk of animal presence, following the valid journey profile. 2. REP informs APM about approaching an area with higher risk of animal presence 3. PER detects an animal within the risk area and determines the possibility of a collision. 4. PER sends information about object to APM 5. APM evaluates object as an obstacle (if evaluated as critical from the accident risk and consequence perspective) 6. APM sends information about obstacle to PAL 7. PAL sets new MA in front of the obstacle 8. The ATO-OB commands brake. 9. The train stops in front of the obstacle 10. The ATO disengaged itself.

	11. APM inform IM about train stop
Postcondition	The train is stopped, and system is ready to receive commands regarding continuation of the journey.
Safety relation	Safety relevant.
Open topics / consideration	From the obstacle detection perspective, each train's operational environment is a specific one with unique characteristics that shall be taken into account. In many regional lines, animals (domestic or wild) are commonly moving around the track and may represent a higher risk of accident when crossing the route of moving train. Similarly, system should accept presence of animals if they are on the safe distance in respect to the train and avoid unnecessary train stops. [Requirement]: Perception system should be validated for use on the specific line, considering potential presence of animals, typical for the region.

23. UC_01_1_7_4: Fire near the track

Use Case Group	Object in the track
Use Case	Object in the tracks – Fire near the track
UC ID	UC_01_1_7_4
Main actor	Perception
Other actors	APM, ADM, Repository
Main goal	Driverless system shall be able to distinguish between the scenario when the train shall be prevented to enter the area under the fire and the scenario of “controlled” fire by local people that doesn`t have any impact on train operation.
Assumptions	• The ATO Perception module can detect obstacles on the track. The areas with higher risk of fire presence may be indicated in onboard repository/register. • Train drive may be alternatively simulated with injected perception data or within real environment with experimental fire/smoke production.
Precondition	• Train receives MA from ETCS. • The ATO is engaged. • The ATO is active and in GoA3/4 mode. • The onboard repository/register contains up-to-date information regarding journey and segment profile.
Flow of events	1. Train automatically approaches an area with presence of the fire, following the valid journey profile. 2. The onboard system detects a fire or smoke and determines whether indicated situation prevents a safe continuation of the train ride. 3. Train adjusts its drive according to the distance and type of the fire/smoke. 4. The train stops in front of the fire/smoke (if evaluated as critical from the accident risk and consequence perspective). 5. The train remains standstill. 6. The train communicates the event to the trackside
Postcondition	The train is stopped, and system is ready to receive commands regarding continuation of the journey.
Safety relation	Safety relevant.
Open topics / consideration	In certain periods of the year, especially in autumn, people burn fallen leaves or other parts of maintained gardens as part of their cleaning routine.

24. UC_01_1_7_5: Parking lot near the track

Use Case Group	Object in the track
Use Case	Object in the tracks – Parking lot near the track
UC ID	UC_01_1_7_5:
Main actor	Perception
Other actors	APM, ADM, Repository
Main goal	Driverless system shall know the areas in close vicinity to the line, where the cars are likely to be present, but very unlikely to enter the line. In these cases, the risk of potential collision with the car is negligible and therefore train shall avoid unnecessary braking or stops on these locations and thus being more energy efficient and provide more fluid service.
Assumptions	The ATO Perception module can detect obstacles on the track. The areas with parking lots with cars parking closer (than usual) to the tracks may be indicated in onboard repository/register. • Train drive may be alternatively simulated with injected perception data or train may pass a real parking lot with cars near the track. •
Precondition	• Train receives MA from ETCS • The ATO is engaged. • The ATO is active and in GoA3/4 mode • The onboard repository/register contains up-to-date information regarding journey and segment profile.
Flow of events	1. Train automatically approaches an area with Parking lot near the track, following the valid journey profile. 2. REP informs APM about approaching an area with Parking lot near the track 3. The onboard system detects the parking lot and determines whether indicated situation is the standard one or the one which prevents a safe continuation of the train ride. 4. Train adjusts its drive according to the evaluated situation. 5. In case that no car or any other objects is heading directly towards the area of railway line, the train will continue its ride.

Postcondition	The train passes a parking lot in close vicinity of the line without any operational disturbance and keeps reporting its position and status to the trackside.
Safety relation	Safety relevant.
Open topics / consideration	In some regional lines in contrast to other types of lines, it is quite common that parking lots are in very close vicinity of that line. [Requirement]: ATO trackside shall provide on-board in advance with the location and characteristics (relevant for perception system) of parking lots near the line.

25. UC_01_1_8_1: Train Driver reports Slippery Rail/Non-Slippery Rail

Applicable to	GoA2
Use Case Group	Adhesion Management
Use Case	Train Driver reports Slippery Rail/Non-Slippery Rail
UC ID	UC_01_1_8_1
Main actor	Train Driver
Other actors	ETCS-OB, ATO-OB, ATO-TS, TMS
Main goal	To describe how Slippery Rail/Non-Slippery Rail conditions are reported when Train Driver presses the Slippery Rail/Non-Slippery Rail DMI button in a specific location of the track.
Assumptions	ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. Train Driver becomes aware of: a. Low adhesion conditions on the track (Slippery Rail) b. Low adhesion conditions no longer present on the track (Non-Slippery Rail) 2. Train Driver presses: a. Slippery Rail DMI button b. Non-Slippery Rail DMI button 3. The DMI: a. Displays the Slippery Rail symbol b. Removes the Slippery Rail symbol 4. ETCS-OB informs ATO-OB on adhesion conditions through SS130 1.0.0 Packet Number 6: a. M_ADHESION_DRIVER = 0 (Slippery Rail is set by the driver) b. M_ADHESION_DRIVER = 1 (Slippery Rail is not set by the driver). 5. ATO-OB informs ATO-TS on adhesion conditions through SS126 1.0.0 Status Report a. Q_STR_Indicators (bit3 = 1): Low adhesion reported by the driver b. Q_STR_Indicators (bit3 = 0): Low adhesion not reported by the driver 6. ATO-TS receives the Status Report and informs the TMS about: a. Slippery Rail in a specific location of the track b. Non-Slippery Rail in a specific location of the track
Postcondition	TMS receives and process adhesion information when reported by Train Driver (UC_01_3_2_1)
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_1

26. UC_01_1_8_2: Adhesion is reported by TCMS/Train

Use Case Group	Adhesion Management
Use Case	Adhesion is reported by TCMS/Train
Applicable to	GoA2, GoA3, GoA4
UC ID	UC_01_1_8_2
Main actor	TCMS/Train
Other actors	Traction/Braking system, ATO-OB, ATO-TS, TMS
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. The traction/braking system of the train identifies a certain adhesion level and transmits it to the TCMS/Train 2. TCMS/Train associates the reported adhesion level with one of the following categories: • Dry Rail • Dry Rail (Medium) • Dry Rail (Low) • Low Adhesion • Very Low Adhesion • Extremely Low Adhesion 3. TCMS/Train reports an adhesion category to ATO-OB 4. ATO-OB reports ATO-TS on the adhesion category through Status Report Packet 5. ATO-TS reports to TMS on the adhesion category
Postcondition	TMS receives and process adhesion information when reported by TCMS/Train (UC_01_3_2_2)
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Requirements: R_01_1_8_1 R_01_1_8_2 R_01_1_8_3 R_01_1_8_4 R_01_1_8_5 Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_2

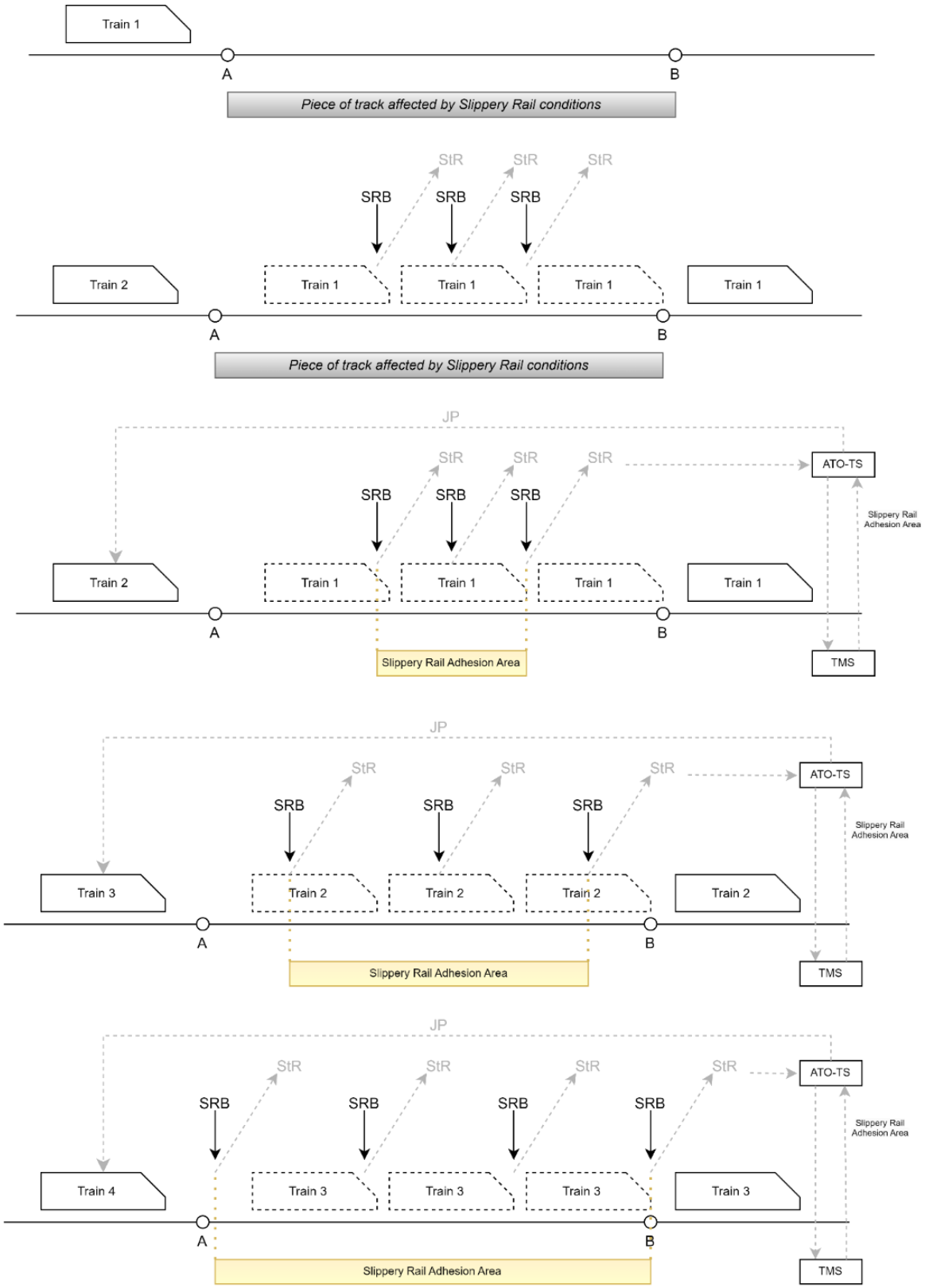
27. UC_01_1_8_3: ATO-TS reports adhesion conditions on the basis of the information received from TMS

Use Case Group	Adhesion Management
Use Case	ATO-TS reports adhesion conditions on the basis of the information received from TMS
Applicable to	GoA2, GoA3, and GoA4
UC ID	UC_01_1_8_3
Main actor	ATO-TS
Other actors	External Source, TMS, ATO-OB
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 by means of the Journey Profile sent by ATO-TS to ATO-OB.
Assumptions	ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. UC_01_3_2_3 2. ATO-TS elaborates a new Journey Profile where: • Q_ADHESION_Category = 0 (Dry Rail) • Q_ADHESION_Category = 1 (Dry Rail, Medium) • Q_ADHESION_Category = 2 (Dry Rail, Low) • Q_ADHESION_Category = 3 (Low Adhesion) • Q_ADHESION_Category = 4 (Very Low Adhesion) • Q_ADHESION_Category = 5 (Extremely Low Adhesion) 3. ATO-TS sends the new Journey Profile to the ATO-OB 4. ATO-OB receives the Journey Profile and adapts the ATO Operational Speed Profile
Postcondition	The ATO Operational Speed Profile is adapted by ATO-OB
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_3

28. UC_01_1_8_4: Construction of a Slippery-Rail area when reported by Train Driver of multiple trains

Use Case Group	Adhesion Management
Use Case	Construction of a Slippery-Rail area when reported by Train Driver of multiple trains
UC ID	UC_01_1_8_4
Applicable to	GoA2
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. Train Driver becomes aware of Slippery-Rail conditions in a section of the track 2. Train Driver reports Slippery-Rail by pressing the Slippery-Rail DMI button in certain locations within the abovementioned track section 3. ETCS-OB informs ATO-OB on adhesion conditions through a certain number of SS130 1.0.0 Packets Number 6: M_ADHESION_DRIVER = 0 (Slippery Rail is set by the driver), which lead to: 1. ATO-OB informing the ATO-TS on adhesion conditions through a certain number of SS126 1.0.0 Status Reports: Q_STR_Indicators (bit3 = 1, Low adhesion reported by the driver), and 2. ATO-TS receiving the Status Reports and informing TMS about Slippery Rail in specific locations of the track 4. UC_01_3_2_4 (events 2 – 3) 5. ATO-TS elaborates a new Journey Profile with: • Q_TC_Type = 1 (Low adhesion) • Q_Range = {0, 1, 2, 3, 4} • D_TC_Start_Location • D_TC_End_Location • Q_Adhesion_Category = {0, 1, 2, 3, 4, 5} (Open Topic 1) 6. ATO-TS sends the Journey Profile to the ATO-OB of following trains, which update their ATO Operational Speed Profile. 7. The Train Drivers of following trains repeat the events 1 to 3 8. UC_01_3_2_4 (event 5)
Postcondition	A low-adhesion area is built and reported to trains through Journey Profiles.
Safety relation	None (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. What adhesion category would the TMS define for the adhesion area? What

	adhesion category would ATO-TS provide to ATO-OB through the Journey Profile? TCMS/Train could provide such information. Requirements: R_01_1_8_6 Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_4



A: Start location of the piece of track affected by Slippery Rail conditions
B: End location of the piece of track affected by Slippery Rail conditions
SRB: Slippery Rail Button
StR: Status Report
JP: Journey Profile

29. UC_01_1_8_5: Construction of an adhesion area when adhesion is reported by the TCMS of multiple trains

Use Case Group	Adhesion Management
Use Case	Construction of an adhesion area when adhesion is reported by the TCMS of multiple trains
UC ID	UC_01_1_8_5
Applicable to	GoA2, GoA3, GoA4
Main actor	TCMS
Other actors	ATO-TS, ATO-OB, TMS
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. The traction/braking system of a train identifies certain adhesion levels throughout the track (Consideration 1) and transmits them to TCMS/Train, which associates the reported adhesion levels with one of the following categories: • Dry Rail • Dry Rail (Medium) • Dry Rail (Low) • Low Adhesion • Very Low Adhesion • Extremely Low Adhesion TCMS/Train transmits adhesion categories to ATO-OB on a regular basis, which sends Status Reports to ATO-TS. 2. ATO-TS receives Status Reports regularly and informs the TMS. 3. UC_01_3_2_5 (events 2 – 3) 4. ATO-TS elaborates and sends Journey Profiles to the ATO-OB of following trains, which update their ATO Operational Speed Profile. 5. Following trains execute events 1 to 5 so that the adhesion area is constantly updated.
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	None (ATO is supervised by ETCS)
Open topics / consideration	Consideration 1: UC_01_1_8_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 UC, 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_1_8_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). Requirements: R_01_1_8_1 R_01_1_8_2 R_01_1_8_3 R_01_1_8_4 R_01_1_8_5 Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_5

30. UC_01_1_8_6: An already-defined adhesion area is shortened/lengthened by TMS

Use Case Group	Adhesion Management
Use Case	An already-defined adhesion area is shortened/lengthened by TMS
UC ID	UC_01_1_8_6
Applicable to	GoA2, GoA3, GoA4
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. These conditions include: adhesion category; Segment Profile coverage; end location; and start location.
Assumptions	• There exists an already-defined adhesion area • ATO-OB is engaged
Precondition	ETCS-OB is in AD mode
Flow of events	1. UC_01_3_2_6 (events 1 – 2) 2. The ATO-TS elaborates a new Journey Profile by updating the following variables: • Q_Range • D_TC_Start_Location • D_TC_End_Location 3. ATO-TS sends Journey Profiles with an update on the length of the adhesion area to ATO-OB 4. ATO-OB is informed about the new length of the low adhesion area and adapts the ATO Operational Speed Profile
Postcondition	The already-defined low-adhesion area is shortened/lengthened
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_6

31. UC_01_1_8_7: An already-defined Slippery Rail area is removed by the TMS on the basis of Status Reports

Use Case Group	Adhesion Management
Use Case	An already-defined Slippery Rail area is removed by the TMS on the basis of Status Reports
UC ID	UC_01_1_8_7
Applicable to	GoA2, GoA3, GoA4
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. A certain number of Status Reports are sent by n ATO-OB units to ATO-TS where: 1. Q_STR_Indicators (bit 3) = 0 (Low adhesion not reported by the driver) 2. Q_STR_Indicators (bit 7) = 0 (Slip/slide not reported by the TCMS/Train) 2. The ATO TS is informed about Slippery Rail or Slip/Slide no longer being reported in an already defined Slippery Rail area and informs the TMS. 3. UC_01_3_2_7 (event 2) 4. The ATO-TS elaborates a new Journey Profile 5. The ATO-TS sends the new Journey Profile to ATO-OB units 6. ATO-OB units are informed and update the ATO Operational Speed Profile
Postcondition	The already-defined Slippery Rail area is removed
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_7

32. UC_01_1_8_8: The adhesion category applied to an existing adhesion area is modified by TMS

Use Case Group	Adhesion Management
Use Case	The adhesion category applied to an existing adhesion area is modified by TMS
UC ID	UC_01_1_8_8
Applicable to	GoA2, GoA3, GoA4
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. UC_01_3_2_8 (events 1 – 2) 2. ATO-TS elaborates a new Journey Profile where the adhesion category is updated: Q_Adhesion_Category = {0,1,2,3,4,5} 3. ATO-TS sends the new Journey Profile to ATO-OB 4. ATO-OB is informed and updates the ATO Operational Speed Profile
Postcondition	The already-defined adhesion area is characterized by a different adhesion category,
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_8

33. UC_01_1_8_9: The adhesion category applied to an existing adhesion area is modified by the TMS on the basis of the information received from the TCMS/Train

Use Case Group	Adhesion Management
Use Case	The adhesion category applied to an existing adhesion area is modified by the TMS on the basis of the information received from the TCMS/Train,
UC ID	UC_01_1_8_9
Applicable to	GoA2, GoA3, GoA4
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_1_8_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 can report different adhesion, categories through the Status Report, • ATO-OB is engaged,
Precondition	ETCS-OB is in AD mode
Flow of events	1. TCMS of a certain number of trains reports a new adhesion category to the ATO-OB within the already-defined adhesion area. 2. ATO-OB units send Status Reports with a new adhesion category to ATO-TS. 3. UC_01_3_2_9 (event 2) 4. ATO-TS elaborates a new Journey Profile where the adhesion category is changed: Q_Adhesion_Category = {0,1,2,3,4,5} 5. ATO-TS sends the new Journey Profile to ATO-OB units, 6. ATO-OB units are informed and update the ATO Operational Speed Profile,
Postcondition	The already-defined adhesion area is characterized by a different adhesion category,
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Requirements: R_01_1_8_1 R_01_1_8_2 R_01_1_8_3 R_01_1_8_4 R_01_1_8_5 Consideration: This use case is linked to FP6 D3.3 UC_01_3_2_9

34. UC_01_1_9_1: Remote on-sight driving within ETCS failure

Use Case Group	Remote driving,
Use Case	Remote on-sight driving within ETCS failure (Note: Not to mix with ETCS OS driving state)
UC ID	UC_01_1_9_1
Main actor	Simulated train dispatcher,
Other actors	Remote train operator,
Main goal	Description of the UC main goal, operational scenario: Remote train driving on sight between marker boards in a ATO environment when no ETCS signalling information available.
Assumptions	ETCS system fails.
Precondition	ETCS system is down and dispatcher has given permission for on sight driving. Train is equipped with necessary devices to be operated from a remote-control centre.
Flow of events	Event sequence: 1. ETCS failure and system goes down, 2. Simulated train dispatcher contacts the remote train operator, 3. Dispatcher gives permission to drive remote on sight, 4. Remote train operator controls the train and drives to the next marker board.
Postcondition	Train successfully moves to the next marker board and stops.
Safety relation	All events are safety relevant.
Open topics / consideration	No ETCS, Network connectivity Requirement: R_01_1_9_1

35. UC_01_1_9_2: Transmission quality of video streaming

Use Case Group	Remote driving,
Use Case	Transmission quality of video streaming from vehicle to remote control center,
UC ID	UC_01_1_9_2
Main actor	Remote train operator,
Other actors	
Main goal	Document continuous video streaming of acceptable quality,
Assumptions	Remote control centre needs visual overview of vehicle environment.
Precondition	1. Train is equipped with necessary devices to be operated from a remote-control centre. 2. No ETCS signaling information available.
Flow of events	Event sequence: 1. Remote train operator turns system on. 2. Continuous video streaming. 3. Logging and storage of data flow, volume and quality in formats that can be used for later analyses. 4. Remote train operator turns system off.
Postcondition	Remote control centre has had visual overview of vehicle environment from turning system on until it is shut down.
Safety relation	All events are safety relevant.
Open topics / consideration	Network connectivity in video channel, various camera set up in the train. Requirement: R_01_1_9_2

36. UC_01_1_9_3: User perspective on video streaming

Use Case Group	Remote driving.
Use Case	User perspective on video streaming from vehicle to remote control centre.
UC ID	UC_01_1_9_3
Main actor	Remote train operator.
Other actors	
Main goal	Document video streaming user/remote control operator perspective.
Assumptions	Different setups provide varying levels of user satisfaction and overview. These setups include: different type of cameras, camera angles, video resolution and frame rate, as well aspossible input from other type of sensors.
Precondition	1. Train is equipped with necessary devices to be operated from a remote-control centre. 2. No ETCS signaling information available.
Flow of events	Event sequence: 1. Remote train operator turns system on with different set ups on vehicle 2. Continuous video streaming 3. Variations of the alternative configurations that can be changed during one test run 4. Logging and storage of relevant data flows and visual observations, 5. Remote train operator turns system off 6. Manual documentation of experiences, including questionnaires if relevant
Postcondition	Remote control centre have had visual overview of vehicle environment from turning system on until it is shut down.
Safety relation	All events are safety relevant.
Open topics / consideration	The quality of the video can influence the remote operator's effectiveness, as their perception relies on clear visuals to enhance safety in operating remote trains. Network connectivity in video channel, various camera set up in the train. Requirement: R_01_1_9_3

37. UC_01_1_9_4: Remote driving by controlling vehicle engine and brakes

Use Case Group	Remote driving.
Use Case	Remote driving by controlling vehicle engine and brakes.
UC ID	UC_01_1_9_4
Main actor	Remote train operator.
Other actors	
Main goal	Document remote train driving.
Assumptions	Remote train operator needs full control of vehicle movements.
Precondition	1. Train is equipped with necessary devices to be operated from a remote-control centre. 2. No ETCS signaling information available.
Flow of events	Event sequence: 1. Remote train operator turns system on. 2. Continuous control of engine and breaks. 3. Logging and storage of data flow, volume and quality. in formats that can be used for later analyses. 4. Remote train operator turns system off.
Postcondition	Train successfully moves and stops as desired.
Safety relation	All events are safety relevant.
Open topics / consideration	Network connectivity in both video channel and control channel. Requirement: R_01_1_9_4

38. UC_01_1_9_5: Stop the train after experiencing a network outage

Use Case Group	Remote driving.
Use Case	Stop the train after experiencing a network outage.
UC ID	UC_01_1_9_5
Main actor	Automatic system.
Other actors	
Main goal	Stop the train Completely.
Assumptions	Network is down or Connectivity interruption in the video channel, the remote train operator receives blurry video.
Precondition	1. Train is equipped with necessary devices to be operated from a remote-control center. 2. No ETCS signaling information available.
Flow of events	Event sequence: 1. Remote train operator turns system on. 2. Continuous operation until the train achieves the maximum speed. 3. Control center experiences issues with video connection (video channel). 4. Remote driver sends the command to stop the train (through control channel) 5. Train stops successfully.
Postcondition	Train stops.
Safety relation	All events are safety relevant.
Open topics / consideration	In cases of video connection loss to the remote train, the remote driver should issue a command to stop the train. Because the video feed requires high bandwidth and network stability, any network instability can result in a blurry video Network instability in the video channel. Requirement: R_01_1_9_5

39. UC_01_1_9_6: Onboard Manual Override

Use Case Group	Remote driving.
Use Case	Onboard Manual Override.
UC ID	UC_01_1_9_6
Main actor	Remote control system and Train attendant.
Other actors	
Main goal	*Train attendant to manually override automated systems in case of unexpected scenarios or system failures.*
Assumptions	System malfunction.
Precondition	1. Train is equipped with necessary devices to be operated from a remote-control center 2. No ETCS signalling information available. 3. Remote control centre starts the train with attendant onboard, 4. The train attain considerable speed.
Flow of events	1. First, an unexpected event or system malfunction is detected. 2. Automated systems send an alert to the remote control center. 3. Train attendant initiates a manual override to take direct control of the train. 4. Train attendant navigates the train through the situation or brings it to a safe stop.
Postcondition	The train manual override achieved, and train manage to go through the situation/stop safely.
Safety relation	All events are safety relevant.
Open topics / consideration	A train can experience unexpected events or malfunctions, so the train attendant must be able to override the remote control and bring the train to a stop. A knowledgeable train attendant, network between remote centre and the train and DMI with override capabilities. Requirement: R_01_1_9_6

40. UC_01_1_9_7: Remote obstacle detection and reaction

Use Case Group	Remote driving.
Use Case	Remote obstacle detection and reaction.
UC ID	UC_01_1_9_7
Main actor	Remote control system.
Other actors	
Main goal	*To detect the object and take the necessary action including Adjust train speed.*
Assumptions	Presence of object around the track.
Precondition	1. Train is equipped with necessary devices to be operated from a remote-control center. 2. No ETCS signalling information available.
Flow of events	1. Remote control centre starts the train, 2. Train attains significant speed (says maximum). 3. An external factor is identified (e.g., foreign matters around the track, foggy conditions). 4. Remote Driver decides on an appropriate action to be taken (eg., slowing down). 5. Train responds accordingly.
Postcondition	Object successful detected and appropriate action taken.
Safety relation	All events are safety relevant.
Open topics / consideration	People, animals, or other objects can be found near or on the tracks, potentially endangering train operations. Thus, the remote driver should be able to detect and respond to it accordingly. The network connection between the remote driving centre and the train, and the quality of the video feeds from the train. Requirement: R_01_1_9_7

41. UC_01_1_9_8: Passing on the level crossing

Use Case group	Remote driving.
Use Case	Passing on the level crossing.
UC ID	UC_01_1_9_8
Main actor	Remote operators, onboard communication system.
Other actors	
Main goal	*To successful pass on the level crossing and alert the surrounding.*
Assumptions	Other mode of transport present around the level crossing.
Precondition	1. Train is equipped with necessary devices to be operated from a remote-control centre. 2. No ETCS signaling information available.
Flow of events	1. Remote control centre starts the train. 2. The train approaches the level crossing. 3. The remote driver waits for the warning lights or flagman to allow the passage. 4. Remote driver alerts the surrounding by honking the horn remotely while passing the level crossing. 5. Train pass on level crossing safely.
Postcondition	Train successful passed the level crossing
Safety relation	All events are safety relevant.
Open topics / consideration	In regional lines, it is common to have active level crossings in areas of considerably high traffic, and passive level crossings for low traffic regions. Active level crossing with the warning lights and the passive level crossing with the flagmen, network connection. Requirement: R_01_1_9_8

42. UC_01_1_10_1: Starting Journey

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Starting Journey
UC ID	UC_01_1_10_1
Applicable to	GoA2
Main actor	Train Driver
Other actors	ATO-OB, ATO-TS, ETCS-OB & TMS
Main goal	Description of the nominal scenario where ATO-OB is energized and assigned a Journey Profile
Assumptions	
Precondition	▪ ATO is not inhibited. ▪ The train is in an ATO area. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. Train Driver energizes ATO-OB manually. 2. ATO-OB executes self-test procedures to check its operational capability and ensures it is fit for service. 3. ETCS-OB transmits validated train data to ATO-OB. 4. ATO-TS requests Journey and Segment Profile data to TMS 5. TMS prepares Journey and Segment Profiles data. 6. ATO-TS elaborates and sends Journey and Segment Profiles to ATO-OB. 7. The Operational Speed Profile is calculated by ATO-OB.
Postcondition	ATO-OB is ready to be engaged by Train Driver.
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

43. UC_01_1_10_2: De-energising ATO on-board

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	De-energising ATO on-board
UC ID	UC_01_1_10_2
Applicable to	GoA2
Main actor	Train Driver.
Other actors	ATO-OB
Main goal	Description of how ATO-OB is de-energized at the end of a journey.
Assumptions	When the train stops accurately, all passengers disembark (or freight is unloaded) and that train doors are closed and locked.
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. ATO-OB stops the train at the Stopping Point. 2. Train Driver de-energizes ATO-OB manually.
Postcondition	ATO-OB is de-energized.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

44. UC_01_1_10_3: Planned GoA1 to GoA2 transition on the move

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Planned GoA1 to GoA2 transition on the move.
UC ID	UC_01_1_10_3
Applicable to	GoA2
Main actor	Train Driver.
Other actors	ATO-OB
Main goal	Description of how a transition from GoA1 to GoA2 is performed while the train is in motion.
Assumptions	
Precondition	▪ ATO engagement conditions are fulfilled. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. ATO-OB is ready to control the train operation as both. operational and engagement conditions have been fulfilled. 2. Train Driver starts automatic driving by selecting “ATO Engage” 3. ATO is engaged.
Postcondition	The Traction Brake Lever (TBL) is returned to neutral position by Train Driver
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

45. UC_01_1_10_4: Driver-initiated GoA2 to GoA1 transition

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Driver-initiated GoA2 to GoA1 transition
UC ID	UC_01_1_10_4
Applicable to	GoA2
Main actor	Train Driver
Other actors	ATO-OB
Main goal	Description of how a transition from GoA2 to GoA1 is performed when triggered by Train Driver.
Assumptions	
Precondition	ATO is engaged
Flow of events	1. Train Driver activates the brake manually via the TBL. 2. ATO-OB is disengaged.
Postcondition	The train operation is assumed by Train Driver.
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

46. UC_01_1_10_5: Automatic GoA2 to GoA1 transition on the move

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Automatic GoA2 to GoA1 transition on the move.
UC ID	UC_01_1_10_5
Applicable to	GoA2
Main actor	ATO-TS.
Other actors	Train Driver, ATO-OB.
Main goal	Description of how a transition from GoA2 to GoA1 is performed automatically while the train is in motion.
Assumptions	▪ Operational conditions loss triggers this transition because no further JP information is to be provided by ATO-TS. ▪ ATO will not be re-engaged again until all engagement conditions are fulfilled again.. If engagement conditions are recovered. within a certain time, ATO-OB can continue in automatic driving. ▪ On-going brake applications will be completed before ATO disengages. ▪ In the event of an ATO-TS failure, ATO-OB should continue driving the train according to the last reported Journey Profile received from ATO-TS.
Precondition	ATO is engaged
Flow of events	1. ATO-TS triggers GoA2 to GoA1 transition. 2. ATO-OB loses operational conditions. 3. ATO is disengaged.
Postcondition	The train operation is assumed by Train Driver.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification

47. UC_01_1_10_6: ATO inhibition

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	ATO inhibition
UC ID	UC_01_1_10_6
Applicable to	GoA2
Main actor	ATO-TS
Other actors	Train Driver, ATO-OB
Main goal	Description of how ATO is inhibited
Assumptions	
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. ATO-TS sends a Journey Profile with ATO Inhibition Zone as a temporary constraint to ATO-OB. 2. Train Driver is informed about ATO being disengaged (“ATO Disengaging” indication is displayed to Train Driver). 3. Train Driver: a) Applies the brake using the TBL or selects “ATO Disengage” within 5 seconds. b) Fails to react within 5 seconds, which leads to ATO-OB to apply Full Service Brake until Train Driver acknowledges. 4. ATO is disengaged.
Postcondition	The train operation is assumed by Train Driver.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

48. UC_01_1_10_7: C-DAS inhibition

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	C-DAS inhibition
UC ID	UC_01_1_10_7
Applicable to	GoA2
Main actor	ATO-TS
Other actors	Train Driver, ATO-OB
Main goal	Description of how C-DAS is inhibited
Assumptions	
Precondition	▪ ATO is engaged ▪ All vehicle and on-board systems are fully operational
Flow of events	1. ATO-TS sends a Journey Profile with DAS Inhibition Zone as a temporary constraint to ATO-OB 2. Train Driver is informed about C-DAS being inhibited
Postcondition	C-DAS is unavailable
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification

49. UC_01_1_10_8: Train stops at a Stopping Point

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Train stops at a Stopping Point
UC ID	UC_01_1_10_8
Applicable to	GoA2
Main actor	ATO-OB
Other actors	Train Driver, ATO-TS, TCMS, Train Door Management System
Main goal	Description of how stopping at a Stopping Point is performed by ATO
Assumptions	▪ When a movement authority is received on-board then the ATO will continue to drive automatically without any further command required from the driver ▪ The opening/release of the doors when the train has stopped accurately can be configured to be automatic or manual. ▪ If the Train Holding Brake force is not sufficient to maintain the train stationary, the ATO-OB shall request to the train the application of the train brake in addition to the Train Holding Brake.
Precondition	▪ ATO is engaged ▪ All vehicle and on-board systems are fully operational ▪ The Stopping Point is contained in the Journey Profile
Flow of events	1. The train approaches and stops accurately within the stopping window 1.1. ATO-OB maintains the train stationary requesting to the TCMS/Train the application of the Train Holding Brake 1.2. Train Driver is informed about the accurate stop 2. ATO-OB disengages 3. ATO-OB starts the count-down of the dwell time 4. Train Driver is informed about the dwell time and: a) Train Driver executes manual door opening command b) ATO-OB sends an automatic door opening command to the Train Door Management System. The Train Door Management System releases the train doors.
Postcondition	Train doors are open
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification

50. UC_01_1_10_9: Train stopped by signalling

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Train stopped by signalling
UC ID	UC_01_1_10_9
Applicable to	GoA2
Main actor	ATO-OB
Other actors	ETCS-OB
Main goal	Description of how a train is stopped by signalling when driven automatically
Assumptions	ATO remains engaged when the train is stopped by signalling and continues running when a new Movement Authority is granted.
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational. ▪ Valid Journey and Segment Profiles have been received and cover the section beyond the current EoA.
Flow of events	1. The train is braked to a stand in rear of the EoA by ATO-OB. ATO remains engaged. 2. ETCS-OB receives a new Movement Authority. 3. ETCS-OB informs ATO-OB about the new safe envelope. 4. ATO-OB calculates the ATO Operational Speed Profile.
Postcondition	ATO-OB resumes automatic driving.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

51. UC_01_1_10_10: Train stops short of a Stopping Point

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Train stops short of a Stopping Point.
UC ID	UC_01_1_10_10
Applicable to	GoA2
Main actor	Train Driver.
Other actors	ATO-OB.
Main goal	Description of how the position of the train is corrected by Train Driver after stopping short of a Stopping Point.
Assumptions	
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational. ▪ The Stopping Point is contained within the Journey Profile.
Flow of events	1. The train is brought to a stop by ATO-OB and the Stopping Point is considered as reached. 2. Train Driver is informed about the stopping window being undershot. 3. Train Driver corrects the position of the train manually.
Postcondition	The train is stopped accurately, and Train Driver is informed about an accurate stop being achieved.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification .

52. UC_01_1_10_11: Train overshoots Stopping Point

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Train overshoots Stopping Point.
UC ID	UC_01_1_10_11
Applicable to	GoA2.
Main actor	Train Driver.
Other actors	ATO-OB.
Main goal	Description of how the position of the train is corrected by Train Driver after overshooting a Stopping Point.
Assumptions	If the train overshoots the stopping window and stands beyond the rollback tolerance, Train Driver is informed and performs manual actions according to operational rules
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational. ▪ The Stopping Point is contained within the Journey Profile.
Flow of events	1. The train is brought to a stop beyond the stopping window and rollback tolerance. 2. Train Driver is informed about the stopping window being overshot. 3. Train Driver corrects the position of the train manually.
Postcondition	The train is stopped accurately, and Train Driver is informed about an accurate stop being achieved.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

53. UC_01_1_10_12: Train departs from a Stopping Point (1)

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Train departs from a Stopping Point (1)..
UC ID	UC_01_1_10_12
Applicable to	GoA2
Main actor	Train Driver.
Other actors	ATO-OB, Train Door Management System
Main goal	Description of how a train departs from a station. Train doors are closed automatically.
Assumptions	
Precondition	▪ ATO is not engaged. ▪ ATO Operational Conditions are fulfilled. ▪ Train stands at a Stopping Point within the stopping window.
Flow of events	1. Dwell time expires. 2. ATO-OB commands the Train Door Management System to close doors. 2.1. Train Driver is informed about train doors being closed. 3. ATO-OB is informed that train doors are closed and locked. 3.1. Train Driver is informed that train doors are closed and locked 4. ATO Engagement Conditions are fulfilled. Train Driver starts automatic driving by selecting “ATO Engage”.
Postcondition	ATO is engaged. Train departs from the station.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

54. UC_01_1_10_13: Train departs from a Stopping Point (2)

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Train departs from a Stopping Point (2).
UC ID	UC_01_1_10_13
Applicable to	GoA2.
Main actor	Train Driver.
Other actors	ATO-OB, Train Door Management System.
Main goal	Description of how a train departs from a station. Train doors are closed manually.
Assumptions	
Precondition	▪ ATO is not engaged ▪ ATO Operational Conditions are fulfilled. ▪ Train stands at a Stopping Point within the stopping window.
Flow of events	1. Dwell time expires. 2. Train Driver is requested to close train doors. 2.1. Train Driver commands the Train Door Management System to close doors. 3. ATO-OB is informed that train doors are closed and locked. 4. Train Driver is informed that train doors are closed and locked. 5. ATO Engagement Conditions are fulfilled. Train Driver starts automatic driving by selecting “ATO Engage”.
Postcondition	ATO is engaged. Train departs from the station.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

55. UC_01_1_10_14: Rerouting

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Rerouting
UC ID	UC_01_1_10_14
Applicable to	GoA2
Main actor	TMS
Other actors	ATO-TS, ATO-OB
Main goal	Description of how a train is rerouted
Assumptions	
Precondition	▪ ATO is engaged. ▪ Train is required to run through a different route.
Flow of events	1. TMS sets a new route for the train. 2. ATO-TS sends updated Journey and Segment Profiles to ATO-OB. 3. ATO-OB updates the ATO Operational Speed Profile.
Postcondition	ATO remains engaged.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

56. UC_01_1_10_15: Trackside initiated ‘Stopping Point Skip’

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Trackside initiated ‘Stopping Point Skip’.
UC ID	UC_01_1_10_15
Applicable to	GoA2
Main actor	TMS
Other actors	ATO-TS, ATO-OB
Main goal	Description of how a Stopping Point is skipped when commanded by trackside.
Assumptions	
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. TMS commands the Stopping Point to be skipped. 2. ATO-TS sends a Journey Profile with “Stopping Point to be skipped” to ATO-OB. 3. ATO-OB updates the ATO Operational Speed Profile.
Postcondition	The Stopping Point is skipped.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

57. UC_01_1_10_16: Driver initiated ‘Stopping Point Skip’

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Driver initiated ‘Stopping Point Skip’.
UC ID	UC_01_1_10_16
Applicable to	GoA2.
Main actor	Train Driver.
Other actors	ATO-OB, ATO-TS.
Main goal	Description of how a Stopping Point is skipped when commanded by Train Driver.
Assumptions	
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational. ▪ ATO Operational conditions are fulfilled.
Flow of events	1. Train Driver becomes aware that the next Stopping Point can be skipped. 2. Train Driver requests to skip the next Stopping Point. 3. ATO-OB updates the ATO Operational Speed Profile.
Postcondition	▪ ATO-OB sends a Status Report with “Next Stopping Point Skip” to ATO-TS. ▪ The next Stopping Point is skipped.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification. Note: ▪ This use case promotes energy efficiency. Regional lines are characterized by infrequent demands for loading and unloading.

58. UC_01_1_10_17: Hold train at the next Stopping Point

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Hold train at the next Stopping Point.
UC ID	UC_01_1_10_17
Applicable to	GoA2.
Main actor	TMS.
Other actors	ATO-TS, ATO-OB.
Main goal	Description of how a train is held at the next Stopping Point.
Assumptions	▪ The train is held until a new Journey Profile is provided.
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. TMS requests the train to be held at the next Stopping Point. 2. ATO-TS sends a Journey Profile with “Hold train” to ATO-OB. 3. ATO-OB holds the train at the next Stopping Point.
Postcondition	Train Hold information is displayed on the DMI so that Train Driver is informed about it.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

59. UC_01_1_10_18: Emergency brake application commanded by ETCS

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Emergency brake application commanded by ETCS.
UC ID	UC_01_1_10_18.
Applicable to	GoA2.
Main actor	ETCS-OB.
Other actors	ATO-TS, ATO-OB, Train Driver.
Main goal	Description of how the emergency brake is applied when commanded by ETCS.
Assumptions	
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. The Emergency Brake is applied by ETCS-OB, which results in ATO being disengaged. 2. ATO-OB informs ATO-TS and Train Driver about ATO being disengaged.
Postcondition	Not until all operational and engagement conditions are fulfilled again can ATO-OB be ready for ATO operation and be engaged.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

60. UC_01_1_10_19: Neutral/Powerless Sections

Use Case Group	Regional G1 Lines – Main Line Interoperability.
Use Case	Neutral/Powerless Sections.
UC ID	UC_01_1_10_19
Applicable to	GoA2.
Main actor	ATO-OB.
Other actors	ATO-TS, Train Driver, External System.
Main goal	Description of how a powerless section is passed by an ATO train.
Assumptions	▪ ATO-OB cannot command traction in the powerless section.
Precondition	▪ ATO is engaged. ▪ All vehicle and on-board systems are fully operational.
Flow of events	1. ATO-TS informs ATO-OB about the current consumption limitation zone 2. The train approaches the powerless section and: a) Train Driver switches off main power and/or lowers the pantograph, or b) An External System switches off power and/or lowers the pantograph. 3. The train passes the powerless section and: a) Train Driver switches on power and/or raises the pantograph, or b) An External System switches on power and/or raises the pantograph
Postcondition	ATO-OB can command traction again.
Safety relation	None (ATO is supervised by ETCS).
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification.

61. UC_01_1_10_20: Unprotected Level Crossings

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Unprotected Level Crossings
UC ID	UC_01_1_10_20
Applicable to	GoA2
Main actor	Train Driver
Other actors	ATO-OB, ATO-TS, ETCS-OB
Main goal	Description of how an unprotected level crossing is passed by an ATO train.
Assumptions	▪ ATO disengagement and manual driving are required so that the unprotected level crossing can be passed over
Precondition	▪ ATO is engaged ▪ All vehicle and on-board systems are fully operational
Flow of events	1. ETCS-TS informs ETCS-OB about the unprotected level crossing through ETCS Packet Number 88. 2. ATO disengages and the train stops in rear of the unprotected level crossing 3. Train Driver drives the train manually through the level crossing
Postcondition	The train passes the level crossing. Once all ATO Operational Conditions and ATO Engagement Conditions are fulfilled, Train Driver shall be able to engage ATO again.
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification

62. UC_01_1_10_21: Change of Train Running Number

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Change of Train Running Number
UC ID	UC_01_1_10_21
Applicable to	GoA2
Main actor	Train Driver
Other actors	ATO-OB, ATO-TS
Main goal	Description of how the Train Running Number is changed
Assumptions	
Precondition	▪ ATO is engaged ▪ All vehicle and on-board systems are fully operational
Flow of events	1. Train Running Number is changed by Train Driver 2. ATO-OB disengages 3. ATO-OB sends a new Handshake Request to ATO-TS 4. ATO-TS sends Journey and Segment Profiles to ATO-OB 5. ATO-OB updates the ATO Operational Speed Profile
Postcondition	ATO-OB is ready to be engaged
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification

63. UC_01_1_10_22: Transition from Class B area

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Transition from Class B area
UC ID	UC_01_1_10_22
Applicable to	GoA2
Main actor	ETCS
Other actors	ATO-OB
Main goal	Description of how a transition from Class B system to ETCS is performed
Assumptions	▪ All ATO engagement conditions are fulfilled after the ETCS level transition is passed ▪ The Operational Conditions are not fulfilled in the Class B area, as there is no ETCS
Precondition	▪ All vehicle and on-board systems are fully operational ▪ There is a communication session established between ATO-OB and ATO-TS, which provides valid JP and SP data
Flow of events	1. The ETCS area is approached by the train 2. The level transition is confirmed by ETCS
Postcondition	ATO-OB is ready to be engaged
Safety relation	None (ATO is supervised by ETCS)
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification

64. UC_01_1_10_23: Transition to Class B area

Use Case Group	Regional G1 Lines – Main Line Interoperability
Use Case	Transition to Class B area
UC ID	UC_01_1_10_23
Applicable to	GoA2
Main actor	ETCS
Other actors	ATO-OB
Main goal	Description of how a transition from ETCS to Class B system is performed
Assumptions	▪ Train Driver acknowledges the transition to Class B system
Precondition	▪ ATO is engaged ▪ All vehicle and on-board systems are fully operational
Flow of events	1. The Class B area is approached by the train 2. The level transition is confirmed by ETCS
Postcondition	None (ATO-OB is disengaged)
Safety relation	ATO is supervised by ETCS
Open topics / consideration	Reference: Subset – 151 ERTMS/ATO Test Specification

8.2 ANNEX 2. REQUIREMENTS COLLECTION

UC - ID	Requirement – ID	Requirement – Description	Rationale	Type
UC_01_1_1_1 UC_01_1_1_2 UC_01_1_1_3 UC_01_1_1_4	R_01_1_1_1	TMS shall be able to receive information about a request for stop at a station, and as such, the TMS should communicate with the ATO-TS regarding the stop.	The traffic management aspect should be the deciding part on the train stops, and as such, it should have all available information to make a decision.	Functional
UC_01_1_1_1 UC_01_1_1_2 UC_01_1_1_3 UC_01_1_1_4	R_01_1_1_2	IM and RU shall determine the minimum time in advance that is required for a stop request at a station to be accepted and send to the ATO-TS.	It should be decided a fixed value upon which it is considered that the train is too close to the station to perform the stop. This value is not necessarily the minimum so that the train can apply the brakes and stop, but it could be the minimum so that there is a benefit from using this functionality (braking curve calculation).	Functional
UC_01_1_5_1	R_01_1_5_1	The information required to operate using ATO should cover the full length of the radio hole area.	The train should enter the radio hole area with all the information necessary, and valid, to leave the radio hole. It should be avoided a mode change in order to exit the radio hole.	Operational
UC_01_1_6_1 UC_01_1_7_1	R_01_1_6_1	There should be a communication between the obstacle detection system and the ATO on-board.	The use case where this requirement comes from is an approach of using ATO to perform the conventional obtainment of FS (or AD mode) where it depends on the driver to detect obstacles. As such, for the use case the ATO should be informed of any by the obstacle detection system.	Functional
UC_01_1_7_1	R_01_1_7_1	The ATO-OB informs ATO-TS about the application of the brake due to an object detection.	The traffic management aspect should be informed of the application of the brake, and furthermore, if there is an object on the tracks.	Functional
UC_01_1_8_2	R_01_1_8_1	The traction/braking system of the train shall be able to identify different adhesion levels	Identifying different adhesion levels enables a more precise adaptation of the ATO Operational Speed Profile	Functional

UC - ID	Requirement – ID	Requirement – Description	Rationale	Type
UC_01_1_8_2	R_01_1_8_2	The traction/braking system of the train shall be able to transmit different adhesion levels to the TCMS/Train	Identifying different adhesion levels enables a more precise adaptation of the ATO Operational Speed Profile	Functional
UC_01_1_8_2	R_01_1_8_3	The TCMS/Train shall be able to associate the adhesion levels reported by the traction/braking system 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 ▪ Extremely Low Adhesion: Conditions where the wheel/rail adhesion is below 0.03	Current ERTMS/ATO specifications (SS125 1.0.0) states that “When the ATO-OB is informed about “slip/slide” from an external system, this information shall be sent to the ATO-TS.” Therefore, current ERTMS/ATO specifications do not consider the TCMS/Train (external system) reporting different adhesion categories to ATO-OB. Reporting different adhesion categories would lead to a more precise traffic regulation and thus a more efficient traffic management system, which contribute to the overall objective of lowering the total cost of ownership of European regional lines in terms of both CAPEX and OPEX.	Functional
UC_01_1_8_2	R_01_1_8_4	The TCMS/Train shall be able to report the following adhesion categories to ATO-OB: ▪ 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	Current ERTMS/ATO specifications (SS125 1.0.0) states that “When the ATO-OB is informed about “slip/slide” from an external system, this information shall be sent to the ATO-TS.” Therefore, current ERTMS/ATO specifications do not consider the TCMS/Train (external system) reporting different adhesion categories to ATO-OB. Reporting different adhesion categories would lead to a more precise traffic regulation and thus a more efficient traffic management system, which contribute to the overall objective of	Functional

UC - ID	Requirement – ID	Requirement – Description	Rationale	Type
		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	lowering the total cost of ownership of European regional lines in terms of both CAPEX and OPEX.	
UC_01_1_8_2	R_01_1_8_5	ATO-OB shall be able to report the following adhesion categories to ATO-TS through Status Report Packet: ▪ 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	According to SS126 1.0.0, ATO-OB reports ATO-TS on “slip/slide reported by TCMS/Train” through Status Report Packet (Q_STR_Indicators, bit7). Therefore, current ERTMS/ATO specifications do not consider ATO-OB reporting different adhesion categories to ATO-TS. Reporting different adhesion categories lead to a more precise traffic regulation and thus a more efficient traffic management system, which contribute to the overall objective of lowering the total cost of ownership of European regional lines in terms of both CAPEX and OPEX.	Functional
UC_01_1_8_4	R_01_1_8_6	The ATO-TS shall be able to interpret adhesion areas information received from the TMS and add it to Journey Profiles.	The establishment of adhesion areas leads to a more precise regulation and thus a more efficient traffic management system.	Functional
UC_01_1_7_2	R_01_1_7_2	The ATO-TS shall provide on-board in advance with the location and characteristics (relevant for perception system) of unprotected level crossings ahead the train.	In some regional lines, there may be significant high number of unprotected level crossings. Driving the train in ATO	Functional

UC - ID	Requirement – ID	Requirement – Description	Rationale	Type
			GoA3/4 mode, it means that obstacle detection system shall be aware about those areas and process the risk of higher probability of potential presence of objects using the crossing path.	
UC_01_1_7_3	R_01_01_7_3	Perception system should be validated for use on the specific line, considering potential presence of animals, typical for the region.	From the obstacle detection perspective, each train operational environment is a specific one with unique characteristics that shall be considered. In many regional lines, animals (domestic or wild) are commonly moving around the track and may represent a higher risk of accident when crossing the route of moving train. Similarly, system should accept presence of animals if they are on the safe distance in respect to the train and avoid unnecessary train stops.	Functional
UC_01_1_7_5	R_01_1_7_5	The ATO-TS shall provide on-board in advance with the location and characteristics (relevant for perception system) of parking lots near the line.	In some regional lines in contrast to other types of lines, it is quite common that parking lots are in very close vicinity of that line.	Functional
UC_01_1_9_1	R_01_1_9_1	Train shall successfully move to the next marker board and stop	No ETCS, Network connectivity.	Functional
UC_01_1_9_2	R_01_1_9_2	Remote control centre shall have visual overview of vehicle environment from turning system on until it is shut down, with acceptable latency and video quality.	Verifies Network connectivity in video channel, various camera set up in the train	Functional
UC_01_1_9_3	R_01_1_9_3	Remote control centre has had visual overview of vehicle environment from turning system on until it is shut down, with acceptable usability.	The quality of the video can influence the remote operator's effectiveness, as their perception relies on clear visuals to enhance safety in operating remote trains.	Functional
UC_01_1_9_4	R_01_1_9_4	Train shall move and stop as desired.	Verifies network connectivity in both video channel and control channel	Functional

UC - ID	Requirement – ID	Requirement – Description	Rationale	Type
UC_01_1_9_5	R_01_1_9_5	Train shall stop if control center experience issues with video connection.	In cases where there is a loss of video connection with the remote train, the remote driver should issue a command to stop the train. Since the video feed requires high bandwidth and network stability, any network instability can result in a blurry video	Functional
UC_01_1_9_6	R_01_1_9_6	The train manual override shall be achieved, and train shall go through the situation or stop safely.	A train can experience unexpected events or malfunctions, so the train attendant must be able to override the remote control and bring the train to a stop.	Functional
UC_01_1_9_7	R_01_1_9_7	Objects shall be detected and appropriate action taken	People, animals, or other objects can be found near or on the tracks, potentially endangering train operations. Thus, the remote driver should be able to detect and respond to it accordingly	Functional
UC_01_1_9_8	UC_01_1_9_8	Train shall pass level crossing safely	In regional lines, it is common to have active level crossings in areas of considerably high traffic, and passive level crossings for low traffic regions	Functional

8.3 ANNEX 3 ETCS AND ATO ADHESION MANAGEMENT IN ACCORDANCE WITH THE EXISTING REGULATORY FRAMEWORK

Adhesion information is used to adapt the ERTMS/ETCS Emergency Brake model of the train, according to the related parameters provided in the national values information, the ATO Operational Speed Profile, and the ATO traction/braking commands.

The actors involved in the Adhesion Management process are illustrated in figure 11.

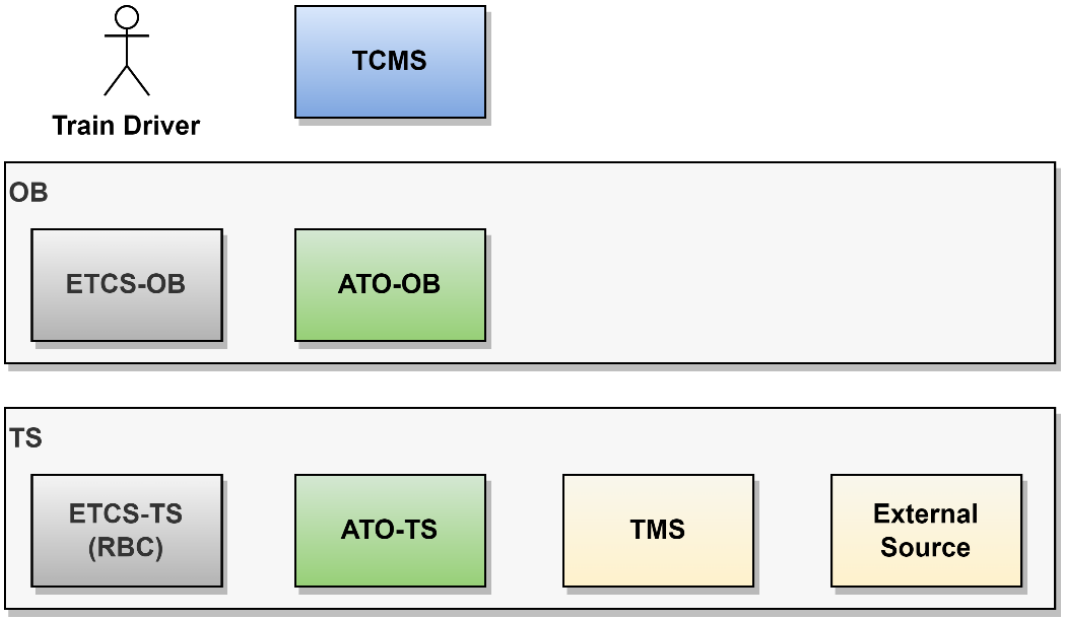


Figure 12: Actors in the Adhesion Management Process

The documents indicated in table 7 establish the regulatory framework considered for the present analysis.

Document	Title	Acronym
SUBSET-125-1.0.0	ERTMS/ATO System Requirements Specification	SS125
SUBSET-126-1.0.0	ERTMS/ATO – ATO-OB / ATO-TS FFFIS Application Layer	SS126
SUBSET-130-1.0.0	ERTMS/ATO – ATO-OB / ETCS-OB FFFIS Application Layer	SS130
SUBSET-026-1 4.0.0	ERTMS/ETCS System Requirement Specification	SS026
ERA_ERTMS_015560 4.0.0	ERTMS/ETCS ETCS Driver Machine Interface	ETCS DMI
	ETCS Driver's Handbook 1.1.0	ETCS DH
SUBSET-139-1.0.0	ERTMS/ATO – ATO-OB / RST Interface Specification	SS139

Table 7: Applicable regulatory framework

According to SS125, adhesion conditions can be reported by Train Driver, an External System (e.g., TCMS), and through the interface between ATO-TS and ATO-OB subsystems. Additionally, in the context of ETCS and according to SS026, adhesion conditions can also be reported by ETCS-TS (RBC) subsystem to ETCS-OB subsystem.

Adhesion conditions are received by ETCS-OB from the following actors:

a) Train Driver, if permitted by a national value, by means of pressing the DMI buttons "Non-Slippery Rail" and "Slippery Rail"

b) ETCS-TS (RBC), by means of Packet Number 71 (Adhesion Factor), which provides the information indicated in table 8.

Packet Number 71 (Adhesion Factor)	
Variable	**Description**
D_ADHESION	Distance to start of area with reduced adhesion factor
L_ADHESION	Length for which the reduced adhesion factor applies
M_ADHESION	0 = Slippery Rail 1 = Non-Slippery Rail

Table 8: Packet 71 variables and values

Therefore, the selection of the adhesion value is limited to “Slippery Rail” and “Non-slippery Rail” when reported by Train Driver and ETCS-TS (RBC) to ETCS-OB.

Adhesion conditions are received by ATO-OB from the following actors:

a) ATO-TS, by means of the Journey Profile where different adhesion categories can be transmitted to ATO-OB (table 9)

Journey Profile – Temporary Constraints (Low Adhesion)	
Adhesion Category	**Value**
Dry Rail	0
Dry Rail (Medium)	1
Dry Rail (Low)	2
Low Adhesion	3
Very Low Adhesion	4
Extremely Low Adhesion	5

Table 9: Journey profile adhesion categories

b) ETCS-OB, by means of the ETCS-ATO on-board interface (SS130).

c) External System (TCMS), which provides slip/slide information (SS139).

ETCS-OB informs ATO-OB (SS130) through Packet Number 6 (ETCS_ATO_Dynamic) to indicate:

a) M_ADHESION_DRIVER = 0, slippery rail is set by the driver

b) M_ADHESION_DRIVER = 1, slippery rail is not set by the driver

ATO-OB informs ATO-TS (SS126) through Status Reports (Packet 8):

a) Q_STR_Indicators:

   i. Bit3 = 1, Low adhesion reported by the driver

   ii. Bit3 = 0, Low adhesion not reported by the driver

b) Q_STR_Indicators:

   i. Bit7 = 1, Slip/slide reported by TCMS/Train

ii. Bit7 = 0, Slip/Slide not reported by TCMS/Train

As opposed to the two values (“Slippery Rail” and “Non-Slippery Rail”) provided to ETCS-OB by Train Driver and ETCS-TS (RBC), ATO-TS reports ATO-OB on different adhesion categories.

Figure 12 illustrates the abovementioned interactions.

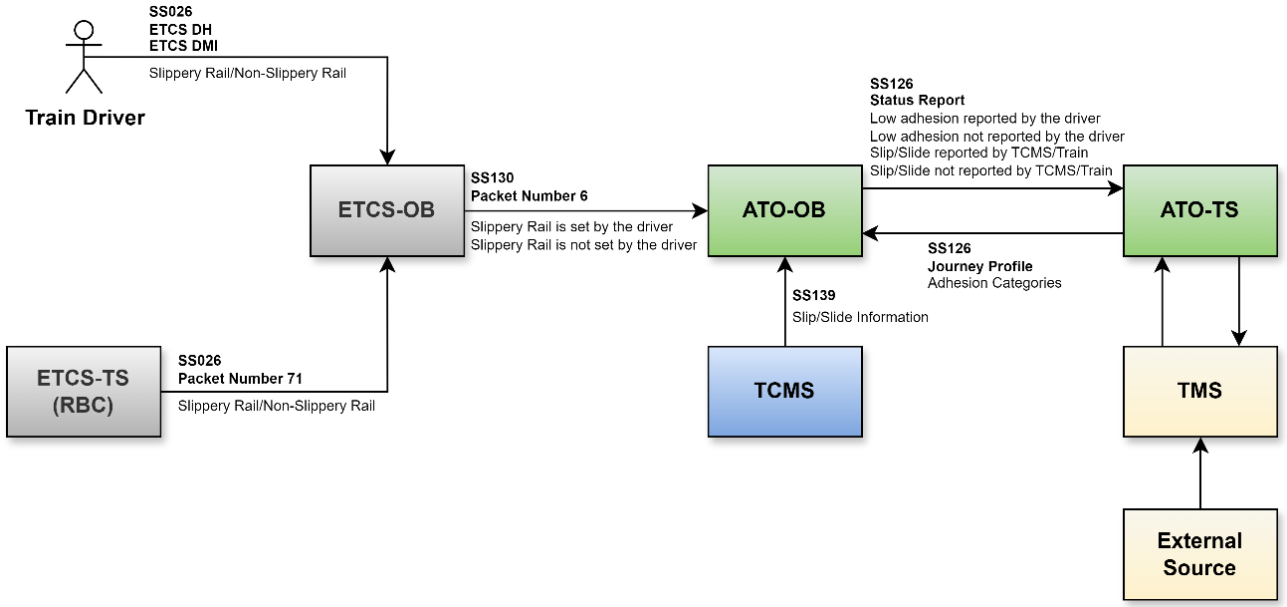


Figure 13: ETCS-ATO interaction in the Adhesion Management Process